

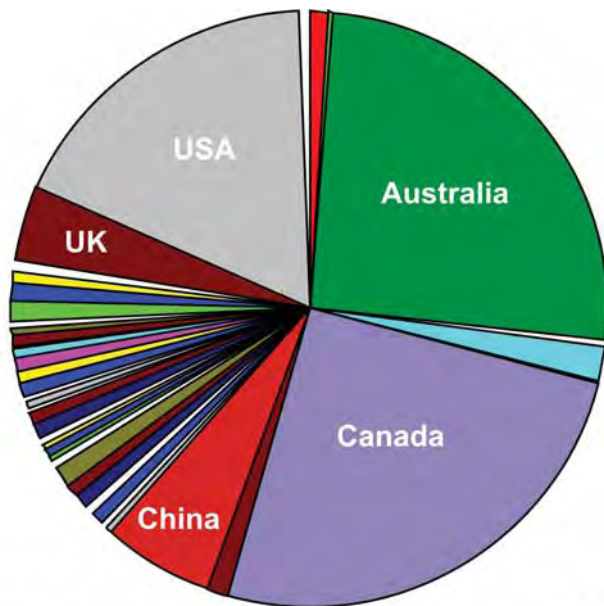


President's Message

Paul Morris

I trust that you have all experienced an enjoyable festive season and are looking forward to 2011, which will, of course, include the 25th IAGS in Rovaniemi, Finland.

It is likely that the last contact you received from AAG in 2010 was the membership renewal notice for 2011, and I trust that you have signed up again with our Association. As of late 2010, the membership of the Association stood at 512, with members drawn from 50 countries. This number is clear evidence that AAG is truly an international organisation. Despite drawing members from far and wide, the accompanying pie diagram shows that five countries (USA, Canada, Australia, China and the UK) account for about 70% of AAG's membership.



AAG membership according to country, December 2010 (n = 512)

Of concern is that there are few members from low-income or developing countries, despite the fact that many of these countries support active mineral exploration programs which usually involve applied geochemistry programs often involving locals. Anecdotal evidence from geochemists who work in these countries (yet are domiciled elsewhere) indicates that although some of the locals would like to belong to AAG and receive the Association's benefits, the \$US 100 annual membership fee is prohibitive. Accordingly, AAG will now trial subsidised membership for applied geochemists in low-income or developing countries, as set out in the panel on page 12 of this edition of **EXPLORE**. As well as offering a subsidy, there is also the opportunity for fully-paid AAG members to subsidise any new member to AAG at the full \$US 100 due. I am hopeful that this approach will lead to not only an increase in AAG's membership, but will also mean that there is a greater representation from more countries.

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Newsletter for the Association of Applied Geochemists

This matter of subsidised membership was discussed at the August 2010 Council meeting, at which the revised committee structure for AAG was endorsed (summarised in **EXPLORE** 149). In line with this, a revamp of the inside back cover of this edition of **EXPLORE** will be commenced to reflect not only the new committee structure, but also the new councillors and office bearers who have agreed to help steer the Association. At the last Council meeting in November 2010, discussion ensued to find a replacement for Kurt Kyser as AAG's Distinguished Lecturer for 2011-12, and an announcement about this will appear on the AAG website in the near future. The website will also be the place to find out about topics being offered in the Distinguished Lecturer program, as well as planned itineraries.

Finally, yet another reminder about the 25th IAGS in Rovaniemi. The second circular is now available from the website, and I would encourage you to visit www.iags2011.fi. By the time you receive this edition of **EXPLORE**, it will be just over 6 months until the Symposium. Pertti Sarala and his group have produced a second circular for the meeting that can be downloaded from the conference website. At two pages, it's suitable in terms of printing off a few copies and distributing them at any meeting you may be attending in the near future.

Paul Morris
AAG President



Notes from the Editor

The March 2011 issue of **EXPLORE** contains one technical article on VMS deposits in the Chahgaz region of Iran written by Fardin Mousivand, Ebrahim Rastad, Jan Peter and Michael Solomon. The article describes the senior author's PhD research that was supported in part by an ioStipend, sponsored by ioGlobal and Acme Analytical Laboratories Ltd.

Many thanks to all that contributed material to **EXPLORE** 150: Matt Leybourne, Michelle Trommelen, Dave Smith, Paul Morris, Steve Amor, Graham Closs, and for the scientific and technical editing by Heather Campbell, Geological Survey of Canada.

Beth McClenaghan



EXPLORE NEWSLETTER wishes to thank our Corporate Sponsors for their support



Age, tectonic setting, lithogeochemistry and hydrothermal alteration of volcanogenic massive sulfide mineralization in the Chahgaz region, South Sanandaj-Sirjan zone of Iran

Introduction

Iran hosts several volcanogenic massive sulfide (VMS) deposit types that occur within different tectonic assemblages formed during discrete time periods (Mousivand et al. 2008a). The most prospective area for VMS exploration in Iran is the Sanandaj-Sirjan zone (SSZ) (Fig. 1), particularly the southern part of this zone.

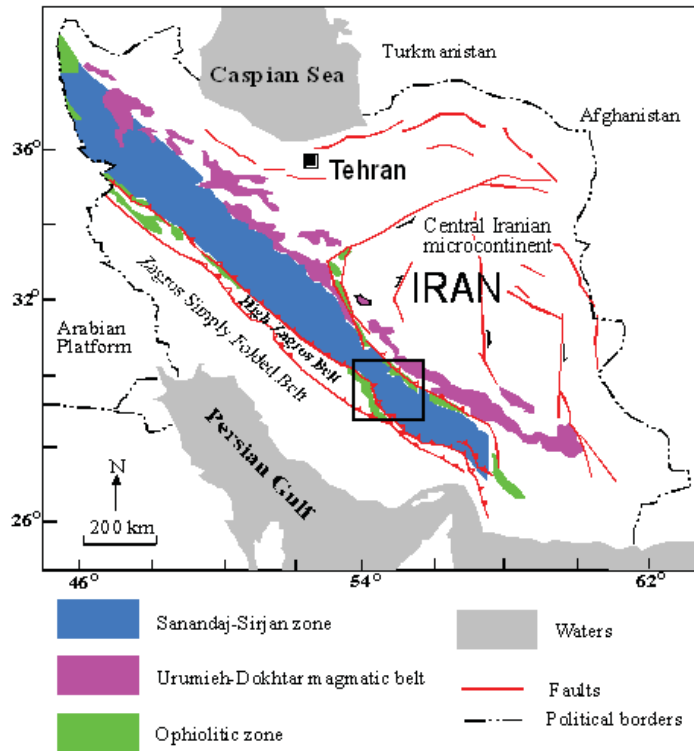


Figure 1. Tectonic element distribution map of the Zagros Orogen (Alavi 1994); black outline shows location of the Bavanat-Chahgaz region within southern SSZ shown in Figure 2.

The Chahgaz region of the SSZ (Fig. 2) is of the most important regions in the south SSZ for VMS exploration and hosts several deposits and occurrences, including the economically important Chahgaz Zn-Pb-Cu deposit (Fig. 2) which was first recognized as a VMS-type deposit by Mousivand et al. (2008b).

