EXPLORE
NUMBER 162
MARCH 2014
Newsletter for the Association of Applied Geochemists

Coupled XRF and XRD analyses for rapid and low-cost characterization of geological materials in the mineral exploration and mining industry

INTRODUCTION

Portable X-ray fluorescence (pXRF) spectrometry has numerous applications in a wide range of studies, including: non-destructive analyses in the alloy metals industry, particularly scrap metal sorting and material identification; archaeometry (Longoni et al. 1998); environmental sciences for conducting contamination characterization, removal, and remedial operations at hazardous waste sites (Kalnicky & Singhvi 2001; Melquiades and Appoloni 2004), archaeology (Romano et al. 2006; Phillips & Speakman 2009; Tantrakarn et al. 2009; Shakley 2010; Shakley 2011; Liritzis & Zacharias 2011); non-invasive analysis of museum artefacts (Karydas 2007; Uhlir et al. 2008); rapid screening of toxic elements in various products, goods and media (Ashley et al. 1998; Palmer et al. 2009); and, soil analysis and agriculture (Clark et al. 1999). In the last decade, portable XRF analysis has emerged as an important analytical technique for exploration and mining (Figueroa-Cisterna et al. 2011; Fisher et al. 2013; Gazley et al. 2011a, 2011b, 2013; Gazley & Fisher in press; Le Vaillant et al. in press). Portable XRF offers rapid, accurate and cost-effective analysis of geologic samples and provides data of high quality where appropriate calibration and quality assurance and quality control (QA/QC) protocols are followed.

With the advancement in hardware technology, namely X-ray tubes, detectors and processors, and more powerful and sophisticated software packages, X-ray diffraction (XRD) has become a qualitative and quantitative tool for the identification of crystalline materials and has tremendous potential applications in exploration and mining. Until now XRD has been a technique that is used mainly in research, but with automation of the data processing, XRD has the potential to become a routine technique for analysis of geologic materials. Ultimately, combined portable XRF and XRD instrument analyses will allow rapid chemical and mineralogical characterization of a sample, which in turn allows discrimination of lithologies, hydrothermal alteration and ore types. Coupled portable XRF-XRD analyses will pioneer a new paradigm in greenfields and brownfields exploration and geometallurgy. Here, we give an example of the application of coupled pXRF-pXRD analysis and software packages for data processing currently available on the market to a set of geologic samples.

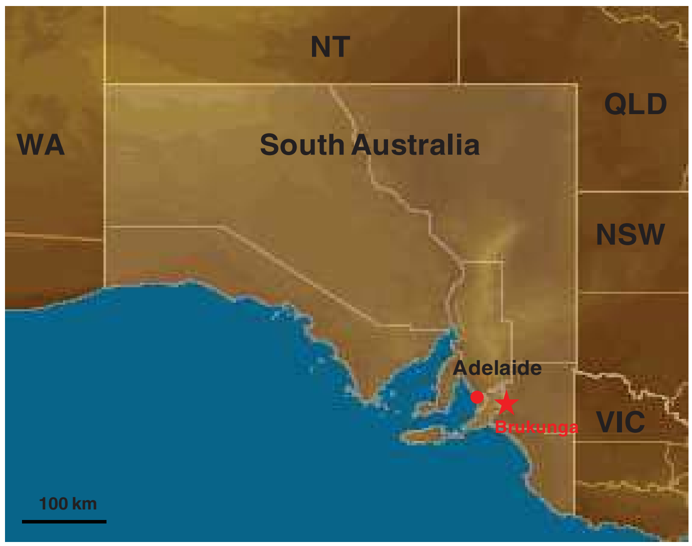

Figure 1. Schematic map showing location of the Deep Exploration Technologies Cooperative Research Centre Drilling Testing and Training Facility at Brukunga, Australia.

SAMPLES AND ANALYTICAL TECHNIQUES

Samples

The samples studied here are from a diamond drill hole at the Brukunga pyrite mine, South Australia, closed in 1970s and currently being used as a Deep Exploration Technologies Cooperative Research Centre Drilling Testing and Training Facility. It is located 47 km east from Adelaide (Fig. 1).

The rocks intersected by the drill hole are metasediments of the Nairne Pyritic Formation comprised of fine- grained greywackes, quartzites and siltstones and pyrite- and pyrrhotite-bearing beds siltstones of Cambrian age (Skinner 1958; Graham 1978). The drill hole intersected the main ore body from 130 to 280 m, and a number of thin zones with iron sulfide veins. The rocks of the Nairne Pyritic Formation are intruded by dolerite dikes. In this study we analyzed a set of 200 pulps by portable X-ray fluorescence (pXRF) spectrometry and lab-based and portable X-ray diffraction (XRD). The corresponding diamond drill core was logged and the analytical data were interpreted in light of the logging data.

Portable X-ray fluorescence spectrometry

Portable XRF analyses were performed on powdered material using an Olympus X-5000 (25 mm^2 detector, 50kV, 10Watt Ta anode) and an Olympus Delta Premium (30 mm^2 detector, 40kV, 4Watt Rh anode) instruments. Samples were analyzed in Soil, Mining Plus and Geochem modes. Prior to use, the instruments were standardized using a 316-steel plate. An instrument check was done prior to

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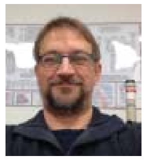
President's Message



As I start my two year term as President of the Association, I would like to express my gratitude to the AAG executive and Councillors who have made the last two years successful for the AAG, especially our esteemed outgoing president Bob Eppinger, as well as Gwendy Hall, Dave Smith, and Beth McClenaghan. Ryan Noble from CSIRO is the Association's new Vice-President. We are going to miss the services of long time AAG Business Manager Betty Arseneault, who has retired from this position. In the interim, Al Arseneault will be taking her place. Sarah Lincoln has retired as business manager for **EXPLORE**, and Pim van Geffen of REFLEX Geochemistry has become the new manager.

I would like to thank outgoing AAG 2012-2013 Councillors Rob Bowell, Bruno Lemiere, Ryan Noble, and Todd Wakefield for all their efforts over the past years. Continuing AAG Councillors include Patrice de Caritat, Cliff Stanley, Romy Matthies, Tom Molyneux, Peter Rogers, and Peter Winterburn. Newly elected Councillors for the 2014-2015 term include Stephen Cook, Paul Morris, Dennis Arne, Mel Lintern, Peter Simpson, and Alejandro Arauz. AAG Regional Councillors are Neil Breward, Theo Davies, Benedetto De Vivo, João Larizzatti, Brian Townley, Xueqiu Wang, and Pertti Sarala.

The AAG recently held its 26th International Applied Geochemistry Symposium in Rotorua, New Zealand. The success of this symposium was in large part because of the dedicated work of the Chair of the Local Organizing Committee Tony Christie, his local organizing team, and the professional conference organizers *Absolutely Organized*. Success was also in part due to the joint meeting with the Geothermal Workshop which allowed for cross-pollination of ideas between those working in the geothermal energy realm and those of us using geochemistry to understand, explore and mitigate the effects of the mineralization styles formed from geothermal processes. Tony has written a summary of the conference in this issue of **EXPLORE**. The 27th IAGS will be held in Tucson, Arizona, USA in April 2015, so start planning your travel now. The Local Organizing Committee, led by Eric Weiland, Sarah Lincoln, and Rob Bowell, have an active website (http://www.27iags.com) with sessions, field trips and short courses already listed. Registrations should be live on April 1, 2014.

The Mineral Deposits Research Unit (MDRU) at the University of British Columbia, Vancouver, Canada has just appointed Dr. Peter Winterburn to the newly established position of Chair in Exploration Geochemistry. This position is critical, as Peter and colleagues will help all of us in developing new ideas, new methods, and new technologies for the search for mineral deposits and our ability to mitigate the impact of metal extraction. One of the strengths of this new initiative at MDRU is the strong link between industry support and academia. In that vein, one of the things that I plan to focus on over the next two years is to raise the profile of our flagship journal GEEA (*Geochemistry: Exploration, Environment, Analysis*). The world of publishing is changing rapidly with an ever increasing number of journals; however, there appears to also be a dilution of the quality of submissions and reviews to these new journals. GEEA serves as a forum for consultants, practitioners, academics and geochemists of all stripes to communicate and share cutting-edge ideas in mineral exploration, related environmental studies, and analytical advances. There are several ways to help raise the profile of GEEA beyond continuing to publish great papers, and these include more review type articles, thematic special issues, and encouraging new and upcoming scientists, especially those in industry, and students to submit their work to our journal. Another area that I intend to strengthen (and will need lots of help with) is the web presence of the AAG. We have a new website coordinator, Bruno Lemiere, who will work closely with Gemma Bonham-Carter on AAG website content. We need more content and updates frequently on our website to engage the AAG membership and broader geochemical community. If you have ideas or content to share, please contact myself or Bruno.

I would also like to take this opportunity to express the condolences of the entire AAG membership to the family of Bill Coker, who passed away recently. We will all miss Bill's presence and contributions to the exploration geochemical community.

I wish everyone a successful 2014.

Matt Leybourne *AAG President*

Past President's Message

Dear AAG Members,

With the ending of 2013, the baton was passed on to Matt Leybourne last month. Good luck Matt! It has been a pleasure serving you over the last two years. The normal process is for the Past President to take over as the Chair of the Awards and Medals Committee. Thanks to Paul for heading this committee over the last two years and for updating/streamlining the awards process.

Our November IAGS in New Zealand was a great success, as future notes from Matt and articles in Explore will describe in more detail. However, our next IAGS is coming quickly. The 27th IAGS will be held in Tucson, Arizona on April 20-24, 2015. See http://www.27iags.com/ for details. Spring time in the Sonoran desert can be spectacular, but it is just over 14 months away!

Now is the time for you to consider deserving colleagues and put forward nominations for AAG's Gold and Silver Medals to be presented in Tucson. Details on how to put together a nomination package are found on our website at http://www.appliedgeochemists.org/index.php/awards . To date we have received one nomination for deserving scientists for this next cycle. Please take the time to nominate those who you think deserve this important recognition.

In case you didn't know, I retired from the USGS, effective January 2014, making room for younger staff to grow under these belt-tightening times! However, I will stay on as an Emeritus Scientist, retaining my office and email. This will allow me to finish a couple papers, among other things. However, I can do it at my own pace, and without dealing with administratrivia. My work email address remains the same, but my private email address is also included here (georiver@wispertel.net)

Time to start planning for my 20-day Grand Canyon float in March!

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Thank you,

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Notes from the Editor

The March 2014 issue of **EXPLORE** features reports and photos of many of the activities that took place in Rotorua, New Zealand as part of the 26th IAGS in November 2013. This issue also contains one technical article by Yulia Uvarova, James Cleverley, Aaron Baensch, and Michael Verrall that describes coupled XRF and XRD analyses of geological materials. We apologize for the error in **EXPLORE** 161 in which an incorrect photo was published as part of the obituary for Patrice Lavergne. The obituary is reprinted in this issue without the photo.

EXPLORE thanks all contributors and reviewers for this first issue of 2014: Steve Amor, Betty Arsenault, Britt Bluemel, Tony Christie, Graham Closs, David Cohen, Mary Doherty, Bob Eppinger, Philippe Freyssinet, Bob Garrett, Justine Gum, Ian Jonasson, Dave Kelley, Sarah Lincoln, Paul Morris, Jan Peter, James Pope, Jessey Rice, and Erick Weiland. This is the first issue of **EXPLORE** under the supervision of the new **EXPLORE** Business Manager, Pim van Geffen. Pim is a senior geochemist with REFLEX Geochemistry and we welcome him to **EXPLORE**. He may be contacted at: explorenewsletter@gmail.com

We thank Sarah Lincoln for her hard work as the **EXPLORE** Business Manager between 2007-2013.

Beth McClenaghan *Editor*

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measurement and then after every 15 samples using standards NIST2702, NIST2709, NIST 2781, NIST 2710a, NIST 2711a and a SiO_2 blank. Detection limits were estimated of the basis of reproducibility of the measurements for certified reference materials (NIST standards). The pulverized samples were placed in plastic vials, with the opening covered with Kapton tape. A small amount of material is required for this analysis, for the studied samples 5 to 10 g were used. The vial was then placed on the instrument window (tape side down) and analyzed with reading time on each beam of 60 seconds. Both Mining Plus and Geochem modes have two beams, and the Soil mode has three beams, with the beam energy stepping down with each subsequent beam. Beam run time can be chosen to vary from 10 to 60 seconds, but as it was shown that the analytical precision improves and the analytical error is reduced with longer counting time (Fisher et al. in press), the counting time was set up at 60 seconds. This resulted in total run times of 120 seconds for the Mining Plus and Geochem modes, and 180 seconds for the Soil mode. The data were processed off-line by QA/QC procedures based on the standard performance and application of appropriate calculated correction factors (Gazley & Fisher in press). The correction factors were developed based on the analysis of certified reference materials NIST2702, NIST2709, NIST 2781, NIST 2710a, NIST 2711a, and comparison of the expected and measured concentrations for each standard (Gazley & Fisher in press).

