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EXPLORE

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of Exploration
Geochemists

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PRESIDENT'S MESSAGE

Paul Taufen

Applying Geochemistry in a Rapidly Changing Minerals Exploration World

My wife's brother lives in a small farming community close to the demographic and geographic center of the United States. Here one might think the life style and economy would be independent and isolated from what goes on in the rest of the world. Not so. The town where he lives has a tractor factory. Due to anticipated demand for tractors in Russia, the small town is in the process of doubling the size of the tractor factory, building houses, and expanding schools to accommodate more workers. A development on the other side of the world has caused a significant change in the local economy and life style of a town in a completely different country!

Like me, you may be struck by the rapid pace of worldwide political and economic change, and like my brother in law, can see the impact close to home in local neighborhoods and work environments. Change in the minerals exploration industry has been characterized by generally decreased funding resources, while the obligations and requirements associated with exploration programs have increased. With less money available, minerals exploration groups need to do more in terms of environmental management, community interaction, and property permitting to maintain our ability to discover and develop natural resources. Also, the capital investments required to develop worthwhile mineral deposits are larger than ever, and this places a premium on ensuring that there is high integrity in the information used to make investment decisions.

What can we exploration geochemists do to contribute effectively to exploration groups as resources shrink and more needs to be done in these times of change?

Two things come immediately to mind:

1) Apply Environmental Geochemistry- In advanced exploration projects, we can generate preliminary understanding of the environmental geochemistry of exploration properties by assessing baseline levels of potentially toxic elements, placing these in the context of "natural pollution" caused by ore deposits. This often is a logical and simple extension of the exploration geochemistry surveys already completed. We also can gain an early understanding of potential acid rock drainage issues on exploration properties by testing water quality early in the exploration process, and assessing relative proportions of acid producing and acid neutralizing rocks in the local geologic environment.

Continued on Page 2

TECHNICAL NOTE

The Baltic Soil Survey

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Introduction

Up to now a major shortcoming of regional geochemical projects is that surveys have typically not crossed political boundaries and consequently results are often not comparable over country borders or, in some cases, within a single country. The Baltic Soil Survey (BSS) project establishes, for the first time in Europe, a directly comparable database of major and trace element concentrations in soils. The database results from the multi-element analysis of agricultural soil samples from 774 sites within ten Northern European countries surrounding the Baltic Sea (Belarus, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russia, and Sweden). The sampling density is approximately 1 site per 2500 km^2 over an area of 1,800,000 km^2 (Fig. 1 - *see page 3*). The minus-2 mm size sieved fraction (minus-1 mm for Poland) was used for chemical analysis. The analytical

Continued on Page 3

CONTENTS

Information for Contributors to EXPLORE

Scope. This newsletter is the prime means of informal communication among members of the Association of Exploration Geochemists, but has limited distribution to non-members. EXPLORE is the chief source of information on current and future activities sponsored by the Association, and also disseminates technical information of interest to exploration and environmental geochemists and analytical chemists. News notes of members are appropriate. We welcome short- to moderate-length technical articles on geochemical tools for exploration, concepts for finding ore, mineral-related environmental geochemistry, new analytical methods, recent deposit discoveries, or case histories. The goal of this newsletter is communication among exploration geochemists, and to that end we encourage papers on new methods and unconventional ideas that are reasonably documented.

Format. Manuscripts and short communications should be submitted in electronic form to minimize errors and speed production. Files can be transmitted on IBM-compatible 3.5 inch diskettes or attached to email. Most popular text and graphics files can be accommodated. Figures and photos can be transmitted in hard copy (which we will scan) or as high quality digital files. Some issues are published with color pages for special maps and figures which should be planned by early communication with the editors.

Length: Technical communications can be up to approximately 1000 words, but special arrangements may be made for longer papers of special interest. High quality figures, photos, and maps are welcome if they present information effectively.

Quality: Submittals are reviewed and edited for content and style through peer reviews. The intent is to improve clarity, not suppress unconventional ideas. If time permits, the author will be shown changes to material, by FAX or email. Time constraints do not allow author review of galley proof from the printer.

All contributions should be submitted to Lloyd James by email (l-njames@central.com) or regular mail to 7059 East Briarwood Drive, Englewood, CO 80112, USA. Only in rare situations should FAX be sent (303-741-5199).

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President's Message

Continued from Page 1

2) Ensure Information Integrity- Exploration geochemists can use our relatively advanced knowledge of sampling theory and laboratory analysis to ensure representative, accurate, and precise data are provided prior to large investment decisions on exploration properties.

Attention in each of these areas provides appreciated contributions by exploration geochemists to exploration teams, environmental assessment teams, and investment groups. This can actually expand the positive impact of exploration geochemistry, even in a time of shrinking financial resources.

The times are changing, and no one is beyond the reach of change. What we can do as geochemists is look for the expanded opportunities to contribute that appear with the changes, and identify where we can effectively help out!

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Technical Note

Continued from Page 1

program covers more than 50 chemical elements and a variety of different methods, giving total and partial element concentrations. The randomised samples from all countries were always analysed together in one laboratory only for each set of parameters to guarantee comparable results.

Exploration geochemists should be interested in large-scale regional environmental studies for several reasons. First, they create baseline knowledge about the variation in background concentrations for a multitude of elements over a large area. Second, low-density geochemical surveys provide data on the distribution of geochemical provinces and can be used to outline prospective ground for more detailed follow-up. Finally, mining companies should be interested in having the natural variation of element concentrations documented for a large range of chemical elements before moving into a new area. Detailed information about the natural variability in geochemical backgrounds is pertinent to a multitude of administrative and legal issues. For example, the disposal of sewage sludge from waste-water treatment plants is an increasing problem in Europe and elsewhere. The sludge can be applied as soil conditioner and fertiliser to agricultural soils if the concentrations of potentially harmful elements in the soil and in the sludge are lower than acceptable regulatory limits. There is a general need for reliable baseline geochemical data to establish such values. Sustainable long-term management of environmental and mineral resources is dependent upon a comprehensive and reliable database (Darnley et al., 1995).

Materials and methods

After much discussion, it was decided to collect agricultural soils over the whole survey area. The sampling density was one site per 2500 km^2. Two samples were collected at each site: topsoil (ploughing layer, A -horizon) at a depth of 0-25 cm, and subsoil (usually B-, BC- or C-horizon) at a depth of 50-75 cm. The samples were 8-10 litres in volume each, composited from five to thirteen subsamples over an area measuring 100 x 100 m.

Field equipment and sampling instructions were sent to all participants from the Geological Survey of Norway (NGU). Thus in most countries samples were collected using the same equipment and technique. All samples were air dried and sieved to minus-2 mm using nylon screening at NGU. Samples from Poland and Sweden were splits of samples taken for different projects carried out earlier. These samples were received dried and sieved (the Polish samples were previously sieved at minus-1 mm). After randomisation and the insertion of a standard and analytical duplicates, NGU delivered a split of all samples to the Federal Institute for Geosciences and Natural Resources in Hannover, Germany (BGR). These splits were milled in a disk mill (agate vessel). Subsequently they were analysed as fused discs by WD-XRF for 41 elements (Al, As, Ba, Bi, Ca, Ce, Cl, Co, Cr, Cs, Cu, F, Fe, Ga, Hf, K, La, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, S, Sb, Sc, Si, Sn, Sr, Ta, Th, Ti, U, V, W, Y, Zn and Zr) at BGR. A second split of the samples was analysed at NGU following an ammonium acetate extraction (buffered at pH 4.5) by ICP-AES (30 elements). Presently all samples are being analysed at the Geological Survey of Finland (GTK) by ICP-AES (33 elements) following an aqua regia extraction. GTK will also analyse the milled samples after a

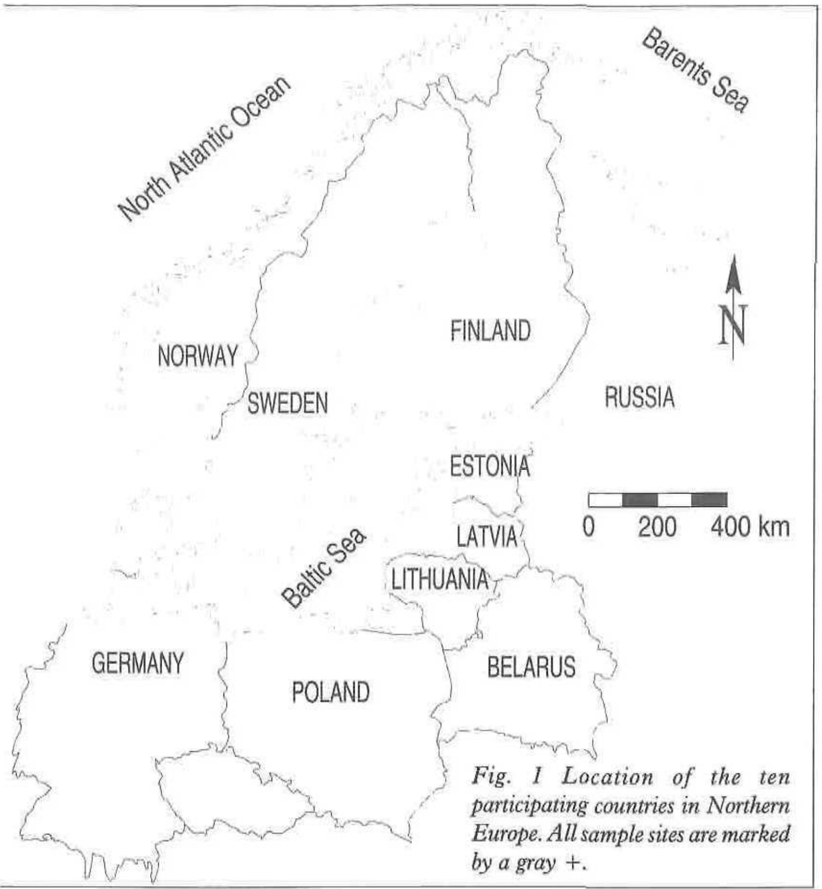

Fig. 1 Location of the ten participating countries in Northern Europe. All sample sites are marked by a gray +.

The Baltic Soil Survey...

Continued from Page 3

total (multi-acid) extraction by ICP-MS (ca. 40 elements). Loss-on-Ignition (LOI) at different temperatures (450°C and 1100°C) and pH and electrical conductivity in water extractions were determined as additional parameters. Examples of selected results from XRF analyses are presented below.

Results

Analytical results for the major and selected trace elements for the whole data set are given in Table 1. Compared with values published for world soils (data from Reimann and Caritat, 1998), the Baltic soils show lower values for Al_2O_3 CaO, Cr, Fe_2O_3 MgO, Sc, Sr, Ti, V, Zn and higher values for SiO_2. Already this result demonstrates that soil background levels have to be established for any one area under

Continued on Page 5

TABLE 1

			TOPSOIL (0-25 cm)		SUBSOIL (50-75 cm)		world soil*		
Element	Unit	DL	MIN	MAX	**MED**	**MED**	MIN	MAX	MEA
Al2O3	wt.-%	0.05	0.3	18.4	**8.94**	**10.4**	0.06	19.6	15.1
Ba	mg/kg	2	26	2007	**404**	**419**	6	2920	500
CaO	wt.-%	0.01	0.1	20	**1.39**	**1.45**	0.08	31	1.96
Cr	mg/kg	3	<3	614	**32**	**36**	<3	269	80
Fe2O3	wt.-%	0.01	0.26	12.82	**2.44**	**2.81**	0.05	15.9	5
K2O	wt.-%	0.01	0.02	4.19	**1.88**	**2.05**	<0.01	4.05	1.69
MgO	wt.-%	0.01	<0.01	4.9	**0.58**	**0.78**	<0.01	8.1	1.49
Mn	wt.-%	0.001	0.002	0.277	**0.055**	**0.052**	<0.001	0.518	0.06
Na2O	wt.-%	0.01	0.05	4.3	**1.21**	**1.43**	0.01	5.01	1.35
P2O5	wt.-%	0.001	0.019	0.953	**0.188**	**0.111**	0.015	0.682	0.17
Pb	mg/kg	4	<4	85	**15**	**12**	<4	109	17
Rb	mg/kg	2	<2	194	**65**	**67**	<2	189	65
Sc	mg/kg	2	<2	36	**7**	**8**	<2	38	12
SiO2	wt.-%	0.1	1.37	94.7	**70.9**	**72.4**	<0.1	96.3	59.9
Sr	mg/kg	2	10	667	**110**	**107**	4	1048	240
Th	mg/kg	5	<5	22	**9**	**9**	<5	27	9.4
TiO2	wt.-%	0.001	0.007	1.664	**0.434**	**0.456**	0.001	1.890	0.66
V	mg/kg	5	<5	258	**37**	**43**	<5	259	90
Y	mg/kg	3	<3	47	**14**	**16**	<3	51	20
Zn	mg/kg	3	<3	264	**43**	**39**	<3	327	70
Zr	mg/kg	3	<3	665	**227**	**219**	<3	632	230
LOI	wt.-%	0.01	1.8	97.2	**7.1**	**3.6**	0.57	99.6	-

Table 1: Minimum, maximum and median concentrations of selected elements in two layers of agricultura soils from Northern Europe as analysed by WD-XRF on the <2 mm fraction. N=774/773 (topsoil, subsoil), DL: detection limit. World soil data as given in Reimann and Caritat, 1998.

