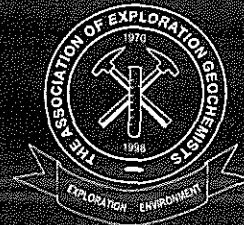


EXPLORE

NUMBER 101

NOVEMBER 1998

Newsletter for
the Association
of Exploration
Geochemists



PRESIDENT'S MESSAGE

The Council of the Association of Exploration Geochemists (AEG) have now agreed upon a new title for the official journal of the AEG which will commence on 1 Jan 2000 following the termination of the present publishing contract with Elsevier. In addition the Council will shortly be completing arrangements for the publication of the new journal. The journal title was selected following an extended period of discussion in which suggestions for the new title were passed freely among the Councillors, Regional Councillors and individual Members who had the opportunity to make an input into the discussions, and many of them did so.



Peter Simpson

The final decision was taken by the Council on the 16th September 1998 during one of the telephone conferences which take place at two or three month intervals and the twelve Councillors who were present were therefore well prepared to make a decision based on a consideration both of the many interesting and innovative proposals which had been submitted for discussion by Councillors and the membership, and also from their own personal preferences. Our new Secretary, Dave Smith who has taken over this important role from Sherman Marsh, our previous Secretary who has recently retired after longstanding service to the AEG, has provided a detailed account of the debate in Council as it unfolded. The record shows that one hundred and twenty individual contributions or comments were recorded in the course of this discussion, which is a good measure of the importance and the interest which this topic has attracted.

The Council took the view that since the matter is one which is of great concern and importance to all those who publish in and read the AEG's official publications the decision should be made by Council who have been elected by the membership to undertake such important duties on their behalf. The new title was selected as the outcome of a conclusive debate in which many aspects of this important topic were reviewed and discussed.

The discussion commenced with an invitation to all Councillors to indicate their preferred title and it was clear from the outset that a high degree of unanimity existed since only a limited number of possible titles were proposed from the extensive list of possibilities originally suggested. The primary objectives of the selection process were to identify a title which will be instantly recognisable in hard copy on the library bookshelf, accurately reflect the editorial goals, and stimulate readers, authors, academic and industrial organisations and advertisers to take note of and contribute to the contents. However, and perhaps even more importantly for a future which is likely to be increasingly dominated by electronic publication,

Continued on Page 2

TECHNICAL NOTE

Relative contamination levels observed in different types of bottles used to collect water samples

Gwendy E.M. Hall and the
Analytical Method Development Laboratory of the GSC
Applied Geochemistry and Geophysics,
Geological Survey of Canada, 601 Booth St, Ottawa, K1A 0E8

INTRODUCTION

Geochemical databases resident in Geological Surveys (GS) are being used increasingly by Environmental Government Departments for various purposes, one being to establish baseline concentrations of elements in surficial media and thereby set criteria (action) levels for those elements in soils, sediments and waters. An impediment to the adoption of water data for this purpose is the fact that the methods of collection usually employed by GSs do not adhere to the strict guidelines recommended by such agencies as the US Environmental Protection Agency (EPA). For example, collection vessels are not made of Teflon and are not usually subjected to the rigorous cleaning recommended by the EPA; 'clean-room' clothing is not worn by field personnel. The cost of adhering to such protocols would be prohibitive in hydrogeochemical surveys. The work described herein forms part of a project carried out by the Analytical Method Development Laboratory of the GS of Canada (GSC) to recommend the most cost-effective and efficient procedures by which to sample (i.e. bottle/vessel type), filter (0.45 μ m) and preserve surface waters for the accurate determination of 'dissolved' Al, Ag, As, Cd, Co, Cr, Cu, Hg, Fe, Mn, Mo, Ni, Pb, Sb, Se, Tl and Zn for both exploration and environmental objectives. This paper focuses on the potential for contamination of different bottle materials and the efficiency of several recommended cleaning methods.

A schematic diagram (Fig. 1) provides a visual summary of the treatment of five types of bottles and the cleaning procedures tested. A review (though not exhaustive) of common practices used by analytical laboratories in Canada led to the choices made in bottle types and cleaning methods investigated. With the

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Information for Contributors to EXPLORE

Scope This Newsletter endeavors to become a forum for recent advances in exploration geochemistry and a key informational source. In addition to contributions on exploration geochemistry, we encourage material on multidisciplinary applications, environmental geochemistry, and analytical technology. Of particular interest are extended abstracts on new concepts for guides to ore, model improvements, exploration tools, unconventional case histories, and descriptions of recently discovered or developed deposits.

Format Manuscripts should be double-spaced and include camera-ready illustrations where possible. Meeting reports may have photographs, for example. Text is preferred on paper and 5- or 3-inch IBM-compatible computer diskettes with ASCII (DOS) format that can go directly to typesetting. Please use the metric system in technical material.

Length Extended abstracts may be up to approximately 1000 words or two newsletter pages including figures and tables.

Quality Submittals are copy-edited as necessary without re-examination by authors, who are asked to assure smooth writing style and accuracy of statement by thorough peer review. Contributions may be edited for clarity or space.

All contributions should be submitted to:

EXPLORE

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Editors: Sherman P. Marsh (303) 986-0939

J. Thomas Nash (303) 236-5515

Assistant Editors:

Steve Cone (303) 232-8371

Robert Eppinger (303) 236-2468

Dave Smith (303) 236-1849

J. Stevens Zuker (303) 989-6608

Business Manager: Owen P. Lavin (303) 708-4140

FAX (303) 236-3200, ATTN: Sherman Marsh, USGS

e-mail: spmarsh@earthlink.net

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President's Message

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it is essential to have a title which will be readily identified and retrieved by electronic search engines. For this to succeed, relevance and simplicity are a priority.

The final choice therefore took full account of all these objectives and it was unanimously proposed by Council that the title be a single word modified by a subtitle to provide the necessary focus:

GEOCHEMISTRY

Exploration Environment Analysis.

The subtitle can be considered from one perspective as the subject matter of a Venn diagram in which various possible combinations of these three topics could form the main thrust of publications in the new journal. However, the order of topics in the subtitle is also important since exploration geochemistry is the principal unifying theme of our association, with environment and analysis providing important links to related disciplines. This will help to overcome the difficulty some of our members have had in the past when selecting a suitable journal to publish the results of their work, especially where there is a significant environmental impact arising from the results of geochemical exploration.

The next edition of **EXPLORE** will contain details of the arrangements for publication of this new journal.

Peter Simpson

British Geological Survey

Keyworth, Notts, NG12 5GG, UK

Tel Int + 44 115 9363532

Fax Int + 44 115 9363200

email: p.simpson@bgs.ac.uk

email: prsimpson@msn.com (business and private)



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Technical Note

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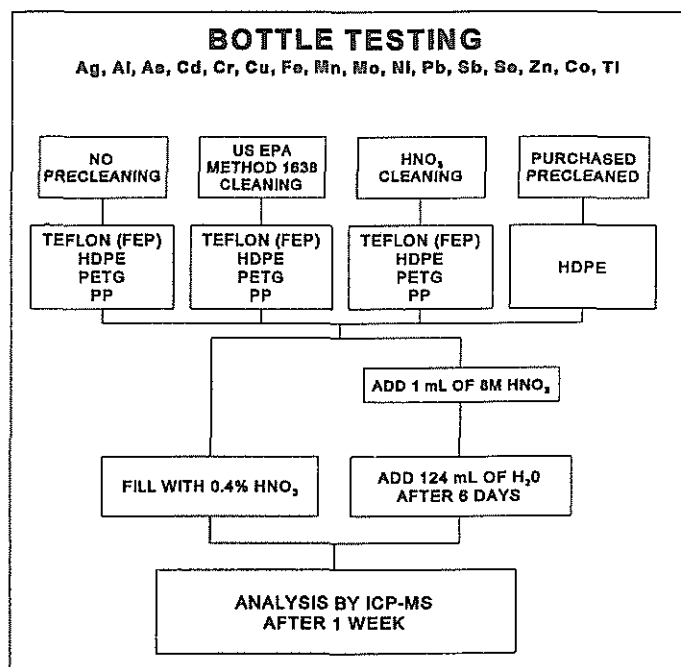


Figure 1

exception of the analysis itself, all this work was carried out in a Class 100 Cleanroom. The bottles selected were those in widespread use for the collection and analysis of water samples for metals/metalloids. These comprise the following bottles of nominal 125 ml capacity:

- FEP (Teflon) Nalge #1600, round with Tefzel ETFE screw, \$28 ea (approx cost Cdn)
- HDPE (High density polyethylene) Nalge #2007, rectangular with polypropylene screw closure, \$0.90 ea
- PETG (Polyethylene terephthalate copolyester), Nalge #2019, square with HDPE screw closure, \$2.60 ea
- PP (Polypropylene) Nalge #2006, round with PP screw closure, \$1.00 ea
- HDPE^p Purchased precleaned, round, "Superfund-Analyzed" to meet or exceed EPA specifications, \$2.30 ea

The term "water" throughout refers to Type I (<18M), produced by a Milli-Q system. Ten bottles of each type were cleaned using the three methods outlined below, making a total of 120 bottles (excluding the precleaned HDPE^p bottles).

