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Gold Homogeneity in Certified Reference Materials; A Comparison of Five Manufacturers

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INTRODUCTION

Certified Reference Materials (CRMs) inserted into analytical batches are a requirement by the international codes governing the mineral industry (JORC 2012; NI43-101; SAMREC) and reporting to the standards laid out in these codes is a mandatory compliance for publicly listed companies on the Australian, New Zealand and Canadian Stock Exchanges. A CRM is a sample where the concentrations of one or more analytes have been quantified by valid methodologies and certified with valid documentation. These certified values are the consensus inter-laboratory mean for an analyte where typically each laboratory analyses multiple subsamples of the CRM.

For gold (Au) CRMs, one of the key properties is the homogeneity of the CRM sample (i.e. testing for nugget effects). Quantifying this homogeneity by the Relative Standard Deviation (RSD) is critical for assessment of laboratory results and the follow up of quality control (QC) failures.

There is vast literature discussing the nugget effect in gold mineralising systems and protocols in reducing the sampling error (e.g., Stanley & Smee 2007), but very little information has been published on the homogeneity of gold CRMs. By their very nature CRMs are assumed to be homogeneous and any variation is attributed to laboratory error (i.e. the variance attributed to the sampling error is less than the analytical error); so how homogenous are commercial gold CRMs?

The homogeneity of a gold CRM sample reflects the capability and competency of a manufacturer to eliminate any nugget effects and provide a homogeneous product that, when analysed, will provide a repeatable result within the statistical limits provided on the CRM certificate. Although all manufactures refer to the homogeneity of their CRMs, only one manufacturer (OREAS), measures the homogeneity of the CRMs and provides this information as routine with their gold CRM Certificate of Analysis. Rocklabs undertake a homogeneity and segregation test, but do not provide the actual homogeneity results.

This independent study evaluates the homogeneity of gold CRMs from commercial CRM manufacturers at four chosen gold grades (0.5 ppm Au, 1 ppm Au, 3 ppm Au and 9 ppm Au). These grades are typical in mining and exploration scenarios and reliable QC data at these grades is critical. This study provides a benchmark for further evaluations of potentially "nuggetty" CRM products including, but not restricted to, platinum group elements (PGEs), rare earth elements (REE), and Au.

CRM MANUFACTURERS AND THEIR PREPARATION

Four auriferous CRMS from each of five manufacturers were assessed (i.e. 20 CRMs in total). The CRMs were sourced from five manufacturers, as listed below alphabetically. A summary description of the preparation process is also provided and taken from their CRM certificates:

- African Mineral Standards (AMIS): http://www.amis.co.za/. The material was crushed, dry-milled and air-classified to <54 microns. Wet sieve particle size analysis of random samples confirmed the material was 98.5% <54 microns. It was then blended in a bi-conical mixer, systematically divided and then sealed into1 kg Laboratory Packs.
- CDN Resource Laboratories Ltd (CDN): http://www.cdnlabs.com/. Material was dried, crushed, pulverized and then passed through a 270 mesh screen. The +270 mesh material was discarded. The -270 mesh (53 microns) material was mixed for 5 days in a double-cone blender.
- Geostats Pty Ltd (GST): http://www.geostats.com.au/. All CRMs are dried in an oven for a minimum of 12 hours at 110 °C. The dry material is then pulverised to finer than 75 microns (nominal mean of 45 microns) using an air classifier. The material is then homogenised and stored in a sealed, stable container ready for final packaging.
- Ore Research and Exploration Pty Ltd (ORE): http://www.ore.com.au/. Materials are jaw crushed to minus 3 mm, dried to constant mass at 105 °C, barren materials are milled to >98% minus 75 microns and gold bearing material milled to 100% minus 20-30 microns, blending in appropriate proportions to achieve the desired grade, packaging into 60 g and 100 g units in laminated foil pouches and 1 kg units in plastic jars.
- Rocklabs (RLB): http://rocklabs.com/. Pulverized feldspar minerals, basalt rock and barren ironpyrites were blended with finely divided gold containing minerals that have been screened to ensure there is no nuggetty gold. (NOTE no sizing information provided).

See also Table 1 for a summary.

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

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

Notes from the Editor

The December 2015 issue of **EXPLORE** features a technical article about gold homogeneity in certified reference materials by Nigel Brand. **EXPLORE** thanks all contributors to this fourth issue of 2015: Steve Amor, Al Arsenault, Dennis Arne, Nigel Brand, Bob Garrett, Pim van Geffen, Matt Leybourne, Paul Morris, Jamil Sader, and Dave Smith. In this last issue of 2015, **EXPLORE** gratefully acknowledges our three corporate sponsors for the year, ALS Minerals, AGAT Laboratories, and REFLEX Geochemistry, as well as our advertizers for their continuing financial support of **EXPLORE**. Pim van Geffen, our Business Manager, is thanked for managing the financial aspects of publishing **EXPLORE** including corporate sponsors and advertizers. Pim and I wish all AAG members and other readers of **EXPLORE** a successful 2016.

Beth McClenaghan
Editor

President's Message

This will be my final message as President of the Association of Applied Geochemists. Ryan Noble will take on the role of President for 2016-2017, ably assisted by Steve Cook from Teck Resources Limited as Vice President. The past two years have, as we all know, been very difficult with a major and sustained slow-down in the mineral exploration industry. Despite that, the Association continues unabated with a number of significant milestones. Since Bob Eppinger penned his final Presidential message (December 2013 **EXPLORE**), the Association has held two successful IAGS conferences (Rotorua, 2013 and Tucson 2015), implemented a number of social media avenues of member expression (LinkedIn, Facebook), and successfully transitioned to a new Editor-in-Chief (Kurt Kyser) for our journal GEEA. I hope that you are all working diligently to produce large quantities of high-quality papers to inundate Kurt with, as he has a lot of time on his hands. As I have stated before, but it bears repeating, Gwendy Hall did an outstanding job as our Editor-in-Chief prior to Kurt taking over. Thankfully, she continues to manage the arduous task of maintaining and growing the Association investments and overall finances as the AAG Treasurer. Dan Layton-Matthews is the 2015-2017 AAG Distinguished Lecturer and, with financial support from the Association for travel, is available to present a talk at an institution near you. Please get in touch with Dan to organize a lecture tour (dlayton@queensu.ca).

I would like to express my thanks and gratitude to all members of Council for their efforts over the last two years, and to all AAG members who continue to support the Association. I would particularly like to thank my Vice-President, Ryan Noble for his help, as well as Gwendy Hall (Treasurer), Dave Smith (Secretary), Beth McClenaghan (**EXPLORE** editor), Pim van Geffen (**EXPLORE** Business Manager), Patrice de Caritat and Dennis Arne (Elements coordinators), Kurt Kyser (GEEA Editor), 2014-2015 Councillors (Alejandro Arauz, Dennis Arne, Stephen Cook, Melt Lintern, Paul Morris, Peter Simpson and Bob Eppinger), and the 2015-2016 Councillors (Dave Cohen, Ray Lett, Tom Molyneux, Juan Carlos Ordóñez Calderón, Peter Rogers, and Peter Winterburn). Also deserving of gratitude are Gemma Bonham-Carter and Bruno Lemiere for their efforts maintaining and managing the Association Website. I also thank all the Regional Councillors, and AAG Committee members for all of their work.

Finally, another change over the last two years was the passing of the reins of managing our Association from Betty Arsenault to her husband Al Arsenault; both have been indispensible, and it has made things easier that they coincidentally have the last name.

Sadly, we have also lost some of the greats in our field over the last couple of years including Eion Cameron, Bill Coker, and Eric Hoffman; all of them are greatly missed.

To close, I wish the incoming president and vice-president an outstanding and successful two years. I hope that the industry is on the upswing that will translate to a stellar IAGS in 2017 or 2018.

Matt Leybourne
AAG President

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Table 1: Summary of attributes of the various manufacturer's CRM as provided on their certificates.

Manufacturer	Material grain size	Homogeneity tested	Lab list provided	Statistical metrics	ISO accreditation	Major and trace element data
AMIS	< 54 um	Stated but details not provided	Yes	SD, Between-lab SD, Within-Lab SD, Combined Standard Uncertainty	Yes	Majors - certified; Traces - indicative
CDN	< 53 um	No	Yes	Between-lab SD	No	Majors only - indicative
Geostats	< 75 um	No	No	SD, 95% Confidence Interval	Yes	Majors & Traces - indicative
OREAS	< 30 µm	Yes (INAA subsample method)	Yes	SD, 95% Confidence limits, Tolerance limits	Yes	Majors & Traces - indicative
Rocklabs	Not specified	Yes (specific sampling/testing regime incl segregation test)	Yes	Between-lab SD, 95% Confidence limits	No	Majors only - indicative

Note: All manufacturers use multiple laboratory round robin for the certification process of gold by fire assay.

CRMS SELECTED

To allow a comparison between CRM manufactures four (4) auriferous grade ranges were chosen centred around 0.5 ppm; 1 ppm; 3 ppm and 9 ppm (see Table 2). The selection of CRMs from these grade ranges were determined by the availability of materials from the manufacturers, and preference given to CRMs that are siliceous in nature and manufactured within the last six years (to minimise any variation due to change in the manufacturing process and/or possible oxidation of sulphides). To this end, low sulphur samples were chosen where available.

Table 2: Summary of CRMs chosen for this study.