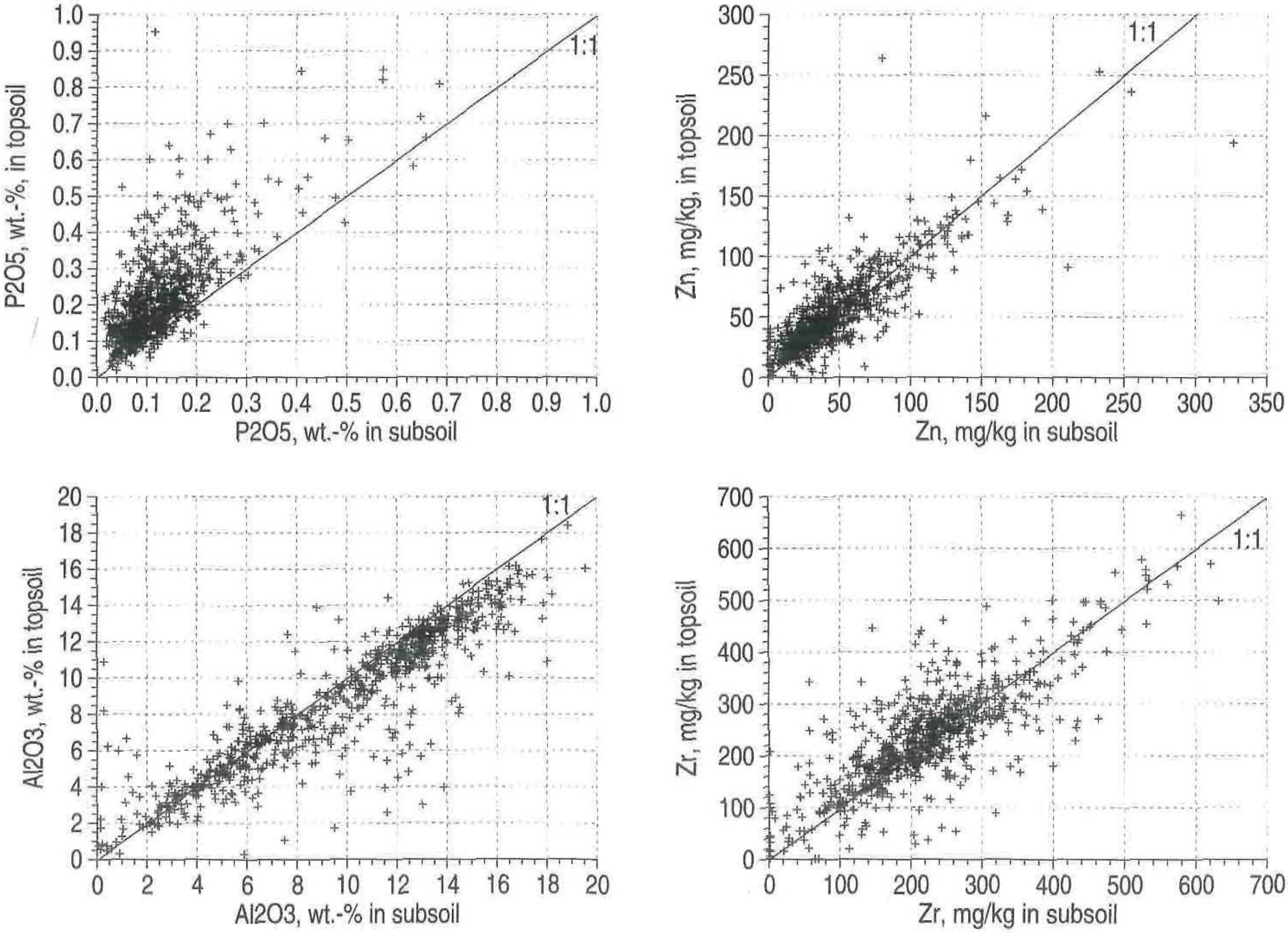

Fig. 2: Selected XY-diagrams showing the element concentrations in sub- and topsoil samples.

The Baltic Soil Survey...

Continued from Page 4

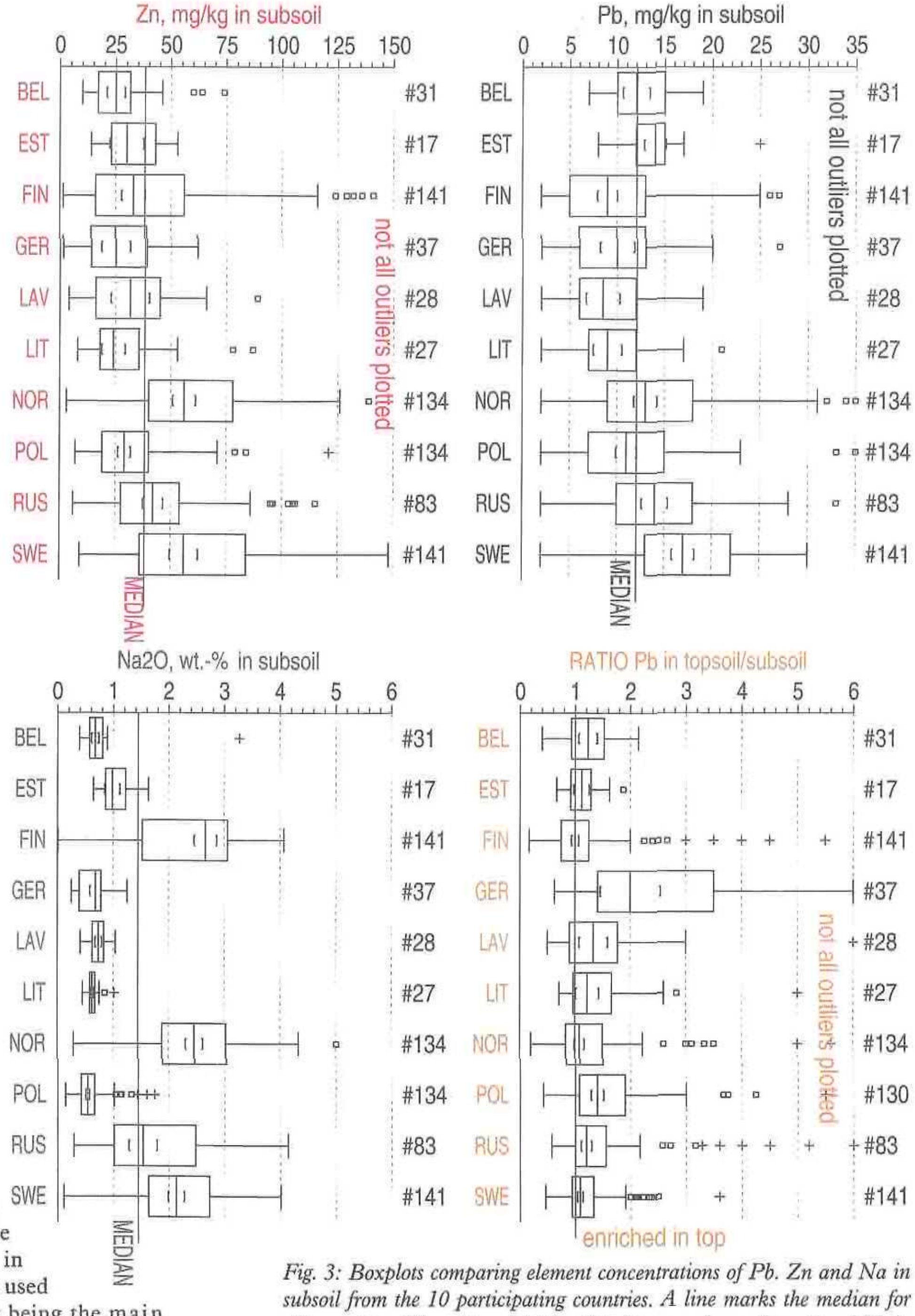

Fig. 3: Boxplots comparing element concentrations of Pb. Zn and Na in subsoil from the 10 participating countries. A line marks the median for all countries. The upper right boxplot diagram shows the ratio of Pb in top-/subsoil. Here the line marks the ratio 1:1.

investigation. Using world soil or "Clarke values" for comparison or decisions on anthropogenic vs. geogenic element sources may have little meaning.

When top and sub-layer samples are compared most elements show a very good correlation, with slightly higher values in the subsoil samples (Table 1, Fig. 2). The most prominent exception is P_2O_5 which is enriched in the top-layer (Fig. 2). With today's land use practice more phosphorus is added to the surface soils via fertilizer and sewage than is exported via harvesting. The few other elements showing a slight enrichment in the top-layer are Mn, Pb, Zn and Zr. The samples deviating from the good correlation in the diagram for Al_2O_3 (Fig. 2) are all from Finland – here some very organic rich soils (LOI up to >90%) are used for agriculture. Zirconium (Zr) occurs principally in the heavy resistant mineral zircon ($ZrSiO_4$). The slight enrichment of Zr in topsoils (Fig. 2) can be explained by weathering of less resistant minerals in the topsoil and by wind erosion.

A comparison of analytical results between the ten countries shows large differences from country to country (Fig. 3) – the most dramatic example is probably shown in the boxplot for Na. The soils from the northernmost part of the survey area (Finland, Norway, Sweden, Russia) give much higher values than those from the other countries. One explanation may be differences in weathering rates and soil age from north to south, with the soils from the northern countries still containing more unweathered alkali-feldspars. Lead (Pb) returned the highest values in the subsoils from Sweden. This is caused by the relatively high proportion of granitic rocks here (see also maps for K and Pb – Fig. 4). If the ratio Pb topsoil/subsoil is compared (Fig. 3) the highest enrichment in the top-layer is found in Germany. This is indicative of leaded gasoline used in automobiles in Europe until very recently being the main source of pollution to the top-layer of agricultural soils and not long range atmospheric transport of industrial emissions. The higher concentrations of Zn in Norway and Sweden can be explained by the presence of some important ore fields (Bergslagen and Skjellefte districts, Juve 1997).

When mapping the analytical results, large-scale regional distribution patterns emerge. Calcium (Ca) gives the best reflection of regional geology (Fig. 4- *see page 6*). The Caledonian Mountain Chain along the Norwegian coast is marked by high values. The Fennoscandian Shield (most parts of Sweden and Finland) mostly returns medium Ca-values (the noise in Finland is related to the organic rich soils). The Northern European Platform is clearly shown by low values, the exception being some areas in the Baltic States, where the occurrence of limestone is reflected by the highest Ca-values in the map. Potassium mirrors the distribution of granites and granitoid rocks, a pattern that is also reflected in the Pb-map (Fig. 4). Important ore fields in Norway and Sweden (Bergslagen and Skjellefte districts, Juve 1997) can be seen in both the Pb and the Zn-map. The deposits at the southern border of Poland are also clearly reflected.