EXPERIMENTAL

The cleaning methods used were as follows:

(1) Simple rinse

Bottle and cap were simply rinsed three times with water before filling or charging with acid.

(2) Modified EPA

This basic procedure is outlined in EPA Method 1631, "Determination of trace metals in ambient waters by ICP-MS" (EPA 821-R-96-005). However, since the Cl⁻ ion is undesirable in the measurement of some elements by ICP-MS, the step of soaking in 1 M HCl was eliminated. Method 1631 (p. 28) does allow for modification to the complete cleaning procedure if results prove satisfactory. Briefly, the modified method involves:

- Bottle is filled with a 0.5% solution of liquid detergent (Alconox) and shaken for 30 min. Bottle and cap are then rinsed with water until there is no sign of soap residue.

- Bottle is filled with reagent-grade 16M HNO₃ and placed in a water bath at 50 °C for 2 h. This was *not* carried out for the PETG bottles as they are not resistant to this concentration of acid and melt in the bath. Therefore, the PETG bottles were filled with 5% (v/v) HNO₃ instead and heated.
- Bottle is rinsed thoroughly with water and filled with water. Each bottle is double-bagged in polyethylene and stored in a Class 100 Cleanroom.

(3) HNO₃ wash

As described in "Quality Assurance Project Plan for Clean Metals" (Dec '96) by the Office of Water Quality Assessment and Planning, Virginia Dept of Environmental Quality.

- Bottle is filled with 5% (v/v) HNO₃, capped and placed in a water bath for 24 h at 50 °C.
- Bottle is well rinsed with water, refilled with 0.5% (v/v) HNO₃, capped and placed in a water bath for 24 h at 50 °C.
- Bottle is rinsed three times with water, and refilled with water to which 250 l of Seastar (double-distilled, CA-01-02-1000; Sidney, BC) conc. HNO₃ are added. Bottle is capped and set aside for 24 h.
- Bottle is rinsed with water and filled with water until usage (again double-bagged and stored in Class 100 Cleanroom).

Thus, the two cleaning procedures are similar in that they focus on the use of HNO₃, but the EPA method employs concentrated (12M) acid, whereas the Virginian method (designated as HNO₃ hereafter) uses a much lower concentration of 5% (v/v) with a subsequent step employing only 0.5% HNO₃. The EPA method incorporates an initial wash with a soap solution.

The suite of ten bottles cleaned by each method was divided in two. One group of five bottles was filled to 125 ml with 0.4% HNO₃ (Seastar Chemicals Inc., double sub-boiling distilled, CA-01-02-1000). To the other five bottles, a charge of 1 ml of 8M HNO₃ (Seastar) was added. Care was taken to use the same lot of Seastar HNO₃ for both treatments. The suite of 10 HDPE^p bottles was treated in the same way (i.e. five were filled to 125 ml with 0.4% HNO₃ and five were charged with 1 ml of 8M HNO₃). These two approaches were used to imitate procedures used in industry: some companies pre-charge bottles with a small volume of concentrated acid, to which the sample is added later in the field, whereas others prefer to add the acid once the sample is collected. The concentration of 0.4% is used in GSC hydrogeochemical surveys and is a compromise between 0.1 and 1% HNO₃, the range of preservative concentration indicated by a scan of reports and literature.

The bottles were allowed to stand for six days, whereupon the 65 bottles containing the 1 ml of 8M acid charges were filled with 124 ml of water. An aliquot was then taken from each bottle and poured into test-tubes ready for analysis. These test-tubes had been already investigated for their contamination levels. The method of direct ICP-MS used to determine Ag, Al, As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Tl and Zn is described in Hall et al. (1996a). Calibration was carried out with standard solutions of 0.4% HNO₃ (same Seastar source as used previously) spiked with known amounts of element standard solutions. Selenium required improved sensitivity by changing the method of introduction, from pneumatic nebulisation to hydride generation. This method is described in Hall and Pelchat (1997a, b). Only Se IV is reactive to form the gaseous hydride, and therefore any Se VI was prereduced to the IV valency state by heating in 6M HCl. A 5 ml aliquot of solution was added to 5 ml of 12 M HCl in a test-tube, capped, shaken and heated in a water bath for 35 minutes. On cooling, the solution was made up

Continued on Page 4

Technical Note

Continued from Page 3

to 15 ml with water and analysed by HG-ICP-MS.

RESULTS

The mean and standard deviation of element concentrations found in the 125 ml volume of water standing in each bottle are presented in Table 1. The instrumental 3 detection limits (DL) shown are based on 'pure' solutions and consequently are the most optimistic: these would be degraded when analysing 'real' waters where oxide corrections would be made for certain elements (e.g. CaO, CaOH on Ni and Co). Values have not been truncated at the DL in order to view trends. Some general observations can be gleaned:

- 8M acid-charged bottles contribute much more contamination than their counterparts containing 0.4% HNO₃;
- FEP bottles are the most contaminating;
- the modified EPA method of cleaning is inferior to that proposed by the State of Virginia; and
- the precleaned HDPE[®] bottles are inferior to their less expensive, untreated HDPE counterparts.

In greater detail, with reference to Table 1:

Al

The 'dirtiest' bottle by far is PP, with a maximum level of contamination of 4.2 ± 0.2 ppb being shown by the uncleaned, acid-charged bottle. Neither the EPA nor the HNO₃ method of cleaning is adequate to completely remove this contamination for the acid-charged bottle (B), though they are acceptable for the dilute acidified sample (A). The cleanest bottle is PETG, showing levels of Al all below the instrumental DL of 30 ppt. Both cleaning methods are satisfactory for FEP, though the level

of contamination 'as is' (rinse only) is minimal (52 ppt for bottle A and 176 ppt for B). The HDPE[®] bottle shows the same level of Al contamination, at 130-150 ppt, for bottles A and B, whereas the 'ordinary' HDPE bottle shows measurable levels of contamination only when in prolonged contact with the acid charge and then at a consistent 281 ± 19 ppt. Al in HDPE bottle A is below the DL of 30 ppt.

Cr

The HDPE, PETG and PP bottles all show negligible levels of Cr at several ppt, though the acid-charged bottle does display slightly higher levels, as does EPA cleaning (to ca 20 ppt). Compared to the HDPE bottle, the HDPE[®] bottle A shows a higher level of Cr, at 35 ± 6 ppt, which increases to 102 ± 23 ppt for bottle B. Maximum contamination is observed for the FEP bottle B, at 218 ± 117 ppt, with the A counterpart indicating lower levels of 67 ± 32 ppt. These concentrations are reduced substantially by HNO₃ cleaning but the EPA method is slightly inferior, showing mean values of 44 and 74 ppt, respectively for bottles A and B.

Fe

Contamination by Fe is severe in the FEP bottle, at 1.9 ± 1.1 ppb, rising to 42 ± 60 ppb in the acid-charged bottle. This contamination in bottle B is random, the range being from several ppb to 140 ppb. Both cleaning methods decrease this level below 1 ppb in bottle A, though the acid-charged bottle still shows 1-2 ppb Fe (equivalent to the DL of the method). The other bottles show less than 1 ppb of Fe contamination with the exception of the acid-charged PETG bottle at 1.2 ± 0.9 ppb. Precleaned HDPE[®] is not cleaner than HDPE in Fe.