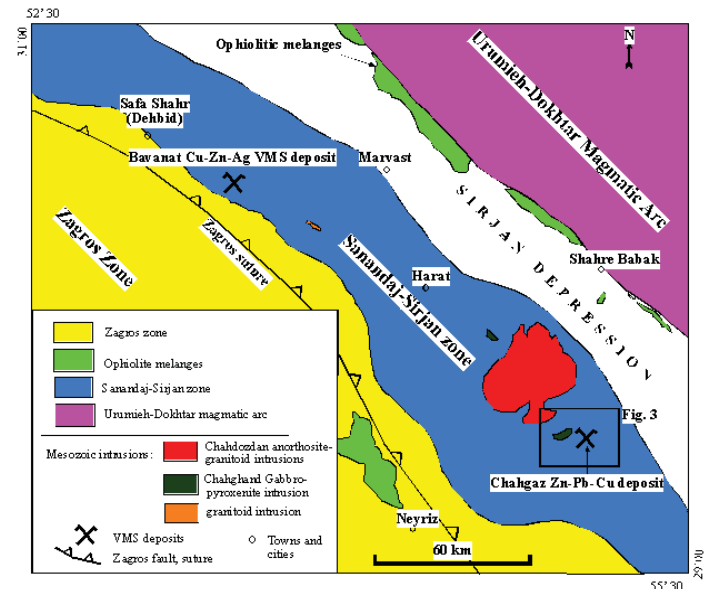


Figure 2. Simplified geological map of the Bavanat-Chahgaz region, based on the Eqlid, Anar and Neyriz 1:250000 scale maps (e.g. Houshmandzadeh & Soheili 1990; Soheili 1981; Sabzehei et al. 1993), showing the location of the Bavanat Cu-Zn-Ag and Chahgaz Zn-Pb-Cu VMS deposits within the SSZ. Black box shows location of the area shown in Figure 3.

Iran has an arid to semi-arid climate with much rock outcrop exposure. For this reason, surficial and lithogeochemical techniques are effective and commonly used in mineral exploration. Host rocks to the Chahgaz deposits are dominantly fresh to weakly weathered, and close to the deposits the rocks have been intensely hydrothermally altered.

Mining in Iran dates back to at least 5000 years B.C., and most mineral deposits in the country show indications of ancient mining (e.g. Momenzadeh 2004). The Chahgaz deposit, one of the largest VMS deposit in the country, was (re) discovered by tracing evidence of ancient mining activities, and modern mining at this deposit commenced in 2007.

Detailed geological and geochemical studies on the Chahgaz deposit were recently completed by Mousivand (2010). Host rock and mineralized samples were analyzed for major, trace and rare earth element contents by inductively coupled-plasma mass spectrometry and inductively coupled-plasma atomic emission spectrometry (ICP-MS/AES) methods at Acme Analytical Laboratories Ltd. (Vancouver, Canada). These data were used to determine rock type, petrotectonic setting, chemostratigraphy, hydrothermal alteration style

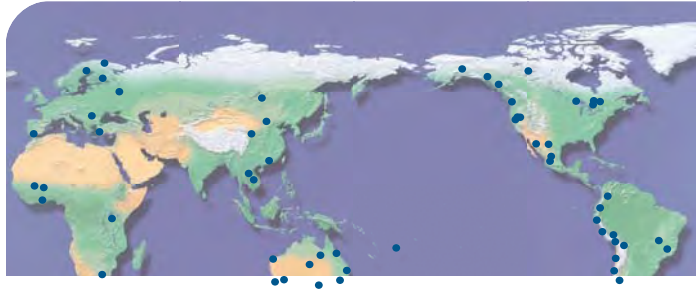
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Age, tectonic setting, lithogeochemistry... *continued from page 2*

and intensity, and sulfide metal zonation. Herein, we provide a brief synopsis of our research on VMS mineralization in the Chahgaz region, including its age, tectonic setting, metal zonation and wallrock alteration.

Tectonic setting

The Tethyan orogen was caused by the collision of Eurasia with Gondwanaland (Sengör & Natal'in 1996). The Zagros orogenic belt is part of the Tethyan orogen (e.g. Berberian & King 1981; Sengör 1991; Alavi 1994), and consists of four parallel tectonic assemblages from southwest to northeast: (1) the Zagros simply folded belt, (2) High Zagros belt; (3) the Sanandaj-Sirjan zone, and (4) the Urumieh-Dokhtar magmatic assemblage (Alavi 1994) (Fig. 1). The SSZ is 150-250 km wide and extends from the extreme northwest of Iran to the southeast for a strike distance of over a 1500 km (Fig. 1). The SSZ consists of regionally metamorphosed and deformed Mesozoic volcano-sedimentary rocks that are spatially associated with abundant deformed and undeformed Mesozoic plutons. Berberian (1983) considered the SSZ to be a paired Mesozoic magmatic-arc and Tertiary fore-arc.

VMS mineralization in the Chahgaz area

The Chahgaz region, situated in the southern part of the SSZ, encompasses an area 100 km by 50 km (Fig. 2). The Chahgaz Zn-Pb-Cu VMS deposit is located 60 km south of

the city of Shahre-Babak and 174 km south east of the Bavanat Cu-Zn-Ag Besshi- or pelitic mafic-type VMS deposit, the only other economically significant VMS deposit in the area (Mousivand 2003; Mousivand et al. 2007; Mousivand et al. 2008b; Mousivand 2010; Fig. 2). The Chahgaz deposit occurs within a Middle Jurassic metamorphosed and highly deformed bimodal volcano-sedimentary sequence (Mousivand et al. 2010) (Figs. 3 and 4). The immediate host rocks to the deposit consist of rhyodacitic volcanoclastics and carbonaceous to tuffaceous shales (Fig. 4).

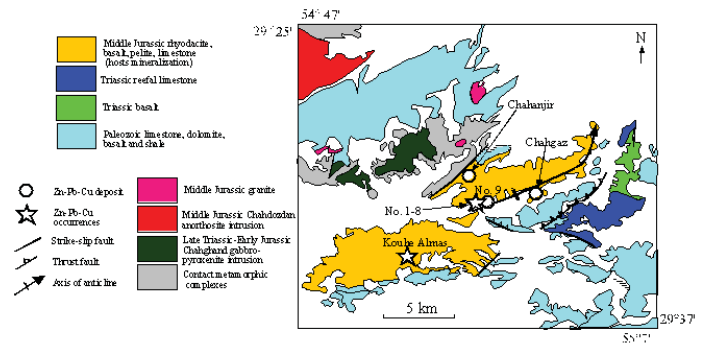


Figure 3. Geological map of the Chahgaz area (based on the geological map of Neyriz; modified from Sabzehei et al. 1993), showing the locations of the Chahgaz deposit and occurrences in the Chahgaz volcano-sedimentary complex.

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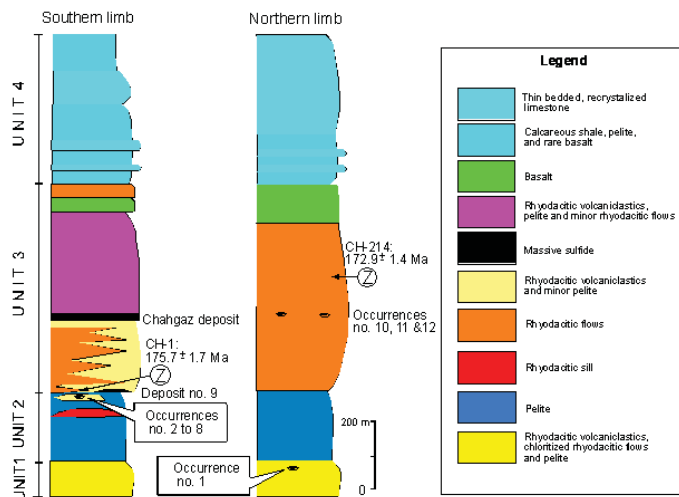


Figure 4. Schematic stratigraphic sections for the northern and southern limbs of the Chahgaz anticline. Z= U-Pb zircon sample locality.

The Chahgaz, Chahanjir and Number 9 deposits, and numerous other occurrences (Kouhe Almas, Occurrences 1 through 8) are characterized by stratabound and stratiform massive sulfide mineralization (Figs. 3 and 4), predominantly in the southern limb (Fig. 4) of the Chahgaz anticline. The Chahgaz ore horizon is 10-30 m thick and has a strike length of over 1 km. The deposit contains approximately 6 Mt grading 15 wt.% Zn, 10 wt.% Pb, 1 wt.% Cu, up to 100 g/t Ag and up to 0.58 g/t Au (Mousivand 2010) and was delineated by induced polarization and resistivity ground geophysical surveys and surficial and lithochemochemical chip sampling surveys.