Manufacturer	CRM	Certified Au (ppm)	Assay Method	Brief Material description	S (%)	SiO_2 (%)	Year of release	# labs
AMIS	AMIS0352	0.45	Fire assay	Andesitic-dacite tuffaceous agglomerate	0.56	62.13	2012	23
	AMIS0310	1.03		Basalt, volcanics & granite	1.58	69.38	2012	17
	AMIS0360	2.94		BIF, mafic volcanics and sediments	6.46	48.05	2014	24
	AMIS0267	9.05		Qtz-carbonate-adularia	0.75	83.27	2012	19
CDN	CND-GS-P5C	0.571	30 g Fire assay	Granitic	0.2	60.7	2014	15
	CND-GS-1M	1.07		Granitic	0.1	65.6	2013	15
	CND-GS-3L	3.18		Granitic	0.1	66.8	2013	15
	CND-GS-8C	8.59		Sourced from Cortez Hills Mine	0.6	56.6	2013	13
Geostats	G909-6	0.57	50 g Fire assay	Composite Gold Ores low sulphide	nr	nr	2009	132
	G313-1	1		Composite Mine Ore	0.035	64.56	2014	157
	G914-6	3.21		High Grade low sulphide ore	0.06	63.69	2015	179
	G914-7	9.81		High Grade low sulphide ore	0.04	60.87	2015	178
OREAS	OREAS 201	0.514	30-50 g Fire assay	Basaltic	0.39	53.69	2012	20
	OREAS 204	1.043		Basaltic	0.794	52.64	2012	20
	OREAS 17c	3.04		Basaltic	1.59	49.1	2009	18
	OREAS 62c	8.79		Andesitic volcanics	0.53	60.9	2009	16
Rocklabs	SE68	0.599	30 g Fire assay	Feldspar, basalt & iron pyrites with minor fine gold minerals	2.3	54.76	2012	53
	SG66	1.086			2.6	54.52	2012	53
	SJ80	2.656			3	56.26	2013	54
	SN75	8.671			3.3	56.17	2013	54

nr = not reported

MATERIAL RECEIVED

Amounts corresponding to the minimum manufacturers order were purchased. To this end:

- Two x 100 g sachets of each of the four CRM were purchased from AMIS andreceived in vacuum sealed foil pouches;
- Four x 100 g sachets of each of the four CRMs from CDN and received in paper bags and sealed in plastic;
- Four x 100 g sachets of each of the four CRMs from Geostats and received in plastic bags;
- Four x 60 g sachets of each of the four CRMs from OREAS and received in foil pouches;
- One 2.5 kg plastic jar for each CRM were ordered and received from Rocklabs.

The materials as received are shown in Photo 1.

Photo 1. CRM's "as received" from the five manufacturers.

SAMPLE PREPARATION AND ANALYSIS

Prior to dispatching the materials for analysis, each CRM was subsampled twenty times in a clean room. A 10 g aliquot of each CRM was placed into a Ziploc® plastic bag using a disposable plastic spatula to avoid any cross contamination. This procedure was repeated for each CRM so that the samples were sequenced in lots of 20, with each lot corresponding to one CRM.

For the homogeneity test work, Instrumental Neutron Activation Analysis (INAA) was used. INAA is a highly precise and unique assay method that focuses on the elements nucleus irrespective of the sample matrix or chemical form of the element. Each sample is subjected to a flux of neutrons to produce radioactive nuclides. These nuclides decay emitting gamma rays that are characteristic for each nuclide. When compared with a known standard, the intensity of the emitted gamma rays can be quantified into an element concentration (Lieser 2001).

The 400 x 10 g subsamples were dispatched to Activation Laboratories Limited (Actlabs) in Ancaster, Canada (www.actlabs.com) for INAA; Actlabs were informed of the purpose of the analysis and requested to weigh out 1 g

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of material from each sample. To minimise any effects of between batch bias, Actlabs were requested not to split any of the 20 sample CRM lots and all possible sources of measurement error (e.g., weighing, counting, detector geometry, flux monitor errors, etc.) be kept to a minimum. Minimising the sources of error and ensuring no sample lots were split provides confidence that the results are a true reflection of CRM sampling errors and hence CRM homogeneity, and that the analytical precision errors are minor in comparison to sampling errors. By subjecting all the samples to the identical non-destructive analytical technique provided by one laboratory that required no sample preparation, reagents or digestion, any laboratory error is constant for all samples and considered minimal. Thus variance in the spread of analytical results from each of the CRMs will represent the degree of homogeneity.

RESULTS

The results of this exercise are presented in Appendix 1, which is available for download from the EXPLORE page of the AAG website (www.appliedgeochemists.org). The certificates of the CRMs used in this study are downloadable from the AAG website (www.appliedgeochemists.org) and the Geochemical Services website (http://www.gspty.com.au/).

Precision/homogeneity

The Certified Value (CV), Relative Standard Deviation (RSD across the 20 x 1 g INAA values of each CRM), Sampling Constant (which is the minimum required sample mass to achieve a 1% RSD), mean INAA sample mass analysed (g), two Relative Standard Deviations at typical fire assay charge weights of 30 g (30 g 2RSD) and 50 g (50 g 2RSD) for each CRM by manufacturer is presented in Table 3. A mean RSD for each manufacturer is also presented as an indication of overall performance.

Table 3: Relative Standard Deviation comparison for the various CRM Manufacturers (based on 20 x 1 g INAA determinations per CRM).

Manufacturer	CRM	Certified Value (ppm)	Mean INAA subsample (g)	1 g RSD INAA	Mean RSD	Sampling Constant (g)	Based on 1 gm INAA data and the Sampling Constant	
							30g 2RSD	50g 2RSD
AMIS	AMIS0352	0.450	1.05	4.48%	12.08%	21.0	1.67%	1.30%
	AMIS0310	1.03	1.06	12.80%		172.7	4.80%	3.72%
	AMIS0360	2.94	1.06	3.60%		13.7	1.35%	1.05%
	AMIS0267	9.05	1.05	27.46%		794.8	10.29%	7.97%
CDN	CDN-GS-P5C	0.571	1.06	10.27%	9.70%	111.8	3.86%	2.99%
	CDN-GS-1M	1.07	1.05	15.85%		263.4	5.93%	4.59%
	CDN-GS-3L	3.18	1.05	11.53%		140.0	4.32%	3.35%
	CDN-GS-8C	8.59	1.05	1.16%		1.4	0.43%	0.34%
Geostats	G909-6	0.570	1.06	2.93%	3.09%	9.1	1.10%	0.85%
	G313-1	1.00	1.04	6.14%		39.4	2.29%	1.78%
	G914-6	3.21	1.06	2.15%		4.9	0.81%	0.63%
	G914-7	9.81	1.05	1.15%		1.4	0.43%	0.33%
OREAS	OREAS 201	0.514	1.06	1.87%	1.61%	3.7	0.70%	0.54%
	OREAS 204	1.04	1.05	1.77%		3.3	0.66%	0.51%
	OREAS 17c	3.04	1.05	1.61%		2.7	0.60%	0.47%
	OREAS 62c	8.79	1.04	1.18%		1.4	0.44%	0.34%
Rocklabs	SE68	0.599	1.06	1.90%	2.35%	3.8	0.71%	0.55%
	SG66	1.09	1.06	5.05%		27.1	1.90%	1.47%
	SJ80	2.66	1.05	1.20%		1.5	0.45%	0.35%
	SN75	8.67	1.04	1.26%		1.7	0.47%	0.36%

NOTE: Sampling Constant is the required grams to achieve a 1% RSD.

The RSD is used as a standardised measure of dispersion that indicates the precision or repeatability of an assay. The lower the RSD, the more repeatable, precise or homogeneous the CRM; conversely the higher the RSD the less homogeneous the CRM. Given the critical importance of CRMs and their mandatory use in the mining and exploration industry, the lower the RSD determined from replicate analysis via the INAA method on reduced analytical subsamples (e.g. 1 g) the more homogenous the reference material and the greater confidence and control the QC officer has in vetting data quality from a laboratory. The overall mean RSD for each manufacturer has been derived from the mean of the individual RSD's of the 1 g INAA data. In order of increasing mean RSD (corresponding to decreasing homogeneity) they range from OREAS: 1.61%, to Rocklabs: 2.35%, to Geostats: 3.09%, to CDN: 9.70%, to AMIS: 12.08%.

The Sampling Constant (Ingamells & Switzer 1973) has been calculated to show the minimum sample mass required to measure gold in each CRM by the 1 g INAA method to achieve a relative standard deviation of 1%. For high grade gold samples (~9 ppm Au), the sampling constant ranges from a low of 1.4 g from CDN, Geostats and OREAS to 794.8 g for AMIS. This suggests AMIS0267 is influenced by a nugget effect.

The 30 and 50 g 2RSDs have been calculated from the Sampling Constants for each CRM and in some instances