Mn

The PETG bottle shows the highest degree of Mn contamination, at 67 ± 7 ppt in A and rising to 5.3 ± 1.1 ppb in the acid-charged bottle B. Both cleaning methods eliminate this contamination from bottle A but are not successful in doing so with bottle B, with the level of Mn remaining at the several ppb level. The other bottle of concern is the FEP, showing 162 ± 201 ppt Mn in the acid-charged bottle; however, cleaning by either method reduces this below 10 ppt. All HDPE and PP bottles show Mn levels below 10 ppt.

Co

Again, PETG bottles, followed by FEP, contribute most contamination. A high amount of Co is extracted from the acid-charged PETG bottle (9.1 ± 1.9 ppb, cf to 121 ± 12 ppb in bottle A). This potential contamination in bottle B is not removed by either the EPA nor HNO₃ cleaning methods, though bottle A Co levels are reduced to several ppt. The difference in results between bottles A and B is less startling for the FEP material, at 30 and 69 ppt Co, respectively. However the cleaning methods do not completely eliminate these contributions, especially in the acid-charged bottles. All HDPE and PP bottles show <3 ppt Co.

Ni

FEP bottles show an unacceptable and random level of Ni contamination which is of the same magnitude in bottle A and B, at ca 500 ppt. Cleaning with HNO₃ eliminates this contribution of Ni (to <20 ppt) for treatment A but not B (remaining at a mean of 233 ppt). The EPA cleaning method is not adequate for either the dilute acidified sample A (126 ppt) or the acid-charged bottle B (245 ppt). Nickel contamination in other bottles is negligible.

Cu

FEP bottles again contribute high and varied levels of Cu

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Continued on Page 5

Technical Note *Continued from Page 4*

Table 1

Mean and standard deviation (n=5) of element concentrations found in 125 ml acidified water samples contained in different bottles precleaned in different ways; all data in ppt (ng l⁻¹) except Fe and those with * which are in ppb. Data have not been truncated at detection limits. A represents bottle filled with 0.4% HNO₃ and B represents acid-charged bottle.

Treatment	Al	Cr	Fe*	Mn	Co	Ni	Cu	Zn	As	Mo	Ag	Cd	Sb	Tl	Pb
3 DL	30	10	1.7	5	3	20	10	20	6	3	2	2	3	0.2	2
FEP bottles															
None, A	52±63	67±32	1.9±1.1	13±4	30±12	492±501	190±199	98±102	-0.7±2	9±4	-0.1±0.4	1±1	2±1	0.09±0.1	10±11
None, B	176±107	218±117	42±60	162±201	69±10	507±54	1.6±2*	766±811	5±7	164±254	1±1	3±1	3±2	0.2±0.1	64±59
EPA, A	-10±7	44±24	0.52±0.89	8±6	17±4	126±24	34±25	156±330	-1±3	4±1	-0.7±0.4	0.3±0.3	0.8±0.4	0.1±0.05	1±0.4
EPA, B	-2±22	74±16	1.1±1.4	10±5	40±12	245±39	31±18	12±7	0.2±1	16±2	-0.7±0.3	1±7	0.3±0.6	0.1±0.06	2±2
HNO ₃ , A	-40±12	-5±5	0.46±0.32	-4±1	6±5	-0.7±8	3±3	16±3	-0.8±2	-0.3±1	-1±0.2	-1±0.2	0.8±0.8	0.1±0.07	1±0.2
HNO ₃ , B	-16±31	58±13	1.8±.8	5±3	42±11	233±45	40±24	34±32	-1±1	20±2	-1±0.2	-1±0.2	-0.2±0.3	0.04±0.1	1±0.2
HDPE bottles															
None, A	-17±15	0.8±4	0.64±0.67	-2±0.8	-0.5±0.4	-6±2	20±7	7±4	-0.9±2	-0.3±1	0.5±1	-0.5±0.2	1±.5	0.1±0.07	0.8±0.8
None, B	281±19	4±5	0.61±0.91	-2±0.6	-0.1±0.1	-3±3	32±23	-0.6±1	-0.7±1	-0.4±0.7	0.1±0.3	-0.1±0.5	-0.1±0.2	0.1±0.07	-0.5±0.2
EPA, A	56±29	16±2	0.29±0.50	-3±1	-0.4±0.3	-9±6	4±1	12±4	-2±1	-0.1±0.6	-0.7±0.3	0.08±0.5	0.6±0.2	0.1±0.08	0.9±0.6
EPA, B	312±24	20±4	-0.5±0.4	-3±0.3	-0.4±0.3	-13±3	-4±2	-4±9	-0.02±2	0.2±0.5	-0.4±0.5	-0.1±0.4	0.3±0.1	0.1±0.02	-0.5±0.4
HNO ₃ , A	-13±8	-9±3	-0.1±0.3	-3±0.4	-0.4±0.1	-15±5	4±3	30±9	-2±2	-0.6±0.5	-1±0.2	0.07±0.5	1±0.4	0.02±0.1	1±.4
HNO ₃ , B	557±773	11±16	0.5±0.5	-4±0.8	-0.7±0.1	-11±17	-5±4	-4±4	-0.4±1	-0.6±0.3	-1±0.2	-0.2±0.3	-0.5±0.2	0.05±0.05	-0.9±0.1
PETG bottles															
None, A	14±28	3±2	0.21±0.34	67±7	121±12	-6±3	72±9	287±141	3±2	1±1	1±0.7	0.4±0.4	3±1	0.1±0.07	1±0.3
None, B	6±15	28±31	1.2±.9	5.3±1.0*	9.1±1.9*	41±10	90±22	138±23	2±2	1±2	0.4±0.4	0.07±0.3	14±1	0.09±0.07	-0.5±0.1
EPA, A	-41±15	-1±5	-0.26±0.61	0.1±1	2±1	4±5	8±2	43±23	0.2±2	-0.5±0.4	-0.7±0.3	-0.04±0.6	0.7±0.5	0.07±0.08	0.9±0.2
EPA, B	-33±7	2±4	0.29±0.68	2.1±.6*	3.3± 1.1*	8±5	3±1	126±220	0.02±2	0.6±0.8	-0.5±0.4	0.2±0.4	7±2	0.1±0.02	-0.5±0.1
HNO ₃ , A	-48±4	-4±4	-0.39±0.53	-1±2	1±2	-11±4	5±3	9±5	-1±0.3	-0.4±0.6	-0.7±0.3	-0.2±0.3	0.8±1	0.02±0.07	-0.5±0.1
HNO ₃ , B	-54±9	-1±3	<0.1±0.4	2.7±1.0*	4.5±1.7*	10±9	-1±3	57±90	-1±0.3	-0.1±0.8	-0.9±0.4	0.2±0.1	9±3	0.05±0.05	-0.7±0.2
PP bottles															
None, A	594±40	-4±6	-1±0.47	-1±1	-0.1±0.2	-6±4	39±13	28±10	2±2	0.05±0.6	0.4±0.4	-0.2±0.2	1±0.6	0.2±0.1	1±0.4
None, B	4.2±0.2*	9±5	-0.2±0.5	-1±1	-0.6±0.3	-0.5±4	86±100	28±33	-1±2	-0.06±0.6	1±0.5	-0.3±0.2	0.6±0.5	0.1±0.1	0.07±0.1
EPA, A	66±26	20±1	0.07±0.64	-2±0.5	-0.3±0.3	-5±6	3±3	2±2	7±2	-0.6±0.2	-0.2±0.1	0.06±0.3	0.6±0.3	0.1±0.1	0.7±0.1
EPA, B	724±62	20±3	0.13±0.40	-2±0.2	-0.08±0.1	-11±4	-3±3	-6±3	-0.06±3	-0.06±0.6	-0.3±0.3	0.04±0.2	0.4±0.9	0.1±0.07	-0.8±0.3
HNO ₃ , A	-47±24	-8±2	-0.3±0.5	-3±1	-0.3±0.4	-12±5	3±4	25±12	0.2±2	-0.2±0.3	-0.6±0.2	0.2±0.4	0.9±0.7	0.02±0.1	1±0.9
HNO ₃ , B	842±100	2±3	0.03±0.50	-5±0.5	-0.6±0.1	-12±3	-2±7	-3±5	-3±4	-0.5±0.8	-1.1±0.5	-0.01±0.4	-0.4±0.4	-0.01±0.0	-0.9±0.2
HDPE bottles, purchased as 'precleaned'															
A	133±48	35±6	0.4±0.5	2±2	-0.1±0.2	17±3	24±5	739±195	0.2±1	0.8±0.8	-0.3±0.3	0.5±0.5	0.2±0.5	0.1±0.1	4±2
B	148±41	102±23	0.8±0.6	5±5	-0.07±0.3	22±9	14±8	2.0±1.2*	0.1±2	0.3±1	-0.3±0.4	0.2±0.4	1±0.8	0.06±0.1	4±2