Powder X-ray diffraction

The same pulps were subsequently analysed by X-ray diffraction (XRD) using two instruments: (1) a lab-based Bruker D4 Endeavor AXS instrument, operating with Co radiation; data collection range of 2θ angle from 5 to 90°, with step size of 0.02°; data collection time of 7 minutes per sample; and (2) an Olympus Terra portable XRD instrument, operating with Co radiation; data collection range of 2θ angle from 5 to 55°, with increment of 0.25°; data collection time of 10 minutes per sample. Sample preparation for the analysis on the Bruker instrument required the material to be mixed with ethanol to form a paste and applied to a glass slide in order to obtain random orientation of mineral crystallites, particularly of platy shape. No additional sample preparation was required for the Terra pXRD instrument as the particles were less than 130 μm, and the pulps were loaded into the piezo-harmonic, Vibrating Sample Holder (VSH) of the Terra instrument (Sarazzin et al. 2005). The vibration frequencies are within the kHz range (Sarazzin et al. 2005). For both Bruker and Terra XRD analyzers 100 to 200 mg of material were used. Quartz contained in all analysed samples was used as an internal standard to verify mineral peak positions and correct for any displacement if required.

The XRD patterns obtained from both instruments were processed and mineral assemblages were quantitatively estimated using two different software packages: Bruker DIFFRAC.EVA which is based on the Reference Intensity Ratio (RIR) method (Smith et al. 1987), and SIROQUANT which is based on the Rietveld method (Rietveld 1967, 1969). Each peak above the background was examined and mineral identification in the analyzed samples was done manually to ensure that all components present in the multiphase mixtures are identified and accounted for, as the quantification data are normalized to 100%.

In addition, two artificial mixtures were prepared by weight using well-characterised mineral standards (i.e., quartz, albite, muscovite, biotite, hornblende and pyrite). Mixtures A and B were analyzed using the same procedures as the samples. The obtained diffractograms were processed with both DIFFRAC.EVA and SIROQUANT software packages, mineral abundances were estimated and compared to the expected percentages (Table 1).

RESULTS

Selected elemental contents determined by pXRF are shown in Figure 2 and are correlated with the lithologic log for the drill hole. The drill hole from which the samples were collected for this study intersected a zone of stratiform sulfide mineralization from 130 to 260 m, a few narrower intervals (5 cm to 1 m) with sulfide veins (e.g., at 65, 100, 103, 275 - 285, and at 300 m) and a few dolerite dikes (48 - 50, 288 - 291, 292 - 293, 295 - 298, 302 - 304, and 315 - 318 m) (Fig. 2). The pXRF data show that sulfide veins and main mineralization are evident as sharp increases in Fe and S contents, whereas dolerite dikes are distinguished by well-defined peaks in Ca (Fig. 2).

XRD analysis employing lab-based and portable instruments and subsequent data interpretation with two software packages based on Reference Intensity Ratio (RIR) and Rietveld methods resulted in four datasets:

(1) Data collected with the lab-based Bruker instrument and processed with DEFFRAC.EVA

Table 1. Mineral percentages obtained for prepared standard mixtures using Bruker and Terra instruments and DIFFRAC.EVA and SIROQUANT software packages.

Mineral	Actual %	Refined % Bruker+EVA	Refined % Terra+EVA	Refined % Bruker+Siroquant	Refined % Terra+Siroquant
Mixture A					
Quartz	25	15	24	24	27
Albite	25	22	28	21	24
Biotite	25	30	22	29	24
Muscovite	25	33	26	26	25
Mixture B					
Quartz	40	40	41	41	42
Albite	40	38	41	37	37
Hornblende	10	14	10	14	11
Pyrite	10	8	8	8	10

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Spinifex Ridge Iron Ore Mine, Western Australia, courtesy Moly Mines Limited

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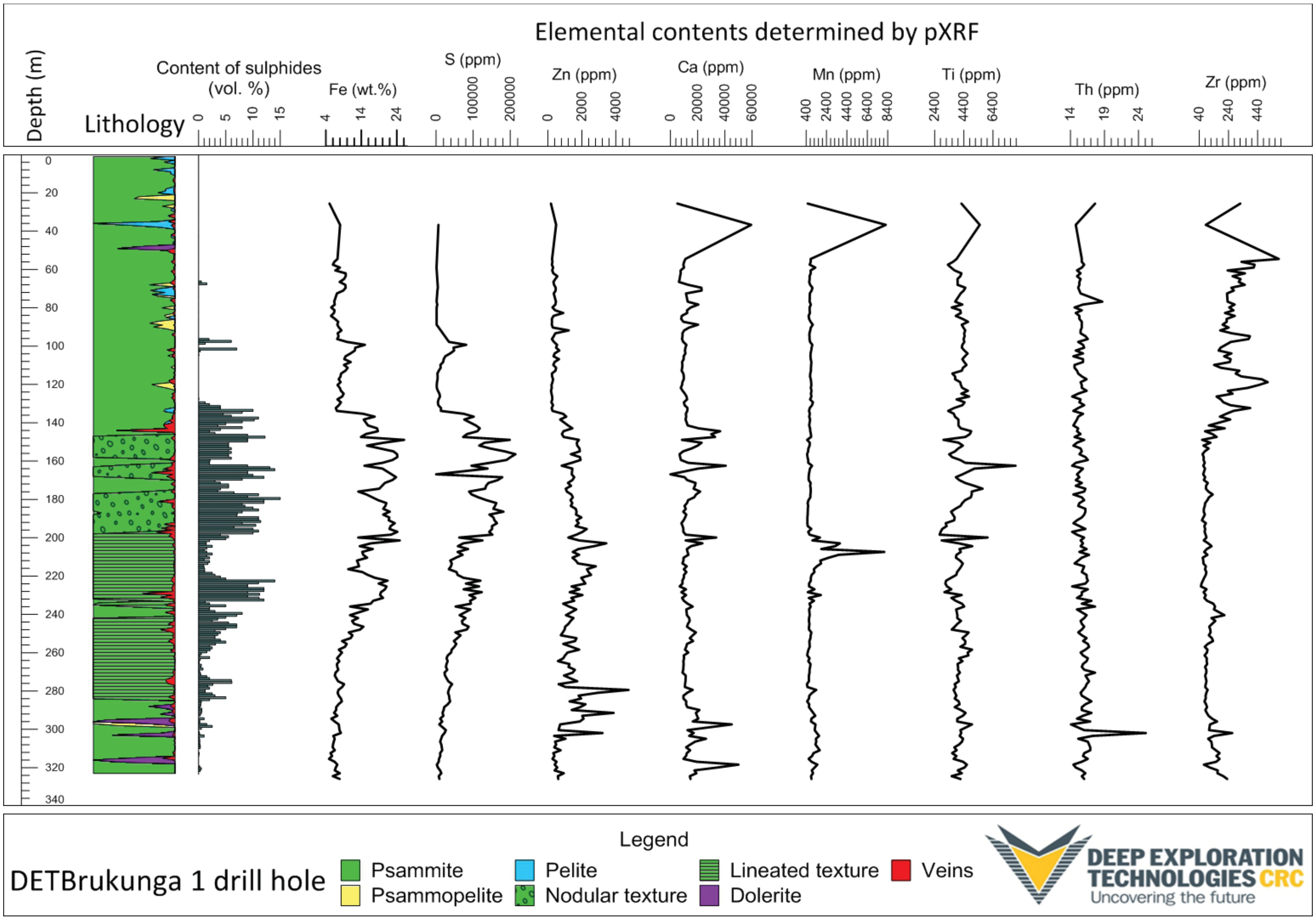

Figure 2. Lithology, sulphide distribution and content logged in the drill core and selected elemental abundances for the pulps from the DETBrukunga1 drill hole analysed by pXRF.

software (RIR method);

(2) Data collected with the lab-based Bruker instrument and processed with SIROQUANT software (Rietveld method);

(3) Data collected with the portable Terra instrument and processed with DEFFRAC.EVA software (RIR method);

(4) Data collected with the portable Terra instrument and processed with SIROQUANT software (Rietveld method).

The final outcome of XRD analysis and processing of the data with both instruments and software packages is the identification of all detectable mineral phases in the sample and an estimate of their abundance. Independent of the instrument or software used, the following minerals were identified by XRD in pulp samples: quartz, feldspar, biotite, muscovite, actinolite, chlorite, pyrite, and pyrrhotite. Figure 3 shows the mineral percentages for four combinations of the instrument and software package used for data collection and processing.

The analysis of artificial standard mixtures shows that all minerals in them are correctly identified, however estimated abundances of each mineral, vary depending on the type of the instrument used for data collection and software used for data processing (Table 1). Thus, percentages of mica-group minerals are overestimated with the use of the lab-based instrument and DIFFRAC.EVA software (Table 1). This, in turn, results in underestimation of other phases in the mixture. If SIROQUANT software is used for processing of the same data collected with the lab-based instrument, the abundances are much closer to the expected ones (Table 1). The data collected with a portable XRD analyser independent of the software used gave phase abundances closer to the expected (Table 1). This can be explained by two issues: sample orientation and availability of an option to refine for preferred orientation in the refinement method. For the lab-based Bruker XRD instrument, sample preparation requires either a back-packed powdered sample loaded in a holder or a small amount of material put on a glass slide. In both cases, sample preparation results in platy crystals creating the preferred orientation which is common for mica-group minerals, chlorites, amphiboles, etc. Portable XRD Terra

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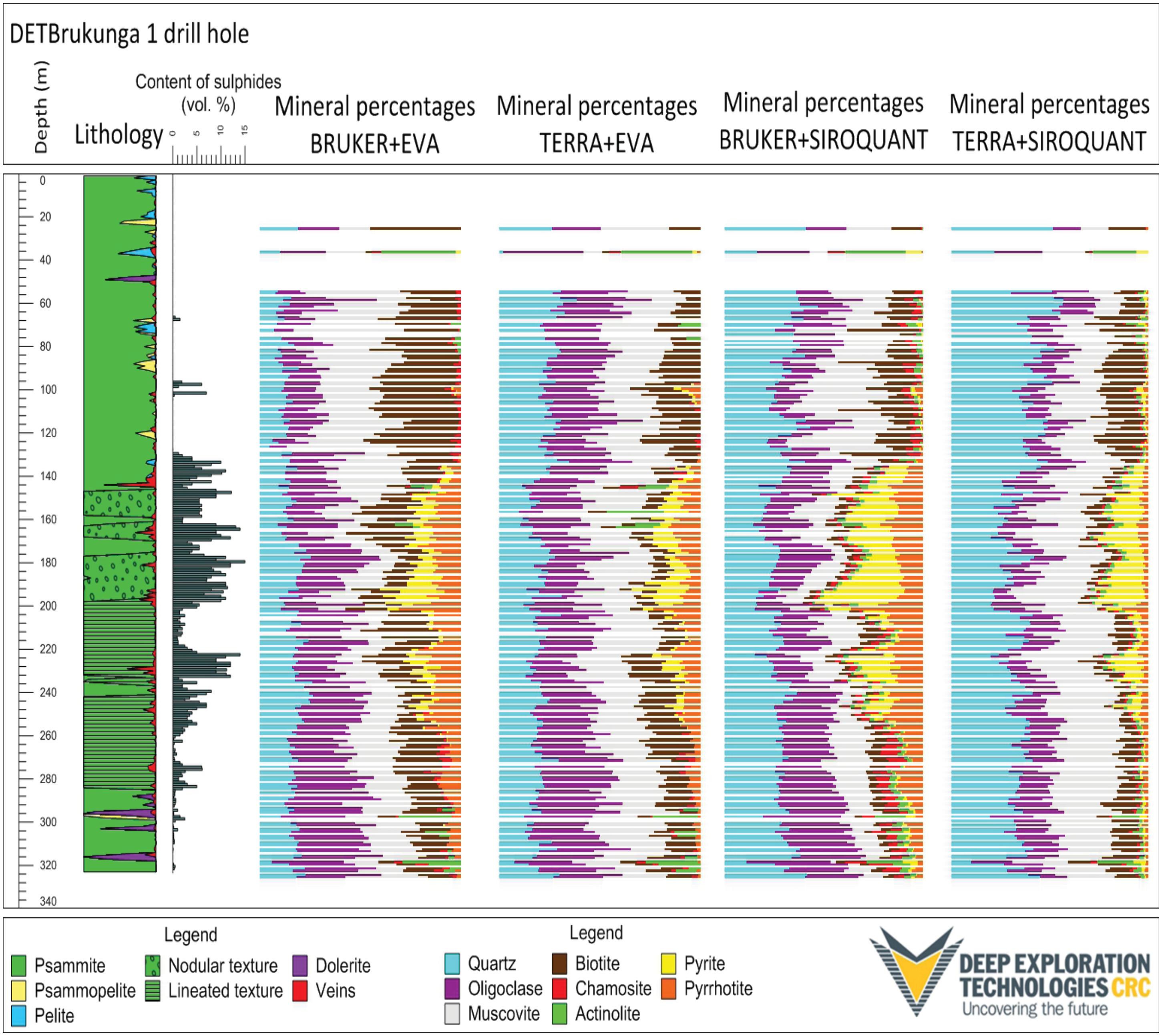

Figure 3. Lithology, sulphide distribution and content logged in the drill core and mineral percentages quantified from the XRD data collected with the portable Terra and lab-based Bruker instruments and processed with SIROQUANT and DIFFRAC.EVA software packages.

instrument has a convectional sample chamber in which the sample resonates during data collection, and it allows random orientation of all crystallites in the sample. Moreover, processing of XRD data in the DEFFRAC.EVA software which is based on the RIR method does not include refinement for preferred orientation. The SIROQUANT software based on the Rietveld method, on the other hand, allows the refinement for preferred orientation of platy minerals.