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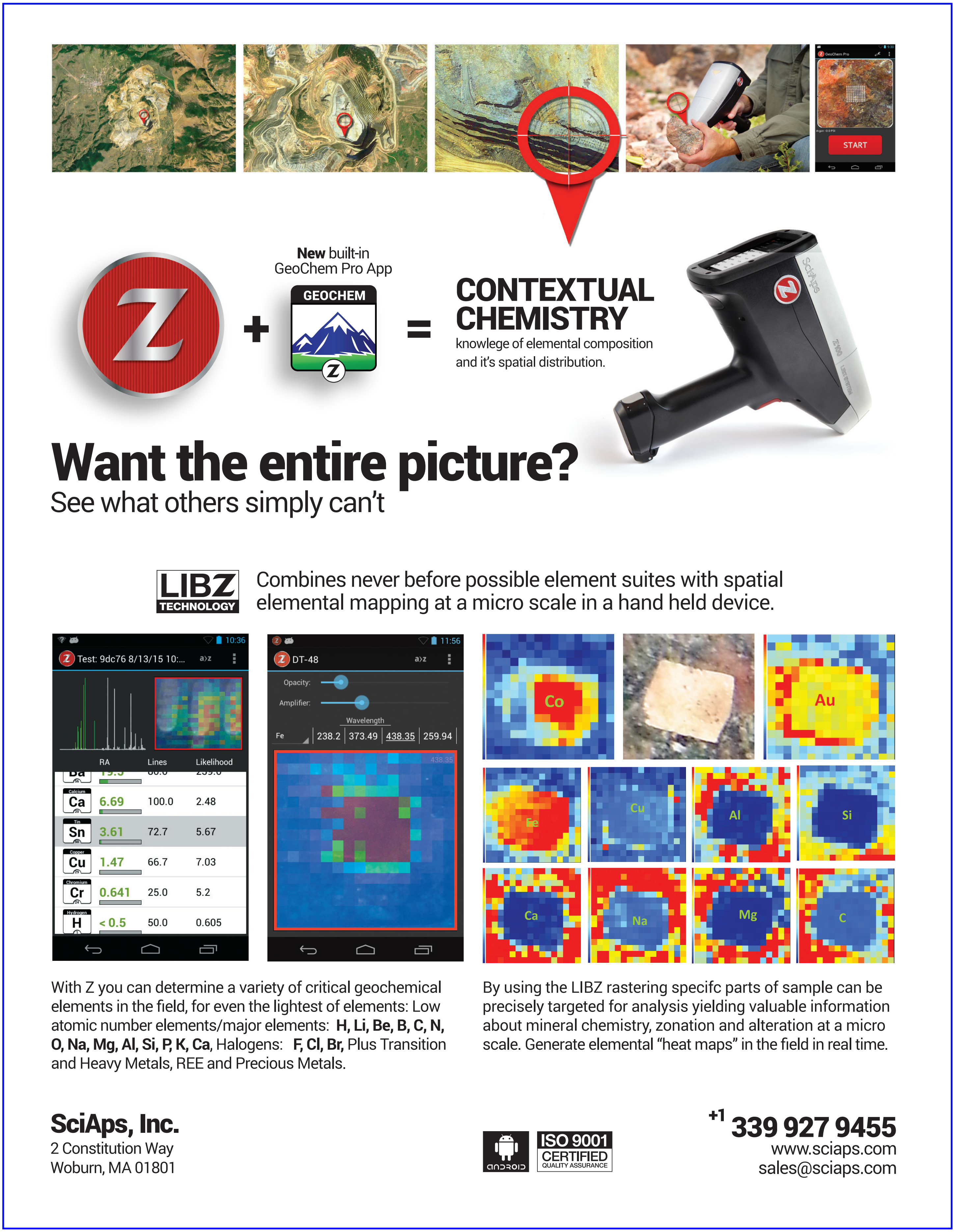
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reveal significant sampling errors. Typical measurement error for 30 or 50 g fire assay charge weights are usually around 5% at commercial laboratories for ore grade methods. The 2RSD values encapsulate the sampling error contribution from the CRM and these can be added to the nominal 5% measurement error laboratories tend to achieve to get a feel for what the overall errors would be in reported analytical results. Results from individual manufacturers are discussed below:

AMIS: homogeneity for individual AMIS CRMs varies from 3.60% RSD (AMIS0360; 2.94 ppm Au) to 27.46% RSD (AMIS0267; 9.05 ppm Au), a spread of 23.86% RSD showing no systematic change in homogeneity with changing grade. The sampling constant for AMIS0267 indicates that 794.8 g of sample would be required to ensure a RSD of 1% during analysis, and for a 30 g fire assay a sampling error of 10.29% applies. At this charge mass only AMIS0352 (30 g 2RSD sampling error of 1.67%) and AMIS0360 (30 g 2RSD of 1.35%) would be fit for purpose CRMs based on these calculations. The gold homogeneity of CRMs produced by AMIS is considered very poor to good.

CDN: homogeneity for individual CDN CRMs varies from 1.16% RSD (CDN-GS-8C; 8.59 ppm Au) to 15.85% RSD (CDN-GS-1M; 1.07 ppm Au), a spread of 14.69% RSD showing no systematic change in homogeneity with changing grade. Of the four CRMs evaluated only CDN-GS-8C (30 g 2RSD of 0.44%), the highest grade CDN gold CRM tested, would be suitable for a 30 g fire assay. For CDN-GS-P5C (0.571 ppm Au) a sample mass of 111.8 g would be required to obtain an RSD of 1% during analysis; equivalent to a sampling error (30 g 2RSD) of 3.86%; 263.4 g for CDN-GS-1M; equivalent to a 2RSD sampling error of 5.93% at 30 g; and 140.0 g for CDN-GS-3L (3.18 ppm Au), equivalent to a 2RSD sampling error of 4.32% at 30 g. While the homogeneity of CDN-GS-8C is very good, the remaining CDN CRMs tested are considered to be poor to very poor.

Geostats: homogeneity for individual Geostats CRM's vary from 1.15% RSD (G914-7; 9.81 ppm Au) to 6.14% RSD (G313-1; 1.00 ppm Au), a spread of 4.99% RSD showing no systematic change in homogeneity with changing grade. Three of the four CRM's (G909-6 at 0.570 ppm Au, G914-6 at 3.21 ppm Au & G914-7 at 9.81 ppm Au) are fit for purpose as grade control CRM's for 30 g fire assay whilst G313-1 at 1.00 ppm Au would be suitable for a 50 g fire assay based on the sampling constant. The 2RSD sampling errors at a 30 g charge weight vary from 0.43% to 2.29%. The homogeneity of CRM's produced by Geostats range from mediocre to very good.

OREAS: All OREAS CRM's show consistently low RSDs ranging from 1.18% RSD (OREAS 62c at 8.79 ppm Au) to 1.87% RSD (OREAS 201 at 0.514 ppm Au) for a spread of 0.69% RSD. An inverse correlation is apparent between grade and RSD suggesting a possible influence of analytical precision. All four OREAS CRM's tested are fit for purpose for 30 g fire assay with sampling constants indicating that a 4 g fire assay charge weight would provide a sampling error of 1% or less for all OREAS CRM's. The sampling error at a 30 g charge weight varies from 0.44% to 0.70%. The homogeneity of CRM's produced by OREAS is considered very good.

Rocklabs: Individual Rocklabs CRM homogeneity varies from 1.20% RSD (SJ80 at 2.66 ppm Au) to 5.05 % RSD (SG66 at 1.09 ppm Au), a spread of 3.83% RSD with the CRM's showing no systematic change in homogeneity with changing grade. Three of the four CRM's (SE68 at 0.599 ppm Au, SJ80 at 2.66 ppm Au and SN75 at 8.67 ppm Au) are fit for purpose for 30 g fire assay while SG66 would probably be more fit for purpose for 50 g fire assay based on the sampling constant. The sampling errors of a 30 g charge weight range from 0.45% to 1.90%. The homogeneity of CRM's produced by Rocklabs is considered good to very good.

Table 4: Summary Statistics for each CRM.

Manufacturer	CRM	Certified Value Au (ppb)	NAA Mean Au (ppb)	NAA Min Au (ppb)	NAA Max Au (ppb)	NAA SDev Au (ppb)
AMIS	AMIS0352	450	445.3	393	467	20
	AMIS0310	1030	1080	946	1450	138
	AMIS0360	2940	3014	2810	3280	109
	AMIS0267	9050	8849	7450	17900	2425
CDN	CDN-GS-P5C	571	492.7	423	642	51
	CDN-GS-1M	1070	975.4	774	1480	155
	CDN-GS-3L	3180	3136	2340	3800	365
	CDN-GS-8C	8590	8238	8100	8440	96
Geostats	G909-6	570	545.8	510	576	16
	G313-1	1000	971.8	885	1130	60
	G914-6	3210	3269	3110	3390	70
	G914-7	9810	9657	9440	10000	112
OREAS	OREAS 201	514	546.2	531	567	10
	OREAS 204	1043	1020	990	1050	18
	OREAS 17c	3040	3009	2940	3110	48
	OREAS 62c	8790	8411	8100	8570	99
Rocklabs	SE68	599	615.5	591	638	12
	SG66	1086	1087	1030	1300	55
	SJ80	2656	2520	2450	2570	30
	SN75	8671	8000	7720	8150	100

INTERNAL CRM VARIATION

Control charts presented below show the variation in results of each CRM for each manufacturer. Figures 1 to 5 (A-D plots) show graphical representation of the 20 x 1 g INAA data where the X axis represents the order of analysis (analytical subsamples 1 to 20) from left to right; and the Y axis shows the measured INAA concentration in Au ppb. A solid red line shows the mean INAA value (see Table 4) for each CRM and for each grade range (i.e. 0.5 ppm Au, 1 ppm Au, 3 ppm Au and 9 ppm Au). The same Y axis concentration range and scale has been used where possible to facilitate visual comparison between the manufacturers. The Y axis in Figures 1-5 (E-H plots) shows the percentage difference from the calculated INAA mean. These diagrams are not intended as verification charts for each CRM by INAA, but as a standardised graphical communication tool.

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NAC+ 2016

21st - 23rd March 2016 | Royal College of Surgeons, Edinburgh, UK

The North Atlantic Craton and surrounding belts:

a craton-specific approach to exploration targeting

Following on from the successful first North Atlantic Craton meeting in St Andrews in March 2014, the organising committee invites you to attend the second meeting in Edinburgh in 2016. The North Atlantic Craton (NAC) stretches from Canada through Greenland, Scotland and into Norway. This meeting welcomes contributions that develop our understanding of the NAC and its surrounding mobile belts, and their mineral resource potential.

Key dates:

Abstract submission deadline: 15 January 2016
Registration deadline: 15 March 2016
Conference icebreaker: 21 March 2016, evening
Conference: 22–23 March 2016

Science themes:

Formation and cratonisation of the NAC: from micro-continents to craton
Proterozoic orogens: the mobile belts surrounding the NAC
The NAC margin in Canada and its mineralisation
Metallogenesis and links to geodynamic setting
Mineral resources of the NAC and adjacent Palaeoproterozoic mobile belts

Registration fees:

Standard: £245
Member of the Mineralogical Society: £205
Student £60
Registration includes conference icebreaker (21 March), conference dinner (22 March), and lunches on two days of conference.

The **post-conference field trip** will run from **24–28 March 2016** and will visit the **Outer Hebrides**. The focus will be on Archaean gneisses of the NAC, Palaeoproterozoic belts formed at the craton margins, and a range of younger intrusions including the Loch Roag dyke, a mantle and lower crustal xenolith locality. There will also be spectacular coastal scenery and the chance to visit some stunning heritage sites.