Conclusions

The Baltic Soil Survey (BSS) establishes for the first time baseline values for the chemical composition of agricultural soils over a large area (1,800,000 km^2) in Northern Europe. It proves

Continued on Page 6

The Baltic Soil Survey...

Continued from Page 5

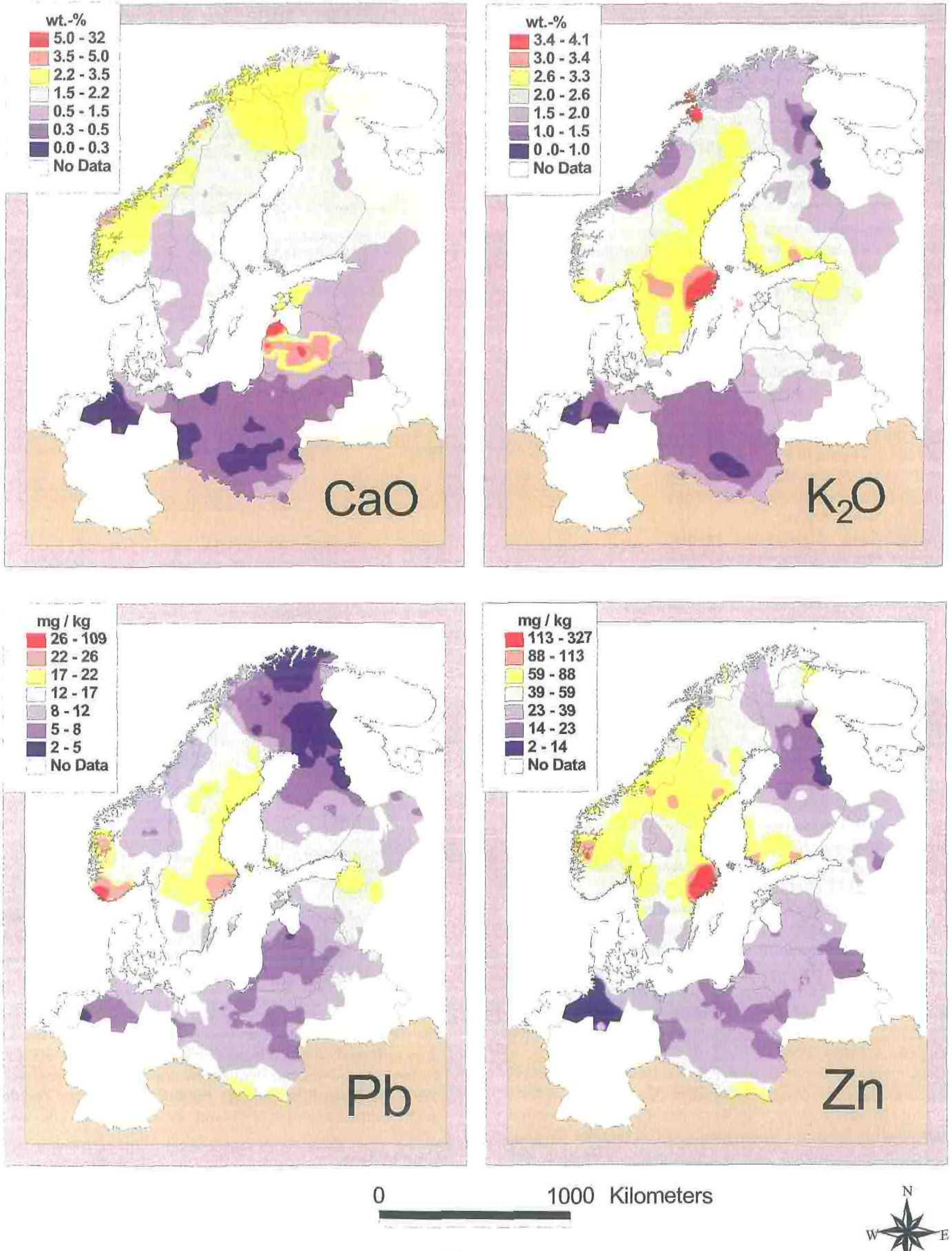

Fig. 4: Geochemical maps for 4 selected elements (Ca. K, Pb and Zn) in the subsoils from the survey area.

The Baltic Soil Survey...

Continued from Page 6

that results from ultra-low density sampling of agricultural soils can still be used to construct meaningful geochemical maps. Geochemical mapping of very large areas at low cost is thus possible and may provide useful results for a multitude of purposes. Element levels and variation are quite different from country to country and area to area. They mostly reflect differences in regional geology. The results demonstrate that setting action levels for heavy metals in soils for a whole country or the whole of Europe may not be wise. The BSS-maps show that it is not possible to use the very old "Clarke values" any longer to differentiate between "background" or "natural" concentrations and "pollution" as often attempted in environmental sciences (e.g., in the calculation of "enrichment factors"). Results between top- and sub-layer are surprisingly comparable. No major build-up of heavy metals in agricultural soils due to human activities can be observed. The results actually suggest that local but widespread sources such as automobile traffic or agriculture may have a more important regional impact on element concentration in the top-layer than industrial emissions. Phosphorus (P) is the one element showing a major build-up in the top-layer. The reason is land-use practice. An exploration geochemist, using such ultra-low density geochemical mapping results in an "unknown region" could hardly avoid finding the most important ore fields in this area, independent of whether topsoil or subsoil is collected.

References

Darnley, A.G. et.al. (1995): A global geochemical database for environmental and resource management.- Final report of IGCP Project 259.- UNESCO Publishing, Earth Sciences 19, 122p.

Juve, G. (ed.) (1997): Mineral Atlas of the World, Map Sheet No. 9, Europe and neighbouring countries, Scale 1:10.000.000. Geological Survey of Norway, Trondheim and CGMW - CCGM, Paris.

Reimann, C. and Caritat, P. de (1998): Chemical Elements in the Environment - Factsheets for the geochemist and environmental scientist. Springer Verlag, Berlin-Heidelberg-New York: 398 p.

TECHNICAL NOTE

Thallium Data for Soil: What Did You Really Get?

In environmental geochemistry, acquisition of valid analytical data for thallium is problematic. In the author's experience, thallium ranks with antimony in terms of unusual, non-reproducible results in soil samples. This paper provides background information about thallium and discusses potential sources of spurious data.

BACKGROUND

Thallium is of regulatory interest because of its high toxicity, i.e., the lethal dose of 6-40 mg/kg of body mass is very low (Sobott, 1993). Its commercial applications have been limited by its toxic nature. Thallium readily forms alloys, some of which have unique properties. Hence, thallium has been used on a limited basis in specialized bearings, contact points, and anodes. The most important alloy is the mercury-thallium alloy, which can be used as a substitute for mercury in switches and seals for equipment used in the polar regions, stratosphere or space program (Kroschwitz, 1999). In the past, one of its major uses was as a rodenticide. It has also been used in mineral separation liquids, optical systems, photoelectric cells, and low-range glass thermometers (ACGIH, 1991). As a result of its toxicity, thallium is included in three of the most common "metals suites" analyzed during environmental investigations: the California Assessment Manual ("CAM 17") metals, Priority Pollutant Metals, and the Target Analyte List ("TAL").

In exploration geochemistry, thallium has been proposed as a pathfinder element for hydrothermal mineral deposits in general (Ikramuddin et al., 1983) and Kuroko-type massive sulfide deposits in particular (Murao and Itoh, 1992).

The crustal abundance level for thallium ranges between 0.05 and 0.75 ppm (Levinson, 1974) and averages 0.85 ppm (Lide and Frederikse, 1994). Sobott (1993) regarded 0.01 to 0.50 ppm as representative of unpolluted soils. Percival and Radtke (1993) reported <0.5 to 1.9 ppm thallium in unaltered sedimentary rocks in Nevada.

ANALYTICAL DATA FOR THALLIUM

Thallium is usually determined by graphite furnace atomic absorption ("GFAA"), ICP atomic emission spectroscopy ("ICP-AES") or ICP mass spectrometry ("ICP-MS"). The typical reporting limits for soil samples are 0.15-0.25 ppm for GFAA, 2-5 ppm for ICP-AES, and approximately 0.025 ppm by ICP-MS. ICP-AES has been the workhorse instrument for metals determination for years. Hence, for samples analyzed by ICP-AES, "background" thallium concentrations in soil will typically fall below the laboratory reporting limit.

Present subsampling practices in environmental laboratories, i.e., no drying, sieving, crushing or pulverizing, tend to produce results that have a wider scatter than would be true with standard geochemical sample preparation. Hence, the results can reflect very small heterogeneites in the sample. The author has observed that this practice can artificially extend the upper end of the crustal abundance range. Coupled with the detection limits achievable by ICP-AES mentioned above, a "typical" background data set for thallium in soils would be made up almost entirely of "non-detects" with an occasional result at or very close to the detection limit, i.e., in the 2 to 6 ppm range.

Although problems with the actual analysis of thallium are not frequently noted in the geochemical literature, the author has to conclude that they must be substantial. In reviewing metals data from soil (and occasionally groundwater) samples collected at many contaminated or potentially contaminated sites, analytical data for thallium emerge as problematic in as many as 5% to 10% of the data sets. Anomalous, non-reproducible data seem to be much more common for thallium than for any of the other metals usually included in environmental investigations, with the possible exception of antimony. The defining characteristics of this anomalous thallium data are:

- Reported concentrations in soils are well above crustal abundance, i.e., are enhanced,
- No probable source for thallium contamination exists,
- The anomalous data are usually produced by a single laboratory analyzing samples from a single sampling event and are often confined to a single analytical batch,
- Re-sampling and/or re-analyzing does not confirm the original data, and
- The results of the re-analyses typically fall into the expected crustal abundance range or are less than the laboratory reporting limit.

Continued on Page 8

Thallium Data for Soil ...

continued from Page 7

For example, at one San Francisco Bay Area site, thallium analyses of 150 soil samples ranged from 20 to 350 ppm with a mean of 93 ppm and a median of 84 ppm. All results were generated by a single laboratory as part of a single sampling event. In the areas sampled, thallium contamination was improbable at best. When re-sampled and re-analyzed by ICP-MS, the results ranged from 0.065 to 0.152 ppm, bringing the values into line with normal crustal abundance levels.

Various explanations for enhanced thallium results are possible; for example, calibration problems or ICP-AES spectral interferences such as lead (Gwendy Hall, personal communication). This may be the case for the data cited above. In addition, Ingamells and Pitard (1986) refer to thallium as "an analytical disaster" because of sample contamination by thallium malonate and other salts used in mineral separations as well as the "capricious" way thallium changes valence states during digestion.

A simpler explanation may apply in many cases; i.e., the misidentification of thallium with thorium at the time of analysis. The chemical symbol for thallium is "Tl"; the chemical symbol for thorium is "Th". For many production ICP units, the analyst must manually input the metals of interest using their chemical symbols. If the analyst inputs "Th" instead of "Tl", the results will be for thorium, not thallium. Such human error is easy to envisage.

Table 1. Thallium and Thorium Soil Data Summary

Data Set	Remarks	N	MEAN (ppm)	MEDIAN (ppm)	MINIMUM (ppm)	MAXIMUM (ppm)
SITE A	Reported as Thallium	14	11.48	11.00	3.40	26.00
SITE B	Reported as Thallium	14	9.79	10.50	6.00	13.00
SITE C	Reported as Thallium	19	13.97	9.30	2.50	76.00
SITE D	Reported as Thallium	47	8.29	8.00	5.60	16.00
TL-REF	Thallium	50	0.56	0.55	0.17	1.10
TH-REF	Thorium	50	15.51	13.50	5.30	36.20
USGS-TH	Thorium	721	9.99	10.00	4.00	26.00

Table 1 summarizes thallium data for soil from four Bay Area sites (Sites A, B, C and D) investigated for potential metals contamination. At none of these sites was there a compelling reason to suspect thallium contamination. For comparison purposes, thallium and thorium data from Benchmark Soils (Bradford et al., 1996) are included (TL-REF and TH-REF, respectively), along with thorium results from a set of 721 USGS soil samples (USGS-TH) collected along the west side of the San Joaquin Valley (Ryder et al, 1989). The thallium data from the four sites match the thorium reference data much more closely than the thallium reference data. Is this a coincidence? It is impossible to know for sure. However, it is highly unlikely that some obscure contamination mechanism can routinely translate entire background thallium distributions into the crustal abundance range proper to thorium.