To verify the results of XRD analysis in a separate way, pXRF data were used and a normative content of pyrite and pyrrhotite was calculated, based on S contents determined and on the reasonable assumption that the only S-bearing minerals present are sulphides (no sulphates are present).

Figure 4 compares the total sulfide (pyrite and pyrrhotite) percentages quantified from the XRD data with the portable Terra and lab-based Bruker instruments and processed with SIROQUANT and DIFFRAC.EVA software packages.

DISCUSSION

Portable XRF is becoming routinely used in mineral exploration (Figueroa-Cisterna et al. 2011; Fisher et al. 2013; Gazley et al. 2011a, 2011b; Gazley & Fisher in press; Le Vaillant et al. in press). With the currently available portable instruments, data collection takes on average 120 seconds to achieve the best analytical precision and minimal

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analytical error. Portable XRF analysis thus allows for the characterization of a large number of samples within a single day at low cost and of high quality where proper QA/QC protocols are followed. In the current study, pXRF data clearly identify the various metasedimentary, the sulfide mineralization and the dolerite dikes and can be used to distinguish between them (Figure 2).

The assemblage quartz – feldspar - biotite – muscovite ± actinolite ± chlorite ± pyrite ± pyrrhotite was identified in all samples studied, but there are differences in the mineral abundances determined by which instrument and data processing software is used (Fig. 3). Accordingly, Figures 5a and b illustrate the downhole abundance variations in biotite and muscovite (respectively) for the different instruments and data reduction software used. Figure 5a shows that biotite abundances determined by the lab-based instrument and RIR method of quantification are greater than those obtained using the lab-based instrument and Rietveld refinement data reduction or with the portable Terra instrument, as the former allows for refining of the preferred orientation and the latter has a convectional sample chamber and reduces the effect of preferred orientation during data collection. Muscovite abundances show similar features amongst the instruments and the data reduction software used (Figure 5b). This is similar to the results obtained for the artificial standard mixtures, where abundances of mica-group minerals were overestimated with the lab-based instrument and RIR refinement (Table 1). Underestimation or overestimation of any mineral affects calculation of percentages of others as the data are normalized to 100%. Thus, for the standard mixture containing quartz, feldspar and mica-group minerals, in cases where mica-group minerals were overestimated, quartz and feldspar abundances were underestimated (Table 1). In the case of the studied samples, percentages of quartz and feldspar were underestimated with the lab-based instrument or RIR refinement because the amount of mica-group minerals overestimated (Figures 5c and d). Chlorite and actinolite abundances quantified with the pXRD analyzer and processed with the SIROQUANT software are lower than those obtained with the lab-based

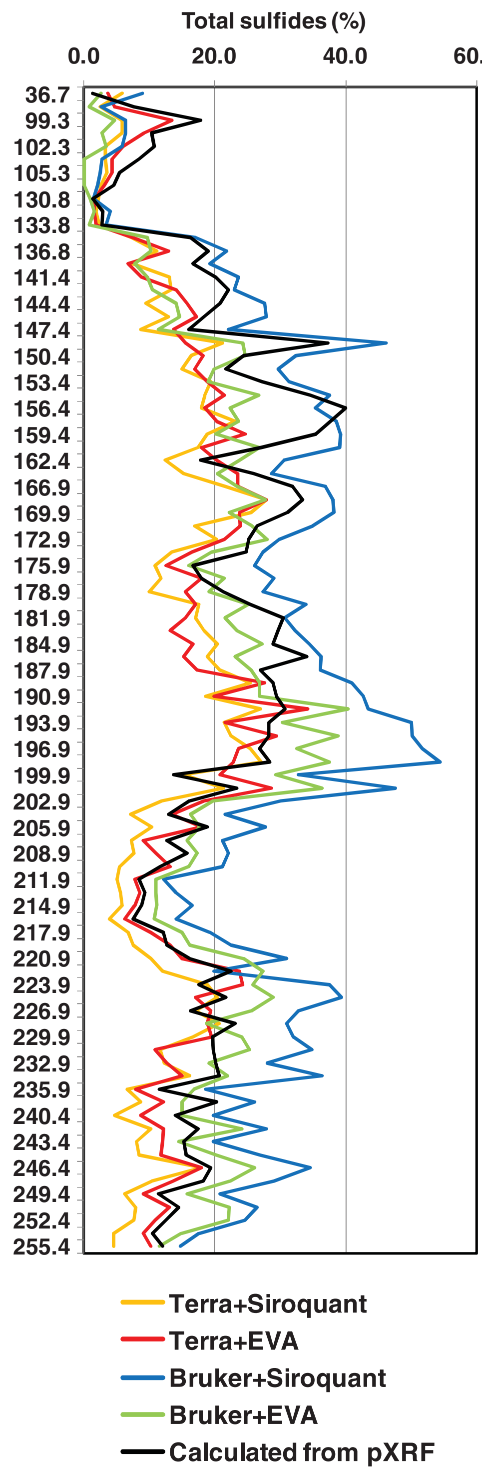

Figure 4. Comparison of total sulphide (pyrite and pyrrhotite) percentages quantified from the XRD data collected with the portable and lab-based instruments and processed with SIROQUANT and DIFFRAC.EVA software packages and theoretical amount of sulphides calculated from pXRF sulphur content in the samples.

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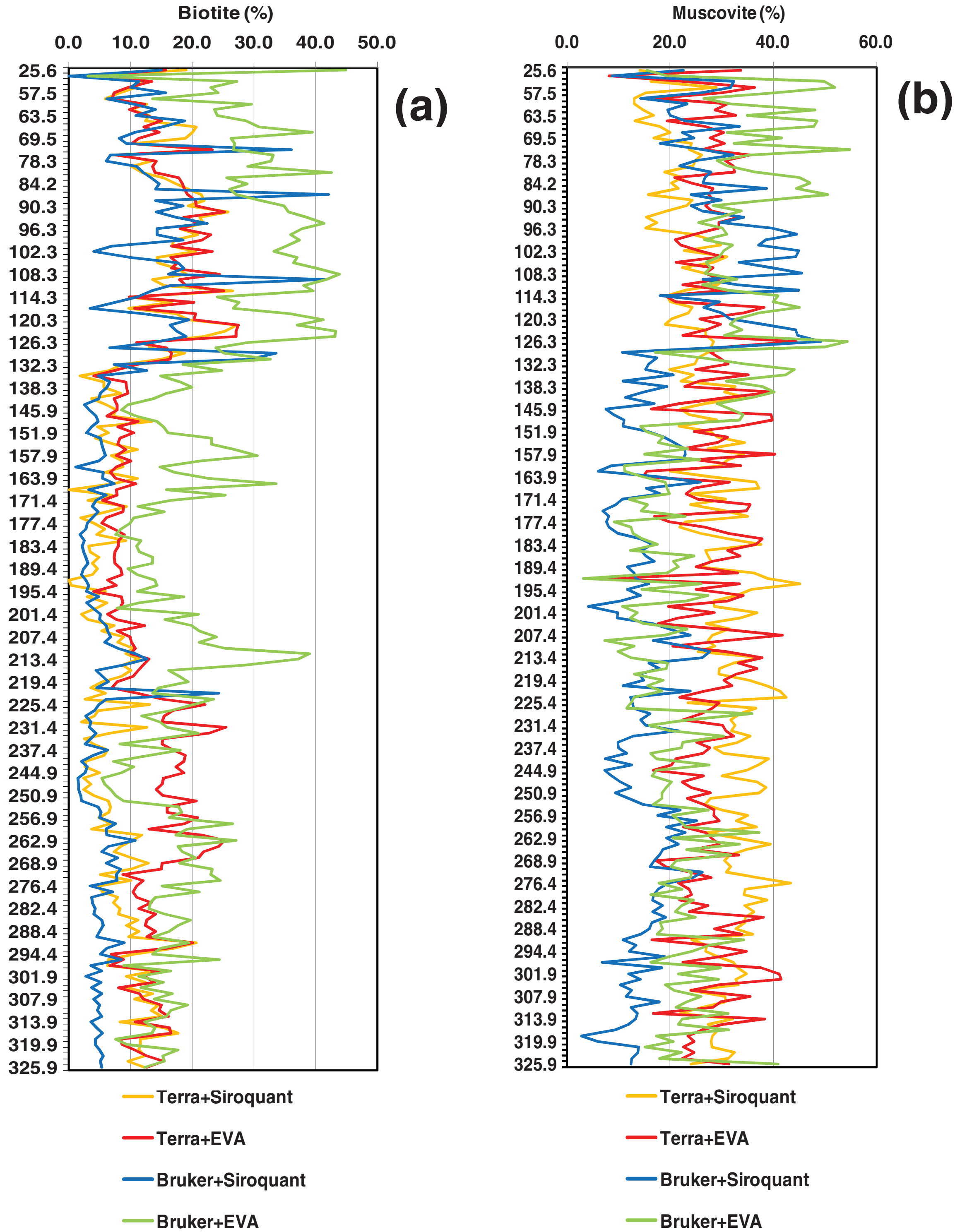

Figure 5. Comparison of (a) biotite, (b) muscovite, (c) quartz, (d) feldspar, (e) chlorite and (f) actinolite percentages quantified from the XRD data collected with the portable Terra and lab-based Bruker instruments and processed with SIROQUANT and DIFFRAC.EVA software packages.

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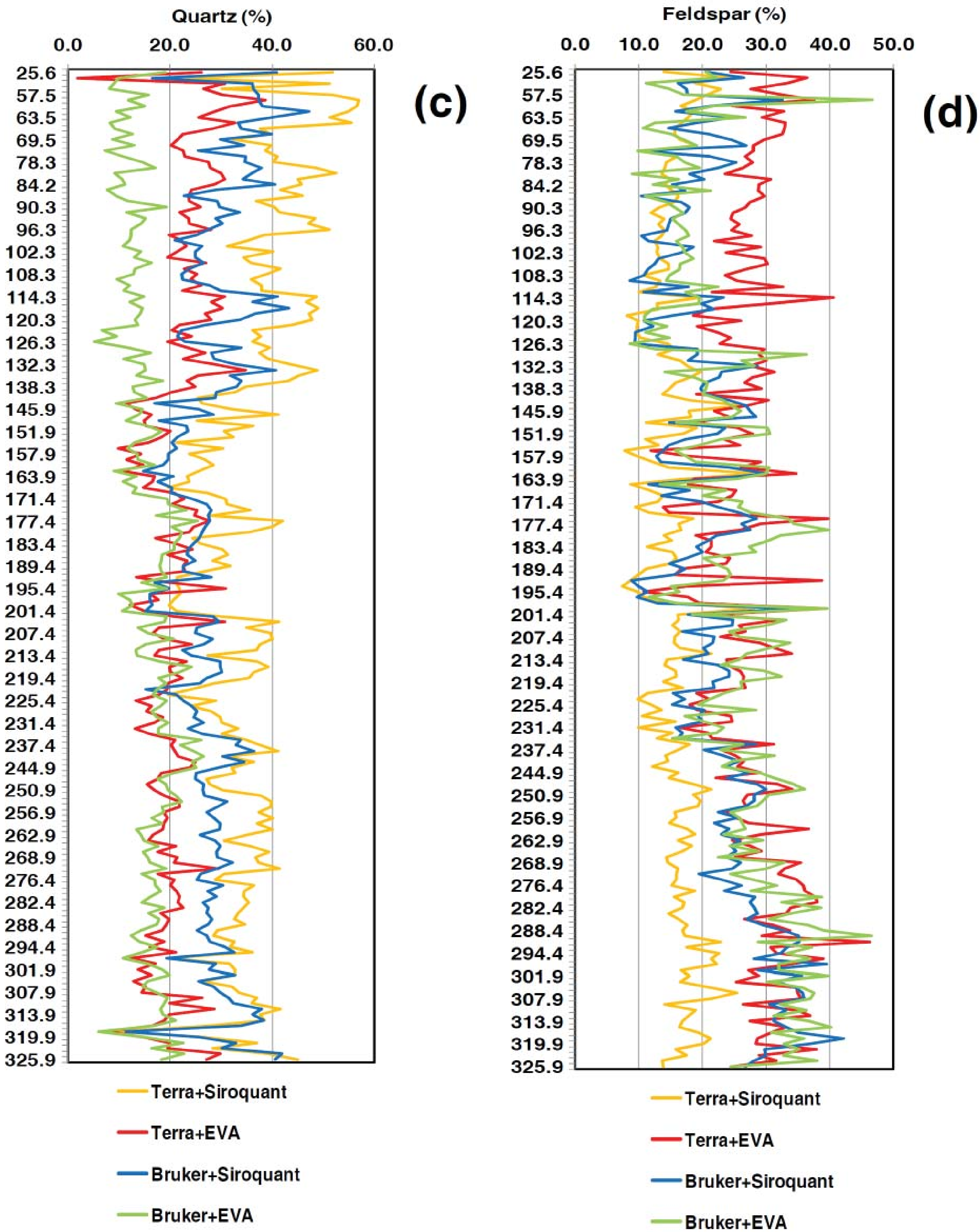