Price is to be confirmed, but likely to be approximately **£500 including all travel, hotel accommodation, meals and field guidebook. A maximum of 15 places will be available.** Please email **NACworkshop@gmail.com to express interest (*before 17th Dec*).**

Thank you to our sponsors
(for enquiries about further sponsorship please contact NACworkshop@gmail.com)

Confirmed keynote speakers:

Prof Nicholas Arndt (University Joseph Fourier, Grenoble)
Sources of metals from the asthenosphere vs. lithospheric mantle, and the formation of continental crust
Dr Alana Hinchey (Newfoundland & Labrador Geological Survey)
Geology of the Makkovik-Ketilidian orogenic belt
Dr Simon Jowitt (Monash University)
Large igneous provinces and the geochronological application of dyke swarm correlation
Prof Raimo Lahtinen (Geological Survey of Finland)
Palaeoproterozoic tectonic evolution and metallogeny of Fennoscandia
Dr Bo Moller-Stensgaard (GEUS)
Archaean-Palaeoproterozoic evolution of the NAC in Greenland

www.bgs.ac.uk/NAC2016

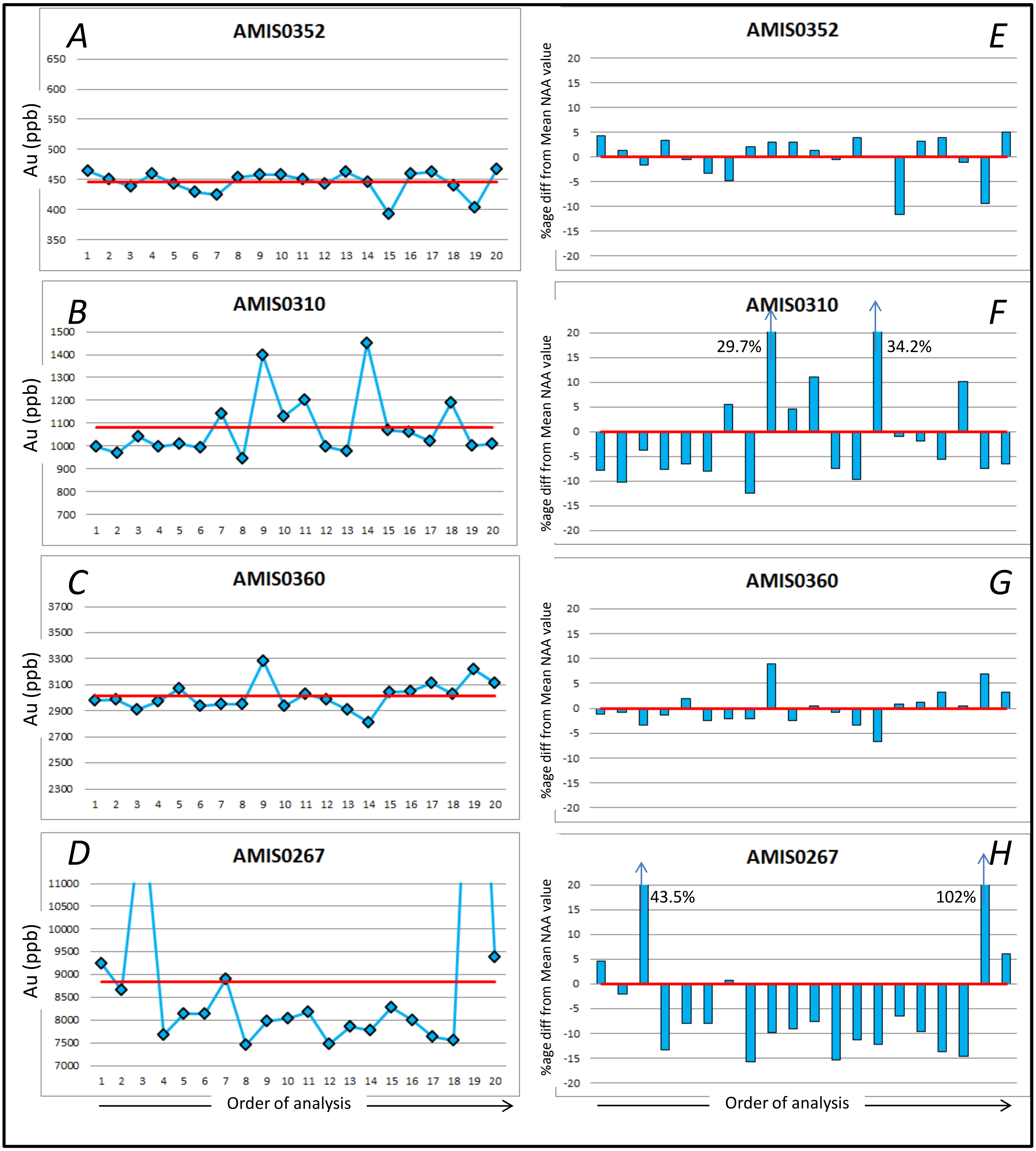
Gold Homogeneity in Certified Reference Materials...

continued from page 8

AMIS: Figure 1 graphically depicts results for the AMIS CRMs. Individual values for each CRM show a wide spread of almost random data with no systematic variation. AMIS0267 (cert 9.05 ppm) ranges from 7.45 ppm Au to 17.90 ppm Au (Fig. 1D) which represents -15.8 % to +102% difference from the INAA mean of this CRM (Fig. 1H). Two samples show a significant departure from the INAA mean, reporting +43.5% (12.70 ppm Au) and +102% (17.90 ppm Au) of the mean value (Fig. 1H) and reflects inhomogeneity (presumably a nugget effect) of the CRM. AMIS0310 (cert 1.03 ppm) also shows (Figs. 1B and F) significant departure from the INAA mean for two samples (+29.7% and

Figure 1. Control charts for AMIS CRMs showing INAA concentration (Au ppb) in relation to the certified value [A-D] and the percentage difference from the INAA mean value [E-H].

continued on page 11



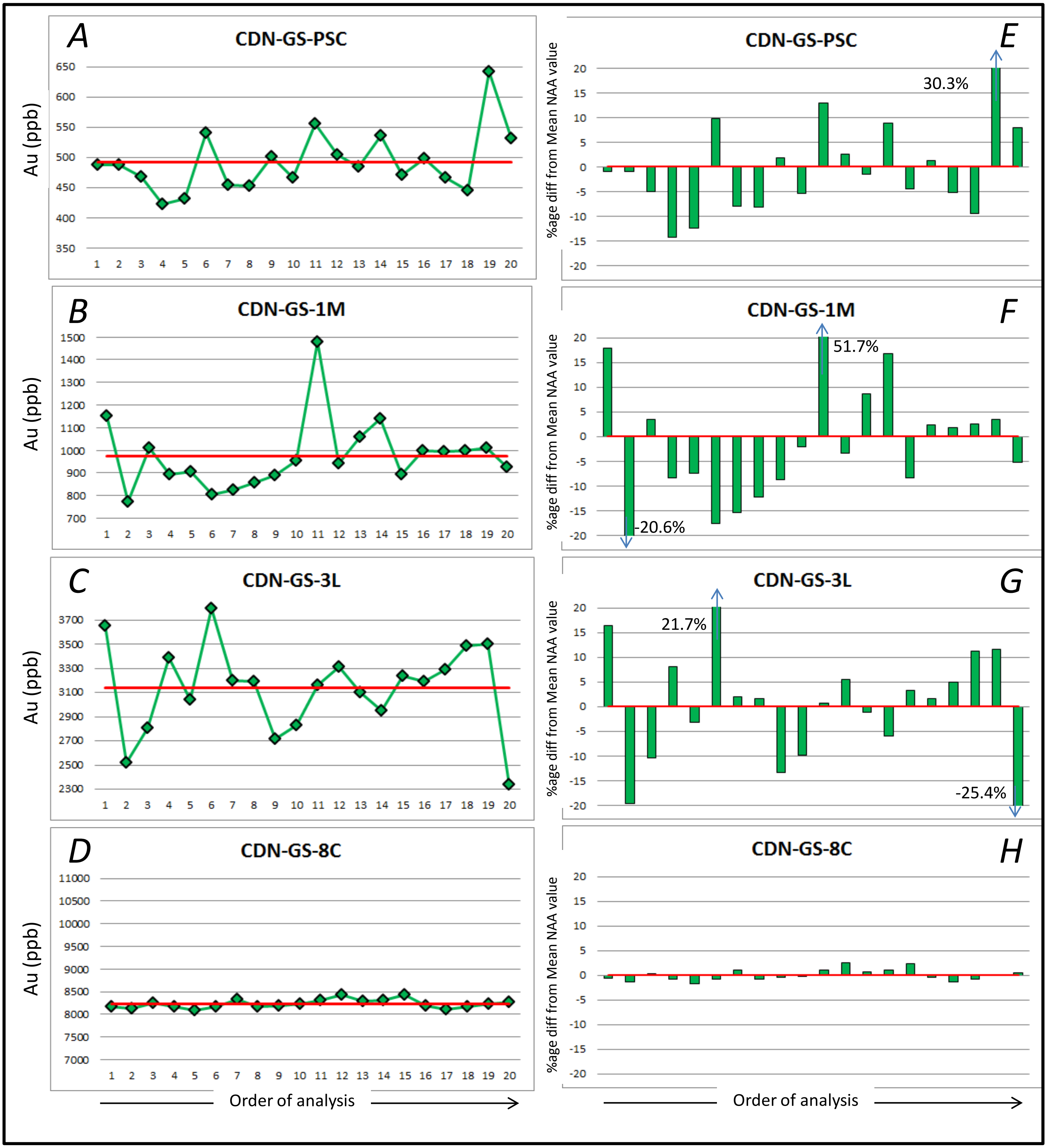
Gold Homogeneity in Certified Reference Materials... continued from page 1

+34.2%). This inhomogeneity of AMIS CRMs has potentially significant implications for laboratory reporting whereby a user would question the laboratory results based on the assumption that the CRM is homogeneous.