Such misidentification can be significant because the resultant concentrations could be viewed as an indication of contamination. Furthermore, such a distortion pushes the perceived thallium values into the range where remedial action may be required. For example, within EPA Region 9, Preliminary Remediation Goals ("PRGs") for thallium in residential soils range from 5 to 7 ppm. (PRGs are chemical concentrations that correspond to fixed levels of risk in soil, air, and water. They are used for evaluating and cleaning up contaminated sites).

The potential problem of thallium misidentification seems to cut across the line separating geochemical from environmental laboratories. In trying to resolve a case of unusual thallium results, the author faxed an inquiry to a prominent geochemical laboratory asking whether thallium could be determined by instrumental neutron activation analysis ("INAA"). The answer that came back via fax was "yes", and the detection limit for "Th" is 0.5 ppm! In fact, thallium cannot be analyzed by INAA and the detection limit quoted was, as implied by the chemical symbol, that of thorium!

It may well be that we are in an era where basic knowledge of the periodic table cannot be assumed to be universal among the analysts and technicians responsible for producing the data we rely on. Whatever the case, applied geochemists have good reason to be skeptical of unusual thallium data and should check it before the results are cast in stone.

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References

ACGIH (American Conference of Governmental Industrial Hygienists), 1991. Thallium, elemental and soluble compounds, in *Documentation of the Theshold Limit Values and Biological Exposure Indices, Sixth edition*. p. 1534.

Continued on Page 9

Thallium Data for Soil …

continued from Page 8

Bradford, G., Chang, A., Page, A., Bakhtar, D., Frampton, J. and Wright, H., 1996. *Background Concentrations of Trace and Major Elements in California Soils*. Kearney Foundation of Soil Science, University of California, Riverside. 52p.

Ikramuddin, M., Asmeron, Y., Nordstrom, P., Kinart, K., Martin, W., Digby, S., Elder, D., Nijak, W. and Afemari, A., 1983. Thallium: a potential guide to mineral deposits. J. Geochem. Explor., 19: 465-490.

Ingamells, C. and Pitard, F., 1986. Thallium, in *Applied Geochemical Analysis*. John Wiley & Sons, New York, p. 241.

Kroschwitz, J. (ed)., 1999. Thallium and thallium compounds, in *Kirk-Othmer Concise Encyclopedia of Chemical Technology*, Wiley-Interscience, New York, pp. 1983-1984.

Levinson, A., 1974. *Introduction to Exploration Geochemistry*, Applied Publishing Ltd., Calgary, 612 p.

Lide, D. and Frederikse, H., 1994, Abundance of elements in the earth's crust and in the sea, in *CRC Handbook of Chemistry and Physics, 75th Edition*, CRC Press, Boca Raton, p. 14-11.

Murao, S. and Itoh, S., 1992. High thallium content in Kuroko-type ore. J. Geochem. Explor., 43: 223-231.

Percival, T. and Radtke, A., 1993. Thallium in disseminated replacement gold deposits of the Carlin-type; a preliminary report. Neues Jahrbuch fur Mineralogie, 166: 67-75.

Ryder, J., Briggs, P., Gent, C., Kennedy, K., Severson, R., Tidball, R. and Wilson, S., 1989. Analysis of 721 soil samples from the Panoche fan area of the San Joaquin Valley, California. U.S.G.S. Open File Report 89-298, 81 p.

Sobott, R., 1993. Environmental aspects of thallium. Neues Jahrbuch fur Mineralogie, 166: 77-81.

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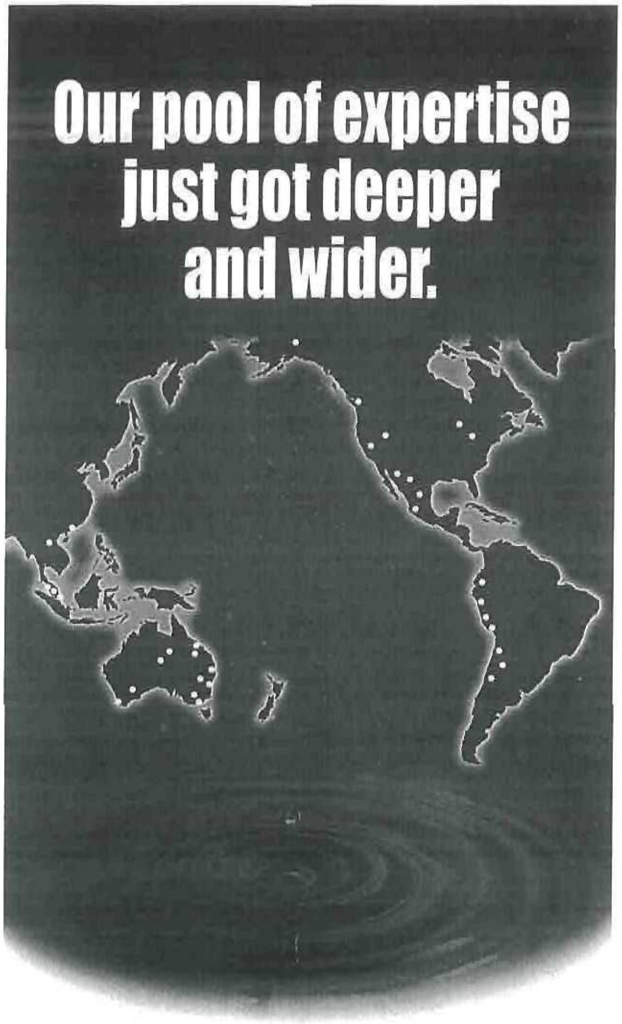

TECHNICAL NOTE

Aqueous Geochemistry — The Under Utilized Science

NO — Aqueous geochemistry is ***NOT*** the magic bullet that will allow someone to find ore deposits wherever they go. But then again - we have yet to find that magic bullet. However, aqueous geochemistry is critical to the formation, weathering, discovery, exploitation, and environmental aspects of every mineral deposit, economic or not, in the world. It is the subtle changes in the aqueous chemistry by which ore deposits form, at high temperatures or at ambient temperatures. Surface and groundwater interactions and rainwater infiltration provide the necessary ingredients to allow the weathering process to work. Without mineral-water interactions there would be ***NO*** geochemical halos developed in stream sediments, soils, or vegetation by which to direct exploration.

Life would be easy without mineral-water interactions as most of the geochemical and analytical tools we use today would not apply to mineralized systems. Additionally, commercial development of mineral deposits would be environmentally safe as no metals would be available to contaminate surface or ground waters. Metals would only leave the site in a processed form.

The study of aqueous geochemistry has matured substantially over the past 30 years. With this maturity has come a much greater understanding of the natural systems. It is realized that reactions occurring at mineral-water interfa central to many, if not most, processes of geochemical im tance. It has also been shown (Sparks and Grundl, 1998; Appelo and Postma, 1994; Sposito, 1994; Allen, Perdue, a Brown, 1993; Drever, 1988; and others) that it is these mi water interactions which control the rates and mechanisn the geochemical reactions key to metal dispersion and th overall weathering processes within the natural system.

This paper will concentrate on the mineral exploratic aspects of aqueous geochemistry. A second paper to be pu lished in a future edition of **EXPLORE** will concentrate c environmental aspects of aqueous geochemistry as it relat the development of mineral deposits. Aqueous geochemis will be evaluated with respect to weathering, dispersion o metal ions, attenuation of metal ions, and how these proc impact on mineral exploration.

When one looks at the geochemical cycle (Rose, Haw and Webb, 1979), it is readily apparent how influential aq geochemistry is within the cycle. Primary dispersion patt are created during the formation of ore deposits. These ar then "locked" into the system until weathering begins. Weathering is the process of breaking down and transforn (altering) minerals which are no longer stable under the ambient conditions to new forms that are stable.

This process includes many aspects of soil formation, transportation, and redeposition. Weathering can be mec cal (physical) or chemical. Mechanical weathering creates exposes additional surface areas to the natural elements w chemical weathering may then take place. The greater th surface areas exposed the faster the weathering process. Chemical weathering requires aqueous solutions to be in contact with the minerals. It is at the *mineral-water interfa* weathering reactions occur. In the vadose zone soil moist levels are critical to the weathering process while beneath groundwater table the concentrations of dissolved oxygen carbon-dioxide may be key components to the control of t reactions and the biological processes which enhance the weathering.

All minerals are soluble to some degree under certain conditions. The solubility of the mineral, often referred t geochemical mobility (Garrels and Christ, 1965), under th various conditions determines how much of that mineral a aqueous solution can hold. The solubility of a mineral is generally evaluated by calculating it's saturation index (A and Postma, 1994; Sposito, 1994; Parkhurst, 1996-1999) A aqueous solution can be under-saturated, saturated, or ove saturated with respect to a given mineral.

If the mineral is under-saturated, then the weathering process may continue destroying the original mineral and forming new minerals while releasing anions and cations i the environment. If the mineral is saturated, the weatheri process is inhibited until there is a change in the water chemistry. If the mineral is over-saturated and other cond tions of its formation are met, it is possible for the mineral re-precipitate and thereby reversing the weathering proces

The understanding of these complex interactions bet the many minerals in the system and the aqueous solution an important aspect in the interpretation and understandi geochemical patterns observed in the field.

Continued on Pa

Aqueous Geochemistry...

Continued from Page 10

Minerals Commonly Controlling Concentrations of Key Aqueous Constituents

Cation	Minerals
Ca	Calcite, Gypsum, Dolomite, Fluorite, Aragonite, Montmorillonite
Mg	Chlorite, Dolomite, Sepiolite, Clays
Na	Clays, Salts
K	Clays, Feldspars, Mica
Si	Quartz, Sepiolite, Mica, Feldspars, Clays, Silica cements
Anion	**Minerals**
CO3	Calcite, Dolomite, Aragonite, Siderite
Cl	Salts, Clays
SO4	Gypsum, Anhydrite, Melanterite
F	Fluorite, Hydroxylapatite
NO3	none
PO4	Hydroxylapatite

In the unsaturated (vadose) zone above the groundwater, rain and surface waters infiltrate slowly downward. This downward movement of water carries soluble ions (from the portions of minerals) with it. For instance, this is the process that may lead to the development of supergene enrichment blankets found at the top of a weathered porphyry system. Ions which may have been carried upward by gases and other mechanisms then deposited at or near the surface may further be leached downward until changes in the solution chemistry again precipitate the metals. As this is a continuous process and the rate is dependant on the amount of rainfall, the soil mineralogy, amount of clay sized materials, and the microbiological activity, the geochemical patterns observed in one area may be very different than those observed in a different area, even though the mineralization is very similar. This means that there are no cookbook approaches which are likely to work everywhere - every time.

Dispersion and dilution are the two most often evaluated processes that affect the travel distance and concentration of a soluble ion. Many of the environmental groundwater modeling packages (*MODFLOW, MT3D, SEEP-W, etc.*) apply numerical constants to approximate the impacts of these processes within the natural system being modeled. Dispersion in the surface water system moves metal ions and small amounts of the mineralized rock downstream from the mineralized zones. Dispersion in the groundwater system also moves metal ions down gradient from the mineralized zone. However, dispersion in the groundwater system may also move metal ions up gradient and laterally outwards from the down gradient path. The rate and degree of dispersion are dependant upon the properties of individual ions (therefore, different ions will yield different dispersion patterns), porosity of the aquifer materials, and the groundwater gradient. Dispersion tends to smear the geochemical halos into an elliptical pattern away from the mineralization. Dilution happens when other waters coalesce with the water source containing the metal ions of interest. Multiple sources of varying metal contents make interpretation of patterns much more difficult, especially within the groundwater aquifers. Good characterization of all sources of water, surface and ground, are essential for reliable interpretation of geochemical patterns within natural systems.