None = rinse three times with water

EPA = Modified EPA cleaning method 1638 based on washing with soap solution followed by concentrated HNO₃ (no HCl step); note 5% HNO₃ substituted for conc. HNO₃ for PETG bottles which would otherwise melt

HNO₃ = State of Virginia cleaning method, based on washing with 5 and 0.5% HNO₃

(A-190 ± 199 ppt; B-1.6 ± 2.0 ppb) in the unwashed bottles.

Both methods of cleaning reduce these levels to below 50 ppt. Similarly, both methods negate the levels of Cu observed in the HDPE, PETG and PP bottles but these levels are much lower, in the range 20-90 ppt Cu. Precleaned HDPE^a bottles show about the same level of Cu as the HDPE (14-32 ppt).

Zn

The dirtiest bottles are the precleaned HDPE^a, contributing 739 ± 195 ppt Zn to bottle A and 2.0 ± 1.2 ppb to bottle B! The cleanest bottle is the HDPE, at <20 ppt Zn, followed by the PP bottles at <30 ppt Zn. Though the cleaning methods reduce the contribution of Zn from FEP and PETG bottles down from averages of 98-766 ppt, random contamination is still evident (e.g. to 750 ppt in one of the FEP bottles, A).

As

No contamination above 10 ppt is evident for As in these bottles.

Mo

Only the FEP bottles show a contribution by Mo above the DL of 3 ppt, at 9 ± 4 ppt in bottle A and 164 ± 254 in the acid-charged bottle, B. Both cleaning methods reduce the level below 4 ppt in the dilute acid treatment, A, but slight traces of Mo remain in the acid-charged bottles (16-20 ppt).

Ag

No contamination above the DL of 2 ppt is evident for Ag in these bottles.

Cd

Only the acid-charged, uncleaned FEP bottle shows a mean value for Cd above the DL of 2 ppt and this is at a level of only 3 ± 1 ppt. The EPA method reduces this below the DL (to 1 ± 0.7 ppt, and <1 ppt for the dilute acid equivalent).

Sb

Levels of Sb are below the DL of 3 ppt in precleaned and ordinary HDPE and PP bottles. PETG shows the highest contamination, at 3 ppt on average for bottle A and 14 ppt for bottle B. Neither cleaning method reduces this level adequately for the acid-charged bottle.

Tl

All Tl concentrations are below 1 ppt.

Pb

Mean levels of Pb are below the DL of 2 ppt in HDPE, PETG and PP bottles. However, the HDPE^a shows 4 ± 2 ppt Pb in both treatments. The FEP bottles are again the dirtiest, at 10 ± 11 ppt in bottle A and 64 ± 59 ppt in bottle B. These levels are reduced to several ppt by cleaning.

Se

All Se concentrations are below 4 ppt.

Hg

A completely separate set of experiments was carried out for Hg as this element requires a different preservation reagent. In summary, it was found that all bottle types - FEP, HDPE, PETG and PP - can be used without any cleaning (i.e. rinsing only) for the determination of Hg in waters down to levels of 1-2 ppt. None of the commonly used preserving agents (BrCl, HCl or K₂Cr₂O₇ in HNO₃) appears to leach out detectable concentrations (<1 ppt) of Hg from the bottle material. Thus, the elaborate cleaning methods, EPA 1631 and 1638, can be avoided for Hg.

DISCUSSION AND CONCLUSION

The approach practiced by some laboratories - to add a charge of concentrated (8M) HNO₃ reagent to the bottle hours

Continued on Page 6

Technical Note

Continued from Page 5

or days before water collection - is *not acceptable*. This strategy causes much higher levels of contamination (for all bottles) than is the case when acidifying during or after sample collection. This occurs in the uncleaned bottles for the elements Al (in FEP, PP, HDPE), Cr (FEP and precleaned HDPE[®]), Fe (FEP, PETG and precleaned HDPE[®]), Mn (PETG), Co (FEP and PETG), Ni (PETG), Cu (FEP), Zn (FEP and precleaned HDPE[®]), Mo (FEP) and Pb (FEP). While the two cleaning methods tested serve to reduce these levels of contamination in the acid-charged bottles, they are not eliminated and elements are leached out during prolonged contact (six-day period used here) with the strong acid. Significant levels remain after cleaning for elements such as Fe and Ni in FEP, Mn and Co in PETG, and Al in PP and HDPE bottles. Thus, a 2-h soaking in 16M HNO₃ at 50 °C (EPA method) has not effectively removed these elements from these materials, and subsequent extended contact with 1 ml of 8M HNO₃ causes more element to be released. Time of contact between acid charge and bottle will clearly vary in a sampling program and thus contaminant level is not predictable.

In order to evaluate whether the contamination levels summarised in Table 1 are significant, we must know the minimum concentration of element to be expected in a natural water sample. Data from two stream surveys in Nova Scotia and Newfoundland carried out by the GSC (Hall, 1993; Hall et al., 1994) have been used to provide values of the mean and standard deviation of these elements in their 'dissolved' (defined as <0.45

m) form. Most of these 868 sites are second and third-order streams remote from industry or farming, sampled to assess the control of underlying geology on the water chemistry. These values, together with the lowest concentration measured in each survey, are presented in Table 2. These data have been used to estimate the method detection limit required ('MDL - geo') in hydrogeochemical surveys, thereby ensuring that the lowest element concentration expected in a survey could be determined with reasonable precision. Also given in Table 2 are the detection limits typically required by environmental regulations; two sets of criteria levels (those of the Canadian Federal and British Columbia Provincial Governments) are presented for reference. For the most part, as expected, the MDLs for environmental assessment purposes are significantly higher than those required to measure natural, geogenic levels of trace elements. However, there are several instances where these two limits are equivalent and this warrants examination. For example, the environmental MDL for Al, at 0.5 ppb, appears to be much too low when compared to the natural range of Al in surface waters. Only 2 samples out of 729 in the Nova Scotia survey contained Al below the analytical detection limit of 2 ppb. The value for the 25th percentile of this survey is 47 ppb and that for the median is 114 ppb. Thus, the requirement to be able to measure at 0.5 ppb for Al in environmental assessment projects seems overly stringent. Similarly, only 2 of the 729 samples contained Cu below the analytical detection limit of 0.1 ppb, the lowest level of measurement required in environmental work. However, the value for the 95th percentile is only 1.5 ppb Cu, demonstrating a much narrower range in natural levels than Al. The mean for Cu in the Newfoundland survey is considerably higher (2.7 ppb, cf. 0.7 ppb) due to some base metal mineralisation in the area. Although both environmental and geochemical MDLs for Cr and Cd are comparable, the natural levels of these elements are close to these limits and therefore the seemingly low environmental MDL may not be excessively rigorous.

The MDLs in Table 2 have been used to evaluate whether potential levels of contamination from the different bottles could be significant, in either a geochemical or environmental application. For each bottle type and cleaning treatment, the value for the 'mean plus two standard deviations' (taken from Table 1) has been compared with the MDL listed in Table 2. This exercise pertains only to the bottle filled with 0.4% HNO₃, not the acid-charged series. Table 3 indicates those elements where this value exceeds the MDL, and therefore where positive significant errors could be expected. Elements are not included where their mean, 'raw' values in Table 1 are below the analytical detection limit.