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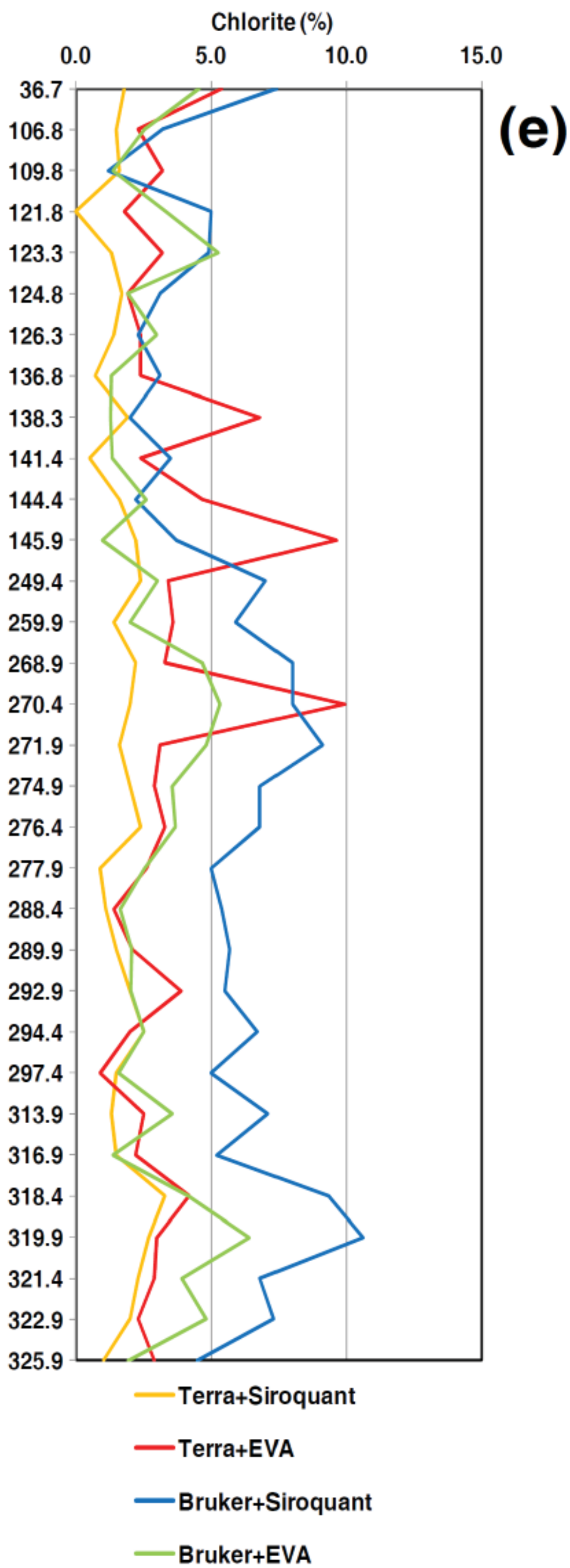

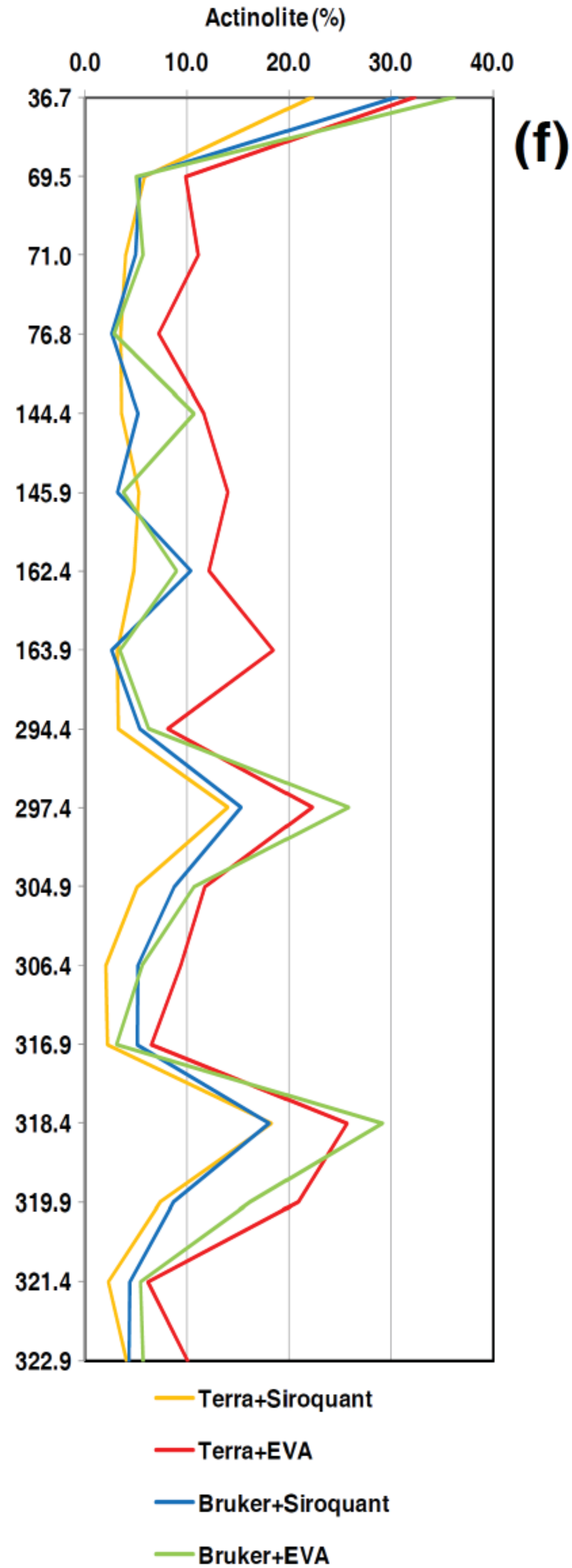

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instrument and the DIFFRAC.EVA software (Figures 5e and f). The observed results are similar to the results for biotite and muscovite, and are most likely due to overestimating of chlorite and actinolite percentages obtained with the lab-based instrument and DIFFRAC.EVA software as a result of the preferred orientation.

The sulfide abundances were estimated using the S contents determined by pXRF and an assumption that pyrite and pyrrhotite occur in ratio 1:1 supported by observations in the core. The results agree reasonably well (R2 varies between 0.76 and 0.85, depending on which data sets are compared) with the total sulfide amounts determined by XRD (Fig. 4), which validates the results obtained by both techniques.

Overall, our data clearly show that mineral mixtures in the studied rocks can be identified and quantified using existing XRD technologies and software packages, and the portable and lab-based instruments give comparable results. However, the convectional sample chamber of the portable XRD Terra instrument provides an advantage in the analysis of samples containing minerals that form platy crystals, as it eliminates preferred orientation. The Rietveld method of data processing solves this problem as well by refinement for the orientation effect (Bish & Post 1993); however, the use of any software package based on this method requires some expertise in XRD and a background in crystallography. In contrast, the RIR method is user-friendly for the non-specialist. Although it does not allow for refinement of the preferred orientation, its use for processing of the data collected with the portable XRD analyzer equipped with the vibrating sample holder gives results that are comparable with those obtained by the refinement with the Rietveld method. For "rapid" data collection and processing, we recommend the use of the portable XRD Terra instrument and data processing using software that is based on the RIR method. For this combination, 10 minutes of data collection time and 10 to 20 minutes for data processing are required per sample. The time for data processing can be significantly decreased with a batch-processing option, which allows simultaneous refinement of a large number of patterns. Therefore, with the use of new instruments that are capable of rapid data collection and batch-processing options in the software, XRD has a strong potential to become a routine technique for analysis of geological materials and become widely applied in mineral industry.

Coupled pXRF-pXRD analysis of the same samples provides chemical and mineralogical data that can be used for discriminating lithologies, alteration and ore types. An example is the sharp increase in Ca contents between the following intervals: 295-298 m, 302-304 m and 315-318 m (Fig. 2); one possible interpretation of this is that they are due to the presence of Ca-bearing carbonate. Light elements (below Mg, atomic number 12 on the periodic table), including C, cannot be analysed by pXRF (due to tube voltage and power restrictions because of safety concerns), and as such the pXRF data cannot provide support for this possible interpretation. However, the pXRD data do not indicate the presence of Ca-bearing carbonate in these intervals, but do indicate the presence of a calcic amphibole actinolite (Fig. 3), which is associated with the dolerite dikes.

CONCLUSIONS

The current study illustrates that combined pXRF-pXRD analysis can be performed on a large set of complex geological samples and the techniques complement each other. Portable XRF results can be used to verify the results of portable XRD and vice versa. Our study also shows the viability and usefulness of portable XRD analysis that is currently underused. Portable XRD analysers can provide data comparable to modern lab-based instruments and the novel, innovative, and unique convectional sample chamber of the Olympus Terra analyser is ideally suited for analysis of samples with minerals with preferred crystallographic orientation such as mica-group minerals, chlorites, and amphiboles. A small amount (less than 5 - 10 g) of sample is required for coupled pXRF-pXRD analysis that can be performed with currently available portable instruments in less than 15 minutes for both measurements. Combined portable XRD-XRF analysis, therefore, offers rapid and low-cost characterization of geologic materials for mineral exploration and mining industry and delivers elemental and mineralogical information of high quality where appropriate QA/QC protocols are followed. The integrated data can then be used to constrain lithologies and contacts between various units, hydrothermal alteration and ore types.

ACKNOWLEDGEMENTS

The work has been supported by the Deep Exploration Technologies Cooperative Research Centre whose activities are funded by the Australian Government's Cooperative Research Centre Programme. The authors would like to thank Professor David Giles for providing the core logging data. The authors are also grateful to Olympus NDT for providing portable XRD Terra instrument. We would like to thank CSIRO reviewers Michael Gazley and Alistair White, EXPLORE reviewer Jan Peter (Geological Survey of Canada) and EXPLORE Editor Beth McClenaghan for their comments and revisions of the manuscript.

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Distinguished Applied Geochemists Fund

The Distinguished Applied Geochemist Fund exists to honour the memory of geochemists in the field of exploration, environmental, and analytical geochemistry. It is administered by the Association of Applied Geochemists and provides financial support for research initiatives at the student level.

The fund was initiated in 2001 by the Association of Exploration Geochemists as the Alan Coope Fund to honour the memory of Dr. J. Alan Coope, who was one of the founding members of Association of Exploration Geochemists, one of its Past Presidents, and a remarkable and dedicated exploration geochemist. In 2006, monies raised in honour of another distinguished geochemist, Dr. Paul K. Theobald, were combined with the Alan Coope Fund to create the Distinguished Applied Geochemist Fund. The new fund allows for donations in the memory of other distinguished geochemists. \

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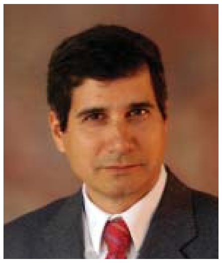

Alejandro J. Arauz

Alejandro is a geologist/geochemist with over 27 years of experience in mineral exploration, environmental studies and mining environmental management in Latin America. As exploration geologist he participated in the discovery of the Crucitas Gold Deposit (2.0 Moz Au) in northern Costa Rica. As an environmental scientist and consultant, he has provided technical and logistical support for several mining projects located in Mexico, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Dominican Republic, Panama, and Peru. Alejandro is a part time professor at Universidad de Costa Rica where he teaches Introduction to Geochemistry and Applied Geochemistry, and is member of the editorial board of "Revista Geológica de América Central." Mr. Arauz has a BS degree in Geology from Universidad de Costa Rica, a MSc Degree in Geology from Colorado School of Mines and an MBA in natural resources from INCAE. He is a member of the AAG (1984), of the SEG of Colegio de Geólogos de Costa Rica, and is honorary member of the Asociación Argentina de Geoquímica.

Dennis Arne

Dennis is Principal Consultant – Geochemistry and Director of CSA Global Canada. He has been a principal geochemical consultant for the last five years based primarily out of Vancouver, initially with ioGlobal (now Reflex Geochemistry), and then with a small consulting group, Revelation Geoscience Ltd, prior to merging with CSA Global in 2012. Before moving to Canada, he was a contract Senior Geochemist and consultant for Geoscience Victoria, Australia where he undertook orientation studies in lithogeochemistry, partial extraction soil geochemistry, hydrogeochemistry and hyperspectral analysis as part of the Gold Undercover initiative. He ran his own geological and environmental consultancy for nearly a decade in Australia where he worked in mineral exploration as well as undertaking geotechnical and land capability assessments. He was previously Senior Lecturer in Applied Geochemistry and Economic Geology at the Western Australian School of Mines, Curtin University, and Lecturer in the same areas at the University of Ballarat, Australia. Dennis was a Killam post-doctoral Fellow at Dalhousie University in the early 1990s where he applied thermochronological methods to petroleum maturation and tectonic studies and prior to that worked for several years as a consultant to the global petroleum industry. He has completed a Graduate Diploma in Hydrogeology and Groundwater Management at the University of Technology, Sydney, a PhD in thermochronology applied to mineral deposits at The University of Melbourne, a MSc in economic geology at Lakehead University, and a BSc Honours at the University of Regina. He has worked extensively in Canada and Australia, with occasional forays into South America and Antarctica.