Mineralization at Chahgaz is comprised predominantly of stratiform, tabular and lenticular massive sulfide lenses that occur at a single stratigraphic horizon; each of these lenses is underlain by a vein network comprising a discrete feeder zone. Within the sulfide lenses, mineralization styles include massive, semi-massive, banded and laminated; in the feeder zones, the mineralization is disseminated and also occurs in veins. Mineralogy of the sulfide lenses is predominated by pyrite, sphalerite, galena, chalcopyrite, arsenopyrite, tetrahedrite, with minor bornite, pyrrhotite, marcasite, and secondary covellite, malachite, cerussite, smithsonite, hematite and goethite. Massive sulfides consist dominantly of sphalerite and/or pyrite, whereas banded mineralization is comprised primarily of sphalerite-galena-, pyrite-, and minor chalcopyrite-rich bands. Gangue minerals are dominated by sericite, chlorite, quartz, calcite and minor barite. Semiconformable and disconformable pipe-like bodies of hydrothermally altered wall rock occur stratigraphically below the massive sulfides and these are sericite-rich, with minor chlorite-rich and silicified zones. Magnetite- and pyrite-rich hydrothermal sediments (exhalites) occur laterally away from the deposit lenses along the same mineralized stratigraphic horizon.

The orebodies and hydrothermally altered and unaltered host rock strata have all been deformed and show evidence of cataclasis and extension; banded and laminated mineral-

ization has been boudinaged, crenulated and folded (Mousivand 2010). Two major regional metamorphic events and three main phases of deformation have been recognized in the area (e.g. Orang 2010). These Late Mesozoic to Cenozoic Barrovian-type metamorphic events occurred at upper amphibolite and greenschist facies, respectively. The two deformational events (D1, D2) have imparted two fabrics (S1, S2) (accompanied by local shearing) foliations in the rock sequences, respectively. A final (D3) shearing and mylonitic event overprinted the earlier foliations, imparting an S3 fabric. Finally, during the Cenozoic, extensional events fractured the rocks (Orang 2010).

Mineralogic and metal zoning

From the stratigraphic base to the stratigraphic top of the massive sulfide lenses, the mineral assemblages, listed in order of decreasing abundance, are: pyrite-chalcopyrite-arsenopyrite-pyrrhotite; pyrite-chalcopyrite-sphalerite-pyrite-tetrahedrite-arsenopyrite; sphalerite-galena-pyrite-chalcopyrite-tetrahedrite; and pyrite-chalcopyrite-sphalerite-galena. Chalcopyrite is generally more abundant in and near the stratigraphic base of the lenses, whereas sphalerite and/or galena are more abundant toward the stratigraphic top of the lenses. This is reflected by a decrease in Cu contents and an increase in Zn and Pb contents from the base to the top of the lenses. However, this metal zoning is not universally present as chalcopyrite is abundant in some banded ores.

Hydrothermal Alteration

Hydrothermal wallrock alteration in the rhyodacitic flows and volcanoclastic rocks and pelites occurs as: 1) semiconformable zones stratigraphically below and within the ore horizons and 2) disconformable or pipe-like zones stratigraphically beneath the orebodies. Alteration minerals include sericite, chlorite, phengite, quartz, pyrite, calcite, dolomite, ankerite, and the clay minerals halloysite, illite, montmorillonite and paragonite.

Based on petrographic studies, x-ray diffraction (XRD) analysis, and short-wavelength infrared spectrometry using a Portable Infra-red Mineral Analyzer (PIMA) (e.g., Herrmann et al. 2001), several wallrock alteration zones are recognized in the Chahgaz deposit. The composition of alteration minerals was determined by a Cameca SX 100 electron probe micro-analyzer (EPMA) at the University of Tasmania. Samples were collected at regular intervals from five cross sections perpendicular to the ore horizon. The following zonation is recognized in the alteration pipes, immediately below the orebodies and progressing peripherally outward from the distal edge of the massive sulfide lenses: 1) quartz-chlorite-sericite-phengite-pyrite; 2) chlorite-phengite-albite; 3) phengite-sericite-chlorite.

The proximal alteration is not extensive, but the chlorite-phengite-albite alteration typically occurs peripheral to the core of the feeder zone and also occurs up to 50 m stratigraphically above the ore horizon (in the hanging wall). The most widespread alteration style at Chahgaz is the distal

Age, tectonic setting, lithochemistry... *continued from page 5*

(weakest) phengite-sericite-chlorite alteration zone that extends up to 200 m stratigraphically below and through the ore horizon, and more than 2 km along strike from mineralization. Chlorite compositions progress from Fe-Mg chlorites (16 wt% Fe) at the outermost margins of the alteration zones, to a more Fe-rich (21 wt% Fe) chlorite in the most intense core of the alteration pipe. Sericite is Ba-rich along the ore horizon and within the core of the alteration system. At the Number 9 deposit there is a carbonate-quartz-sericite-pyrite alteration zone developed in the stringer zone. This zone contains quartz-carbonate veins-veinlets and disseminated quartz, pyrite and sericite in a groundmass of Fe-Mg-rich carbonates. Carbonate minerals are predominantly dolomite and minor calcite.

Petrochemistry of volcanic rocks

Major, trace, and rare earth element analyses were conducted on representative least altered samples of the Chahgaz footwall and hanging wall felsic volcanic flows. Furthermore, because the volcanic and volcanoclastic rocks in the vicinity of the Chahgaz deposit are strongly altered, we have relied primarily on the immobile major element TiO₂, the high field strength elements (HFSE) Zr, Nb and Y, and the rare earth elements (REE) to characterize the primary compositions. We have not used most of the major elements or low field strength elements (LFSE), which substitute for Na, K, and Ca, due to their potential mobility during hydrothermal alteration and metamorphism.

The host felsic volcanic flows plot in the rhyolite and dacite

fields of the SiO₂ versus Zr/TiO₂ plot of Winchester and Floyd (1977). Furthermore, the volcanic rocks show dominantly subalkaline, rhyolitic compositions on this discriminant diagram (Fig. 5a), display calc-alkaline affinities on an Y versus Zr diagram of Barrett and MacLean (1999) (Fig. 5b), and indicate volcanic arc (I-type) character on the Nb versus Y plot of Pearce et al. (1984) (Fig. 5c). Chondrite-normalized (Sun & McDonough 1989) rare earth element (REE) profiles of the footwall and hanging wall rhyodacites from the Chahgaz host sequence are shown in figure 5d. REE patterns for the rhyodacites are steep, with only a small negative Eu anomaly (Fig. 5d), which suggests that little plagioclase fractionation took place (e.g. Cullers & Graf 1984). The primitive mantle-normalized patterns of the rhyodacites (Fig. 5e) show LREE enrichment and negative Nb, Eu, and Ti anomalies on a primitive mantle-normalized spider diagram of Sun and McDonough (1989); such Nb and Ti anomalies are characteristic of arc or subduction zone-influenced rocks (Murphy 2007). The rhyodacites have slightly concave upper continental crust-normalized (McLennan 2001) patterns, with variably developed Eu anomalies (Fig. 5f), likely indicating derivation from (or extensive interaction with) upper crust (e.g. Wood and Williams-Jones 1994).