CDN: Figure 2 graphically displays the results for the CDN CRMs. With the exception of CDN-GS-8C (cert 8.59 ppm) which has a very tight spread of data around the INAA mean ranging from -1.7% to +2.5 % (Fig. 2H). The lower three of the four CDN CRMs (CDN-GS-P5C, CDN-GS-1M and CDN-GS-3L), show a wide scatter of data that commonly exceeds ±20% of the INAA mean value; CDN-GS-

Figure 2. Control charts for CDN CRMs showing INAA concentration (Au ppb) in relation to the certified value [A-D] and the percentage difference from the INAA mean value [E-H].

continued on page 12



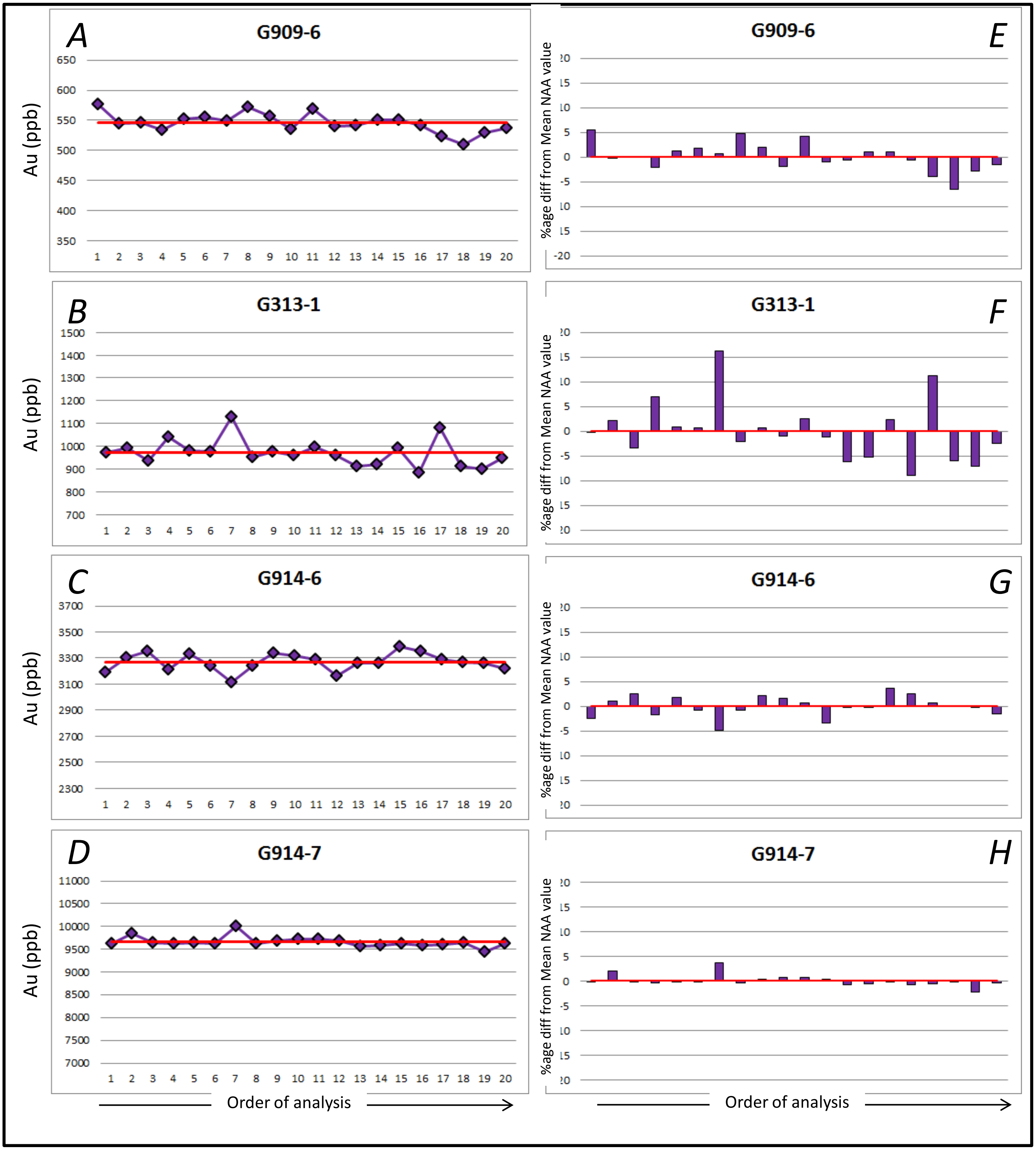
Gold Homogeneity in Certified Reference Materials... continued from page 11

P5C (cert .0.571 ppm) shows a range of -14.2 to +30.3% from the INAA mean (Figs. 2A and 2E); CDN-GS-1M (cert 1.07 ppm) ranges from -20.6 to +51.7 (Figs. 2B and 2F) and CDN-GS-3L (cert 3.18 ppm) ranges from -25.4 to +21.2% (Figs. 2C & 2G). This indicates inhomogeneity in three of these CRMs produced by CDN. The exception is CDN-GS-8C (cert 8.59 ppm) which has a very tight spread of data around the INAA mean ranging from -1.7% to +2.5 % (Figs. 2D and 2H).

GEOSTATS: Figure 3 shows the individual results for the Geostats CRMs. G914-6 (cert 3.21 ppm) and G914-7 (cert

Figure 3. Control charts for Geostats CRMs showing INAA concentration (Au ppb) in relation to the certified value [A-D] and the percentage difference from the INAA mean value [E-H].

continued on page 13



Gold Homogeneity in Certified Reference Materials...

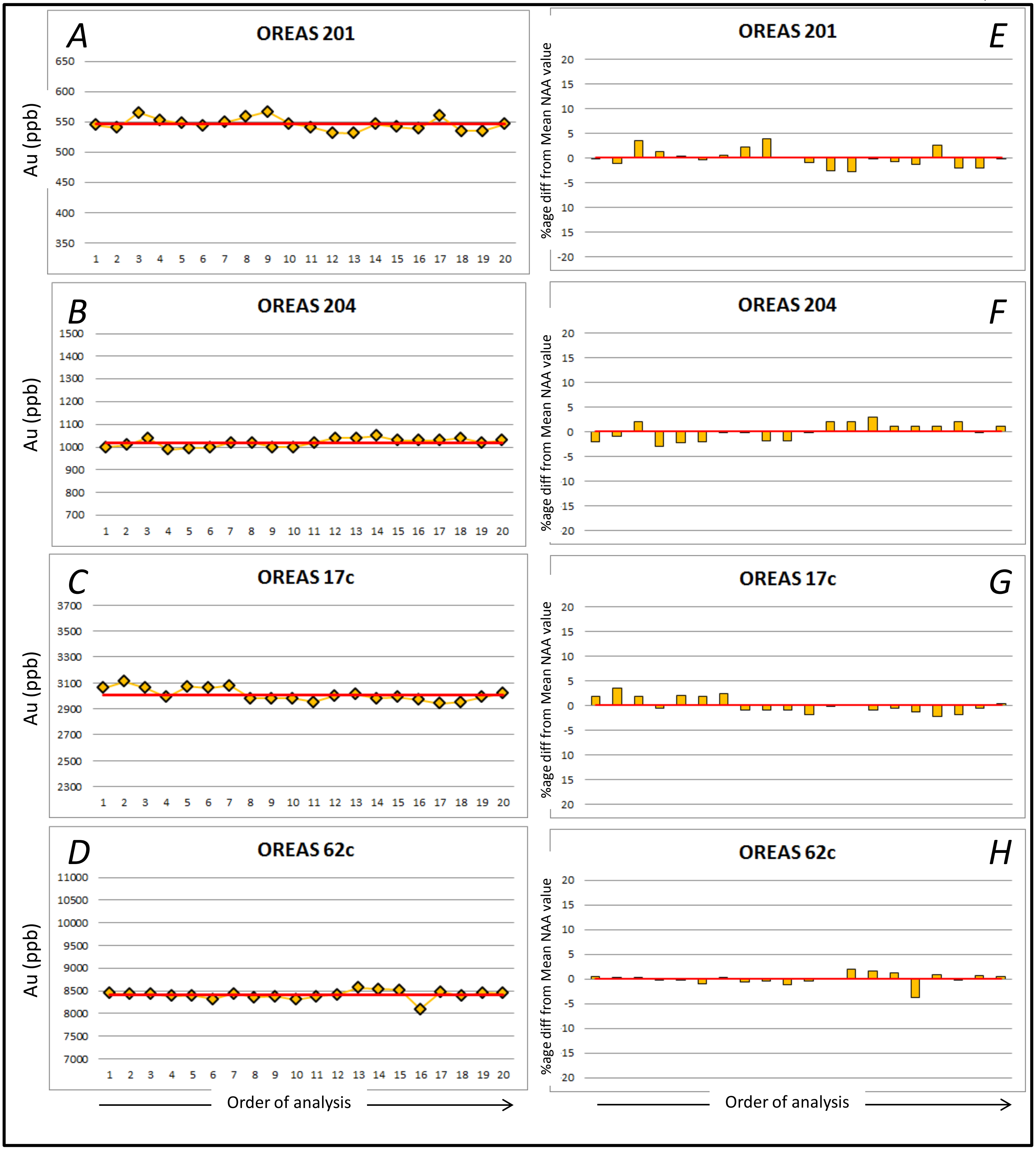
continued from page 12

9.81 ppm) show a relatively tight cluster around the INAA mean with G914-6 ranging from -4.9% to +3.7% (Figs. 3E and 3G) and G914-7-ranging from -2.2 to +3.6% (Figs.3 D and H). G909-6 (cert 0.57 ppm) shows a wider scatter whilst G313-1 (cert1.0 ppm) shows the widest scatter of all Geostats CRMs ranging from -8.9% to +16.3% of the INAA mean (Figs. 3B and 3F).