Mel Lintern

Mel is a research geochemist for CSIRO's Minerals Down Under Flagship and Earth Science and Resource Engineering division. He holds a PhD Applied Geology, a graduate Diploma in Environmental Science, and a Bachelor of Science (Zoology). His expertise lies in the application of geochemistry, including biological media and calcrete (a common soil component in arid Australia) for minerals exploration. Mel joined CSIRO in 1980, and has since achieved numerous scientific breakthroughs that have had a direct impact on mineral exploration. He has translated the science of biogeochemistry, gold's mobility in the surficial environment and how abiotic-biotic geochemical anomalies form into robust mineral exploration tools used by industry to find new mineral deposits. In the last ten years, Mel has led a number of large, multi-client

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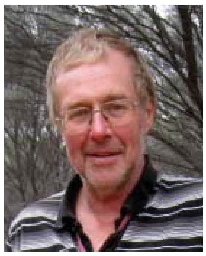
externally-funded projects involving more than 40 domestic and international exploration companies, geological surveys and academic institutions. Mel's research has demonstrated that vegetation creates detectable surficial geochemical anomalies in calcrete, even where there are significant thicknesses of transported cover such as sand dunes. He also discovered that gold occurs in both ionic and metallic forms within calcrete, which has helped explain the chemical mobility of gold in soil and allows partial extraction analysis to be confidently applied by mineral explorers to detect mobile surficial gold anomalies. Mel's research is enabling mining companies to explore with more confidence when tackling greenfield areas where sedimentary cover dominates, particularly in arid and semi-arid regions of Australia.

Paul Morris



Paul holds a BA as well as BSc (from Otago Univeristy) and PhD (from Victoria University of Wellington) degrees in Geology. He has held several postions including Senior Tutor, Geology Department, University of Sydney; JSPS post-doctoral fellow, Shimane University (Japan); post-doctoral research associate, University of Sydney; Geologist, Mineral Resources (Geological Survey of Western Australia (GSWA); Senior Geologist, Regional Geoscience Mapping (GSWA); and Associate Professor in Geology, Shimane University, Japan. Curently, Paul is the Chief Geochemist of the Geological Surevy of Western Australia, a positon he has held since 1996. Paul has been a AAG Fellow since 2002 and he has held several important positons within AAG, including Vice-president of the AAG in 2008-2009 and President of AAG in 2010-2011. Most recently, Paul was Chairman of AAG's Awards and Medals Committee 2012-2013.

Stephen Cook

Stephen Cook received a B.Sc. degree in geology from Carleton University in 1984, and a M.Sc. in geology, specializing in exploration geochemistry, from The University of British Columbia in 1991. He worked with the Geological Survey of Canada 1985-1988 in the regional geochemical surveys group, and in 1991 joined the British Columbia Geological Survey in Victoria, where he worked as an exploration geochemist for several years. In 2000, he joined Anglo American in Vancouver as Senior Geochemist - North America & Europe, where until 2004 he was involved in geochemical exploration programs for base metals in Canada, Mexico, the U.S. and Ireland. He ran his own consultancy, Cook Geochemical Consulting, from Victoria for two years until joining the exploration group of then-Teck Cominco in 2006 as Chief Geochemist. For the past 7 years he has directed geochemical exploration work on Teck's global exploration programs. Stephen was a member of the organizing committee for the 19th International Geochemical Exploration Symposium (IGES) held in Vancouver in 1999.

Peter Simpson

Peter was President of AAG in 1998. He is presently located at the Royal School of Mines, Department of Earth Science and Engineering, London, UK. His main interests currently include the development of new and innovative research topics that are designed to help meet the requirements of potential MSc and PhD students in Exploration and Environmental Geochemistry. These students will benefit from access to a broad spectrum base making use of a lifetime of knowledge concerning the practices of mining companies and regulatory authorities. The objective of this approach is designed to help identify and undertake further research into the exploration for and development of mines and mineral deposits worldwide. The intention in this instance is thereby to continue to assist in the training of postgraduate geoscience students involved in exploration and environmental geochemistry who have mineral exploration as one of their primary professional interests. This approach has proved very successful hitherto with the result that many previous students from Imperial College are now playing a leading professional role in mining companies and consultancies worldwide.

26th International Applied Geochemistry Symposium, Rotorua, New Zealand, November 2013 — Overview

The 26th International Applied Geochemistry Symposium (IAGS), incorporating the 35th New Zealand Geothermal Workshop (NZGW), was held at the Rotorua Convention Centre, 18-21 November. Registrations included 536 delegates attending the technical programme (275 IAGS and 261 NZGW, including 104 students), an additional 22 exhibitors, and 34 accompanying persons, representing 31 countries (Fig. 1).

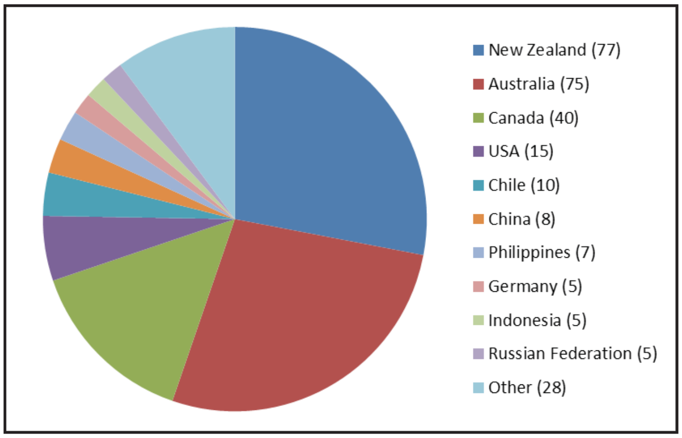


Fig. 1. Country of origin for the 275 IAGS registrations.

Inclusion of the NZGW delegates increases the proportion of New Zealand delegates from 28% to 51%. The technical programme commenced with a plenary session of four keynote presentations on the geology, geothermal systems and geothermal mineralisation in the Taupo Volcanic Zone.

Subsequently, the programme split into separate IAGS and NZGW plenary and concurrent sessions with a total of 32 keynote and 222 standard oral presentations, and 55

Fig. 2. Conference opening in the Rotorua Convention Centre Theatre

poster presentations. There was a maximum of three concurrent IAGS sessions and five IAGS plus NZGW sessions. Posters were presented in two groups, one Monday and Tuesday and the other Wednesday and Thursday, each with special late afternoon poster sessions. The IAGS sessions included 6 sessions sponsored by the Society of Economic Geologists with some notable international speakers such as Richard Arculus (ANU), Stephen Cox (ANU), Rich Goldfarb (USGS), David Groves (UWA), Iain Pitcairn (Stockholm University), Terry Seward (VUW), and Stephen Turner (Newmont). The conference finished with a keynote presentation on wine terrior by Larry Meinert (USGS) who explained why the Gimblet Gravels area in Hawkes Bay produces great wine. Apparently Gimblet Gravels is the only appellation in the world defined by a geological unit.

Eight short courses and workshops (all 1-day), and eleven field trips (1-7 days duration) were run in association with the conference. All the field trips were blessed with great weather. Short course registrations ranged from

Fig. 3. Audience at the opening session in the Rotorua Convention Centre Theatre.

8 to 29, whereas field trip registrations ranged from 5 to 31 with the low numbers of the range representing the helicopter trips to White Island. An accompany persons programme provided tours on five days, Sunday to Thursday inclusive.

The meeting had social functions on each evening providing plenty of opportunity for networking. Sunday was the Powhiri and Welcome function. Monday was a Students meet Industry evening, but open to all. More than 320 attended the Tuesday night conference dinner that was held at the Blue Baths, a very attractive and historic venue. Wednesday night had a choice of three activities: the Tamaki Maori Village Hangi and concert, attended by

Fig. 4. More than 320 attended the conference dinner at the Blue Baths.

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Faces in the Crowd... 26th International Applied Geochemistry Symposium












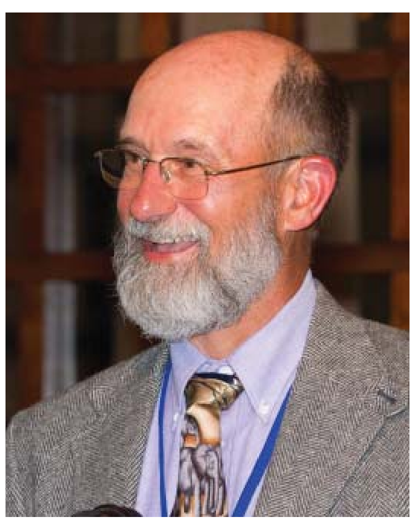


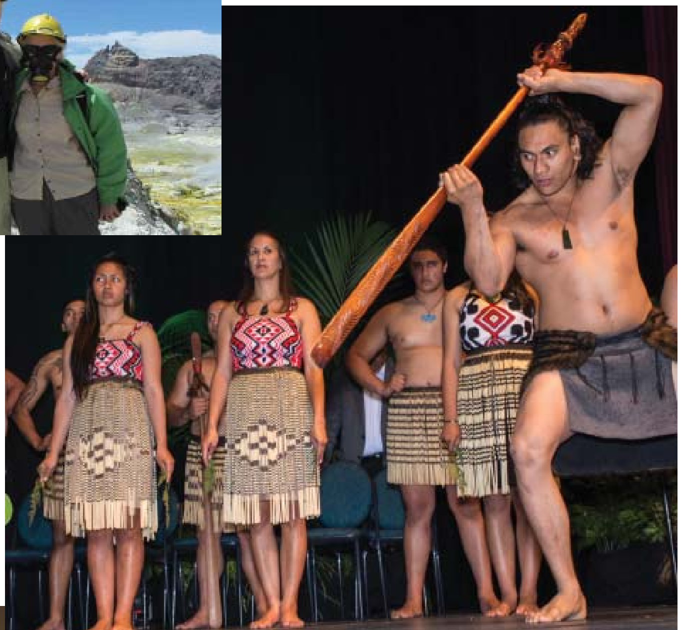


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more than 80 of the overseas delegates, a pub crawl with more than 100 participants, and the Hydrothermal Fluid Society wine tasting attended by 27, with 83 bottles of wine up for tasting! Eighty delegates attended the Thursday evening farewell dinner poolside at the Millennium Hotel.

The 2013 conference was a real departure from the norm for the biennial IAGS, because of the incorporation of the NZGW and SEG sessions. Positive responses from the delegates indicated that the combined conference was a great success.

Tony Christie, *Chair*
26th IAGS Organizing Committee

Field Trip Review:

Active and Extinct Hydrothermal Systems, North Island, New Zealand

As part of the 26th IAGS, this pre-meeting field trip began in Auckland on 10 Nov 2013 and ended in Rotorua on 16 Nov. The fabulous trip was led by Stuart Simmons (Energy and Geoscience Institute, University of Utah; stuart@hotsolutions.co.nz) and by Tony Christie (GNS Science; t.christie@gns.cri.nz). There were 26 attendees, including the leaders, representing 11 countries (Australia, Chile, Croatia, Germany, Indonesia, Germany, New Zealand, the Philippines, Russia, Turkey, and the USA). The group was an interesting mix of disciplines, including students, geologists, geochemists, a geophysicist, and geothermal engineers, who are involved in mineral and geothermal exploration, geothermal development, and academia. This group mix led to interesting and diverse discussions on the outcrop. A good field trip guide and numerous references were provided, from which this review is derived.

Leaving Auckland, our first stop was Kawakawa Bay, to view exposures of relatively unaltered Mesozoic meta-sedimentary basement units that are the host rocks for the hydrothermal systems we were to visit later. We soon learned that bedrock exposures are indeed rare on the North Island. This was followed by a stop at Karangahake Gorge at the southern end of the Coromandel Peninsula. At the Karangahake mine, we examined 6 Ma old, Au-Ag-bearing quartz vein deposits hosted by adularia- and propylitically-altered rhyolite lavas and andesite breccias and flows. The historic mining area, site of a gold rush in 1875 and the first place to commercially use cyanide treatment in 1889, has been turned into a self-guided tourist attraction with numerous trails along the old rail line, occasionally passing through open tunnels and adits (where we saw a few glow worms in addition to mineralized veins). Geologic signage helps tourists understand what they are viewing; our group was treated to more in-depth descriptions by Tony and Stuart. We did not visit the numerous historic and active gold mines further north on the Coromandel Peninsula, which is a multi-day trip in itself.

Following a night in Waihi, we next visited Newmont's active Martha Mine, an open pit located on the very edge of Waihi. After an excellent geologic overview of the Martha and nearby Favona deposits provided by Newmont's Jackie Hobbins, we examined some drill core and then walked to the edge of the pit. Hosted by Miocene andesite to dacite flows and pyroclastics, the 7-12 Ma deposits at Waihi have produced 7.2 M oz Au and 43 M oz Ag. In progressive fashion, Newmont has constructed an accessible self-guided walkway that completely surrounds the roughly 1 km diameter active pit, with informative signage to provide locals and tourists with a better understanding of the current mining process and historical mines worked between 1883 and 1952. Particularly interesting was a LIDAR instrument located high on the side of the pit that continuously scans the pit walls for evidence of movement, an advanced safety feature. After this visit, we proceeded to Rotorua, making a short late afternoon stop along the way to sample New Zealand wines at the Morton Estate winery. We based in Rotorua for several nights.