U-Pb zircon geochronology

Age dating was conducted using a laser-ablation quadrupole ICP-MS at the University of Tasmania. Analyses were conducted using both laser and solution modes of the

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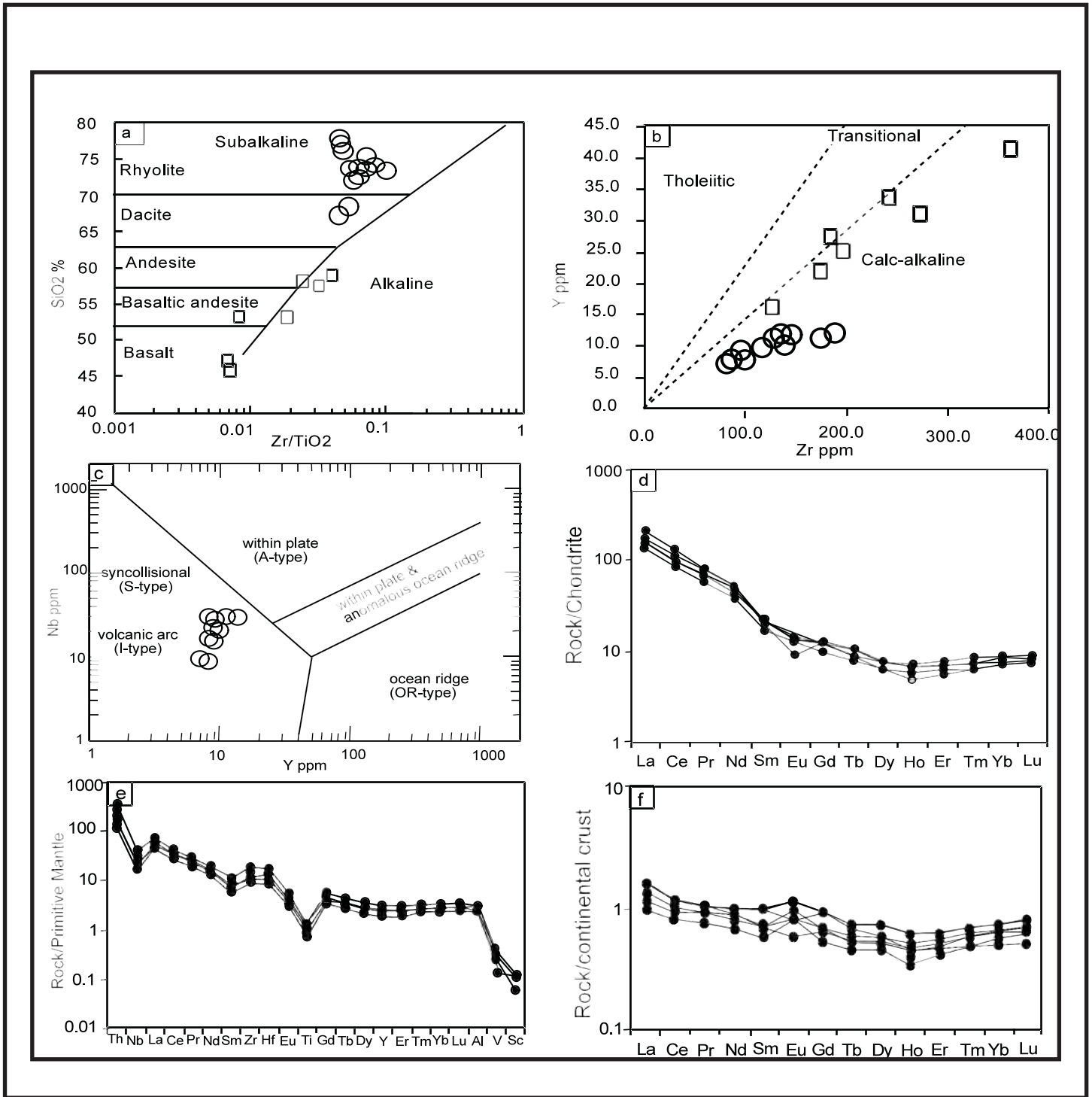


Figure 5. (a) SiO_2 versus Zr/TiO_2 diagram of Winchester and Floyd (1977), indicating rhyolitic composition for the rhyodacite samples (circles), and basaltic to andesitic composition for basalts (rectangles); (b) bivariate plot of Y versus Zr (after Barrett & MacLean 1999) showing dominantly calc-alkaline magmatic affinity for the footwall and hanging wall rhyodacite rocks of the Chahgaz deposit; (c) Nb versus Y plot (after Pearce et al. 1984) illustrating the volcanic arc-type (I-type) nature of the samples; (d) chondrite-normalized (Sun & McDonough 1989) REE plot of the footwall and hanging wall rhyodacites showing steep patterns, with only a small negative Eu anomaly for the rhyodacite samples; (e) Primitive mantle-normalized multi-element plots for the footwall and hanging wall rhyodacites (primitive mantle values from Sun & McDonough 1989) showing characteristic calc-alkaline patterns; and (f) upper continental crust-normalized REE plots for the footwall and hanging wall rhyodacite rocks (upper crust values from McLennan, 2001); the flat patterns relative to upper crust (f) indicate derivation from (or extensive interaction with) upper crust.

Age, tectonic setting, lithochemochemistry... *continued from page 7*

instrument; for further details of the method, see Meffre et al. (2008). Three samples for geochronology were taken from both surface outcrops and underground workings of the Chahgaz deposit. Samples are from the stratigraphic footwall and hanging wall rhyodacitic flows from the southern and northern limbs (Fig. 4), respectively, as well as the host rhyodacitic volcanoclastic rocks. The sample from the footwall of the Chahgaz deposit is a feldspar porphyry flow which is at the same stratigraphic horizon as stratiform mineralization of the Number 9 deposit (Fig. 4). The sample 100 meters stratigraphically above the Chahgaz deposit ore horizon (Fig. 4) from the hanging is also from a feldspar porphyry flow.

The U-Pb dating of stratigraphic footwall and hanging wall rhyodacitic flows from the southern and northern limbs yield concordant ages of 175.7 ± 1.7 Ma and 172.9 ± 1.4 Ma, respectively. The age of the youngest zircon from the volcanoclastic host rock is 177.0 ± 1.8 Ma, and the mean age of all zircons in the volcanoclastic host rocks is 184.45 ± 0.91 Ma which indicates that the ore horizon is about 8.75 million years younger than the footwall. The ages of the stratigraphic footwall and hanging wall rhyodacitic flows show that VMS mineralization at the Chahgaz deposit formed between 175.7 ± 1.7 and 172.9 ± 1.4 Ma. However, the other deposits and occurrences formed at 175.7 ± 1.7 Ma (deposit no. 9) and earlier (Number 1 through Number 8 occurrences; Fig. 4).

Collectively, the data give a Middle Jurassic age (mean age of the footwall and hanging wall samples = 174.0 ± 1.2 Ma) (Fig. 6) for the mineralization at the Chahgaz deposit, based on the age of the enclosing rhyodacitic flows.

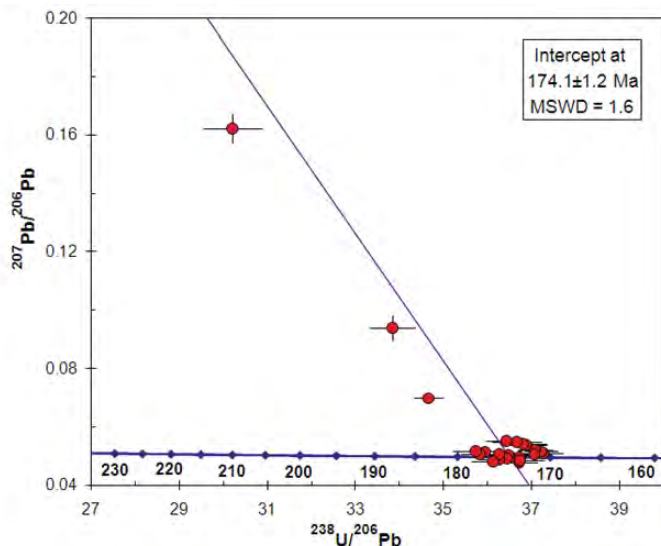


Figure 6. U-Pb zircon concordia plot for zircons from the footwall rhyodacite samples from the NW and SE limbs of the Chahgaz anticline. Data point error crosses are 1 sigma.

Discussion

VMS mineralization in the southern SSZ is hosted by volcanic and sedimentary rocks, and both mineralization and host rocks are of Middle Jurassic age. The Chahgaz deposit and several occurrences occur along three discrete stratigraphic horizons in a sequence of predominantly felsic flows

and volcanoclastic rocks intercalated with pelites.