It is clear from this table that:

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Technical Note *Continued from Page 6*

Table 2

Element concentrations found in stream water surveys used to estimate method detection limits (MDL) required for hydrogeochemical exploration; values in ppt except where designated as * to indicate ppb

	Al*	Cr*	Fe*	Mn*	Co	Ni*	Cu*	Zn*	As*	Mo	Ag	Cd	Sb	Tl	Pb
Nova Scotia survey of 729 streams															
Minimum	<2	<0.1	<3.5	1.4	<50	<0.2	<0.1	<0.5	<0.1	<50	<50	<50	<10	<5	<100
Mean \pm SD	142 \pm 114	0.2 \pm 0.2	277 \pm 259	87 \pm 177	234 \pm 441	0.34 \pm 0.88	0.77 \pm 2.8	2.6 \pm 2.4	0.5 \pm 2.8	89 \pm 326	all <50	51 \pm 62	46 \pm 541	3 \pm 1.8	284 \pm 495
Newfoundland survey of 139 streams															
Minimum	<10	<0.1	23	<1	16	0.4	<0.1	0.4	<0.2	<50	<50	<10	6	<5	<20
Mean \pm SD	207 \pm 185	0.2 \pm 0.2	274 \pm 284	33 \pm 83	306 \pm 544	1.2 \pm 1.1	2.7 \pm 5.9	2.7 \pm 3.7	0.21 \pm 0.44	93 \pm 171	all <50	39 \pm 162	24 \pm 25	3 \pm 0.6	112 \pm 476
MDL - geo	0.5	0.05	1	0.1	10	0.05	0.05	0.1	0.05	10	1	5	1	<1	10
MDL - env	0.5	0.2	30	10	5000	2	0.1	2	5	200	10	10	2000	30	100
Criteria ¹	5	20	300		50000	25	2	30	50		100	200			1000
Criteria ²	5	2	300	50	900	25	2	14	5	10000	50	10	6000	300	3000

SD: standard deviation

MDL-geo: method detection limit required in hydrogeochemical surveys

MDL-env: method detection limit typically required by environmental regulations

Criteria¹: Lowest remediation criteria level (for irrigation, freshwater aquatic life, drinking water) required by CCME (1991)

Criteria²: Lowest remediation criteria level required by B.C (Larry Pommen, Victoria, pers. comm., 1998)

Table 3

Elements are shown where the value in the filled test bottle (0.4% HNO₃) for the 'mean plus two standard deviations' (taken from Table 1) is greater than the required method detection limit in hydrogeochemical and environmental surveys. Underlined indicates elements of particular concern (i.e. high contamination levels expected).

Cleaning - application*	FEP	HDPE	HDPE ^P	PETG	PP
None - geo	Cr, Fe, Co, Ni, Cu, Zn, Mo, Pb		Zn	Co, Cu, Zn, Sb	Al, Cu, Ag, Sb
None - env	Cu				Al
EPA - geo	Cr, Co, Ni, Cu, Zn,				
EPA - env					
HNO ₃ - geo	Co				
HNO ₃ - env					

*geo- geochemical, env - environmental

- The FEP bottles are by far the dirtiest and cleaning, for either application, is mandatory. Both methods of cleaning adequately reduce contamination by Cr, Fe, Co, Ni, Cu, Zn, Mo and Pb for environmental projects but concern remains for some of these elements (e.g. Cr and Ni) if geochemical mapping is the focus.
- Only the HDPE bottle performs well using this criterion of mean plus two standard deviations. The only element possibly of concern in uncleaned HDPE bottles is Ag, but this is due to one bottle which measured 3 ppt (analytical 3 detection limit is 2 ppt), the others registering less than 2 ppt. Cleaning does not demonstrate a real improvement and hence is probably unnecessary for HDPE bottles. In fact, Al levels are raised slightly in these bottles after cleaning by the EPA method.
- The 'precleaned' HDPE^P bottles are definitely not worth the added cost (at least double) as they are, indeed, *inferior* to their uncleaned counterparts and show a startling increase in Zn contamination, to 739 \pm 195 ppt (cf. 7 \pm 4 ppt). Higher levels of Al, Cr, Ni and Pb are also evident.
- The unwashed PETG bottles show significant levels of Co, Cu, Zn and Sb but the bottles cleaned using 5% HNO₃ (note PETG does not withstand concentrated HNO₃ and heat) show acceptably low levels of all elements.
- The only element of concern for environmental studies in the unwashed PP bottles is Al, at a contamination level of 594 \pm 40 ppt. Cleaning by either method reduces this consistent level of contamination to insignificance. For hydrogeochemical purposes, contamination by Cu, Ag and Sb

in the unwashed bottles is almost acceptable and is easily removed by cleaning.

ACKNOWLEDGEMENTS

This work carried out by the Analytical Method Development Laboratory of the GSC was partially funded by the Aquatic Effects Technology Evaluation (AETE) Program.

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AEG MEETINGS

COUNCIL ELECTION

Once again it's time to elect a new slate of Councilors for the 1999-2001 term. Fellows of the Association are asked to vote for five Councilors for this term and this year we have seven highly qualified candidates to choose from. Ballots must be returned to the Secretary before January 1, 1999 in order to be counted in the election. In past years we have received about 50% response to the Council election and this year we would like to encourage all Fellows to vote and help get the response over that 50% mark. Your Council and Executive are in the process of making some significant decisions that will have lasting effects on the Association so it is important to vote for Councilors that will reflect your ideas. Please return your completed ballot as soon as possible.

ANNUAL GENERAL MEETING

The Association of Exploration Geochemists normally holds its Annual general meeting during the year at some symposia or jointly sponsored meeting where a number of AEG members are present. This year (1998) there has been no appropriate meeting for our AGM and we are planning to try

something different. We will hold our AGM on **December 16, 1998** via telephone conference call at 3:00 PM mountain standard time (US). For those members who wish to join the conference call and attend the AGM, please contact the Secretary or the Business Office (email, FAX, phone, or "snail" mail) and let us know that you wish to be included on the conference call and the phone number where you can be reached. You will be called at the appropriate time on the day of the meeting and will be included in the conference call. All members are encouraged to attend the 1998 AGM of The Association of Exploration Geochemists.

The 1999 AGM will be held in conjunction with the 19th IGES in Vancouver, BC in April. Those members planning to attend the symposium should put the 1999 AGM on their agenda.



NEWS OF MEMBERS

Don Runnels, former President of Association of Exploration Geochemists, has been appointed by President Bill Clinton to the U. S. Nuclear Waste Technical Review Board. Runnels, professor emeritus of geology at the University of Colorado and currently Vice-President of Shepherd Miller, Inc. of Fort Collins, Colorado, brings his geologic, geochemical, and hydrochemical expertise to the eleven-member board charged with evaluating the scientific and technical validity of activities undertaken by the U.S. Secretary of Energy to manage and dispose of the nation's commercial spent nuclear fuel and high-level nuclear waste. Don continues his activities as an environmental and engineering consultant.



AEG STUDENT PAPER PRIZE

The AEG sponsors a Student Prize for the best published paper in the field of, or closely related to, exploration geochemistry. Its aim is to encourage students to publish their research results in a timely manner. In the past we have received entries from all over the world and a very high standard has been achieved. For further information, please see our web site at: <http://leme.anu.edu.au/education/aegstudent.html>.

Entries should be submitted to Dr. Ian D. M. Robertson, CRC, LEME, CSIRO Exploration and Mining, Private Bag P. O. WEMBLEY, WA 6014, AUSTRALIA. The deadline for receipt of the nominations is December 31st, 1998. Information can be obtained from Robertson at: FAX 61-8-9387-8642, or email: i.robertson@per.dem.csiro.au i.robertson@per.dem.csiro.au.

Additional information is provided in the advertisement on page 9.



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1998 AEG Student Paper Competition

The Association of Exploration Geochemists will hold its twelfth biennial Student Paper Competition this year. Papers eligible¹ for the competition must address an aspect of exploration geochemistry and represent research performed as a student. The student must be the principal author, and the paper must have been published in any refereed scientific journal no more than five years after completion of the degree for which the research was performed. A nomination may be made by anyone familiar with the work of the student. Nominations must be accompanied by four copies of the paper.

The deadline for receipt of nominations is December 31, 1998.