Figure 1. Boiling sulfuric-acid- and clay-rich main crater lake surrounded by steaming and smoking vents, White Island.
Photo by Stuart Simmons.

On the third day we drove to Whakatane airport, where we boarded three helicopters for a 20 minute flight out to White Island, an active volcano at the northeast

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Field Trip Review: Active and Extinct Hydrothermal Systems... continued from page 22

end of the Taupo Volcanic Zone. Normally, the pilots themselves lead the excursions at White Island, but on this trip, they took advantage of Stuart Simmons' presence to learn more about the volcano. The White Island volcanic-hydrothermal system is believed to represent the chemical conditions that lead to the formation of high-sulfidation Cu-Au ore deposits. Altered andesite ejecta contain alunite, anhydrite, and pyrite. With gas masks around our necks in case of a wind shift, we observed mud pots, fumaroles, and acid springs, the latter two belching sulfurous smoke and hydrogen-sulfide-laden steam. We observed one small acidic stream moving and depositing fine sulfur sediment that formed small-scale depositional patterns reminiscent of those found in large-scale glacial deposition. The crater lake itself appeared to be a boiling, steaming vat of sulfuric acid-rich water (Fig. 1). All-in-all it was a scene fit for a doomsday scene at Mordor in Lord of the Rings! But for this geologist, it was truly enlightening.

Day 4 was spent visiting two thermal areas, Orakei Korako and Waiotapu, more centrally located in the Taupo Volcanic Zone. Access to Orakei Korako was by boat across Lake Ohakuri, where we observed extensive modern silica sinter terraces offset by active faults. Prior to dam construction and formation of Lake Ohakuri in 1961, about 1,100 springs issued from the banks of the Waikato River. Waiotapu has numerous fumaroles, collapse craters, mud pools, acid-chloride pools, and intensely altered rocks due to acid-sulfate fluids that form above the water table. However, the single feature that impressed me the most was the world-famous Champagne Pool that fills a hydrothermal eruption crater. I have wanted to see this gold deposit in-the-making for over 30 years. The unusually-colored orange rim of this 65 m diameter, >60 m deep, CO_2-bubbling pool (hence, "Champagne") is composed largely of As and Sb colloids, and contains near-ore-grade gold, plus high concentrations of Ag, Hg, S, and Tl (Fig. 2). The sinter ledge surrounding the pool is

Figure 2. The steaming Champagne Pool at Waiotapu. Photo by Bob Eppinger.

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Field Trip Review: Active and Extinct Hydrothermal Systems... continued from page 23

tilted, with the southern rim rising about a meter above the northern rim due to active seismicity. Formed 900 years ago by a hydrothermal eruption, the Champagne Pool is truly spectacular!

Day 5 began with an overview stop at Wairakei, New Zealand's first geothermal power station. Reasons for the maze of large to small, straight, curved, and looping networks of pipes with steaming vents were explained by Stuart, but further elucidated by geologist-engineers from Indonesia and the Philippines who were field trip participants. We then visited Craters of the Moon, a geothermal reserve where vegetation was noticeably stunted due to the high heat gradient in the soils. Stuart's thermometer randomly placed in soil away from obvious geothermal features read 76° C. By this time we were all getting adept at distinguishing collapse craters from hydrothermal explosion craters. Our next stop was the Waimangu Valley, where geothermal features are concentrated along the valley bottom and sides. These features, combined with the exotic (for me!) natural vegetation at this preserve, make this valley a very photogenic spot to observe geology in action. We did not have time to continue the walk down to Lake Rotomahana, where a devastating 1886 fissure eruption of basalt magma destroyed the famous Pink and White Terraces, evident now only in paintings and rare photographs. The day was completed with a traditional Maori hangi dinner at Tamaki Village. Tony Christie excelled as our "chief" when meeting and greeting the Maori warriors.

On day 6 we visited Ohakuri, Lake Taupo, and Tongariro National Park. Thermal activity at Ohakuri ceased around 42,000 years ago and subsequent erosion reveals pyroclastic rocks altered to quartz and adularia in a shallow hydrothermal environment. The favorable-looking rocks have been prospected and drilled from the 1980s to the present, but only a sub-economic disseminated gold resource of around 2 million oz has been found to date. A planned visit to the Rotokawa hydrothermal field was precluded by road access problems, so we drove to Taupo for a lunch on the shores of the lake. Lake Taupo, the largest lake in New Zealand, fills a caldera that was created by a supervolcanic eruption around 26,500 years ago. Underwater hydrothermal activity and shoreline hot springs attest to on-going geothermal activity. From Taupo, we drove to Tongariro National Park, which contains the active Ruapehu, Ngauruhoe, and Tongariro volcanoes. A quick drive up Mount Ruapehu to the Whakapapa ski resort, where we took a group photo at a large andesite dike (Figure 3), was followed by a great dinner and lodging at the stately Chateau Tongariro on the slopes of Mount Ruapehu.

On our last day we took a 7 km morning hike within Tongariro National Park to visit Silica Rapids. Here, emerging groundwater below a lava cliff becomes turbulent and loses CO_2, causing precipitation of creamy-white alumino-silicates that cement alluvial cobbles. Following a visit to the Whakapapa Visitor Center, our bus returned to Rotorua for the conclusion of the trip.

All-in-all, it was a great trip viewing a broad spectrum of epithermal to geothermal deposits, run by very knowledgeable leaders. It brought together an interesting and fun group of geoscientists having diverse backgrounds, and was a perfect prelude to the exciting symposium that followed.

Bob Eppinger
U.S. Geological Survey (retired, Scientist Emeritus)

Figure 3. Group photo at andesite dike in Tongariro National Park with Mount Ngauruhoe behind.
Photo by Evren Eucel.

26th IAGS Field Trip 04 South Island Orogenic gold and placer deposits

Dave Craw (University of Otago) led this excursion to the orogenic and placer gold deposits of the central Otago region of the New Zealand South Island. Eight participants, representing 5 countries, thoroughly enjoyed the five-day fieldtrip, mainly due to Dave's encyclopaedic knowledge of the region and his excellent gold-panning skills. All participants attempted to pan gold from the rivers of central Otago under Dave's tutelage, with the majority being rewarded with samples to take home. First stop was to several of the orogenic shear hosted deposits that are the source of rich placer deposits in the region. The best known of these is the Macrea's Mine. Due to safety concerns we could only view the open pit from a public viewing platform and examine samples of the ore on display. Gold mineralisation is contained within sheared Mesozoic sandstones and argillaceous metasediments which have been variably hydrothermally altered. Unlike most mesothermal systems, the amount of quartz veining is quite low. Gold is contained in pyrite and arsenopyrite associated with veins and alteration halos. Significant amounts of scheelite are also present. Exposures of veins were examined at the next stop, Golden Point Battery, where we were also able to see an amazingly well preserved stamping battery and Wilfley table used for mercury amalgamation of the roasted sulphide ores.

The afternoon was spent examining the placer deposits at Hamilton's Workings and Naseby Forest. These deposits consist of a coarse quartz pebble conglomerate sitting on a folded and faulted Miocene surface. Rare, silicified boulders of conglomerate, too large to process by the sluicing methods used by the original miners, remained to give an idea of the original deposit. Several participants commented on the similarity with the Witwatersrand conglomerates. Our first attempts at gold panning of the remnant sediments provided good visible gold for most of the participants (Fig. 1). That night we stayed at the Royal Hotel in Naseby where we were treated to an excellent dinner accompanied by wonderful examples of the Otago wines, a theme of the trip.

The second day we first visited the historic Golden Progress Mine which has been partially restored as a tourist site. Examples of the mineralisation could be seen as steep, narrow, quartz veins with associated ankerite alteration. The main ore mineral was pyrite with trace sphalerite and galena. One spectacular sample of a 1cm wide quartz vein, shot through with gold was found by field trip participant Rob Bowell near the rebuilt headframe. In general, the only economic gold was found in the oxidised zone where nanometre scale gold of the fresh basement had been enriched during the weathering process.

Figure 1. One of many opportunities to pan for visible gold.

Next stop was the scenically spectacular Blue Lake at St Bathan's (Fig. 2). Here Miocene quartz gravels deposited on an unconformity surface, were mined using sluicing techniques. The gravels were followed to the limit of the hydraulic methods and further gold is interpreted to be present on the unconformity surface as it dips to the west under the town of St. Bathan's.

Figure 2. Spectacular Blue Lake at St. Bathan's.

The afternoon continued with a spectacular drive along the Thompson Gorge, where we visited excellent exposures of The Rise and Shine Fault with similar vein hosted mineralisation to the Golden Progress Mine. An excellently restored example of a double 5-head battery was seen at the Come in Time Battery.

Figure 3. Bannockburn alluvial workings.

Day 3 started with a visit to the Bannockburn alluvial workings which looked more like a ruined mud-brick castle (Fig. 3). This was followed with a drive through to Queenstown where one of the group (Justin Gum) entertained the rest with a bungy jump from the Kawarau Bridge during a coffee break. At lunch, we visited historic Arrowtown where some spectacular examples of local gold nuggets were viewed at a mineral store. This was followed by a visit to the Shotover River, one of the richest placer deposits in

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26th IAGS Field Trip 04 South Island Orogenic gold... continued from page 25

the area which is now the scene of regular jetboat tours. Day 4 saw several of the participants having to leave early and the rain close in which unfortunately dulled the views of Mt Cook and the Tasman Glacier. Here we had moved into a region to the northeast of the Otago Schist where gold mineralisation occurred in Pliocene-Pleistocene quartz veins associated with the Alpine fault.

On the final day, we visited the Rakia Gorge where fine, Pliocene-Pleistocene gold is present in the river where the gorge cuts down into Tertiary sediments. This is a very unusual occurrence as the nearest primary orogenic source is 40 km away. The rest of the day was spent driving to Christchurch where the effects of the devastating 2011 earthquakes were seen first-hand in the dramatic offsets of fences/roads and the demolition of so much of the buildings in downtown Christchurch.

Overall it was a wonderful trip which all participants thoroughly enjoyed. Thanks to organiser Dave Craw, we also have an excellent understanding of the gold deposits and wines of the Otago Region.

Justin Gum
Principal Geologist, Musgrave Minerals Ltd.
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26th IAGS Field Trip 05 Environmental Geochemistry of North Island New Zealand Gold and Coal Mines

Eight (8) IAGS attendees participated in this post-symposium field trip. First stop was the Waihi Gold Mine (operated by Newmont). This is an open cast mine with several underground deposits. This is a well operated mine that started its environmental stewardship early in its development. Waste rock from the pit is transported by conveyor to the tailings storage facility and used to construct the wall of the tailings dam, after classification on geotechnical and geochemical properties. Capping and closure are implemented progressively as the dam grows limiting the time that the materials are exposed. Tailings underdrainage is collected and pumped to the traditional high density sludge (HDS) water treatment plant that has the capability to implement reverse osmosis if required. Treated water then returns for operational use or released under a detailed monitoring program.

Second stop was the Rotowaro Coal Mine (operated by Solid Energy New Zealand) on the west side of the north island. Here ash from the power plant are encapsulated and biosolids are used in the rehabilitation program. Boron is a concern within the ash and requires specialized handling and placement to minimize leaching and discharge to groundwater aquifers. Biosolids are used on site for rehabilitation because there is a topsoil deficit. The biosolids have been shown to be better at establishing plant growth than the previously used fertilizers on the emplaced subsoil layers.

We stayed overnight in Waihi Beach, a beautiful ocean-side town. The motel was a clean and restful choice plus we had an excellent dinner at the local restaurant that was within walking distance.

The final stop was at the rehabilitated Golden Cross mine (operated by Coeur Mines). This is a mixed underground and open cast mine that has been closed for over a decade. Waste rock has been successfully rehabilitated as has the open pit with close to 100% vegetation cover although there have been rare slope stability issues after rehabilitation of pit walls. Water discharge from the underground workings is pumped to a water treatment plant (HDS). Sludge from the water treatment plant is pumped back into the underground workings. Passive treatment options including a bioreactor, cascade and slag leach bed have been investigated for treating the underground water discharge, however, these have not been implemented by the operator to date.

We also had a brief stop at the historic Waikino gold mining area where historic (>100 years old) underground mines in the southern Coromandel area processed ore through early cyanide dissolution techniques. This is an interesting site where historic mining equipment and infrastructure are explained in lay terms to the passing tourists.

Sincere thanks from the IAGS participants on this field trip to the mining companies for allowing access to their sites and for the time taken by company representatives to show us around.