OREAS: Figure 4 shows the individual results for the OREAS CRMs. All OREAS CRMs show a consistent

Figure 4. Control charts for OREAS CRMs showing INAA concentration (Au ppb) in relation to the certified value [A-D] and the percentage difference from the INAA mean value [E-H].

continued on page 14



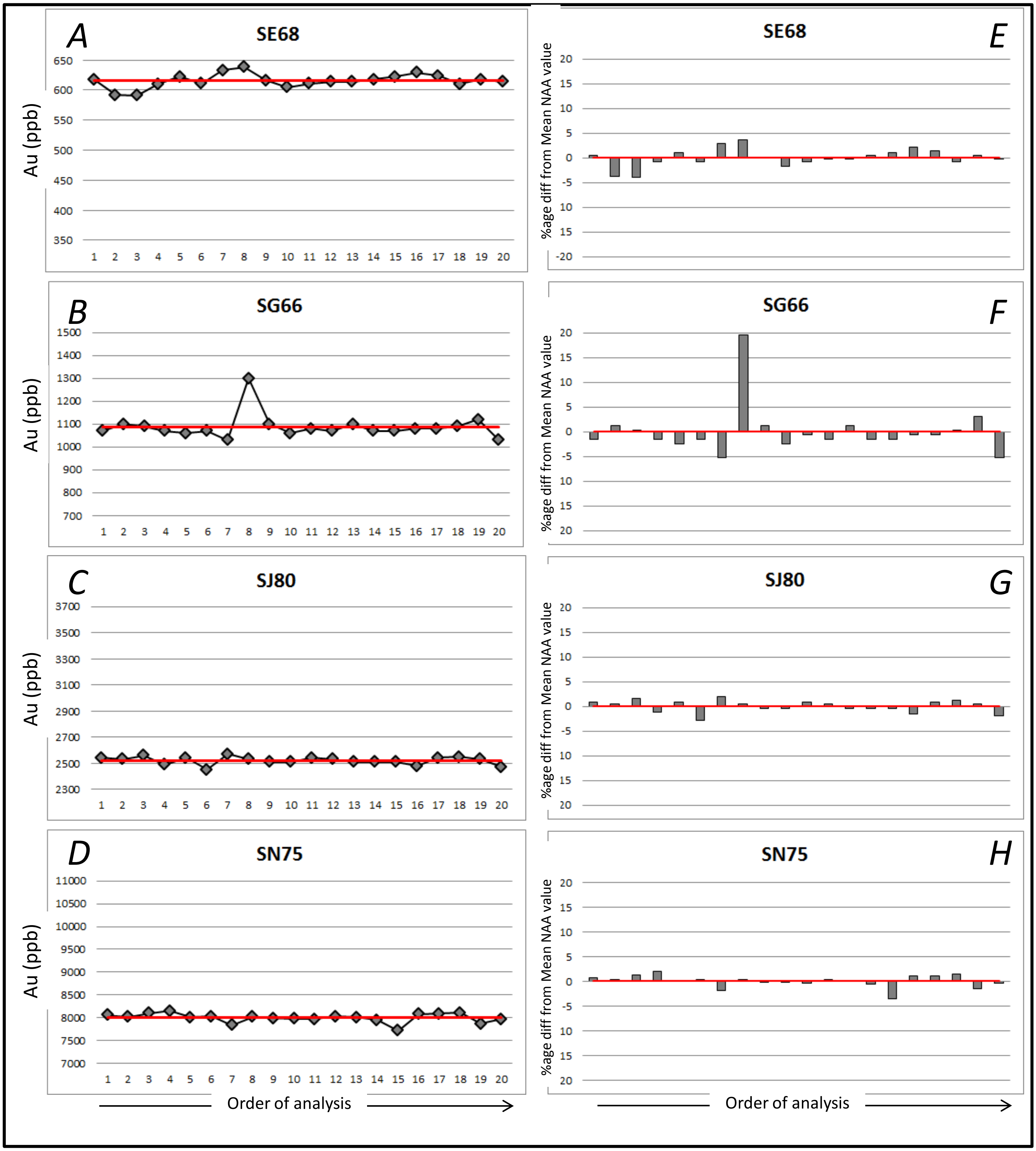
Gold Homogeneity in Certified Reference Materials... *continued from page 13*

tight range within ±5% of the INAA mean indicating a consistent homogenous CRM product over the range of CRMs tested.

Rocklabs: Figure 5 shows the individual results for the Rocklabs CRMs. Three of the four CRMs evaluated show a tight range within ±5% of the INAA mean indicating a consistent homogenous product. SG66 (cert 1.086 ppm) is slightly less homogenous with values ranging from -5.2% to +19.6% including one outlier (Figs. 5B and 5F).

Figure 5. Control charts for Rocklabs CRMs showing INAA concentration (Au ppb) in relation to the certified value [A-D] and the percentage difference from the INAA mean value [E-H].

continued on page 15



Gold Homogeneity in Certified Reference Materials...

continued from page 14

DISCUSSION

The application of CRMs in the mining and exploration industry is to monitor laboratory quality and to comply with mandatory reporting requirements (e.g., TSX, ASX). They are also utilised during ore reserve calculations to understand the uncertainty in a resource that ultimately feeds into an economic model. It is thus essential that users have confidence in the quality and homogeneity of their CRMs. The CRM certified values are consensus values derived by inter-laboratory round robin programs. The methods used by some manufacturers to filter outliers can mask potential issues with the homogeneity of the materials. Only outliers confidently reasoned to be analytical should be removed and this confidence only exists where homogeneity has been independently validated.

Results from this study show that the degree of homogeneity of CRMs available from the five manufacturers is variable; users and analysts of these materials need confidence that the CRMs are homogenous to a level fit for purpose so that QC failures are genuine and not a function of sampling error (i.e. inhomogeneous materials). A ranking system based on the values for the 30 g 2RSD sampling error would provide a guide to homogeneity of a CRM and enable users to select appropriate CRMs for their projects such that <1% is considered Very Good; 1-2% considered Good; 2-3% considered Mediocre; 3-4% considered Poor and >4% considered Very Poor.

AMIS (McWha & Smee 2012a-c, 2014) certificates contain no evidence of homogeneity testing but state, “Samples were randomly selected for homogeneity testing and third party analysis. Statistical analysis of both homogeneity and the consensus test results were carried out by independent statisticians”. CDN certificates (Sanderson & Smee 2013a-c, 2014) make no mention of homogeneity; Geostats certificates (Geostats 2009, 2014, 2015a,b) provide an unsupported statement that “materials are tested regularly to ensure stability and homogeneity”. OREAS publishes homogeneity test results with their gold CRM certificates (Hamlyn, 2009a,b, 2012a,b). Rocklabs (Smith & Ball 2012a,b,2013a,b) certificates contain a ‘Homogeneity Assessment’ section with the RSD reported but do not provide the actual results. Segregation/Settling information is also provided.

To enable the exploration and mining industry to have confidence in the quality of gold CRMs used for QC and mandatory reporting, manufacturers need to provide data on the homogeneity of every gold CRM. This homogeneity test work could be through the Reduced Analytical Subsample Method as utilised routinely by OREAS and chosen for this study or through the Replicates of Large and Small Sample Mass as described by Bagley et al. (2015). Without CRM manufacturers providing transparency on the homogeneity through test work, users should not assume all CRMs represent quality products.

CONCLUSIONS

The homogeneity of twenty commercial gold ore CRMs produced by AMIS (South Africa), CDN (Canada), Geostats (Australia), OREAS (Australia) and Rocklabs (New Zealand) have been evaluated and compared. The CRMs range in gold content from 0.45 to 9.81 ppm, typical of the levels commonly encountered in mining exploration projects.

The CRMs of AMIS, CDN, Geostats and OREAS are produced from naturally occurring gold ores to which variable quantities of barren/waste rock material has been added to achieve target grades. Rocklabs CRMs are produced from a range of rock and mineral products to which fine gold dust particles have been added in concentrations to achieve desired grades.

The investigation has shown a remarkable contrast in homogeneity between the various producers. These contrasting levels of homogeneity have serious ramifications with regard to sampling errors, which in some instances are of a magnitude equal to or greater than typical 30 g fire assay measurement errors rendering them of questionable value as a QC tool. Sampling errors for a typical fire assay charge weight (25 to 50 g) should be very minor compared to laboratory measurement errors. Otherwise the CRM cannot be deemed fit for purpose as the user is unable ascertain the source of the error seen in analytical data.

The homogeneity of the 20 gold CRM’s were evaluated using the Sampling Constant, the minimum sample mass (charge weight) required to achieve a 1% relative standard deviation in repeat analyses. For the four AMIS CRM’s tested, the Sampling Constants returned a range from 14 to 791 g. CDN had one CRM with a Sampling Constant of 1.4 g while the other three ranged from 111.8 to 263.4 g. Geostats had one CRM with a Sampling Constant of 1.4 g with the other three ranging from 4.9 to 39.4 g.

The OREAS CRM’s all returned Sampling Constants of less than 4 g. For Rocklabs, three of the four CRM’s returned Sampling Constants of less than 4 g with the fourth coming in at 27.1 g. Currently, OREAS is the only CRM manufacturer routinely evaluating and publishing the results of homogeneity test work on all their gold CRM’s using the Reduced Analytical Subsample INAA method.

This study clearly demonstrates that there is a wide range in quality amongst commercially available gold ore CRM’s and that the homogeneity of gold CRM’s from most manufacturers varies from one product to the next. It is proposed that all manufacturers be encouraged to undertake and publish results of homogeneity test work on gold in CRM’s, thereby providing end users irrefutable data on the magnitude of CRM sampling errors and their impact on QC protocols.

ACKNOWLEDGEMENTS AND DISCLOSURE

The author would like to acknowledge two reviewers who assisted in framing this article and Robert Garrett, Emeritus Scientist, Geological Survey of Canada, for his constructive comments on the manuscript. The author has no financial interests, direct or indirect, in any of the five CRM manufacturers.

continued on page 16

Gold Homogeneity in Certified Reference Materials... continued from page 15

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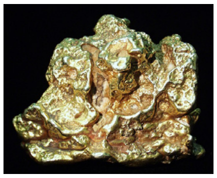
Geochemical Nuggets

New Feature

Sometimes an ICP-MS Never Forgets!



As a general rule, it is always a good idea to match both the matrix and grade of certified reference materials (CRM) with the samples in a geochemical survey. The following example illustrates what can happen when this is not the case.

Table 1 illustrates a sub-sample of ICP-MS aqua regia Au data for soil samples in a regional survey designed to detect sub-10 ppb Au anomalies. The control material chosen for the survey was a sulphidic, ore grade Au CRM because this is what the exploration crew had on hand. As the table illustrates, regional background is probably on the order of 2 ppb, so the CRM chosen was more than three orders of magnitude above this level. The high levels of Au in the CRM have carried across to the "downstream" samples within the analytical sequence, giving them values that would otherwise be considered anomalous. The effect possibly continues further along the analytical sequence although the level of contamination gradually diminishes. As a consequence, the most obviously affected samples had to be filtered out of the interpretation of a survey involving several hundred soil samples.