The Chahgaz rhyodacitic flows show enrichments in both HFSE and REE, which is a common feature of felsic volcanic rocks associated with VMS deposits (e.g. Lesher et al. 1986; Lentz 1998; Piercey et al. 2001; Dusel-Bacon et al. 2004). The rhyodacite volcanic flows show calc-alkaline affinities and subduction and arc-related features. These characteristics are similar to those for the Late Triassic-Early Jurassic Chahghand gabbro-pyroxenite and the Middle Jurassic Chahdozdan anorthosite intrusions in the area (Fig. 3; e.g., Jamshidi 2003; Shahabpour 2005; Sheikholeslami et al. 2008).

The Chahghand intrusion (e.g. Otrodi 2006; Otrodi et al. 2006) shows transitional to calc-alkaline and within-plate geochemical characteristics. However, an intracontinental rift setting for the intrusion has been suggested by Otrodi et al. (2006). Sheikholeslami et al. (2008) suggested that emplacement of the Chahdozdan and Chahghand intrusions occurred within extensional basins due to oblique subduction at 167 and 159 Ma, respectively. Fazlnia et al. (2007, 2009) proposed that the opening and expansion of the Neotethys Ocean occurred in the Middle Jurassic (173.0 ± 1.6 Ma) at the time of emplacement of the Chahdozdan anorthosite intrusion, and based on age of the trondhjemitic, suggested that the onset of its subduction beneath the southern part of the SSZ took place in the Volgian, Late Jurassic (147.4 ± 0.76 Ma). However, the calc-alkaline nature of the Chahdozdan and Chahghand intrusions (e.g., Sheikholeslami et al., 2003) cannot be attributed to the opening of the Neo-Tethyan ocean, as suggested by Fazlnia et al. (2009), but rather may be related to the same subduction event as the Chahgaz volcanic rocks.

Based on the geological relationships and geochemical features, we suggest that both the Chahgaz volcanic rocks and the Mesozoic intrusions were emplaced during a discrete subduction arc-magmatism phase. The age and geochemical characteristics of the Chahgaz host volcanic rocks suggest that they are related to the subduction of Neo-Tethys oceanic crust beneath the Central Iranian microcontinent in the Mesozoic (e.g. Ghasemi & Talbot 2006; Omrani et al. 2008). Our data show that arc-related calc-alkaline bimodal volcanism in the Chahgaz area occurred at 174.0 ± 1.2 Ma, approximately contemporaneous with emplacement of the Chahdozdan anorthosite intrusion, in an arc pull-apart basin. We suggest that the bimodal volcanism at Chahgaz area occurred in a rifted continental margin arc basin and was accompanied by VMS mineralization.

Conclusions

The Chahgaz region of the Sanandaj-Sirjan zone in southern Iran is highly prospective for VMS deposits. This region hosts the Chahgaz Zn-Pb-Cu VMS deposit which occurs within a metamorphosed sequence of bimodal volcanic and sedimentary rocks. This deposit is hosted by rhyodacitic volcanoclastic rocks and is underlain and overlain by rhyodacitic flows, volcanoclastics and pelites. The rhyodacitic flows are calc-alkaline, and show REE and trace element

Age, tectonic setting, litho geochemistry... *continued from page 8*

features characteristic of arc magmatism. Zircons extracted from stratigraphic footwall and hanging wall rhyodacitic flows of the Chahgaz deposit yield concordant U-Pb ages of 175.7 ± 1.7 and 172.9 ± 1.4 , respectively, and a mean age of 174 ± 1.2 Ma. This time period is interpreted to represent the age of mineralization of the Chahgaz deposit. This time period in the Middle Jurassic is suggested to be a time of significant VMS deposit formation within rifted or extensional basins formed during Neo-Tethyan oblique subduction-related arc volcano-plutonism in the SSZ. The VMS mineralization exhibits pronounced metal zoning and hydrothermal alteration.

Acknowledgments

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Geological Survey of Canada contribution number 20100375.

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Of AAG's current membership, approximately 70% come from three countries (Canada 26%, Australia 25% and the USA 18%), yet developing countries (as defined by the OECD's Development Assistance Committee, DAC) account for only eight AAG memberships, less than 2% of the total membership. In order to support applied geochemists in developing countries, AAG offers subsidised membership to those who fulfil certain criteria. Subsidised membership includes provision of **EXPLORE**, Geochemistry: Exploration, Environment, Analysis (GEEA), and **ELEMENTS**. Developing countries are those shown in the list on the AAG website, which is drawn from a compilation by the Organisation for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC) (www.oecd.org).

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Least Developed Countries	Other Low Income Countries (per capita GNI < \$935 in 2007)	Lower Middle Income Countries and Territories (per capita GNI \$936-\$3 705 in 2007)	Upper Middle Income Countries and Territories (per capita GNI \$3 706-\$11 455 in 2007)
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Angola	Ghana	Algeria	Antigua and Barbuda ¹
Bangladesh	Kenya	Armenia	Argentina
Benin	Korea, Dem. Rep.	Azerbaijan	Barbados ²
Bhutan	Kyrgyz Rep.	Bolivia	Belarus
Burkina Faso	Nigeria	Bosnia and Herzegovina	Belize
Burundi	Pakistan	Cameroon	Botswana
Cambodia	Papua New Guinea	Cape Verde	Brazil
Central African Rep.	Tajikistan	China	Chile
Chad	Uzbekistan	Colombia	Cook Islands
Comoros	Viet Nam	Congo, Rep.	Costa Rica
Congo, Dem. Rep.	Zimbabwe	Dominican Republic	Croatia
Djibouti		Ecuador	Cuba
Equatorial Guinea		Egypt	Dominica
Eritrea		El Salvador	Fiji
Ethiopia		Former Yugoslav Republic of Macedonia	Gabon
Gambia		Georgia	Grenada
Guinea		Guatemala	Jamaica
Guinea-Bissau		Guyana	Kazakhstan
Haiti		Honduras	Lebanon
Kiribati		India	Libya
Laos		Indonesia	Malaysia
Lesotho		Iran	Mauritius
Liberia		Iraq	*Mayotte
Madagascar		Jordan	Mexico
Malawi		Kosovo ³	Montenegro
Maldives		Marshall Islands	*Montserrat
Mali		Micronesia, Federated States	Nauru
Mauritania		Moldova	Oman ¹
Mozambique		Mongolia	Palau
Myanmar		Morocco	Panama
Nepal		Namibia	Serbia
Niger		Nicaragua	Seychelles
Rwanda		Niue	South Africa
Samoa		Palestinian Administered Areas	*St. Helena
São Tomé and Príncipe		Paraguay	St. Kitts-Nevis
Senegal		Peru	St. Lucia
Sierra Leone		Philippines	St. Vincent and Grenadines
Solomon Islands		Sri Lanka	Suriname
Somalia		Swaziland	Trinidad and Tobago ²
Sudan		Syria	Turkey
Tanzania		Thailand	Uruguay
Timor-Leste		*Tokelau	Venezuela
Togo		Tonga	
Tuvalu		Tunisia	
Uganda		Turkmenistan	
Vanuatu		Ukraine	
Yemen		*Wallis and Futuna	
Zambia			

*Territory.

(1) Antigua & Barbuda and Oman exceeded the high income country threshold in 2007. In accordance with the DAC rules for revision of this List, both will graduate from the List in 2011 if they remain high income countries until 2010.

(2) Barbados and Trinidad & Tobago exceeded the high income country threshold in 2006 and 2007. In accordance with the DAC rules for revision of this List, both will graduate from the List in 2011 if they remain high income countries until 2010.

(3) This does not imply any legal position of the OECD regarding Kosovo's status.





Exploration Geochemist - Ivanhoe Australia

Ivanhoe Australia is focused on the exploration and development of its portfolio of Cu-Au-U-Mo-Re projects situated near Mt Isa, Queensland, within one of the world's richest mining districts.

In 2008 we successfully listed on the Australian Stock Exchange and subsequently discovered Merlin, the world's highest grade Mo-Re deposit. In 2010 we raised an additional \$269 million, purchased the Osborne Cu-Au mine and commenced development on Merlin. We are currently assessing a further six advanced IOCG Cu-Au projects for mining. Our tenements and applications cover more than 6,000 km² of highly prospective ground, and include well over 300 significant prospects that require evaluation for Cu, Au, Mo, Re, Pb, Zn, Co and U. There is excellent potential for further discoveries, and exploration is well funded with the 2011 exploration budget being over \$20 million.