Natural attenuation is the process that limits the travel distance and concentration of a soluble ion within the aqueous system. If attenuation did not occur, geochemical halos would match the chemistry but not necessarily the intensity of the mineralization. Dilution affects the concentration levels but not the proportions of metals found within the aqueous system. However, attenuation may alter dispersion and dilution patterns in very complex ways. Attenuation generally occurs through precipitation (especially colloids), adsorption, ion exchange, and ion hydration.

Much research is being done to determine the rates and degree of attenuation of metals within the natural environment. Quantitative estimations of the effects of natural attenuation on metal ion transport can be made by calculation of attenuation coefficients (Kd). The attenuation coefficient for a specific chemical species may be defined as the ratio of the mass sorbed onto a solid phase to the mass remaining in solution according to the following formula:

$$Kd = \frac{\text{(mass of solute on the solid phase per unit mass of solid phase)}}{\text{(mass of solute in solution per unit volume of the liquid phase)}}$$

with units of mL/g (g solute /g solid divided by g solute / mL solution). The attenuation coefficient is usually determined using column testing or procedures like the Short Term Batch Method (*ASTM, D 4319-83*). The Electrical Power Research Institute (EPRI) has completed studies on many of the metals. Unfortunately, unless you are associated with a power utility, it is very difficult to obtain this information. Universities, mining companies, and consulting firms have also done batch testing to determine the natural attenuation for specific metals

Continued on Page 12

Aqueous Geochemistry *Continued from Page 11*

within targeted geological materials. Most of this data however has ended up in reports and permit applications to State and Federal agencies and not readily accessible by the general professional. However, if you can obtain this information it may provide a much appreciated key to geochemical patterns observed around mineralized systems. Examples of attenuation coefficients (Kds in units of ug/Kg) that I have obtained from the literature and laboratory testing on client projects include: Arsenic (<10 to >10,000), Cadmium (<5 to >1,000), Copper (<5 to >1,000), Lead (<10 to >100,000), Molybdenum (<10 to >10,000), Selenium (<5 to >1,000). Therefore, these values would indicate that under some conditions arsenic concentrations in a surface water or groundwater system may be reduced by a factor of 10,000 due to natural attenuation processes.

If an exposed mineralized zone weathers to create an aqueous geochemical anomaly of say 100 ppm arsenic. If the material in the streambed or soils has a Kd of 10,000 then the concentration of arsenic would be reduced by a factor of 10,000, or less than detection limits used by conventional analytical methods as the solution traveled through the geological materials surrounding the mineralized zone. In many of the projects on which I have worked, I have observed surface waters with very high metal concentrations (>1000 mg/l) flowing through soils with ten to fifteen percent clays and minor calcite ending up with no detectable or very low concentrations (<5 mg/l) of metals in groundwater only 30 feet below the streambed. Negative attenuation coefficients indicate that the metal concentrations increase when passing through the material. Attenuation may be especially important in the soil (vadose zones) and will depend greatly on the source area of the weathered soil materials.

Several of the properties of an aqueous solution which may greatly influence the degree of attenuation observed in the field or determination of attenuation coefficients in the laboratory are pH, total dissolved solids concentration, chloride concentration, redox potential, carbon dioxide concentration, and degree of mineral-water surface area contact. Fine-grained sediments having the same mineralogy as fractured bedrock will almost always exhibit a greater attenuation capacity because of the larger surface area for sorption and/or chemical reactions. Cation exchange capacities indicate a materials ability to adsorb and is highly dependant upon the clay content, clay minerals, organic matter, and oxide or hydroxide content (Appelo and Postma, 1994). Column tests generally yield lower values and may, if analyzed over long time periods, provide a much more accurate indication of the processes occurring in the natural system. Column test are especially helpful if the materi analyzed to determine the metal speciation in the sedim [exchangeable metal, metal sulfides, metals associated w calcium carbonate, manganese oxides, amorphous iron (or organic matter, etc.(Allen, et. al. 1993)]. However, sh term batch tests generally provide good estimates on the attenuation coefficients at a fraction of the costs.

Often one must look at indicator cations rather tha metal of interest, just as pathfinder elements are used in and rock geochemical surveys. Adsorption and ion exch processes release one cation while attenuating another. Calcium, magnesium, and sodium are commonly exchan when a material attenuates a heavy metal ion such as ars cadmium, copper, and lead. This produces a secondary geochemical halo of constituents not directly associated the mineralization. Calcium and magnesium are general mobile than sodium, especially if iron and manganese ox and hydroxides are present. As a result, the geochemical pattern observed would be that as one gets nearer the tar there would be an increase in sodium, then calcium and magnesium, and then finally the metals associated with t mineralization.

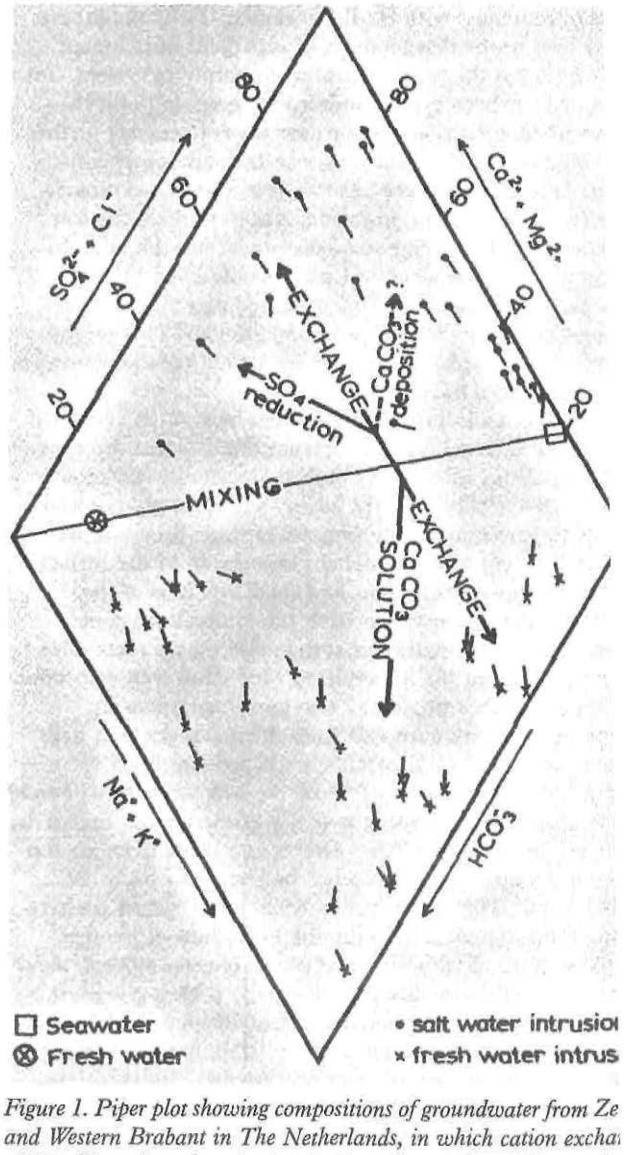

Figure 1. Piper plot showing compositions of groundwater from Ze and Western Brabant in The Netherlands, in which cation excha visible. The tail at plotted points is directed towards position on the ing line based on Cl⁻ concentration of the groundwater sample.

Aqueous Geochemistry *Continued from Page 12*

Piper diagrams can be of great assistance in unraveling the geochemical processes occurring in regional groundwater or surface water systems. This example (Figure 1) from Appelo and Postma (1994) is one such case history. Using this tool, ground waters undergoing sulfate reduction can be easily differentiated from those where cation exchange, calcite deposition or solution are the primary processes affecting changes in water chemistry.

Observed time variations of aqueous geochemistry patterns makes its direct use as an exploration tool difficult. This is especially critical in surface water geochemical patterns. However, similar changes are observed in groundwater aquifers as well. Rain events, temperature changes, bio-activity, and many other factors continually modify aqueous geochemical patterns around mineralized systems. This does not mean that these patterns cannot be used within an exploration setting, however, it does mean that the geochemist must be aware of the influences which may be modifying the patterns from an ideal classical model. The periodicity of these variations must be understood in order to develop an appropriate sampling strategy. Surface water chemistry can be an excellent indicator of the distance that a metal ion can travel before precipitating or becoming adsorbed onto mineral surfaces which may provide the key understanding to how a stream sediment survey can be most efficiently conducted. It has never ceased to amaze me that when evaluating a stream system how very small changes in the water chemistry and changes in the minerals found in the streambed will cause one or more minerals to precipitate removing much if not all detectable amounts of a given metal ion from the surface water. It is the downstream transport of these precipitated minerals and materials with adsorbed metal ions on their surfaces that produce geochemical patterns in the stream sediments.

In conclusion, I would suggest that each of us consider aqueous geochemical processes to assist in the interpretation and understanding of the geochemical patterns that we observe in the field no matter what media we are sampling. This understanding may help us to better use the geochemical observations in our decision making process.

References

Allen, H.E., Perdue, E.M., and Brown, D.S, 1993. Metals in Groundwater. Lewis Publishers. 437pp.

Appelo, C.A.J. and Postma, D., 1994. Geochemistry, Groundwater and Pollution. A.A. Belkema. 536pp.

ASTM, 1984. Standard Test Method for Distribution Ratios by the Short-Term Batch Method. American Standard Testing Method number D 4319-83 published January 1984.

Drever, J.I., 1988. The Geochemistry of Natural Waters. Prentice Hall. 437pp.

Garrels, R.M. and Christ, C.L., 1965. Solutions, Minerals, and Equilibria. Harper and Row, New York, 450 pp.

McDonald, M.G. and Harbaugh, A.W., 1984. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (MODFLOW). U.S. Geological Survey. Updated in 1988 as U.S. Geological Survey Open-File Report 83-875.

Papadopulos, S.S., 1991. A Modular Three-Dimensional Transport Model (MT3D). S.S. Papadopulos & Associates Inc. Rockville, Maryland.

Parkhurst, D.L., 1995. User's Guide to PHREEQC: A computer model for Speciation, Reaction-Path, Advective-Transport, and Inverse Geochemical Calculations. U.S. Geological Survey Water Resources Investigations Report.

Rose, A.W., Hawkes, H.E., Webb, J.S., 1979. Geochemistry in Mineral Exploration. Academic Press. 657pp.

Sparks, D.L. and Grundl, T.J. (Editors), 1998. Mineral-Water Interfacial Reactions, Kinetics and Mechanisms. ACS Symposium Series 715, American Chemical Society, Division of Geochemistry meeting 1997 San Francisco, California. 438pp.

Sposito, G., 1994. Chemical Equilibria and Kinetics in Soils. Oxford University Press. 268pp.

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GEOLOGICAL SOCIETY OF NEVADA

"Geology and Ore Deposits 2000: The Great Basin and Beyond" is the theme of the upcoming Geological Society of Nevada Symposium, May 15-18. The past GSN symposia have been some of the best meetings on ore deposits, and this symposium is shaping up as one of the best ever.

Co-sponsors include the Society of Economic Geologists, Association of Exploration Geochemists, U.S. Geological Survey, and Nevada Bureau of Mines and Geology. Papers will be presented on ore deposits, regional geology, and tectonics throughout the world. The format for the meeting is excellent in that you have the opportunity to see all the oral presentations (eight, non-competing sessions over four days, each with a top-notch keynote speaker) as well as approximately 90 poster presentations. There are plenty of breaks for refreshments, including late afternoon beer in the poster-exhibit areas. You'll have an opportunity to examine core from recently discovered ore deposits in the exhibit area as well. Several pre- and post-meeting field trips are scheduled to visit ore deposits and exciting geologic exposures in Nevada, and several pre- and post-meeting short courses are being offered. Two special luncheons, the "Big Party" Wednesday night, and an evening alumni gathering help round out the symposium.