The "memory effect" is a well-known issue with analyses by conventional ICP-MS using an aqua regia digestion (Wang and Brindle, 2014), or even un-acidified samples. Essentially, metals may be adsorbed from solution onto glass ware or tubing during sample injection and nebulization within an ICP. These metals may not be effectively removed by standard, dilute acidic wash solutions and it may be some time before cross contamination levels are reduced to background levels, as was the case here. Had the issue been recognized in time, the sample solutions might have been re-read before disposal, without the CRMs.

While advances in instrumentation now allow us to detect the levels of some analytes down to the ppb or even ppt level, these advances must be matched with an understanding of instrumentation and the consequences of failing to use appropriate CRMs. In this instance a well-intentioned attempt to introduce quality controls samples into a low-level Au soil survey succeeded only in compromising the data due to poor CRM selection.

Table 1. Gold analyses by ICP-MS following an aqua regia digestion, with a lower detection limit of 0.1 ppb and an upper detection limit of 100 ppb.

Sample Type	Au (ppb)
Soil	1.5
Soil	2
Fresh sulphide CRM	2720
Soil (memory effect)	**32.1**
Soil (memory effect)	**7.5**
Soil	3.4
Soil	2.5
Soil	2.3
Soil	2.2
Soil	1.5
Soil	1.3

References

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Minutes of the 2015 AAG Annual General Meeting

Minutes of the 2015 Annual General Meeting of the Association of Applied Geochemists, held at the 27th International Applied Geochemistry Symposium, Tucson, Arizona, USA, 20 April 2015

I. Call to Order – Establishment of Quorum

President Leybourne called the Annual General Meeting (AGM) to order at 6:00 PM local time. More than 30 AAG Fellows were present, exceeding the necessary 15 required for a quorum.

II. President's report (M. Leybourne)

President Leybourne thanked the AAG Executive, Council, and Regional Councilors for their contributions to AAG during the time since the 2014 AGM. He extended a special thank you to Gwendy Hall for her tremendous contribution to AAG as Editor of GEEA since its inception (Volume 1, Number 1 being published in February 2001) to 2015. He also welcomed Kurt Kyser as the new Editor of GEEA. He thanked Beth McClenaghan (Editor) and Pim van Geffen (Business Manager) for their contributions to the AAG newsletter EXPLORE. He also extended thanks to Patrice de Caritat for serving as AAG's liaison with Elements magazine for the past few years and announced that Dennis Arne would be taking over those responsibilities. Bruno Lemière and Gemma Bonham-Carter were recognized for their outstanding contributions to AAG's website and Al Arseneault for his dedication to AAG as the Association's Business Manager. Lastly, President Leybourne thanked Erick Weiland, Rob Bowell, Sarah Lincoln, and Rick Schwarz for their hard work as the Local Organizing Committee for the 27th International Applied Geochemistry Symposium.

President Leybourne announced that Daniel Layton-Matthews of Queen's University, Kingston, Ontario, Canada, will be AAG's Distinguished Lecturer for 2015–2016.

III. Vice President's report (R. Noble)

Vice President Noble reported on progress in the publication of Bob Boyle's book on the history of geochemistry and cosmochemistry. An editorial team is now in place and it is hoped this book might be ready for the next IAGS in 2017.

During this year, AAG has received three updates from Regional Councilors. Neal Breward has stepped down as Regional Councilor for the UK and Republic of Ireland. Vice President Noble extended his thanks to Neal for his service to the Association.

Vice President Noble recognized Peter Bradshaw who reported on progress of the book about the contributions of Tony Barringer to the field of geochemistry. The first draft is largely edited and the first two chapters have been print set. When complete, the book will be available for purchase on the AAG website.

Lastly, Vice President Noble announced that Steve Cook will be AAG's new Vice President beginning in January 2016.

IV. Treasurer's report (G. Hall)

In 2014, AAG successfully accomplished all the paperwork necessary to continue its non-profit status under the new Canada Not-for-Profit Corporations Act.

Our investment holdings at 3 Macs for March 31, 2015: $615,301.29 in Cdn $ (7% of that is cash) and $89,514.85 in US$ cash (soon to be invested).

Also as of March 31, our accounts are:

CIBC Cdn	$ 25,539
CIBC US	$ 15,303

V. GEEA (G. Hall)

AAG's share of the profit from GEEA for 2014 was US$ 43,797. The rejection rate for submitted manuscripts is about 64%.

VI. EXPLORE (B. McClenaghan and P. van Geffen)

B. McClenaghan thanked all the corporate sponsors and advertisers for EXPLORE. In 2014, we lost one corporate sponsor. The newsletter operated at a small profit in 2014.

VII. Awards and medals (B. Eppinger)

Colin Dunn (2014) and Ravi Anand (2015) will be receiving AAG's Gold Medal during the IAGS. Beth McClenaghan will be receiving the Silver Medal. Requests for nominations for 2016 will be sent to AAG members soon.

VIII. Symposia (D. Cohen)

The bid to hold the 2017 IAGS in Florence, Italy was rejected by Council because of concerns about some of the cost estimates. The Association is currently investigating holding the 2017 IAGS in Canada. More information will be available in the next few months.

IX. Other business

President Leybourne opened the meeting to questions from the attending AAG Fellows. A variety of topics were discussed that were related to other sections of the minutes and concluded.

X. Adjournment

President Leybourne thanked all the participants for attending the 2015 AGM and declared the meeeting adjourned at 6:47 PM local time.

Recently Published in Elements

Volume 11, no. 4 Social and Economic Impact of Geochemistry

The August edition of Elements focused on the many ways that applied geochemistry impacts society. It starts with an overview of the impact of geochemistry (Ludden, Albarède & Coleman), looks at how geochemistry is used in mineral exploration (Kyser, Barr & Ihlenfeld) and then at new challenges and materials in the field of environmental mineralogy (Calas, McMillan & Bernier-Latmani). An article based on a case study from the City of London examines how geochemistry can be applied to urban planning (Ludden, Peach & Flight), whilst another explores the use of stable isotopes in forensic geochemistry (Ehleringer, Chesson, Valenzuela, Tipple & Martinella). The final contribution explores the uses of metal stable isotopes in medicine (Rakovan & Pasteris). The AAG Society News included a summary of the successful 27th IAGS by Erick Weiland and an abstract of Bob Garrett's thought-provoking article on QA/QC plots that appeared in Explore 167. There certainly should be something for nearly every geochemist in this volume!

Volume 11, no. 5, Supergene Metal Deposits

The October edition of Elements focuses on supergene metal deposits. It begins with an overview of the geological and economic significance of supergene metal deposits (Reich & Vasconcelos), explores supergene alteration of ore deposits (Dill), paleoclimatic signatures of this deposit type (Vasconcelos, Reich & Shuster), the use of Cu isotopes in understanding supergene processes (Mathur & Fantle), predicting geological corrosion with electrodes (Renock & Shuller-Nickles), and finishes with an examination of the geomicrobiology of supergene metal deposits (Zammit, Shuster, Gagen & Southam). The AAG Society News included a short obituary for Eric Hoffman, as well as citations for the winners of the 2014 and 2015 gold and silver medals. This is certainly an issue for those involved in regolith geochemistry and with an interest in supergene mineral deposits.

Dennis Arne

Eric L. Hoffman Memorial Scholarship

In loving memory of Dr. Eric Hoffman, Ph.D, P.Geo, the Eric L. Hoffman Memorial Scholarship has been established at the University of Toronto, Canada. This Earth Sciences graduate scholarship will be able to help future students advance a field that Eric was so passionate about. Dr. Eric Hoffman was the President and founder of Activation Laboratories Ltd. (Actlabs), with headquarters in Ancaster, Ontario, Canada, specializing in contract analytical services to many industries including; Minerals, Metallurgy, Petroleum, Life Sciences, Environmental, Forensics, Materials Testing, and Agriculture. Eric dedicated his career to advancing Actlabs and the geochemical field and quickly became a respected and valuable contributor to the geochemistry community. Eric was a strong supporter of collaborative industry-University research supporting both undergraduate and graduate students while providing project guidance and contributing to hundreds of research publications.

Even in his absence, Actlabs will continue to provide industry-leading innovative technologies and high quality services and support students through Actlabs and the Eric L. Hoffman Memorial Scholarship. Eric's memory will never be forgotten and his legacy will live forever.

To contribute to the scholarship, visit the webpage on the University of Toronto web site:

https://donate.utoronto.ca/give/show/85

If you have any questions regarding the Memorial Scholarship or have memories or comments about Eric that you would like to share, contact: ahoffman@actlabs.com

AAG's Student Support Program Resurrected in 2015

Research carried out by students of applied geochemistry usually involves geochemical analysis, the cost of which can be onerous. Recognising this fact, the Association of Applied Geochemists (AAG) instituted a Student Support Program in 2011, in which analytical laboratories offered support to applied geochemistry students in the form of free analyses. This program has been implemented by the AAG for over two years. Due to the downturn in the mineral exploration sector, participating laboratories were not being able to sustain their involvement and the program was suspended in 2014. However, all participating laboratories (ALS, Ultratrace, Genalysis, Becquerel) and AAG agreed that the aim of the program was sound, and the program has been revised. Actlabs, ALS-Australia, Intertek-Genalysis, and Bureau Veritas Ultratrace have agreed to be part of this revised version of the Student Support program.

In its revamped form, participating laboratories do not have to pre-commit funds to the program, but can choose whether they will offer support – and to what level – on a case-by-case basis. This revision means that laboratories are not obliged to support all projects offered to them, but also that projects endorsed by AAG's Education Committee may not receive support, or may only receive partial support. These changes to the program have not, however, affected the application process. Applications can be made using the form available on the Students page of the AAG website (www.appliedgeochemists.org). Following submission of the completed form to AAG's Education Committee (education@appliedgeochemists.org), the merit of the application is assessed, and those worthy of support are recommended to participating laboratories. In making the application, it is useful to look at the scope of work that is offered by participating laboratories as set out in their schedule of services available on their respective websites. These schedules also provide analytical costs: in making the application, it is more likely that an application will receive support from AAG's Education Committee and commitment from laboratories if the scope of work requested is strongly aligned with applied geochemistry and realistic in terms of costs.