We are seeking an **Exploration Geochemist** to work from our exploration site south of Cloncurry. You will report to the Principal Geoscientist or Exploration Manager based at the project. We have a large, multi-national exploration team within which mentoring and cross-pollination of ideas is actively promoted. There is also scope for future work and interaction with other subsidiaries of the parent company Ivanhoe Mines (Asia, South America and Africa). More experienced candidates are also encouraged to apply and will be considered for the position of Chief Geochemist.

Required skills and experience:

- Over 3 years relevant exploration experience. Experience in Cu-Au systems is an advantage.
- A BSc Geology degree. A higher qualification (Honours, Masters or PhD) is an advantage.
- A good leader and team player with the ability to build and lead efficient sampling teams.
- The ability to plan and manage regional- and prospect-level geochemical programs.
- Experience with a wide range of survey styles, preferably including lag, stream, soil and organic sampling, portable XRF surveys and RAB/Aircore drilling.
- Experience in regolith mapping, litho-geochemistry or semi-arid environments are all advantages.
- Proficiency with relevant GIS, database and geochemical software.
- Skilled in analysing and interpreting geochemical data.
- Experience with validating, levelling and organising large geochemical databases
- Able to mentor the exploration teams evaluation and integration of geochemical data.
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AAG Councillors 2011-2012

John Carranza

John M. Carranza obtained a BSc degree in geology (Adamson University, Manila, Philippines) in 1983, a MSc degree (with distinction) in mineral exploration (International Institute for Geo-Information Science and Earth Observation, Enschede, Netherlands) in 1994 and a PhD degree in GIS-based mineral potential mapping (Delft University of Technology, Delft, Netherlands) in 2002. He started his professional career in 1983 as a geologist in the Bureau of Mines and Geosciences of the Philippines where he was involved with geological mapping, stratigraphic studies, geological hazard mapping, evaluation of industrial rocks/minerals and geochemical exploration for gold. His work on exploration geochemistry led to recognition of a previously unknown mineralized area in a Quaternary volcanic terrane in Bicol Region of the Philippines. He received the 1998 ITC Research Award for his paper on catchment-basin analysis of stream sediment geochemical anomalies.



In 2001-2003, he was a Researcher in the Earth Systems Analysis (ESA) department of ITC where he is involved with (a) research in developing geospatial data infrastructure for mineral resource management, (b) teaching at post-graduate level and (c) supervising MSc and PhD students. Since 2003 to the present, he is Assistant Professor in the ESA depart-

ment of ITC with more-or-less similar teaching and research tasks as his Researcher appointment. He has supervised and led to graduation of 4 PhD students and at least 25 MSc students.

John's research interests include GIS-based mineral potential mapping, geological/mineral remote sensing, spatial predictive modeling of geo-objects, and exploration/environmental geochemistry. He has published more than 45 papers in international peer-reviewed geoscience journals and more than 40 papers in international conference proceedings. He has written and published a book on Geochemical Anomaly and Mineral Prospectivity Mapping in GIS.

Patrice de Caritat



Patrice de Caritat obtained his university degrees in geology from Belgium (Hons) and Australia (PhD). His Hons thesis was on the geochemical and petrographic characterisation of a scheelite-bearing skarn in Calabria, Italy. His PhD focused on the diagenetic evolution of clastic sediments in the Denison Trough,

Queensland, and on compactional fluid flow. Freshly graduated, he took up a brief industry supported Post-Doctoral Fellowship at the Australian National University, working on the geodynamic evolution of eastern Australian basins, then a 3-year Post-Doc at the University of Calgary, Canada, where he studied water-rock interaction in the Western Canada Sedimentary Basin. Subsequently, Patrice took up a Senior Research Scientist position at the Geological Survey of Norway, working mostly on the Kola Ecogeochemistry project (www.ngu.no/kola), which mapped the geochemical distribution of 60+ elements in snow/rain, stream/lake and ground water, moss, lichen, humus, O, B and C soil horizons, overbank sediments, till and bedrock, in the Barents region of northern Norway-Finland-Russia. After this, he returned to Australia to take up a Program Leader position in the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME), where he was particularly involved in developing geochemical and isotopic indicators to improve the usefulness of groundwater as a sampling medium for mineral exploration in regolith-dominated terrains.

He currently is Principal Research Scientist at Geoscience Australia, where he leads the National Geochemical Survey of Australia project (www.ga.gov.au/ngsa). The NGSAs aims to provide the first geochemical atlas of Australia and pre-competitive dataset to assist the energy and minerals exploration industry. Over the last few years, Patrice has also become involved in monitoring groundwater quality in the Otway carbon storage project of the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC). Patrice's main research interests are regolith and groundwater geochemistry, particularly water-rock interaction, isotope geochemistry and continental-scale geochemical mapping.

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AAG Councillors... *continued from page 14*

Matt Leybourne

Matt Leybourne is a Senior Research Scientist at GNS Science in Lower Hutt, New Zealand. He was previously an Assistant Professor at the University of Texas at Dallas, UAS following PhD research at the University of Ottawa and a Post-doctoral research at the Geological Survey of Canada.



Most of his research at GNS is focused on the following: 1) analysis and interpretation of hydrothermal plumes associated with venting along submarine volcanic arcs; 2) analysis of vent fluids and associated seafloor massive sulfide (SMS) mineralization; and 3) petrogenesis of fresh and hydrothermally altered volcanic rocks associated with SMS mineralization. He is also involved in method development work in IC-MS and LA-ICP-MS for water and mineral samples, respectively, and stable isotope analyses of secondary minerals related to supergene processes. He uses geochemistry to increase our understanding of igneous petrogenesis, the controls on water composition (water-rock reaction, weathering and supergene oxidation of mineral deposits), mobility and transport of trace metals and metalloids in solution (both hydrothermal and low temperature), and mechanisms of species attenuation in both ground and surface water environments. Most of his research has focused on volcanic, hydrothermal and groundwater systems associated with undisturbed ore deposits.

Romy Matthies

Romy is a biogeochemist with six years of experience in the mining industry and research. She holds a B.Sc. and an M.Sc. in Geoecology from the Bergakademie, Freiberg, Germany, and an M.Sc. in Environmental Management and Ecoaudit from Leon University, Spain. Romy has currently completed her Ph.D.



at Newcastle University, UK, where she investigated the biogeochemical cycling of iron, sulfur and carbon in passive mine water treatment systems including fractionation processes of traditional stable isotopes. In November 2010, Romy will join Tohoku University, Japan, as a JSPS fellow to investigate the microbiological catalization during mineral sulfide oxidation and biomineral formation. As a consultant at SRK Chile and SRK UK, Romy was mainly involved in issues related to acid mine drainage impacts and prediction techniques. For the last three years, Romy has been working on the editorial board of the journal Mine Water and the Environment and has been part of the scientific committees of two conferences of the International Mine Water Association. Romy is looking forward to being part of AAG Council and feels she can contribute many new ideas to carry the Association forward.

Cliff Stanley

Cliff Stanley obtained his bachelors degree in Earth Science from Dartmouth College, and his MSc (applied geochemistry, economic geology) and PhD (mathematical geology) from the University of British Columbia. Cliff has been a professor in the Department of Earth & Environmental Science at Acadia University, Wolfville, Nova Scotia since 1998, and beforehand served seven years as Adjunct Professor with the Mineral Deposit Research Unit at UBC. Cliff is author of over 50 papers in Economic Geology, Geochemistry, and Mathematical Geology, has supervised numerous bachelors, masters, and doctoral students and post-doctoral fellows. His present research interests are in the field of litho-geochemistry, hydrothermal alteration, sampling, geochemical quality control, mathematical applications in geochemistry, and partial digestion geochemistry. Cliff has served four terms on the AAG Council (2000-2004, and 2005-2009), was the AAG distinguished lecturer (2003-2004), and is eager to continue his commitment to the association by serving on council once again. Cliff's recent administrative experience includes service as Acting Chair of the Department (1.5 years), vice-chair of the admissions committee for the Association of Professional Geoscientists of Nova Scotia (10 years), and the provincial representative from that association on the Canadian Geoscience Standards Board (10 years).