If you are at all interested ore deposits or how tectonics and ore deposits are linked, this meeting should be of great interest to you. Regular registration is only $275 and on-site registration is $300. Student registration is $125. Registrants will receive a program with abstracts on the oral and poster presentations. A few months after the symposium, registrants will also receive a CD with copies of the 70+ full papers that are currently in the process of being reviewed and revised.

You can find registration information at www.gsnv.org/symp2k.asp or simply www.gsnv.org

We look forward to an excellent symposium and to your participation.

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NOTICE

To All Analytical Laboratories

The Association of Exploration Geochemists (AEG) is in the process of updating its web site at http://aeg.org. The AEG is inviting all analytical laboratories to create or update their existing web sites, and to facilitate links with the AEG web site. The goal is to create links so that visitors to the AEG site can easily access analytical laboratory information on available services and pricing. We plan to establish the links by May, 2000. If your laboratory currently has a web site, and you would like to have a link to the AEG site established, please notify us of the web address. If you plan to create a web site, please confirm your intent with us so that we can plan accordingly.

If you have any questions, please feel free to contact David Kelley or Beth McClenaghan.

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NEWS OF MEMBERS

Laurence P. (Larry) James will be spending much of on a Korean government - funded effort to identify metal resources in northeast Asia, present short courses, and lect on mineral deposits of Asia. He says he can now read simp Hangul, or Korean script (but the work is in English). He enjoys working on the variety of deposit types of the regior and sampling the culture, but would like to hear from fello explorationists. He accesses email intermittently at james@mail1.pknu.ac.kr and jamesgeoa@cs.com. The forn works best, but both servers have occasional problems.

Todd Wakefield, previously living in Reno, Nevada, h joined Newmont Mining Corporation as Senior Geochemis responsible for South America. He is based in Lima, Peru.

YANDAL BELT SYMPOSIUM

REGOLITH, GEOLOGY AND MINERALISATION
THE YANDAL GREENSTONE BELT

PERTH, WESTERN AUSTRALIA
10-11 JULY, 2000

The Yandal greenstone belt, Western Australia, is one c the worldwide exploration highlights of the 1990's based on discovery of 13 million ounces of gold during the period an successful mining of Bronzewing, Mt McClure, Jundee and Darlot/Centenary. The belt now produces about 10% of Australia's total gold output.

Historically, the belt produced small amounts of gold fr quartz-hosted, outcropping ore zones. Previous exploration had concentrated on the base metal and nickel sulphide potential of sulphide host environments and gossan outcrop Some relatively extensive gold exploration programmes wer carried out in the 1980s revealing uneconomic resources. In general, however, the applied exploration methodology did r adequately allow for the deeply weathered greenstones and t extensive alluvial cover. Well under fifteen percent of the greenstone belt is reasonably fresh rock outcrop, a large part deeply weathered, and more than half of the belt is overlain transported overburden of various ages.

However, within the last ten years, a greater emphasis h been placed on appreciation of regolith and bedrock geology This has resulted in the discoveries of the Bronzewing, Jund Darlot/Centenary and Mt McClure gold deposits and confirr the Yandal belt to be a major gold producing province. Few areas around the world could match this success, and even fewer from what was essentially a 'standing start' in 1990.

For the past ten years, the regolith and geology of the Yandal belt have been well researched by the Co-operative Research Centre for Landscape Evolution and Mineral Exploration (CRCLEME), several companies, University of Western Australia, University of Melbourne, Geological Surv of Western Australia and Australian Geological Survey Organisation. The rapid development of mining in the Yand belt has been paralleled by, and to some extent relied upon, significant conceptual breakthroughs in understanding of th Yandal belt geology and regolith. Some of these breakthroug

Continued on Page

Yandal Belt Symposium...

Continued from Page 14

altered the perceptions held about Yandal belt prospectivity, others drew upon comparisons from other parts of the Yilgarn Craton, and some were innovations which have implications to exploration in other greenstone belts and weathered terrains.

The fruit of the research will be presented in a variety of papers at the Yandal Belt Symposium to be held in Perth over two days, 10th and 11th July 2000. This will be the first conference and volume attempting to bring together all aspects of Yandal belt geology and regolith.

The scientific programme will focus on issues of recognizing concealed mineral deposits in areas of transported overburden or deep weathering, or both. It comprises a balance of regional and detailed presentations covering regolith, exploration geochemistry, primary geology, geophysics and several presentations on mineralisation.

This Symposium is a joint association of the CRCLEME, Australian Institute of Geoscientists, The Association of Exploration Geochemists, Geological Society of Australia and the Society of Economic Geologists.

Registration details are as follows:

Members of the above Associations	$A 300 (+10% GST)
Non Members	$A 450 (+10% GST)
Students and Unemployed	$A 150 (+10% GST)

Registration includes the volume, morning and afternoon tea, and lunch for each of the 2 days.

To register, or for more information please contact Jocelyn Thomson at The Australian Institute of Geoscientists-, Phone No: +61-8-9226 3996; Fax: +61-8- 9226 3997; e-mail aigwa@iinet.net.au ; or mail to AIG (WA), PO Box 606, West Perth, Western Australia, 6872.

The substantial discount for AEG members illustrates the Association's commitment to providing value for money to its members.

RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 106. *Journals routinely covered and abbreviation used are as follows:* Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); 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: Applied 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 8001-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs (lcloss@mines.Colorado.Edu), not to **EXPLORE**.

Anderson, C.W.N., Brooks, R.R., Chiarucci, A., LaCoste, C.J., Leblanc, M., Robinson, B.H., Simcock, R., and Stewart, R.B., 1999. Phytomining for nickel, thallium, and gold. J. Geochem. Explor. 67: 407-415.

Arne, D.C., Stott, J.E., and Waldron, H.M., 1999. Biogeochemistry of the Ballarat East goldfield, Victoria, Australia. J. Geochem. Explor. 67: 1-14.

Ayras, M. and Kashulina, G., 2000. Regional patterns of element contents in the organic horizon of podzols in the central part of the Barents region (Finland, Norway, and Russia) with special references to heavy metals (Co, Cr, Cu, Fe, Ni, Pb, V, and Zn) and sulphur as indicators of airborne pollution. J. Geochem. Explor. 68 (1/2): 127-144.

Bailes, A.H. and Galley, A.G., 1999. Evolution of the Paleoproterozoic Snow Lake Arc Assemblage and geodynamic setting for associated volcanic-hosted massive sulphide deposits, Flin Flon Belt, Manitoba, Canada. Can. J. Earth Sci. 36(11): 1789-1805.

Barrie, C.T., Corfu, F., Davis, P., Coutts, A.C., and MacEachern, D., 1999. Geochemistry of the Dundonald Komatiite-Basalt Suite and Genesis of Dundeal Ni deposit, Abitibi Subprovince, Canada. EG 94(6): 845-866.

Bebout, G.E., Ryan, J.G., Leeman, W.P., and Bebout, A.E., 1999. Fractionation of trace elements by subduction-zone metamorphism - effect of convergent margin thermal evolution. Earth Planet. Sci. Letters 17(1): 63-82.

Bierlein, F.P., Waldron, H.M., and Arne, D.C., 1999. Behavior of rare earth and high field strength elements during hydrothermal alteration of meta-turbidites associated with mesothermal gold mineralization in central Victoria, *Australia. J. Geochem. Explor. 67: 109-125.*

Boni, M., Costabile, S., De Vivo, B., and Gasparrini, M., 1999. Potential environmental hazard in the mining district of southern Iglesiente (SW Sardinia, Italy). J. Geochem. Explor. 67: 417-430.

Bowell, R.J., Baumann, M., Gingrich, M., Tretbar, D., Perkins, W.F., and Fisher, P.C., 1999. The occurrence of gold at the Getchell mine, Nevada. J. Geochem. Explor. 67: 127-143.

Brand, N.W., 1999. Element ratios in nickel sulphide exploration: vectoring towards ore environments. J. Geochem. Explor. 67: 145-165.

Bushlyakov, I.N. and Kholodnov, V.V., 1999. Halogens as indicators of the ore-forming potential of granitoids. Geol. of Ore Deposits 41(4): 332-

Chao, E.C.T. et al., 1997. The Sedimentary Carbonate-Hosted Giant Ayan Obe REE-Fe-Bn-Ore Deposit of Inner Mongolai, China: A Cornerstone Example for Giant Polymetallic Ore Deposits of Hydrothermal Origin. USGS Bull. 2143. 65 p.

Christie, T. and Fletcher, W.K., 1999. Contamination from forestry activities: implications for stream sediment exploration programmes. J. Geochem. Explor. 67: 201-210.

Cocker, M.D., 1999. Geochemical mapping in Georgia, US: a tool for environmental studies, geologic mapping, and mineral exploration. J. Geochem. Explor. 67: 345-360.

Continued on Page 16

Recent Papers

Continued from Page 15

Cooke, D.R., Bull, S.W., Large, R.R., and McGoldrick, P.J., 2000. The Importance of Oxidized Brines for the Formation of Australian Proterozoic Stratiform Sediment-Hosted Pb-Zn (Sedex) Deposits. EG 95(1): 1-18.

Costa, M.L., Angelica, R.S., and Costa, N.C., 1999. The geochemical association Au-As-B-(Cu)-Sn-W in latosol, colluvium, lateritic iron crust, and gossan in Carajas, Brazil: importance for primary ore identification. J. Geochem. Explor. 67: 33-49.

Criss, R.E., Singleton, M.J., and Champion, D.E., 2000. Three-Dimensional Oxygen Isotope Imaging of Convective Fluid Flow Around the Big Bonanza, Comstock Lode Mining District, Nevada. EG 95(1): 131-142.

Durn, G., Miko, S., Covic, M., Barudzija, U., Tadej, N., Namjesnik-Dejanovic, K., and Palinkas, L., 1999. Distribution and behavior of selected elements in soil developed over a historical Pb-Ag mining site at Sv. Jakob, Croatia. J. Geochem. Explor. 67: 361-376.

Ebinghaus, R., Turner, R.R., de Lacerda, L.D., Vasiliev, O., and Solomons, W. (eds.), 1999. Mercury Contamination Sites: Characterization, Risks Assessment, and Remediation. Springer-Verlag. 538 p.

Fletcher, W.K. and Muda, J., 1999. Influence of selective logging and sedimentological process on geochemistry of tropical rainforest streams. J. Geochem. Explor. 67 211-222.

Gaboury, D., Daigneault, R., and Beaudin, G., 2000. Volcanogenic-related origin of sulfide-rich quartz veins: Evidence from O and S isotopes at the Geant Dormant gold mine, Abitibi belt, Canada. Min. Deposita 35(1): 21-36.

Gehring, A.U., Schosseler, P.M., and Weidler, P.G., 1999. Mineral formation and redox-sensitive trace elements in a near-surface hydrothermal alteration system. GCA 63(13/14): 2061-

Giza, A.P. (ed), 1999. A Special Issue on Organic Matter and Ore Deposits: Interactions, Applications, and Case Studies. EG 94(4): 963-1180.

Gleason, J.D., Marikos, M.A., Barton, M.D., and Johnson, D.A., 2000. Neodymium isotopic study of rare earth element sources and mobility in hydrothermal Fe oxide (Fe-P-REE) systems. GCA 64(6): 1059-1068.

Gomez-Fernandez, F., Both, R.A., Mangoa, J., and Arribas, A., 2000. Metallogenesis of Zn-Pb Carbonate-Hosted Mineralization in the Southeastern Region of the Picas de Europa (Central Northern Spain) Province: Geologic, Fluid Inclusion, and Stable Isotope Studies. EG 95(1): 19-40.

Gray, D.J., Wildman, J.E., Longman, G.C., 1999. Selective and partial extraction analyses of transported overburden for gold exploration in the Yilgarn Craton, Western Australia. J. Geochem. Explor. 67: 51-66.

Grimes, S., Richard, D., Hawkesworth, C., van Calsteren, P., and Browne, P., 2000. The Broadlands-Ohaaki geothermal system, New Zealand. Chem. Geol. 163(1/4): 247-286.