Examples of geochemical research supported by AAG's Student Support Program include projects carried out by Andy Lucas and Xin Du, both of whom received in-kind analytical support from Intertek-Genalysis. Both Andy and Xin fulfilled their obligations from the AAG Student Support Program by publishing in **EXPLORE**:

Lucas, A.R., Rate, A.W., Salmon, S.U., Reid, N., Anand, R.R., 2013. Evaluating the diffusive gradients in thin films technique for the detection of multi-element anomalies in soils. **EXPLORE**, 161, 1-15.

Du, X., Rate, A.W., Gee, M.A.M., 2012. Particle size fractionation and chemical speciation of REE in a lateritic weathering profile in Western Australia. **EXPLORE**, 157, 1-14.

Currently, students Marcus Phua (University of Melbourne) and Enerst Tata (University of Buea, Cameroon) have received support for their research. Marcus's work involves the petrogenesis of gabbroic intrusions hosting Ni – Cu – PGE mineralization in Western Tasmania (supported by Bureau Veritas – Ultratrace), and Enerst's PhD thesis deals with granite-hosted gold mineralization from south-east Cameroon (supported by Intertek-Genalysis).

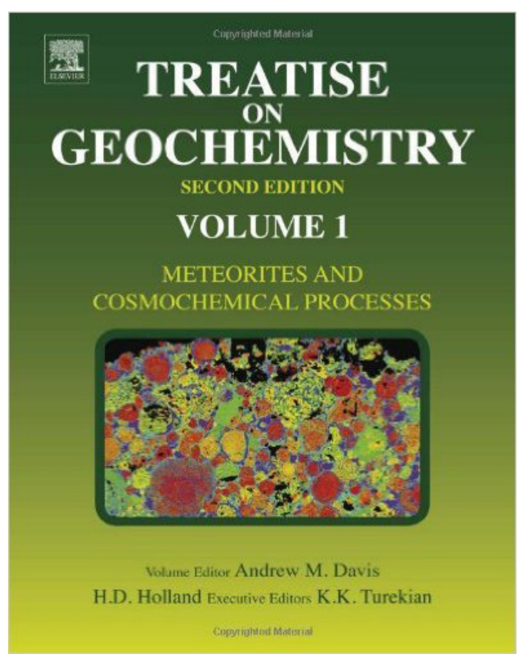
If the AAG Student Support Program is of interest to you as a supervisor, or as a student of applied geochemistry, please visit the Student page of the AAG website (https://www.appliedgeochemists.org) to find out more about this program, and download an application form.

Paul Morris
Chair, AAG Education Committee

Treatise on Geochemistry. Edition No. 2

This extensively updated new edition of the widely acclaimed Treatise on Geochemistry has increased its coverage beyond the wide range of geochemical subject areas in the first edition, with five new volumes which include: the history of the atmosphere, geochemistry of mineral deposits, archaeology and anthropology, organic geochemistry and analytical geochemistry. In addition, the original Volume 1 on "Meteorites, Comets, and Planets" was expanded into two separate volumes dealing with meteorites and planets, respectively. These additions increased the number of volumes in the Treatise from 9 to 15 with the index/appendices volume remaining as the last volume (Volume 16). Each of the original volumes was scrutinized by the appropriate volume editors, with respect to necessary revisions as well as additions and deletions. As a result, 27% were republished without major changes, 66% were revised and 126 new chapters were added.

For more information please go to on:
http://www.researchandmarkets.com/publication/me5b86z/treatise_on_geochemistry



Student-Industry mineral exploration workshop

In an effort to attract more students into the mineral exploration industry, the Prospectors and Developers Association of Canada (PDAC) convened its 9th annual Student-Industry Mineral Exploration Workshop (S-IMEW) from May 1-15, 2015. Twenty-six senior geoscience students from universities and colleges from across Canada converged on Sudbury to participate in lectures, presentations and hands-on sessions covering exploration techniques, mineral deposits, geophysics, geochemistry, environmental, health and safety and corporate social responsibility issues. The two-week, all expenses-paid gathering provided the students with an opportunity to experience the many facets of the mineral exploration industry.

'Geochemistry Day' is one of the highlights of the workshop each year and was organized and taught this year by Stew Hamilton, Richard Dyer, Andy Bajc, and Sarah Hashmi of the Ontario Geological Survey and Beth McClenaghan from the Geological Survey of Canada. They introduced students to exploration geochemical techniques and provided hands-on field and lab experiences that students were unlikely to receive at university, including organic lake sediment sampling, soil profiles and till sampling, and the microscopic world of indicator minerals.

The workshop was a great opportunity for students to learn about the wide variety of career opportunities in mineral exploration, gain experience with exploration techniques not typically taught to undergraduate students and experience some of the adventures of being a geoscientist.

Information about the PDAC's S-IMEW program is available at this weblink: http://www.pdac.ca/programs/students/s-imew/

Beth McClenaghan
Geological Survey of Canada

Students examining indicator minerals during Geochemistry Day lab exercise.

New AAG Members

Voting Members

David Murphy
Anglogold Ashanti Ltd.
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Membership no. 3675

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Regular Members

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Kiama, NSW
AUSTRALIA 2533
Membership # 4311

Student Members

Jasmine A. Moertle
California State University, Long Beach
6750 E. Rosebay St.
Long Beach, CA
USA 90808
Membership # 4309

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: +1-709-729-1161

2016

10-16 JANUARY	Winter Conference on Plasma Spectrochemistry. Tucson AZ USA. Website: icpinformation.org/Winter_Conference.html
19-21 JANUARY	10th International Symposium on Environmental Geochemistry. Perth Australia. Website: www.iseg10.com/
25-28 JANUARY	Mineral Exploration Roundup. Vancouver BC Canada. Website: amebc.ca/roundup
5-6 FEBRUARY	Atlantic Geoscience Society Annual Colloquium. Truro NS Canada. Website: www.acadiau.ca/~raeside/ags2016/
14-18 FEBRUARY	The Minerals Metals & Materials Society 145th Annual Meeting & Exhibition. Nashville TN USA. Website: tinyurl.com/nbdyqeh
21-26 FEBRUARY	2016 Ocean Sciences Meeting. New Orleans LA USA. Website: osm.agu.org/2016/
6-9 MARCH	Prospectors and Developers Association of Canada Annual Convention. Toronto ON Canada. Website: www.pdac.ca/convention
21-23 MARCH	North Atlantic Craton Meeting Edinburgh UK. Website: www.bgs.ac.uk/nac2016
17-22 APRIL	European Geosciences Union General Assembly 2016. Vienna Austria. Website: www.egu2016.eu/
16-18 MAY	7th Geochemistry Symposium with International Participation. Side Turkey. Website: jeokimya.ankara.edu.tr/en
22-25 MAY	10th South American Symposium on Isotope Geology. Puerto Vallarta Mexico. Website: www.ssagi10.geofisica.unam.mx/
1-3 JUNE	GAC/MAC Annual Meeting. Whitehorse YT Canada. Website: whitehorse2016.ca/
13-17 JUNE	8th International Siberian Early Career GeoScientists Conference. Novosibirsk Russia. Website: conf.ict.nsc.ru/sibconf2016
19-23 JUNE	6th International Congress on Arsenic in the Environment. Stockholm Sweden. Website: www.as2016.se
26-30 JUNE	Australian Earth Sciences Convention. Adelaide SA Australia. Website: aesc2016.gsa.org.au
26 JUNE-1 JULY	Goldschmidt 2016. Yokohama Japan. Website: www.geochemsoc.org/programs/goldschmidtconference/
10-13 JULY	3rd International Conference on 3D Materials Science. St. Charles IL USA. Website: tinyurl.com/psr55at
10-13 JULY	9th International Conference on Environmental Catalysis. Newcastle Australia. Website: tinyurl.com/pts5mtv
11-15 JULY	4th International Workshop on Highly Siderophile Element Geochemistry. Durham UK. Website: community.dur.ac.uk/hse.ws
17-22 JULY	Eurosoil 2016. Istanbul Turkey. Website: www.eurosoil2016istanbul.org
19-21 JULY	39th International Symposium on Environmental Analytical Chemistry. Hamburg Germany Website: tinyurl.com/pnaswjw
23-27 JULY	Euroscience Open Forum 2016. Manchester UK. Website: www.esof.eu
24-28 JULY	Microscopy & Microanalysis 2016. Columbus OH USA. Website: tinyurl.com/pdyxkpz
27-28 JULY	8th International Congress of Environmental Research. Lübeck Germany. Website: www.icer16.jerad.org
20-21 AUGUST	6th International Conference on Environmental Pollution and Remediation. Budapest Hungary. Website: icepr.org
21-25 AUGUST	33rd International Geographical Congress. Beijing China Website: www.igc2016.org
27 AUGUST – 4 SEPTEMBER	35th International Geological Congress Cape Town South Africa. Website: www.35igc.org
4-7 SEPTEMBER	IAP 2016: Interfaces Against Pollution. Lleida Spain. Website: www.iap2016.org
4-7 SEPTEMBER	15th Workshop on Progress in Trace Metal Speciation for Environmental Analytical Chemistry. Gdansk Poland. Website: chem.pg.edu.pl/tracespec
5-9 SEPTEMBER	13th International Nickel-Copper-PGE Symposium. Fremantle WA Australia. Website: www.iagod.org/node/58
11-15 SEPTEMBER	2nd European Mineralogical Conference. Rimini Italy. Website: emc2016.socminpet.it/
25-28 SEPTEMBER	SEG 2016 Conference: Tethyan Tectonics and Metallogeny. Çeşme Turkey. Website: www.seg2016.org
9-13 OCTOBER	World Water Congress & Exhibition. Brisbane QLD Australia. Website: tinyurl.com/pgrbkwu
16- 21 OCTOBER	Water Rock Interaction 15. Évora Portugal. Website (pdf): tinyurl.com/lch75x8