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AAG Councillors... *continued from page 15*

Erick Weiland

An internationally respected geochemist with over thirty years of professional experience and technical knowledge across multiple disciplines, Erick has successfully completed projects in fourteen (14) countries. Expertise includes: mining/mineral geochemistry, rock/waste characterization, environmental impact assessments, water quality and soil remediation investigations, material characterization, geochemical evaluation of surface water, groundwater, and mineral interactions, and assessing the acid generation potential (acid rock drainage) with associated leaching of potentially hazardous constituents from natural materials.



He is an expert in the application of geochemistry supporting exploration, engineering, and environmental projects including site characterization, feasibility studies, permitting, remediation, water quality, soil remediation, evaluation of acid mine drainage, waste rock dumps and tailings dam engineering/design, and mine closure activities.

Erick has successfully designed, implemented, and evaluated field and laboratory investigations related to geochemical processes in the surface and sub-surface environments. Projects include: attaining and maintaining compliance with federal and state permits; environmental assessment, safe recharging of surface and waste waters to groundwater aquifers, monitoring and cleanup; CERCLA emergency clean-up actions; risk assessment; fate and transport analysis of metals and non-metals within the natural environment; hydrological modeling; geochemical and contaminant transport modeling; and environmental analysis.

Erick joined the Association in 1978 and has been an active member ever since. He has participated as an AAG Councilor, President, Database Chairman, Editorial board, Canadian and Australian Geosciences Council representative, and other miscellaneous duties.



CALENDAR OF EVENTS

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

2011

21-24 March 2011. Conference on Mathematical and Computational Issues in the Geosciences. Long Beach CA USA. Website: www.siam.org/meetings/gsl1/

3- 8 April 2011. General Assembly of the European Geosciences Union. Vienna Austria. Website: <http://meetings.copernicus.org/egu2011>

10-13 April 2011. 28th European Conference of the Society for Environmental Geochemistry and Health. Ormskirk UK. Website: www.edgehill.ac.uk/segh2011

13-15 April 2011. Earth Observation of Global Change. Munich Germany. Website: www.eogc2011.tum.de/

2-6 May 2011. Congreso Geologico Argentino, Neuquen Argentina. Website: www.congresogeologico.org.ar

15-19 May 2011. 12th European Workshop on Modern Developments and Applications in Microbeam Analysis. Angers France. Website: <http://tinyurl.com/3x6tzr>

25-27 May 2011. GAC/MAC Annual Meeting, Ottawa ON Canada. Website: www.gacmacottawa2011.ca

28 May-2 June 2011. American Crystallographic Association (ACA) Annual Meeting, New Orleans LA USA. Website: <http://tinyurl.com/4betcd>

29-30 May 2011. GIA Symposium 2011: Advancing the Science and Business of Gems. Carlsbad CA US. Website: www.gia.edu/symposium2011/

2-12-June 2011. Electron Crystallography - New Methods to Explore Structure and Properties of the Nano World, Erice, Italy. Website: <http://tinyurl.com/468ypos>

5-10 June 2011. Gordon Research Conference: Interior of the Earth, South Hadley MA USA. Website: <http://tinyurl.com/2598ze4>

20-24 June 2011. Frontiers in Environmental Geoscience 2011, Aberystwyth Wales UK. Website: <http://tinyurl.com/yhyxllj>



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28 June-7 July 2011. XXV IUGG General Assembly: Earth on the Edge: Science for a Sustainable Planet, Melbourne Australia. Website: www.iugg2011.com

4- 9 July 2011. Seventh Hutton Symposium on Granites and Related Rocks, Avila Spain. Website: www.seventh-hutton.org

10-15 July 2011. Catchment Science: Interactions of Hydrology, Biology & Geochemistry. Lewiston ME USA. Website: <http://tinyurl.com/35vxyuy>

20-27 July 2011. International Union for Quaternary Research (INQUA) XXVIII Congress, Bern Switzerland. Website: www.inqua.tcd.ie/congress.html

24-29 July 2011. 10th International Conference on Mercury as a Global Pollutant, Halifax NS. Website: Canada. <http://mercury2011.org>

25-27 July 2011. 6th International Conference on the Impact of Environmental Factors on Health, Riga Latvia. Website: <http://tinyurl.com/2ayqw2j>

31 July-4 August 2011. The Society for Organic Petrology (TSOP) Annual Meeting, Halifax NS Canada. Website: <http://tinyurl.com/4rgy4pj>

1-5 August 2011. 10th ICAM International Congress for Applied Mineralogy, Trondheim Norway. Website: www.icam2011.org

6-9 August 2011. 9th International Eclogite Conference, Tepla Czech Republic. Website: <http://tinyurl.com/29oaxrk>

14-19 August 2011. Goldschmidt 2011, Prague Czech Republic. Website: www.goldschmidt2011.org

22-26 August 2011. 25th International Applied Geochemistry Symposium, Rovaniemi Finland. Website: www.iags2011.fi

4-7 September 2011. 7th European Conference on Mineralogy and Spectroscopy. Potsdam Germany. Website: <http://www.physchemgeo.com/ECMS/>

20-24 September 2011. GEOMED2011 - 4th Hemispheric Conference on Medical Geology, Bari Italy. Website: www.geomed2011.it

27-30 September 2011. 20th International Symposium on Environmental Biogeochemistry, Istanbul Turkey. Website: <http://tinyurl.com/4gyu2pz>

9-12 October 2011. GSA 2011 Annual Meeting, Minneapolis MN USA. Website: www.geosociety.org/meetings/2011/index.htm

1-3 November 2011. 8th Fennoscandian Exploration and Mining, Levi Finland. Website: <http://fem.lappi.fi/en>

14-17 November 2011. Conference on Arsenic in Groundwater in Southern Asia, Hanoi Vietnam. Website: <http://www.as-hanoi.org/>

2012

6-11 February 2012. 10th International Kimberlite Conference, Bangalore India. Website: <http://10ikcbangalore.com>

11-15 March 2012. The Minerals Metals & Materials Society 2012: Linking Science and Technology for Global Solutions, Orlando FL USA. Website: <http://tinyurl.com/4q388lq>

27-29 May 2012. GAC/MAC Annual Meeting, St. Johns NL Canada. Website: www.stjohns2012.ca

31 May-10 June 2012. Present and Future Methods for Biomolecular Crystallography, Erice, Italy. Website: <http://tinyurl.com/4vqxw7s>

2-8 June 2012. 11th International & 2nd North American Symposium on Landslides. Banff AB Canada. Website: www.isl-nasl2012.ca/

24-29 June 2012. Goldschmidt 2012. Montréal QC Canada. Website: www.goldschmidt2012.org/

5-15 August 2012. 34th International Geological Congress, Brisbane Australia. Website: www.34igc.org

17- 20 September 2012. Geoanalysis 2012, Buzios Brazil. Website: www.ige.unicamp.br/geoanalysis2012

9-13 September 2012. First European Mineralogical Conference. Frankfurt Germany. Website: <http://emc2012.uni-frankfurt.de/>

4-7 November 2012. GSA 2012 Annual Meeting, Charlotte NC USA. Website: www.geosociety.org/meetings/2012/

Please let us know of your events by sending details to:

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Geological Survey of Newfoundland and Labrador

P.O. Box 8700

St. John's NL Canada. A1B 4J6

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RECENT PAPERS

This list in **EXPLORE 150** comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 149. 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: 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 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.

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RECENT PAPERS

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Book Review

Title: *Geochemistry of European Bottled Water*

Edited by: Clemens Reimann and Manfred Birke

Published by Gebr. Borntraeger Verlagsbuchhandlung, Stuttgart, Germany

2010, 268 pages + CD-ROM.