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The prize consists of a \$500 Canadian cash prize, donated by **XRAL Laboratories**, a Division of SGS Canada, a two-year membership to the Association of Exploration Geochemists with receipt of the **Journal of Geochemical Exploration** and **EXPLORE**, and up to US \$500 for expenses to attend an AEG sponsored meeting. A photograph and curriculum vitae of the author and an abstract of the prize-winning paper will be published in **EXPLORE** as soon as possible after the announcement of the award.

Mail to: Dr. Ian D. M. Robertson
Chairman, Student Paper Competition
Cooperative Research Centre for Landscape Evolution and Mineral Exploration
c/o CSIRO Exploration and Mining
Private Bag P.O. WEMBLEY
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AUSTRALIA
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FAX: +61 8 9387-8642
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1. Full details are available from the Chairman of the competition (address above) or from the AEG Home Page (<http://www.aeg.org/>) or, more specifically at <http://leme.anu.edu.au/education/aegstudent.html>

NEW ELECTROCHEMICAL STUDIES BY ONTARIO GEOLOGICAL SURVEY

In July 1998, the Ontario Geological Survey (OGS) carried out an overburden drilling program at the "Shoot Zone", an undeveloped gold deposit just east of Timmins, Ontario, Canada owned by St. Andrew Goldfields Ltd. The deposit is covered by approximately 30 m of glacial sediments and peat.

A geotechnical drill was used to core 3 inch diameter holes into bedrock at 3 locations to compliment existing plastic-cased boreholes on the property. Platinum electrodes were then installed in each hole at various depths in glacial sediments and bedrock. The electrodes were used to measure spontaneous potentials (ground voltages) in overburden in three dimensions over mineralisation and adjacent bedrock. The data were gathered to test for the presence of a chemically reduced "column" in overburden, which, according to a recent theory should be present over the gold mineralisation.

The theory proposed this year by the OGS attributes selective leach soil geochemical anomalies at the Shoot Zone and other sites in the Abitibi region to electrochemical processes. The results so far are very encouraging (see OGS Summary of Fieldwork, 1998, in press) and may have widespread implications for mineral exploration in glaciated terrain.



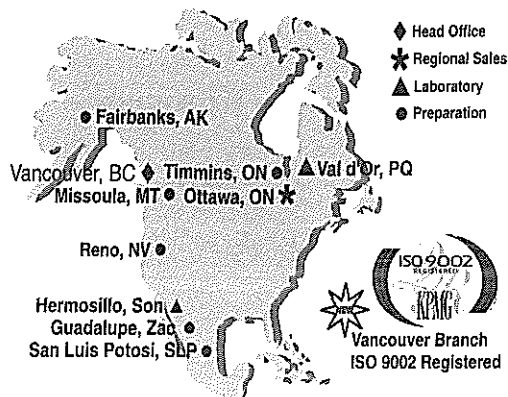
OGS Shoot Zone Project leader Stew Hamilton (fourth from left) was visited by, from left to right, Bob Middleton, Brian Main, AEG President Peter Simpson, retired JGE editor Eion Cameron and the new JGE editor Gwendy Hall. Photo by Beth McClenaghan.



Cam Baker (OGS) installing platinum electrodes into test well #1. Photo by Beth McClenaghan.

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Geological Survey of Canada
Ottawa, Ontario K1A 0E8
Tele: (613) 992-7805
email: mailto:bmcclena@nrcan.gc.ca
bmcclena@nrcan.gc.ca

Stew Hamilton
Ontario Geological Survey
933 Ramsey Lake Road P3E 6B5
Tele: (705) 670-5915
email: hamilts@gov.on.ca



GEOCHEMICAL MEETINGS IN NAPLES

On October 1-3, Naples, Italy was the host city for a joint meeting of the IUGS/IAGC Working Group on Global Geochemical Baselines and the Forum of European Geological Surveys' (FOREGS) Geochemical Baseline Program. Representatives from twenty countries (Albania, Austria, Belgium, Canada, Czech Republic, Finland, France, Germany, Greece, India, Italy, Japan, Lithuania, The Netherlands, Norway, Slovakia, Slovenia, Ukraine, United Kingdom, and the United States) participated in two days of business meetings and presentations of ongoing baseline studies. The third day was devoted to a field trip to observe and discuss geochemical sampling methodologies used for the mountainous terrain of southern Italy.

The primary focus of the meetings was the FOREGS Geochemical Baseline Program (FGBP), which is Europe's contribution to the IUGS/IAGC Working Group. FGBP was established in 1996 to provide high quality environmental geochemical baseline data for Europe. Under the leadership of Dr. Reijo Salminen of the Geological Survey of Finland, FGBP has made remarkable progress toward its goal of a published geochemical atlas of Europe by 2001. The goals of this program are to 1) Collect, analyze, and archive multiple sample media (stream sediment, floodplain sediment, soil, water, and humus) from approximately 700 sub-sites based on the 160 km x 160 km grid cells of the Global Geochemical Reference Network as defined in the final report of IGCP Project 259 (Darnley and

others, 1995); 2) Using data from the reference network samples, standardize national geochemical mapping data sets across national boundaries, and 3) Publish a geochemical atlas of Europe in 2001.

In 1998 and 1999, the following countries will be conducting sampling in support of FGBP: Albania, Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, The Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland, and the U.K. The complete sampling protocol has been published by the Geological Survey of Finland and is also available at their web site: www.gsf.fi. Analytical work is scheduled to be completed in 2000 and a geochemical atlas published in 2001.

A symposium will be sponsored by FGBP in September 1999 in Vilnius, Lithuania entitled The 2nd Conference on Environmental Geochemical Baseline Mapping in Europe.

David B. Smith

U.S. Geological Survey

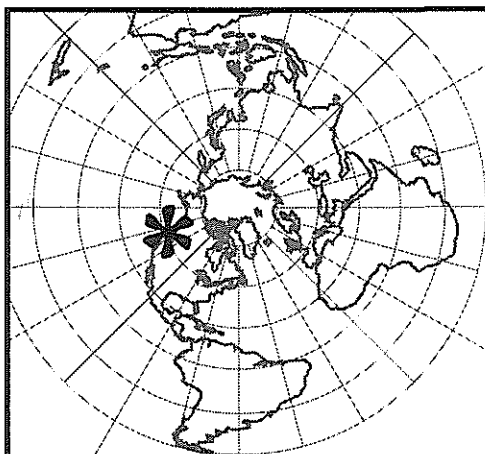
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AEG DISTINGUISHED LECTURE #1

Selective leaching — a tool in identifying an element's provenance

Gwendy E.M. Hall, Geological Survey of Canada, Ottawa

Selective extraction schemes, where operationally-defined phases are dissolved using a sequence of suitable chemical reagents, are employed in the analysis of soils and sediments to provide information as to the binding sites of elements (metals and non-metals). The objective of selective leaching in the exploration context is to map specifically that fraction of an element which was previously in a labile (free) form and has been "trapped" or immobilised in the surficial environment. Controversy abounds as to the dominant mechanisms of transport of the element from oxidising mineralisation at depth, whether it be by gaseous or fluid movement through faults and fractures, under the influence of electrogeochemical cells and so on (J. Geochem. Explor., 1998, volume 61, special issue). However, there is agreement that the principal resident sites in the secondary environment for these migrating elements comprise hydrous Fe and Mn oxides, humic and fulvic components of humus material, and clay minerals. Thus, leaches have been developed to extract these "phases" (used in a broad sense) in their entirety or to dissolve elements loosely sorbed to them. These phases are generally not discrete, but rather exist linked

together as colloids. Furthermore, binding mechanisms are not simple, comprising physical and chemical adsorption at surfaces, occlusion within structures, chelation, complexation and coprecipitation. These factors confound the design of a selective extraction which is often based on changing the pH and/or Eh environment of the sample to promote specific dissolution. Thus, true specificity is almost impossible to achieve and the term "operationally defined" is used to describe more loosely the phase or form measured.