Grunsky, E.C. and Smee, B.W., 1999. The differentiation of soil types and mineralization from multi-element geochemistry using multivariate methods and digital topography. J. Geochem. Explor. 67: 287-299.

Guangzhi, T. (ed.), 1996. Geochemistry of Strata-Bound Deposits in China. Science Press (Beijing, China). 638 p.

Haben, P.W. and Kuzvart, M., 1997. Industrial Minerals: A Global Geology. Ind. Min. Info (London). 462 p.

Halfpenny, R. and Mazzucchelli, R.H., 1999. Regional multi-element drainage geochemistry in the Himalayan Mountains, northern Pakistan. J. Geochem. Explor. 67: 223-233.

Hanlie, H., 2000. Behavior of gold in the weathered mantle at Shewushan, Hubei, China. J. Geochem. Explor. 68 (1/2): 1-20.

Harris, J.R., Wilkinson, L., Grunsky, E., Heather, K., and Ayer, J., 1999. Techniques for analysis and visualization of lithogeochemical data with applications to the Swayze greenstone belt, Ontario. J. Geochem. Explor. 67: 301-334.

Hill, G.T., Campbell, A.R., and Kyle, P.R., 2000. Geochemistry of southwestern New Mexico Fluorite occurrences: implications for precious metal exploration in Fluorite-bearing systems. J. Geochem. Explor. 68(1/2): 1-20.

Keay, S., Steele, D., and Compston, W., 1999. Identifying granite sources by SHRIMP U-Pb zircon geochronology: An application to the Lachlan foldbelt. Contrib. Min. and Petrol. 137(4): 323-341.

Kiratisevee, S., Prewett, W., and Asnachinda, P., 2000. Synthetic manganese dioxide as a collector for trace elements in stream water surveys. J. Geochem. Explor. 68(1/2): 47-55.

Klassen, R.A., 1999. The application of glacial dispersal models to the interpretation of till geochemistry in Labrador, Canada. J. Geochem. Explor. 67: 245-269.

Kontak, D.J. and Jackson, S.J., 1999. Documentation of variable trace- and rare-earth-element abundances in carbonates from auriferous quartz veins in Meguma lode gold deposits, Nova Scotia. Can. Min. 37(2): 469-488.

Large, R.R., Bull, S.W., and McGoldrick, P.J., 2000. Lithgeochemical haloes and geochemical vectors to stratiform sediment host Zn-Pb-Ag deposits. Part 2. HYC deposit, McArthur River, Northern Territory. J. Geochem. Explor. 68(1/2): 105-126.

Continued on Page 17

Recent Papers

Continued from Page 16

Laurua, K.A. and Fletcher, W.K., 1999. Gold distribution in glacial sediments and soils at Boston Property, Nunavut, Canada. J. Geochem. Explor. 67: 271-285.

Loredo, J., Ordonez, A., Gallego, J.R., Baldo, C., and Garcia-Iglesias, J., 1999. Geochemical characterization of mercury mining spoil heaps in the area of Mieres (Asturias, northern Spain). J. Geochem. Explor. 67: 377-390.

Malo, M., Pelchat, C., Dube, B., and Chagnon, A., 1998. Contrasting styles of gold mineralization along the Grand Pabos-Restigouche fault system: Implications for Carlin-like Au mineralization in the southwestern Gaspe Appalachians. Explor. Mining Geol. 7(3): 217-235.

McCaffery, K.J.W., Lonergan, L., and Wilkinson, J.J. (eds.), 1999. Fractures, Fluid Flow and Mineralization. Geol. Soc. (London) Spec. Pub. No. 155. 328 p.

McInnes, B.I.A., Farley, K.A., Sillitoe, R.H., and Kohn, B.P., 1999. Application of Apatite (U-Th)/He Thermochronometry to the Determination of the Sense and Amount of Vertical Fault Displacement at the Chuquicamata Porphyry Copper Deposit, Chile. EG 94(6): 937-948.

McLemore,, V.T., Munroe, E.A., Heizler, M.T., and McKee, C., 1999. Geochemistry of the Copper Flat porphyry and associated deposits in the Hillsboro mining district, Sierra County, New Mexico, USA. J. Geochem. Explor. 67: 167-189.

McQueen, K.G., Hill, S.M., and Foster, K.A., 1999. The nature and distribution of regolith carbonate accumulations in southeastern Australia and their potential as a sampling medium in geochemical exploration. J. Geochem. Explor. 67: 67-82.

Melcher, F., Morey, G.B., McSwiggen, P.L., Cleland, J.M., and Brink, S.E., 1996. Hydrothermal Systems in Manganese-Rich Iron Formation of the Cuyana North Range, Minnesota: Geochemical and Mineralogical Study of the Gloria Drill Core. Minnesota Geol. Surv., Rept. Invest. 46. 59 p.

Melo, G., Jr. and Fletcher, W.K., 1999. Dispersion of gold and associated elements in stream sediments under semi-arid conditions, northeast Brazil. J. Geochem. Explor. 67: 235-243.

Morford, J.L. and Emerson, U.S., 1999. The geochemistry of redox sensitive trace elements in sediments. GCA 63(11/12): 1735-17

Munroe, E.A., McLemore, V.T., and Kyle, P., 1999. Waste rock pile characterization, heterogeneity, and geochemical anomalies in the Hillsboro Mining District, Sierra County, New Mexico. J. Geochem. Explor. 67: 391-405.

Panhorst, T., 1999. Use of blasthole assay results for structural interpretation at Lone Tree mine, Humboldt County, Nevada, USA. IMM Trans. 108: B64-B72.

Pearson, W.N., 2000. The Qualified Person concept – Implications for geoscientists. CIM Bull. 93(1037): 37-40.

Percival, J.B. and Kwong, Y.T.J., 1999. Mining and the Environment II: An Integrated Approach to Planning and Rehabilitation for the Future (Conference Report). Geoscience Can. 26(4): 198-201.

Piestrzynski, A. and Wodzicki, A., 2000. Origin of the gold deposits in the Polkowice-West Mine, Lubin-Sieroszowice Mining District, Poland. Min. Deposita 35(1): 37-47.

Prendergast, M.D., 2000. Layering and Precious Metal Mineralization in the Rincon del Tigre Complex, Eastern Bolivia. *EG 95(1): 113-130.*

Pwa, A., McQueen, K.G., Scott, K.M., and von Moort, J.C., 1999. Regolith geochemical exploration using acid insoluble residues as a sample medium for gold and base metal deposits in the Cobar region, N.S.W., Australia. J. Geochem. Explor. 67: 15-31.

Rebagliati, C.M., Haslinger, R.J., and Oliver, J.L., 1998. The Specogna gold deposit: A Late Tertiary, low sulfidation epithermal hot spring deposit, Graham Island, Queen Charlotte Islands, British Columbia, Canada. Explor. Mining Geol. 7(3): 253-269.

Richard, D., 1999. European Phanerozoic metallogenesis. Min. Deposita. 34(5/6): 417-421.

Russell, D.W. and van Moort, J.C., 1999. The chemical characterization of auriferous vein quartz, Beaconsfield gold mine, Tasmania. J. Geochem. Explor. 67: 191-200.

Sabins, F.F., 1999. Remote sensing for mineral exploration. Ore Geol. Rev. 14(3/4): 157-184.

Scott, K.M. and van Riel, B., 1999. The Goornong South gold deposit and its implications for exploration beneath cover in Central Victoria, Australia. J. Geochem. Explor. 67: 83-96.

Seoane, J.C.S. and de Barros Silva, A., 1999. Gold – anomalous catchment basins: a GIS prioritization model considering drainage sinuosity. J. Geochem. Explor. 67: 335-344.

Serala, P. and Rossi, S., 2000. The application of till geochemistry in exploration in the Rogen moraine area Petajavaara, northern Finland. J. Geochem. Explor. 68(1/2): 87-104.

Schandl, E.S., Sharara, N.A., and Gorton, M.P., 1999. The origin of the Atshan talc deposit in the Hamata area, Eastern Desert, Egypt: A geochemical and mineralogical study. Can. Min. 37(5): 1211-1228.

Scheepers, R., 2000. Granites of the Saldania mobil belt, South Africa: radioelements and P as discriminators applied to metallogeny. J. Geochem. Explor. 68(1/2): 69-86.

Shayakubov, T., Islanov, F., Krementsky, A., and Seltmann, R. (eds.), 1999. Au, Ag, and Cu Deposits of Uzbekistan.

Continued on Page 18

Recent Papers

Continued from Page 17

Intern. Field Conf. of IGCP-373. Intern. Assoc. Genesis of Ore Deposits. 112 p.

Southwick, D.L., Boerboom, T.J., and Jirsa, M.A., 1998. Geologic Setting and Descriptive Geochemistry of Archean Supracrustal and Hypabyssal Rocks, Souden-Bigfork Area, Northern Minnesota: Implications for Metallic Mineral Exploration. Minnesota Geol. Surv. Rept. Invest. 51. 69 p.

Syme, E.C., Lucas, S.B., Bailes, A.H., and Stern, R.A., 1999. Contrasting arc and MORB-like assemblages in the Paleoproterozoic Flin Flon Belt, Manitoba, and the role of intra-arc extension in localizing volcanic-hosted massive sulphide deposits. Can. J. Earth Sci. 36(11): 1767-1788.

Townley, B.K., Maksaev, V., Palacios,J.C., Lashen, A., and Parada, M.A., 2000. Base and precious metals geochemistry of rock units of the mainland Aysen region, Chilean Patagonia. J. Geochem. Explor. 68(1/2): 21-46.

Watkinson, D.H., 1999. Platinum-group element enrichment in Cu-Ni-rich sulfides from footwall deposits, Sudbury Igneous Complex, Canada. Chronique de la Researche Miniere (June): 29-

Wilkinson, L., Harris, J., and Grunsky, E., 1999. Building a lithogeochemical dataset for GIS analysis: Methodology problems and solutions. GSC OF 3788. 44 p.

Williams, T.M. and Smith, B., 1999. Hydrochemical characterizations of acute acid mine drainage at Iron Duke mine, Mazowe, Zimbabwe. Environ. Geol. 39(3/4): 272-

Wilson, A.H., Lee, C.A., and Brown, R.T., 1999. Geochemistry of the Merensky reef, Rustenberg section, Bushveld Complex: Controls on the silicate framework and distribution of trace elements. Min. Deposita. 34(7): 657-672.

Xie, X., 1999. Empirical prospecting, scientific exploration, and information exploration. J. Geochem. Explor. 67: 97-108.

Xu, G., 2000. Methane-rich fluid inclusions in the Proterozoic Zn-Pb-Ag deposit at Dugald River, NW Queensland: Potential as an exploration guide: Applied Geochem. 15(1): 1-12.

CALENDAR OF EVENTS

International, national, and regional meetings of interest to colleagues working in exploration, environmental and other areas of applied geochemistry.

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

■ April 27–29, 2000, **Cordilleran GSA Sectional Meeting, Vancouver, British Columbia.** INFORMATION: Peter S. Mustard, pmustard@sfu.ca.

■ May 12-14, 2000, **Europe's major base metal deposits,** Galway, Ireland. INFORMATION: Leo Fusciardi, Irish Association for Economic Geology, Minorco Services Ireland, Ltd., Killoran, Moyne, Thurles, Co., Tipperary, Ireland, +353.504.54369. 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@nbmg.unr.edu.

■ May 21-24, 2000, **ICARD 2000, 5th International Conference on Acid Rock Drainage,** Denver, Colo. INFORMATION: SME, PO Box 625002, Littleton, Colo. 80162-5002. E-mail: davis@smenet.org.

■ May 29-June 1, 2000, **GAC/MAC Annual Meeting, The Millenium Geoscience Summit,** Calgary, AB,. INFORMATION: www.geocanada2000.com/frameset.html

■ May 30–June 2, 2000, **International Symposium on Environmental Issues and Waste Management in Energy and Mineral Production (SWEMP 2000),** Calgary, Canada. INFORMATION: Raj Singhal, P.O. Box 68002, Crowfoot Postal Outlet, 28 Crowfoot Terrace N.W., Calgary, AB, T3G 1Y0, Canada, phone (403) 241-9460, fax 403-241-9460.