List price: 78.00 Euros (but also available from on-line bookstores for 10-15 Euros less)

Geochemistry of European Bottled Water is a new publication (2010) produced as part of EuroGeoSurveys (EGS). In the foreword to the book, the function of EGS (which involves 32 geological surveys from across Europe) is described as providing public interest (non-profit) science with a pan-European approach to allow more informed policy, regulatory and management practices in a variety of areas including resource management, geological natural hazard identification, sustainable development, environmental and waste planning, and enhanced access to data.

This new book aims to fulfil some of the above functions with respect to water quality in Europe. The book is divided into nine chapters. The first chapter provides the introduction to the study and its rationale. This study was aimed at producing a comprehensive overview of European groundwater quality. As the authors note, sampling of well waters is complicated by a multitude of factors including; multiple aquifers, variability in well construction and screening methods, uneven spatial variability, cross aquifer mixing, and problems of access. The approach taken in this study to overcome many of these issues was to use commercially available bottled water. The introduction nicely identifies many of the problems of such an approach (differences in water treatment, such as adding carbon dioxide, differences in water bottle type, and so forth). The rest of the introduction also provides a brief introduction to groundwater and bottled water as a resource, the European bottled water legal framework, and changes in consumer demand.

Chapter 2 represents a very brief introduction to the basic controls on the chemistry of groundwater, including precipitation, vegetation, soil type, pH, hydrolysis, redox and mixing

Book Review... *continued from page 19*

with saline waters. This chapter is short (4 pages) and is the weakest of the book. Having said that, there is enough information that a non-expert would understand enough of the basics to appreciate the main part of the book, the element maps. Chapter 3 provides a more in depth look at some of the influences on water chemistry and includes a number of very useful color maps. Covered here is the topography of Europe, the geology and terranes of Europe, major structures, ophiolite belts, distribution of igneous rocks, climate, soil, vegetation and land-use. This chapter is overall well done and the maps are great. My only criticism here would be that I would have liked these maps to be on the CD-ROM so that they could be enlarged on a computer screen.

Chapter 5 is one of the more important parts of the book; it covers sampling and analytical methods and quality control. This chapter is excellent, and a good example of how a well-conceived survey is carried out. In total some 1785 samples of bottled water were analyzed (purchased in 2008 from supermarkets throughout Europe). Some samples represented different brands derived from the same source, so the data presented in the book were reduced to one bottle per site, or 884 distinct sources of bottled water. All the data for the 1785 analyses are given in the accompanying CD-ROM. All of the samples were analyzed in one laboratory in Germany, using a variety of methods including ICP-MS, ICP-OES and IC, AFS (for Hg), titration (alkalinity), photometry (NH₄⁺), and electrical conductivity. The chapter provides a number of key data tables with method used (isotope monitored, where appropriate), results for international certified reference materials, detection limits (instrumental, reported and practical detection limits are provided for each analyte), and results of duplicate analyses. Other issues covered include differences in bottle type and leaching of analytes from bottles, effects of changing water pH through carbonatization.

Chapter 5 is a one-page treatment of the datasets on the CD-ROM, including a dataset of 500 tap water analyses that were measured in the same lab using the same methods, allowing for a comparison with tap drinking water. The data in this study are also compared to a surface water dataset for Europe (807 samples) and a hardrock groundwater dataset from Norway (476) samples. Chapter 6 then provides a comparison of the four different datasets, with cumulative probability plots of all the analytes (69) covered in the study.

Chapter 7 is the main part of the book. Here, each analyte is presented over two pages. One page of text provides information on the source and type of the analyte (i.e., metal, metalloid etc), discusses the mobility and attenuation of the analyte in the environment, provides a sense of natural and anthropogenic background values, the possibility of bottle leaching, and the regulatory (health) limits, if applicable. The second page is graphical; for each analyte, a proportional dot map is presented over a map of Europe, with only country borders. Three other plots are given; cumulative-probability (with European health standard indicated, as appropriate), box and whisker plot (based on Europe subdivided into four quadrants), and a combination plot that shows a histogram, a density trace, a one dimensional scatter-plot, and a box-plot.



The analyte maps are uncluttered, as there are no detailed underlay's (geology, topography etc), allowing for a rapid visual assessment of the variation of an analyte of interest in Europe. I spent hours just looking at the various analytes that are of particular interest to me. I think that the only thing really missing here would be to have the maps in Chapter 3 as georeferenced images on the CD-ROM so that the data could be overlaid on each parameter in a GIS. Chapter 8 provides an overview of the health implications of the study, with a brief analysis of the main (inorganic) analytes of concern in drinking water. Chapter 9 is the conclusion.

There are also some appendices in the book, which include detailed tables of drinking and bottled water standards for a number of European, WHO and US EPA agencies (Appendix A), and a tabular comparison of the four datasets from Chapter 6 for each analyte (Appendix B). Finally, there is a CD-ROM, which provides all the data in Excel format, as well as all of the maps in Chapter 7 as .tif files.

Overall, this is an excellent book, and should appeal to both practicing aqueous geochemists and those in the area of policy, land-use planning and environmental regulation. I would expect that this book would also appeal to a number of non-governmental organizations and environmental groups. The good news is that of the 884 sources of bottled water in Europe, only a small number exceed health limits for one or more parameters.

Matthew Leybourne
GNS Science, New Zealand



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The grant is intended to promote the collection of high quality, base-line data for comparison with more “esoteric data” (eg, isotopic data, partial digests, non-standard sample media) generated during the course of research, and to promote broad training in fundamental geochemical principals across the geosciences.

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David Lawie, John Gravel



EXPLORE

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March newsletter: January 15

June newsletter: April 15

September newsletter: July 15

December newsletter: October 15

Information for Contributors

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

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

Submissions should be sent to:

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Exploration Geochemistry Modular Course 5806, Laurentian University, Sudbury, Ontario, Canada

In late December 2010, I had the opportunity to participate in the Exploration Geochemistry Modular Course 5806 at Laurentian University (LU) in Sudbury, Ontario. The modular course was offered by the Department of Earth Sciences as part of their Applied M.Sc. in Mineral Exploration (<http://earthsciences.laurentian.ca>).

For an intensive five days, participants were involved in lectures and labs that covered all aspects of geochemistry as it relates to mineral exploration. These five days included basic analytical methods, litho-geochemistry, alteration indices and mass balance and radiogenic and stable isotopes. The next five days were slightly less intensive, and focused on application of background knowledge in the mineral exploration world. Deposit types covered include hydrothermal sediments, SEDEX, VMS, Uranium, Ni-Cu-PGE sulfide systems and diamonds.

The class included a whirlwind tour through processing and interpretation of geochemical data and GIS modeling techniques specific to exploration. Drift exploration, soil and lake sampling was also covered. Beth McClenaghan of the Geological Survey of Canada (GSC) brought in diamond indicator minerals for the class to view and 'pick' using microscopes, while Dan Schultze from University of Toronto (UofT) brought in numerous kimberlite hand samples and several sub-mm size diamonds.

Twenty-seven people partook in the course, from grad students (LU, Queen's University, University of Ottawa, North Carolina State University, University of Waterloo) to industry (FNX, HudBay Minerals, Wallbridge Mining Company, and Xstrata) and government professionals (Ontario Geological Survey (OGS)). Backgrounds of the students varied from bedrock geology to surficial geology, but no one was left behind and in only 10 days, I don't think anyone had time to be bored.

The main lecturer was Dr. Steve Piercey, now at Memorial University but with ties to LU. Participants benefitted from numerous guest lecturers of varied backgrounds, including professors (Micheal Lesher, LU; Kurt Kyser, Queen's; Dan Schultze, UofT), industry (Peter Lightfoot, Vale) and government (GSC – Jan Peter, Jeff Harris, Wayne Goodfellow, Beth McClenaghan; OGS – Stew Hamilton). Sudbury in the winter was a pleasant experience, but I'd recommend anyone that goes in the future to have winter tires.

Michelle Trommelen

PhD student

University of Waterloo



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