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New Member Applications

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2014 Member
Aleksei Marchenko
Deputy Director General
Tellur N-E L.L.C.
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Saint Petersburg, SPE
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26th IAGS Field Trip 07 Hawkes Bay Terroir

"A New Zealander, an American, two Finns and four Australians walked into a winery". This is not the start of some weak joke, but the start of the most rigorous field excursion ever attempted at an IAGS. It represented the merger of the two great loves of AAG members – geochemical landscape evolution and wine. The excursion commenced with presentation of a conceptual model by the trip's technical director, legendary winemaker and economic geologist Larry Meinert, in the last plenary session at the symposium. A detailed orientation survey had been conducted under the auspices of the Hydrothermal Fluids Society on the Wednesday night of the conference to ensure sampling and analytical methods would be valid.

Sampling was conducted on an irregular grid that spanned 10 wineries (Esk Valley, Mission Estate, Church Rd, Trinity Hill, Te Awa, Sileni, Clearview, Elephant Hill, Craggy Range and Black Barn), various regolith-landform-climate settings. Multiple sampling media (Sauvignon Blanc, Viognier, Pinot Gris, Chardonnay, Riesling, Gewürztraminer, Pinot Noir, Syrah, Merlot , Malbec, Marzemino, Cabernet Sauvignon, and Cabernet Franc) and sample processing methods (e.g. oaked or un-oaked) were applied. Only one site refused entry, because an access agreement had not been previously negotiated. Analysis was performed in octuplicate which far exceeds the QC requirements of IGCP 259 or the atlases of Europe, Finland, Australia and Cyprus. Some old analytical variables such as 'acidity' were included, and new ones such as "white pepper influence" and "balance" added. Field notes were compared at lunch and dinner between mouthfuls of lamb, salmon and beef. This included discussion of the unusual "elephant ears anomaly" observed at Elephant Hill.

A heuristic application of SVD-SDD designed for sparse data matrix clustering delivered the peak anomaly as the 2011 Trinity Hills Hillside Syrah. This was confirmed by resampling at the site and bulk analysis at dinner in Napier. While there was initially some concern about the lack of certified reference materials, Larry's encylopaedic memory of wines was accepted as the standard.

The main conclusion of the field trip was the utter rejection of low-density geochemical sampling that may have reduced us to sampling just one wine from one winery and then contouring the data. It was abundantly clear that significant terroir-determined patterns could only be established on the basis of 100 wines from 10 wineries.

Many thanks to wine guru and guide Larry Meinert, tour director and "sticky" devotee Tony Christie and driver Paul Bryan for a fantastic two days. We are all much better educated in matters viticultural and oenological, and will apply this knowledge to all future terroir surveys.

Disclaimer: The AAG and LOC accept no responsibility for the potential deleterious health or wealth effects induced by this field trip.

David Cohen
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AAG Gold Medals 2013

The Association of Applied Geochemists Gold Medal is awarded for outstanding scientific accomplishments in the field of applied geochemistry. This year's recipients represent such accomplishments from both ends of the academic-industry continuum that defines the field of applied geochemistry.

Clemens Reimann

Clemens Reimann, of the Geological Survey of Norway, has had an outstanding scientific career on the academic side of this continuum. During more than 30 years of work in both government and academic circles, Clemens gained international recognition as a leader in the fields of environmental geochemistry, geostatistics, and geochemical mapping at scales ranging from local to continental. His prolific publication record includes numerous journal articles and book authorship. Clemens effectively led regional geochemistry projects in Europe across geographical and political boundaries and his work has subsequently influenced the formulation of regional surveys worldwide. His service to professional organizations has included the Association of Applied Geochemistry as a Distinguished Lecturer and a Regional Councillor. For the International Association of Geochemistry Clemens has served as President and Vice President., He has also been on the editorial boards of Applied Geochemistry and Science of the Total Environment. Clemens, congratulations on behalf of the Association of Applied Geochemists.

Eric Hoffman

Eric Hoffman is recognized for his career as an industry leader in bringing novel analytical techniques to commercial fruition. Through his company ActLabs, Eric has repeatedly been at the vanguard in bringing techniques developed by research laboratories to commercial viability for use by applied geochemists worldwide. He has anticipated the evolving needs of the applied geochemist through technique design and instrument modification for a variety of sample media. This has been particularly important as exploration has moved into progressively more difficult concealed terranes. Eric has published consistently throughout his career, but equally important he is always in attendance at scientific meetings to present and promote the latest in techniques and instrumentation. Eric, congratulations on behalf of the Association of Applied Geochemists.

AAG Silver Medal

The Association of Applied Geochemists' Silver Medal is awarded to a member of the Association for their dedicated service to the Association. It gives me great pleasure to ask Gwendy Hall to come up and receive the AAG Silver Medal for dedicated service to the Association. At this stage, I would like to thank the other members of the Awards and Medals Committee – Chris Benn, Eion Cameron, and Pertti Sarala – for their input to this award.

In looking around the members gathered here, I can see many who have belonged to AAG for a number of years, as well as those who have been office bearers. However, I would suggest that few – if any – have held as many offices in the Association for as protracted a time period as Gwendy Hall; vice president, president, councillor, treasurer (since 1996-), committee member, and journal editor, the latter which I will talk about in the following.

Quite a few of us here have been office bearers in AAG, and all of us have benefitted from having Gwendy Hall in the Association. A source of wisdom and knowledge, of wise counsel, and always putting the good of the association and its membership first.

About eight years ago, AAG faced a crisis with Journal of Geochemical Exploration, in that Elsevier wanted to renegotiate its arrangements with AAG, which would have been to our disadvantage. With Gwendy leading the discussion, it was agreed to sever ties with Elsevier and create Geochemistry: Exploration, Environment, Analysis, a difficult challenge. Thus GEEA came into being, which is really Gwendy's journal, and she is and remains its only editor.

Although AAG's silver medal does not take into account scientific achievement, it is important to realise that Gwendy's voluntary work for AAG over many years in many capacities has been undertaken in parallel with a distinguished and prolific scientific career. For anyone who has used an ICP, or used ICP data, you would have read a Gwendy Hall paper. In conclusion, I reiterate a comment made by one of the nominators for Gwendy's silver medal, that the award is not only deserved but long overdue.

Paul Morris
AAG Past President
Chair of the AAG Awards and Medals Committee

OBITUARY

Tribute to William (Bill) B. Coker (1946-2014)

It is with great sadness that we announce the passing of William (Bill) Coker on January 22nd, 2013 after a courageous 16 year battle with prostate cancer. He was 67 years old. Bill was a brilliant applied geochemist, mentor, teacher, friend, world-traveller and exemplary family man. He served the Association in many capacities, including President of our predecessor organization, the Association of Exploration Geochemists in 1996.

Bill was born in Brandon, Manitoba on May 1st, 1946. He obtained his BSc in Geology at Carleton University in 1971 and his PhD in Geochemistry and Geology at Queen's University, under the supervision of Ian Nichol, in 1974. His PhD thesis was 'Lake sediment geochemistry in the Superior province of the Canadian Shield.' In conjunction with colleagues at the Geological Survey of Canada, this work evolved to both regional and follow-up geochemical surveying of the Canadian Shield under the Uranium Reconnaissance Program.

Over his career, he accumulated a broad range of scientific and leadership experience in government, industry and consulting. He was with the Geological Survey of Canada for the periods 1975-1981 and 1986-1996. His focus was surficial environments of the Canadian Shield with emphasis on both reconnaissance lake sediment geochemistry and Quaternary overburden programs. He was early to recognize the use of regional geochemical data, initially collected for mineral exploration, for environmental issues. During the latter period of his employment at the GSC he was a Research Scientist involved in many aspects of exploration geochemistry across the continent, and had a major involvement in several of the Federal/Provincial Mineral Development Agreements as well as helping to mould the newly developing Environmental Geochemistry program. He had the rare ability to be able to competently cope with his ongoing research while holding the position of Subdivision Head (Exploration Geochemistry) and frequently filling in as Director of the GSC's Mineral Resources Division.

Bill had experience in industry with Gulf Minerals (1981-1982) and Kidd Creek Mines (1982-1986) where he designed and supervised geochemical and Quaternary geological aspects of their exploration programs and provided in-house training to field geologists in exploration geochemistry. In 1996 Bill joined BHP Billiton/BHP World Exploration where he was involved in exploration worldwide. He stayed with BHPB through closure of the Denver office, later becoming the Chief Geochemist for BHPB based in Vancouver. Bill was particularly adept at working with the geologists in training and introducing new concepts. He worked on lake sediment sampling, soil gas, soil hydrocarbon, and heavy mineral till programs amongst others. He uniquely demonstrated reduced chimneys over kimberlite deposits in a variety of terrains, and frequently successfully screened geophysical targets using sodium pyrophosphate on humus samples over prospective conductors. In later years he was involved with potash work for BHPB. He was energetic with a strong sense of humour that brought people together. In 2009 he retired from BHPB and set up his own consulting practice: World Exploration Geochemistry Consulting, Inc. based in Kanata, Ontario, where he provided training and expert consulting to a number of international mining companies

Bill combined the standard, but not necessarily common, characteristics for a productive and successful career: native intellect, curiosity, a lifetime of preparation through experience, extensive field experience, and hard work. Bill also possessed qualities that are less common: a keen focus allowing him to efficiently execute the tasks before him and a genuine likeable personality. It was the latter quality that opened doors through the relationships he built with co-workers. The recognition of these qualities by his peers and colleagues resulted in Bill being called on to serve on committees and advisory boards throughout his career, to the benefit of the profession at large. This included organizing and participating in workshops and short courses in exploration geochemistry both within organizations he represented and the public at large. Someone once stated that if you wanted something done, get a busy but capable individual. That fits Bill to a "T".

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Bill leaves behind his wife of 43 years, Jane. She was 'his person' and the love of his life. He was the loving and proud father to his 7 kids: Laura, Ken, David, Sarah, Susan, Ellen and Tim; and his 11 grandchildren: Stephen, Lizzie, Emily, Makenzie, Jaylin, Shayla, Kale, Tom, Jamie, Audrey and Liam. They are all devastated by the loss of their father and grandfather, a truly wonderful man, and thankful for all that he gave during his lifetime. He was the best of the best.

The geochemistry community is fairly small and tight knit. His loss will be the loss of an extraordinary person, geochemist and family man. He brought much to our field and will be missed. He leaves a strong legacy to us and to his family. Our thoughts are with him and his family. We wish him peace.

In honour of Bill and other great geochemists that have passed before him, contributions to the AAG Distinguished Applied Geochemists Fund are welcomed. Funds are used for scholarships to benefit the next generation of geochemists in their honour. Contributions can be made online at the AAG website using the web link listed below or by mailing a cheque to the AAG Business Office, P.O. Box 26099, 72 Robertson Road, Nepean, Ontario, K2H 9R0, CANADA, Tel: +1 613-828-0199. (https://www.appliedgeochemists.org/index.php/membership/donate-to-aag)

Graham Closs, Sarah Lincoln, Mary Doherty, Dave Kelley, and Colin Dunn

Patrice Lavergne (1929-2013)

Pat Lavergne was one of the unsung heroes of applied geochemistry, he worked at the Geological Survey of Canada for 50 years, retiring in 1997, and died in August at the age of 84. He was one of the first employees hired by Hal Steacey (later Curator of the National Mineral Collection) to work in the Radiometric Laboratory of the GSC's Mineral Deposits Division, September 20, 1947. At that time the search was for uranium deposits, his task was to scan samples submitted by prospectors and the public with a Geiger counter to identify those that were uraniferous. Pat's later, and major work, after he joined the recently formed Geochemistry Section in 1960, was in sample preparation, an often unacknowledged task, working over the years on all the materials in the geochemist's catalogue. What he excelled at were mineral separations, he could perform incredible feats with his heavy liquids, modified Superpanner and Frantz separator. This was particularly valuable to the mineral studies of both Bob Boyle and Ian Jonasson for over 35 years. Pat was the only Survey employee to receive a 50 year service gold-plated medal and citation signed by the Prime Minister of Canada. It was presented to a very shy and embarrassed Pat at a special meeting on his retirement, October 1, 1997. He was seen to bite it, just to make sure it was gold. He retired a month later, he had achieved his goal.

There was not a single GSC geochemist or mineral deposit geologist that did not benefit from his quiet diligence and inventiveness working in the background to support our research studies. His lab contained a collection of equipment accumulated over the years, much of which he had modified to improve its performance or make it easier to clean so as to avoid cross-contamination. He wrote two excellent papers to impart his very specialized knowledge of sample preparation and mineral separation. He preferred to work quietly away on the top, eighth, floor of the Geological Survey building on Booth Street. The 1988 Open File is a complete set of instructions for establishing a sample preparation facility in the lab or field that is still a valuable contribution today. Behind the scenes he contributed to hundreds of papers and Open File reports by the Ottawa geoscientists.

As an example of Pat's versatility and inventiveness there is the story of the refrigerator rescued from the Whitehorse, Yukon, dump in 1965 for use in Operation Keno led by Chris Gleeson and Bob Boyle. Why the refrigerator was rescued is lost to history, but Pat got it up to Keno Hill and running again in its propane mode, where it was used to keep the dithizone cold and away from light to be used each day for the Bloom (1955) field test for heavy metals in stream sediments and waters. At the end of the field season it was shipped back to Ottawa where it continued to work in its electrical mode. In the late 1960s it was in the Room 733, the Section meeting room, being used to keep lunches, and the like, cold. Eventually it found its way to the Operations Room on the fifth floor. It continued to run until 2007 before it finally died, probably after some 50 years of service. Pat was contacted, but a second resuscitation proved impossible. They simply don't make them like they used to. And the same can be said of Pat Lavergne.