Though the advantages of selective leaches were certainly recognised in the '70s, inadequate detection limits using techniques such as AAS and ICP-AES and relatively high analytical cost limited widespread adoption until recently. Transfer of the analytical technique ICP-MS, generally more sensitive than ICP-AES by several orders of magnitude, from research-oriented laboratories to commercial labs in the 1990s has opened the door to high production, affordable selective analysis. It has also produced data for elements otherwise not usually determined, such as the halogens. Growth in the use of such leaches, alone or in sequential extraction schemes, is also evident in the sister discipline of environmental geochemistry. It is interesting that the tendency exists in environmental studies to attribute an anthropogenic source, particularly air-borne, to labile elements leached out early in these schemes, whereas the philosophy underpinning these selective extractions in exploration assumes a geogenic source from buried mineralisation.

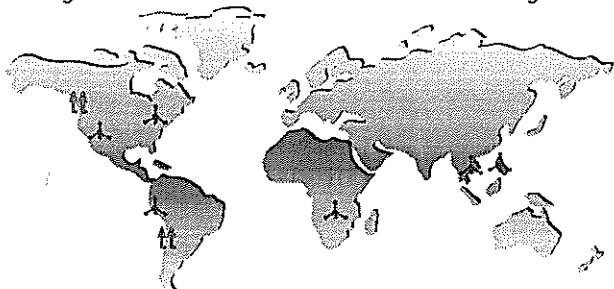
Using mostly the work carried out at the GSC on leaches designed to measure labile elements, this presentation will focus on the:

- collection and preparation of the sample (e.g. medium's homogeneity; size fraction; drying);
- design of a selective leach (selectivity; cost-effectiveness);
- pH control of the leach (e.g. influence of high carbonate samples);
- readsorption during the leach (e.g. particularly important for Au, Pt, oxyanions in acidic conditions, Pb in non-acidic solutions);
- stability of analyte in the leach awaiting analysis;
- analytical considerations such as calibration strategies;
- typical figures of merit to be expected in such datasets; and
- comparison of data between laboratories, for single and multiple extractions.

Finally, several applications of selective leaching, taken from both exploration and environmental projects, will be discussed.



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AEG DISTINGUISHED LECTURE #2

Cost-effective protocols for the collection, filtration and preservation of water samples collected in hydrogeochemical surveys

Gwendy E.M. Hall, Geological Survey of Canada, Ottawa

The usefulness of water, both surface and ground, as a sample medium in mineral exploration is currently being demonstrated by the release of hydrogeochemical survey data in digital map form by, amongst others, Geological Surveys such as those of Finland, Britain, Canada, the US and Germany. In addition to guiding exploration activities, these data are now

Continued on Page 13

Distinguished Lecturer *Continued from Page 12*

finding application by those in Government Environmental Departments, not only to highlight geographical areas of concern but to set criteria levels (safety limits) for element concentrations with respect to aquatic life, irrigation, livestock watering and drinking water. The number of samples collected in a geochemical survey, typically well into the thousands, and the different bedrock and surficial geology covered combine to provide a broad database from which to make sound estimates of natural concentration ranges. One drawback to the acceptance of these data by Environmental Agencies is that the methods of collection employed do not adhere to the strict guidelines recommended by the US Environmental Protection Agency. For example, collection vessels are not made of Teflon and are not usually subjected to the rigorous cleaning recommended by the EPA; 'clean-room' clothing is not worn by field personnel. The cost of adhering to such protocols would be prohibitive and hence the number of samples collected would be much smaller, an outcome which is apparent when the databases held by Geological and Environmental Agencies are compared.

The objective of the work described in this talk was to recommend the most cost-effective and efficient procedures by which to sample (i.e. bottle type), filter (0.45 μ m) and preserve surface waters for the accurate determination of "dissolved" Al, Ag, As, Cd, Co, Cr, Cu, Hg, Fe, Mn, Mo, Ni, Pb, Sb, Se, Tl and Zn for both exploration and environmental objectives. The bottles studied comprise: Teflon (FEP, Nalge #1600); high density polyethylene (HDPE, Nalge #2007); polyethylene terephthalate copolyester (PETG, Nalge #2019); polypropylene (PP, Nalge #2006); and precleaned HDPE ('Superfund-Analyzed' to meet or exceed EPA specifications). Three cleaning methods were investigated: a modified EPA Method 1638; one promoted by the State of Virginia based on washing with HNO₃; and a third, that of simply rinsing each bottle with deionised water three times prior to filling. The majority of the 12-0.45 μ m and 2-5 μ m filters tested (of syringe, in-line and vacuum type) were from two leading manufacturers, Gelman and Millipore. These filters were investigated not only for their levels of contamination but also for their propensity to retain elements which are present as colloids which should pass through a 0.45 μ m pore size. Four samples of different matrix - Ottawa, Rideau and Gatineau Rivers and a spiked water sample - were used to test the preservation of the 16 analytes (i.e. all except Hg) in a medium of 0.4% HNO₃ for one month. Preservation of Hg was tested in three reagent media: 0.5% BrCl; 2% HCl; and 0.04% K₂Cr₂O₇.

By far the 'dirtiest' bottle studied is the most expensive, Teflon (ca \$Cdn28), which remained unacceptable in its Cr and Ni contamination after rigorous cleaning. The least expensive bottle (ca \$Cdn 0.90), made of HDPE, shows the best characteristics and is highly recommended. It could be used without rigorous cleaning (only rinsing with deionised water) if batches are checked, but a rinse with weak HNO₃ (5%) is probably advisable. HDPE bottles purchased 'precleaned' are an unnecessary expense (ca \$Cdn 2.30) as they are inferior to their uncleaned counterparts. The approach practised by some laboratories - to add a charge of concentrated (8M) HNO₃ reagent to the bottle hours or days before water collection - is not acceptable. This strategy causes much higher levels of contamination for all bottles than is the case when acidifying during or after sample collection. Cleaning does not remove 'available' elements as prolonged contact with HNO₃ leaches out significant quantities.

The evaluation of filter systems concluded that optimum performance, in terms of contamination and ease of use, was achieved with the ion chromatography Acrodisc syringe filter with Supor membrane from Gelman, and the Sterivex syringe filter capsule with Durapore membrane from Millipore. However, the Durapore membrane was superior to the Supor brand in its significantly lower retention of colloidal species which should pass a 0.45 μ m filter size. These findings and others will be discussed in this presentation.



NEW MEMBERS

To All Voting Members:

Pursuant to Article Two of the Association's By-Law No.1, names of the following candidates, who have been recommended for membership by the Admissions Committee, are submitted for your consideration. If you have any comments, favorable or unfavorable, on any candidate, you should send them in writing to the Secretary within 60 days of this notice. If no objections are received by that date, these candidates will be declared elected to membership. Please address comments to Sherman P. Marsh, Secretary AEG, 8384 West Illif Avenue, Lakewood, Colorado 80227, USA.

Editors note: Council has decided that all new applicants will receive the journal and newsletter upon application for membership. The process of application to the Nepean office, recommendation by the Admissions Committee, review by the Council, and publication of applicant's names in the newsletter remains unchanged.

FELLOWS

Kwolek, Julian K.
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Nigel Weller & Co.
Brighton, U.K.

Wilson, Graham C.
Consulting Geologist & Research Scientist
Turnstone Geological Services
Toronto, ON, CANADA

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Ionex
Sydney, NSW, AUSTRALIA

Baldwin, Bruce
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Brown, Graham M.
Regional Exploration Manager
Minorco
Budapest, HUNGARY

New Members *Continued from Page 13*

Brukhanov, Natalya N.
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 Institute of Geochemistry
 Irkutsk, RUSSIA

Galeschuk, Carey
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 Tantalum Mining Corp
 Pinawa, MB, CANADA

Graves, Garth D.
Senior Geologist
 Noranda Mining & Exploration
 Santiago, CHILE

Jones, Richard
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Kumar, Suresh
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Issue	Publication date	Contributor's Deadline
102	January 1999	November 30, 1998
103	April 1999	February 28, 1999
104	July 1999	May 31, 1999
105	October 1999	August 31, 1999

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■ November 16-18, 1998, Fifth Annual African Mining Investment Symposium, Marrakech, Morocco. Field excursions before and after. Sponsored by MIGA (World Bank). INFORMATION: Ms. S. Persaud at MIGA, Washington D.C., TEL 1-202-473-1818, fax 1-202-522-2650, e-mail: spersaud@worldbank.org.