■ May 31, June 3, 2000, **AGU Spring Meeting,** San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

■ 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: 31igc@31igc.org, http: www.31igc.org.

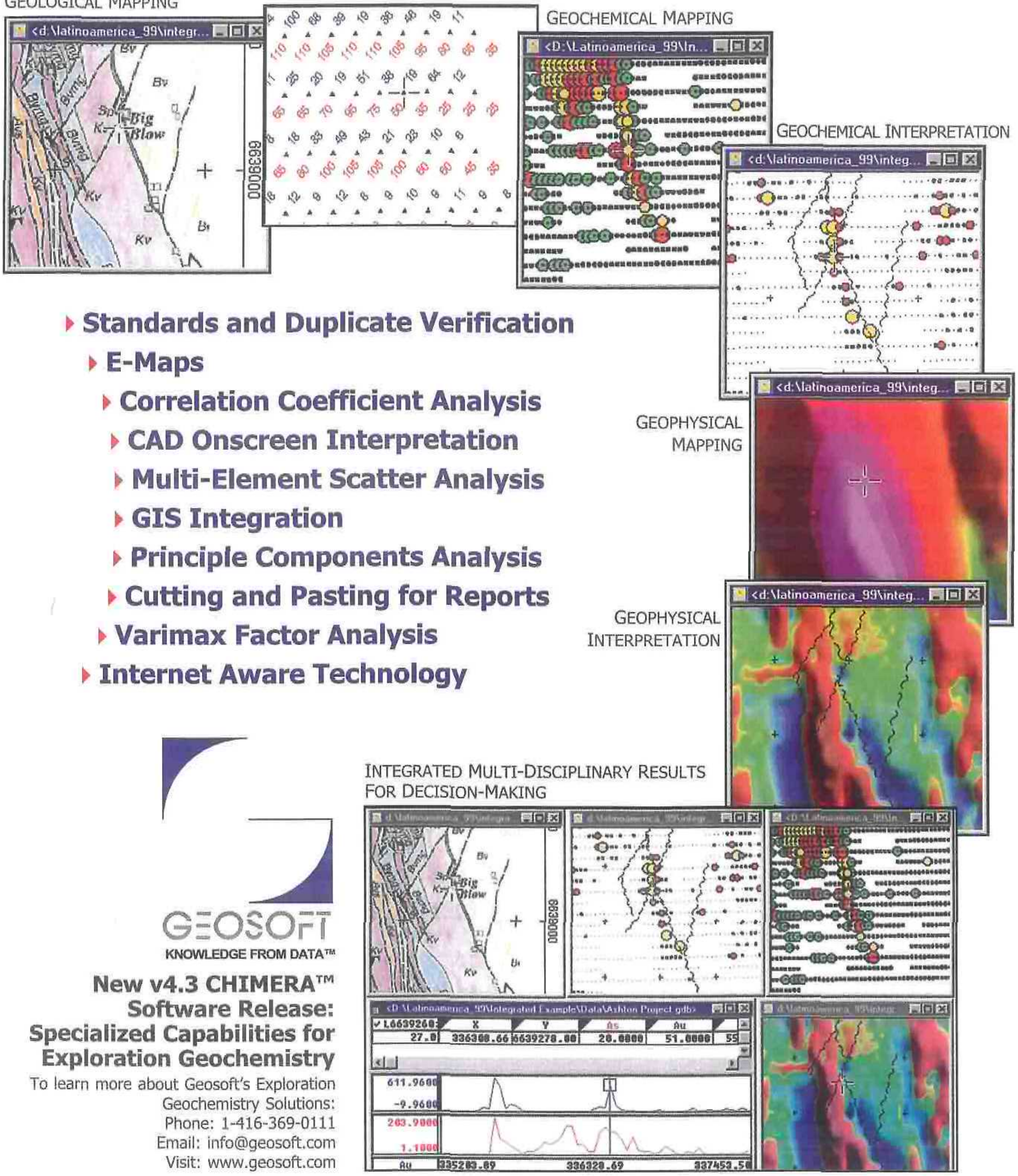
■ August 30–September 1, 2000, **Geoanalysis 2000: 4th International Conference on the Analysis of Geological and Environmental Materials,** Abbaye des Prémontrés, Pont à Mousson, Lorraine, France. INFORMATION: Jean Carignan, CRPG-CNRS, 15 rue Notre Dame de Pauvres, B.P. 20, 54501 Vandeouvre-lès-Nancy cedex, France, phone 33-3-83-59-42-17, fax 33-3-83-51-17-98.

■ September 3-8, 2000, **Goldschmidt 2000**. Oxford, UK. INFORMATION: P. Beattie, Cambridge Publications, Publications House, PO Box 27, Cambridge, UK CB1 4GL. TEL: 44-1223-333438, FAX: 44-1223-333438, E-mail: gold2000@campublic.co.uk.

■ November 13-16, 2000, **Annual Meeting of the Geological Society of America,** Reno, Nev. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ December 14 - 19, 2000, **Pacifichem 2000,** Honolulu. INFORMATION: Congress Secretariat, c/o American Chemi-

Continued on Page 21



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THE ASSOCIATION OF EXPLORATION GEOCHEMISTS APPLICATION FOR NON-VOTING MEMBERSHIP*

Please complete the section relevant to the class of membership sought and supply your address on this form. Mail the completed application, together with annual dues, to the address below.

*Details of requirements and application forms for **voting membership (fellowship)** can be obtained from the AEG website (http://www.aeg.org) or business office.

MEMBER

I ______________________ wish to apply for election as a Member of the Association of Exploration Geochemists. I am presently employed by:

______________________ as a ______________________.
(employer) (employment title)

I am actively engaged in scientific or technological work related to geochemical exploration and have been so for the past two years. Upon receipt of the Code of Ethics of the Association I will read them and, in the event of being elected a Member, agree to honour and abide by them. Witness my hand this_____day of__________19_____. ______________________
(Signature of applicant)

STUDENT MEMBER

I ______________________ wish to apply for election as a Student Member of the Association of Exploration Geochemists. I am presently engaged as a full-time student at ______________________, where I am taking a course in pure or applied science. Upon receipt of the Code of Ethics of the Association and in the event of being elected a Student Member agree to honour and abide by them. Witness my hand this_____day of__________19_____.

____
(Signature of applicant)

Student status must be verified by a Professor of your institution or a Fellow of the Association of Exploration Geochemists. I certify that the applicant is a full-time student at this institution.

______________________ ______________________
(Signature) (Printed Name and Title)

NAME AND ADDRESS

(to be completed by all applicants)

Name: ______________________
Address: ______________________
____
____
____

Telephone:
bus: ______________________
fax: ______________________
home: ______________________
email: ______________________

Annual Dues

All applications must be accompanied by annual dues. Select one or two below:

1	2000 member dues	US$	70	______
2	2000 student member dues		40	______
	If you require a receipt, include a self-addressed envelope and add		2	______
	If your check is not drawn from a U.S.A. or Canadian bank, add		15	______
			TOTAL	______

All payments must be in US funds. Payment by check, International Money Order, UNESCO Coupons, International Postal Orders, VISA and Master Card are acceptable. For users of VISA or Master Card, minor variations in your billing may reflect currency exchange rate fluctuations at time of bank transaction.

If you pay by charge card, please provide the following information: type: Master Card _____ VISA _____

Credit card account number:______________________ Expiration date: __________.

Name:______________________ Signature:______________________

Please note: Your completed form should be mailed to the Business Office of the Association and will be acknowledged upon receipt. The Admissions Committee reviews all applications and submits recommendations to Council, who will review these recommendations at the next Council Meeting or by correspondence. If no objection is raised the names, addresses and positions of candidates will be listed in the next issue of the Association Newsletter. If after a minimum of 60 days have elapsed following submission of candidate information to the membership no signed letters objecting to candidates admission are received by the Secretary of the Association from any Member, the Candidate shall be deemed elected, subject to the receipt by the Association of payment of required dues. Send completed application, together with annual dues to:

Association of Exploration Geochemists, P.O. Box 26099, 72 Robertson Road, Nepean, Ontario, CANADA K2H 9R0
TEL: (613) 828-0199, FAX: (613) 828-9288, email: aeg@synapse.net

Calendar of Events

Continued from Page 19

cal Society, 1155 16th St. N.W., Washington, D.C. 20036, fax: 202-872-6128. E-mail:pacifichem@acs.org.

■ December 15-19, 2000. **AGU Fall Meeting,** San Francisco, CA. INFORMATION: AGU Meeting Department, 2000 Florida Ave., NW, Washington, DC 20009, TEL: 202-462-6900. FAX: 202-328-0566. E-mail: meetings@kosmos.agu.org.

■ May 6-10, 2001, **20th International Geochemical Exploration Symposium: Geochemistry and Exploration in Latin America,** Santiago, Chile.

■ August 27-29, 2001,**The 6th Biennial Meeting Society For Geology Applied To Mineral Deposits: Mineral Deposits at the Beginning of the 21st Century,** Krakow, Poland. http://galaxy.uci.agh.edu.pl/~sga

■ November 5–8, 2001, **Annual Meeting of the Geological Society of America,** Boston, Massachusetts. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ October 27–30, 2002, **Annual Meeting of the Geological Society of America,** Denver, Colorado. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

■ November 2–5, 2003, **Annual Meeting of the Geological Society of America,** Seattle, Washington. INFORMATION: TEL 1-800-472-1988, meetings@geosociety.org.

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

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Deadlines for the Next Four Issues of EXPLORE

Contributors's deadlines for the next four issues of **EXPLORE** are as follows:

Issue	Publication date	Contributor's Deadline
108	July 2000	May 31, 2000
109	October 2000	August 31, 2000
110	January 2001	November 30, 2000
111	April 2001	February 28, 2001

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 David B. Smith, Secretary AEG, USGS, Box 25046, MS 973, Denver, CO 80225, 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.

FELLOW

Puig, Alvaro G.
Chief Geochemist
CODELCO Exploration
Santiago, CHILE

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Heimbach, Joseph E.
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Geochemist
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Wayville, SA, AUSTRALIA

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University of Quebec at Chicoutimi
Canton-Tremblay, PQ, CANADA

UPDATE TO AEG MEMBERS

Dear AEG Members,

As you know, our contract with Elsevier to publish the AEG journal ended Dec 31, 1999. Your association has a new journal set for publication in 2001 entitled Geochemistry: Exploration, Environment, Analysis (GEEA). We are now accepting papers for GEEA which will be published by the Geological Society of London (GSL) in partnership with us (at a LOW institutional price). We are in the final stages of creating the Editorial Board and policy matters. The AEG website will be updated shortly with such information. Our journal office is in the same location as previously:

c/o Marcia Scrimgeour, Editorial Assistant, GEEA,
72 Robertson Road, P.O. Box 26099
Nepean, ON K2H 9R0, CANADA
Tel: (613) 828-1222 Fax: (613) 828-2567
E-mail: geea@compmore.net

We have learned recently that Elsevier, who are continuing to publish the Journal of Geochemical Exploration on their own (they have rights to the title), have begun invoicing some members approximately US$ 200 for annual subscriptions to the Journal of Geochemical Exploration. This action by Elsevier is entirely independent of the Association of Exploration Geochemists and is not endorsed or supported by the AEG. You are under absolutely no obligation to pay: simply send an email to Elsevier (l.veenstra@elsevier.nl) stating that you have not placed any such order and decline it.

Just to remind you, your AEG membership for 2000 ($70) covers the cost of a hard-back book entitled "Drift Exploration in Glaciated Terrain" edited by Beth McClenaghan, Steve Cook, and Peter Bobrowsky. This book will be sent to you in the second half of 2000 and is being published by our (not-for-profit) partner, the GSL. Your membership fee also includes **EXPLORE** and any other services the AEG can offer you.

We regret the confusion that Elsevier's action has caused our membership. If you have further questions, please contact the AEG business office at:

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