Thank you Pat for your dedication and all the work you did for the Ottawa geochemists.

Bob Garrett and Ian Jonasson,
Geological Survey of Canada
Ottawa, Ontario.

Bibliography:

BLOOM, H. 1955. A field method for the determination of ammonium citrate-soluble heavy metals in soils and alluvium. Economic Geology, 50, 533-541.

LAVERGNE, P.J. 1965. Field and Laboratory Methods used by the Geological Survey of Canada in Geochemical Surveys - No. 8 Preparation of Geological Materials for Chemical and Spectrographic Analysis. Geological Survey of Canada, Paper 65-18, 23 p.

LAVERGNE, P.J. 1988. Field and Laboratory Methods used by the Geological Survey of Canada in Geochemical Surveys: Preparation of Geological Materials for Chemical and Spectrochemical Analysis; Separation and Concentration of Minerals; and a Guide to the Identification of Common Minerals. Geological Survey of Canada, Open File 1428, 57 p.

26th IAGS Short Course 01 Student Publishing Workshop

The Student Publishing Workshop held on the Saturday preceding the 26th biennial IAGS was well attended, but not because they provided free pizza and local New Zealander beer. Hosted by Drs Gwendy Hall and Matt Leybourne, the Editor in Chief and Associate Editor of GEEA, respectively, the workshop addressed many questions that new authors might have regarding the publishing process, and also provided advice for avoiding many potential pitfalls in writing, editing, submitting, reviewing, and re-submitting your first paper.

One difficult and nebulous area of the paper-writing process choosing co-author(s), and in what order are the authors will be listed. Ideally, this problem never arises and the authors are listed by either increasing or decreasing (depending on the field of study and the journal) level of involvement and contribution to the paper. Realistically, there are politics and motives and hidden agendas, especially where tenure track professors are involved, and the naive student can easily be bullied into including authors on the paper that should not necessarily be included.

The other frequent issue for new authors is which journal they publish their paper in. With that comes the common oversight of submitting a paper to a second journal before it has been rejected by the first, therefore the same manuscript is being considered by two publications simultaneously. This is a copyright infringement and could land the student into serious trouble.

Between them, Gwendy Hall and Matt Leybourne have published hundreds of papers in a variety of journals, books, and government publications. Their combined experience and advice in the Student Publishing workshop was invaluable, and the many students who attended are now better equipped to write high quality scientific research papers and submit them to any number of peer-reviewed academic journals.

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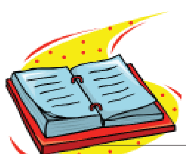

CALENDAR OF EVENTS

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

Please let us know of your events by sending details to:
Steve Amor
Geological Survey of Newfoundland and Labrador
P.O. Box 8700, St. John's, NL Canada. A1B 4J6
Email: StephenAmor@gov.nl.ca Tel: 709-729-1161

- 27 April – 2 May 2014. European Geosciences Union General Assembly 2014. Vienna, Austria. Website: www.egu2014.eu

- 11-16 May 2014. 5th International Congress on Arsenic in the Environment. Buenos Aires Argentina. Website: www.as2014.com.ar

- 21-23 May 2014. GAC/MAC Annual Meeting. Fredericton NB Canada. Website: www.unb.ca/conferences/gacmac2014

- 24-28 May 2014. American Crystallographic Association Meeting. Albuquerque NM USA. Website: www.amercrystalassn.org/content/pages/main-annual-meetings#

- 8-12 June 2014. 20th World Congress of Soil Science. Jeju Korea. Website: www.20wcss.org

- 9-13 June 2014. Goldschmidt 2014. Sacramento CA USA. Website: goldschmidt.info/2014

- 15-19 June 2014. 2nd International Symposium on Ethics of Environmental Health. Ceske Budejovice, Czech Republic. Website: www.iseeh2014.org

- 17-20 June 2014. 38th International Symposium on Environmental Analytical Chemistry. Lausanne Switzerland. Website: tinyurl.com/p4q2qgd

- 21-26 June 2014. Euroscience Open Forum. Copenhagen Denmark. Website: esof2014.org

- 29 June - 2 July 2014. 2nd International Conference on 3D Materials Science. Annecy France. Website: www.tms.org/Meetings/2014/3DMS2014

- 7-10 July 2014. Australian Earth Sciences Convention, Newcastle NSW Australia Website: www.aesc2014.gsa.org.au

- 14-19 July 2014. Earth Sciences and Climate Change: Challenges to Development in Africa. Nairobi Kenya. Website: www.aawg.org

- 29-30 July 2014. Sampling 2014 (AusIMM). Perth WA Australia. Website: www.ausimm.com.au/sampling2014

- 3-7 August 2014. Microscopy & Microanalysis 2014. Hartford CT USA. Website: tinyurl.com/mrtf48v

- 5-12 August 2014. 23rd Congress and General Assembly of the International Union of Crystallography. Montreal QC Canada. Website: www.iucr2014.org

- 11-13 August 2014. 4th International Conference on

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CALENDAR OF EVENTS

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Environmental Pollution and Remediation. Prague Czech Republic. Website: icepr.org

■ 11-14 August 2014. XII International Platinum Symposium Yekaterinburg Russia Website: tinyurl.com/qyle4lp

■ 19-22 August 2014. 14th Quadrennial IAGOD Symposium Urumqi China. Website: www.14iagod.org/en

■ 25 August – 3 September 2014. EMU School 2014: Planetary Mineralogy. Glasgow UK. www.eurominunion.org

■ 1-5 September 2014. 21st General Meeting of the International Mineralogical Association (IMA2014). Johannesburg South Africa. www.ima2014.co.za

■ 17-19 September 2014. ERA12: An International Symposium on Nuclear & Environmental Radiochemical Analysis. Bath UK. Website: tinyurl.com/on9vn9p

■ 21-25 September 2014. Uranium Mining and Hydrogeology 2014 International Conference. Freiberg Germany. Website: tu-freiberg.de/umh-vii-2014

■ 21-26 September 2014. IWA World Water Congress and Exhibition. Lisbon Portugal. Website: www.iwa2014lisbon.org

■ 24-27 August 2014. 7th International Conference on Environmental Catalysis. Asheville NC USA. Website: www.efrc.lsu.edu/ICEC

■ 1-5 September 2014. 21st General Meeting of the International Mineralogical Association (IMA2014). Johannesburg South Africa. Website: www.ima2014.co.za

■ 24-26 September 2014. XX Congress of Carpathian Balkan Geological Association. Tirana Albania. tinyurl.com/kxegtd8 (Facebook)

■ 27-30 September 2014. SEG 2014: Building Exploration Capability for the 21st Century. Keystone CO USA. Website www.seg2014.org

■ 19-22 October 2014. GSA 2014 Annual Meeting. Vancouver BC Canada. Website: www.geosociety.org/meetings/2014

2015

■ 20-24 April 2015. 27th International Applied Geochemistry Symposium. Tucson AZ USA. Website: http://www.27iags.com

■ 27 July -2 August 2015. 19th INQUA Congress (Quaternary Perspectives on Climate Change, Natural Hazards and Civilization). Nagoya, Japan. Website: inqua2015.jp

■ 8-14 August 2015. Geoanalysis 2015. Leoben, Austria. Website: geoanalysis.info

■ 16-21 August 2015. Goldschmidt 2015. Prague Czech Republic. Website: www.geochemsoc.org/programs/goldschmidtconference

■ 20-25 September 2015. 8th Hutton Symposium on Granites and Related Rocks. Florianopolis Brazil. Website: www.hutton8.com.br

■ 1-5 November 2015. GSA 2014 Annual Meeting. Baltimore MD USA. Website: www.geosociety.org/meetings/2015

2016

■ 26 June-1 July 2016. Goldschmidt 2016. Yokohama Japan. Website: www.geochemsoc.org/programs/goldschmidtconference

■ 27 August – 4 September 2016. 35th International Geological Congress. Cape Town South Africa. Website: www.35igc.org

27th INTERNATIONAL APPLIED GEOCHEMISTRY SYMPOSIUM

Visit the 2015 IAGS website

www.27IAGS.com

for detailed information.

AAG Student Support Initiative
Analytical Support for BSc (Hons), MSc and PhD Students in Applied Geochemistry

In 2011, AAG implemented a coordinated program with analytical laboratories to provide In-Kind Student Support for applied geochemical research projects. We are off to an exciting start with several students currently being assisted, multiple laboratories participating, and the first student paper published in EXPLORE #157: "Particle size fractionation and chemical speciation of REE in a lateritic weathering profile in Western Australia". Ms. Xin Du is from University of Western Australia with Genalysis Laboratory Services (Intertek) sponsoring the analyses. The latest Student/Laboratory match-up is Markham Phillips from the University of Otago in New Zealand who is being supported by ALS Geochemistry in Vancouver, Canada on his research into *"Granite host and it's alteration suites as well as geochronology of gold bearing sulphide minerals"* in New Zealand.

Investment in Applied Geochemistry

The AAG Council believes that securing both the future of the Association and that of applied geochemistry requires attracting more students to the science. As an investment in the future, the AAG wishes to encourage and support students whose area of study is Applied Geochemistry. For students of applied geochemistry, a major cost component in any research is the geochemical analyses. AAG believes that by identifying appropriate students, using a set of simple criteria, and coordinating with analytical laboratories that are willing to offer support in terms of geochemical analyses, high quality research and training in fundamental geochemical principles can result. The research is then published through the AAG journal (***Geochemistry: Exploration, Environment, Analysis***) or the ***EXPLORE*** newsletter.

Laboratories Participating in the In-Kind Student Support Initiative

Four laboratories generously signed on to provide the analytical support to students during 2012; committing over $35,000 in terms of analytical support:

- Becquerel Laboratories Inc., Mississauga, Ontario, Canada
- ALS Geochemistry, North Vancouver, BC, Canada
- Genalysis / Intertek, Gosnells, Western Australia
- Ultratrace / Bureau Veritas, Canning Vale, Western Australia

If your laboratory or student is interested in being a part of this program, please contact the chair of AAG's Education Committee, Erick Weiland (education@appliedgeochemists.org), who can provide you with details of this program. Student applications and instructions may also be found on the AAG web site: http://www.appliedgeochemists.org/ student's page under the Student Support link.

Education Committee
Eric Grunsky, Ray Lett, Ryan Noble, Nigel Radford, Erick Weiland (Chair)

EXPLORE

Newsletter No. 162 MARCH 2014

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EXPLORE is published quarterly by the Association of Applied Geochemists, P.O. Box 26099, 72 Robertson Road, Ottawa, ON Canada K2H 9RO.

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Type and layout of EXPLORE: Vivian Heggie, Heggie Enterprises, Thornton, CO (303) 288-6540; vjmheggie@comcast.net

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EXPLORE Publication Schedule

Quarterly newsletters in March, June, September, December

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

Information for Contributors

Manuscripts should be double-spaced and submitted in digital format using WORD. Photos and figures (colour or black and white) should be submitted as separate digital files and as high resolution jpg or PDF files. Tables should be submitted as separate digital files in EXCEL format. All scientific/technical articles will be reviewed. All contributions may be edited for clarity or brevity.

Formats for headings, abbreviations, scientific notations, references and figures must follow the Guide to Authors for *Geochemistry: Exploration, Environment, Analysis* (GEEA) that are posted on the GEEA website at: http://www.geolsoc.org.uk/template.cfm?name=geea_instructions_for_authors

Submissions should be sent to:
Beth McClenaghan, Geological Survey of Canada, 601 Booth Street, Ottawa, ON, CANADA K1A 0E8 Email: beth.mcclenaghan@NRCan-RNCan.gc.ca

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International Union of Geological Sciences' (IUGS) Task Group on Global Geoscience Professionalism (TGGGP)

website
http://tg-ggp.org/professionalism-in-geoscience/

Geoscientists directly serve the public by providing expert services and opinions on which others rely for key decision-making. This has resulted in geoscience being considered a true "professional calling".

This site provides information on professionalism in geoscience, and the activities of the TGGGP, to the global geoscience community including:

- Applied geoscience professionals
- Learned geoscience societies
- Geoscience researchers
- Geoscience educators
- Early-stage geoscience graduates
- Geoscience students and those considering geoscience studies
- Governments
- NGOs
- Academic institutions, and
- Members of the public interested in Earth Science.

The information on this site will benefit society and the global geoscience community by acting as a forum for collaboration on matters of professionalism in geoscience on a local, national, and international level, by facilitating:

- Rapid conversion of research findings to applied geoscience technologies and methodologies;
- Greater relevancy in applied geoscience at the university level;
- Increased education in professional skills at the university level;
- Research project design and fund allocation through greater appreciation of societal needs;
- Clear pathways and assessment criteria for geoscience graduates seeking to attain professional qualifications; and
- A greater understanding of geoscience professionalism by employers, governments, NGOs, academic institutions, and the general public.

Collaboration will result in greater public and environment protection through increased communication and understanding of professionalism in geoscience.