■ November 29-December 4, 1998, Northwest Mining Association 104th Annual Meeting and Exposition, Spokane, WA. INFORMATION: Hazel Hoeft, Northwest Mining Assoc., 10 N. Post St., St. 414, Spokane, WA 99201, TEL. 509-623-1241. E-mail: hhoeft@nwma.org.

■ December 2-4, 1998, The 1st Asia Pacific Symposium on Environmental Geochemistry, Hong Kong. INFORMATION: Dr. X. D. Li, Dept. of Civil and Structural Engineering, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. TEL 852-27666041, fax: 852-2334-6389, e-mail: cexdli@polyu.edu.hk.

■ January 24-27, 1999, Conference on Tailings and Mine Waste, Fort Collins, Colorado. INFORMATION: Linda Hinshaw, Dept. of Civil Engineering, Colorado State University, Fort Collins, CO 80523-1372, (970) 491-6081, fax 970-491-3584 or 7727, lhinsaw@engr.colostate.edu.

■ March 1-3, 1999, Annual meeting of Society for Mining, Metallurgy, and Exploration (SME), Denver, Colo. INFORMATION: Donald Taylor, BHP Minerals, 1597 Cole Blvd., St. 250, Golden, CO 80401, TEL 303-235-4414, Fax 303-235-4435. E-mail: taylor.don.dr@bhp.com.au.

■ March 15-16, 1999, South-central Section, GSA, Lubbock, TX. INFORMATION: James Barrick, Dept. of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, TEL. 806-742-3107. E-mail: ghjeb@ttu.edu.

■ March 22-24, 1999, Northeastern Section, GSA, Providence, Rhode Island. INFORMATION: Anne I. Veeger, Dept. of

Geology, University of Rhode Island, 8 Ranger Rd., St. 2, Kingston, RI 02881, TEL. 401-874-2187. E-mail: veeger@uriacc.uri.edu.

■ March 25-26, 1999, Southeastern Section GSA, Athens, Georgia. INFORMATION: Mike Roden, Dept. of Geology, University of Georgia, Athens, GA 30602, TEL. 706-542-2416. E-mail: mroden@gly.uga.edu.

■ April 8-10, 1999, GSA Rocky Mountain Section Meeting, Quality Inn Pocatello Park Hotel, Pocatello, Idaho. INFORMATION: Paul Link, Dept. of Geology, Idaho State University, 785 South 8th Ave., Pocatello, ID 83209-8072, 208 236-3846. E-mail: linkpaul@isu.edu.

■ April 11-16, 1999, 19th International Geochemical Exploration Symposium, Vancouver, Canada. INFORMATION: Venue West Conference Services Ltd., #645-375 Water Street, Vancouver, BC, Canada V6B5C6, TEL. 604-681-5226, FAX 604-681-2503, email: congress@venuewest.com.

■ April 22-23, 1999, GSA North-Central Section Meeting, Chancellor Hotel and Conference Center, Champaign-Urbana, Illinois. INFORMATION: C. Pius Weibel, Illinois State Geological Survey, 615 Peabody Dr., Champaign, IL 61820, (217) 333-5108, E-mail: wiebel@isgs.uiuc.edu.

■ May 26-28, 1999, Geological Association of Canada-Mineralogical Association of Canada Joint Annual Meeting, Sudbury, Ontario, Canada. INFORMATION: Dr. P. Copper, Dept. of Earth Sciences, Laurentian University, Sudbury, Ontario P3E 2C6, TEL. 705-675-1151 (ext. 2267), FAX: 705-675-4898, e-mail: gacmac99@nickel.laurentian.ca.

■ June 2-4, 1999, GSA Cordilleran Section Meeting, University of California, Berkeley, California. INFORMATION: George Brimhall, Dept. of Geology & Geophysics, University of California, Berkeley, CA 94720-4767, (510) 642-5868, e-mail: brimhall@socrates.

■ June 26-July 1, 1999, Clay Minerals Society 36th Annual Meeting, Purdue University, West Lafayette, Indiana. INFORMATION: Patricia Jo Eberl, Clay Minerals Society, P.O. Box 4416, Boulder, CO 80306, (303) 444-6405, fax 303-444-2260, e-mail: peberl@clays.org.

■ July 7-10, 1999, Geocongress '98, University of Pretoria, South Africa. INFORMATION: P.O. Box 798, Pretoria, 0001 South Africa, fax: 012-841-1221, e-mail: eaucamp@geoscience.org.za.

■ August 22-25, 1999, Society for Geology Applied to Mineral Deposits 5th Biennial Conference, London, UK. INFORMATION: Dr. Chris J. Stanley, Associate Keeper of Mineralogy, Department of Mineralogy, Natural History Museum, Cromwell Rd., London, SW7 5BD, UK, Tel 44-171-938-9361. E-mail: cjs@nhm.ac.uk.

■ October, 25-28, 1999, Annual Meeting of the Geological Society of America, Denver, Colo. INFORMATION: TEL 1-800-472-1988, e-mail: meetings@geosociety.org.



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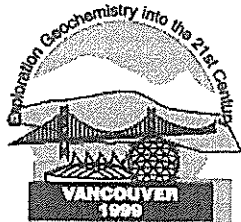
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Anyone interested in submitting a paper for the 19th IGES should complete the Reply Form for more information.

Deadline for Abstracts was October 1, 1998

SHORT COURSES

Short Courses will take place April 10 - 11th before the symposium.

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Field trips will take place after the meeting, starting April 17th. The field trips are intended to complement short course and technical session themes by providing applied demonstration of methods and interpretation.

Reply Form

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Calendar of Events *Continued from Page 16*

■ November 3-5, 1999, International Symposium on Geochemical and Mineralogical Tracers in Mining Exploration, Santiago, Chile. The meeting will focus on the supergene environment. INFORMATION: Brian Townley, E-mail: btownley@tamarugo.cec.uchile.cl.

■ April 24-28, 2000, 5th International Symposium on Environmental Geochemistry, Cape Town, South Africa. INFORMATION: SISEG, Department of Geological Sciences, University of Cape Town, Private Bag, Rondebosch, 7701, South Africa, FAX 27-21-650-3783. E-mail: Sisege@geology.uct.ac.za.

■ May 12-14, 2000, Europe's Major Base Metal Deposits, Galway, Ireland: INFORMATION: Leo Fusciardi, Irish Assoc. for Economic Geology, c/o Minorco Services Ltd., Killoran, Moyne, Thurles, Co., Tipperary, Ireland: FAX: 353-504-45344; E-mail: lfusciardi@minorco.ie

■ May 15-18, 2000, Geology and ore deposits 2000: The Great Basin and Beyond, Reno/Sparks, Nevada, USA. INFORMATION: Geological Society of Nevada. 702-323-3500, ax 702-323-3599, e-mail: gsnsymp@nbgm.unr.edu.

■ August 6-17, 2000, 31st International Geological Congress, Rio de Janeiro, Brazil. INFORMATION: Secretariat Bureau, Casa Brazil 2000, Av. Pasteur, 404 Urca, Rio de Janeiro-RJ, Brazil, CEP 22.290-240, phone 55 21 295 5847, fax: 55 21 295 8094. E-mail: 31ligc@31ligc.org; http: www.31ligc.org.

Please check this calendar before scheduling a meeting to avoid overlap problems. Let this column know of your events.

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This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 100. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GSC Paper) and Open File Report (GSC OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull.); Transactions of Institute of Mining and Metallurgy, Section B: Applies Earth Sciences (Trans. IMM). Publications less frequently cited are identified in full. Compiled by L. Graham Closs, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.

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Melbourne **Friday 4th December, 1998.** 5 for 5:30-7.30 pm; Fritz Loewe Lecture Theatre, School of Earth Sciences, The University of Melbourne, Level 2 (off main entrance foyer) Mc Coy Building, Corner Swanston and Elgin Streets, Carlton/Parkville (Inquiries D. Lawie 0418 122 611)

Sydney **Monday 7th December, 1998.** 4.00 for 4:30-6:30 pm; CSIRO Ground Floor Conference Room, Building 12, 51 Delhi Road, North Ryde. (Inquiries D. Garnett 029 5432644)



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601 Booth Street, Room 702
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