The Gangue

GAC - Mineral Deposits Division Newsletter

Issue 41 *January 1993*

1992 BOLDY AWARD WINNERS
R.P. Wares and A.E. Williams-Jones

Submitted by R.J. Cathro

Two Montreal researchers with ties to McGill University are the winners of the 1992 Boldy Award, awarded to the best paper with a practical field application presented at the Annual General Meeting in Wolfville, Nova Scotia, in 1992. **The winning paper was presented by Robert P. Wares of Ixion Research Group and was co-authored by A.E. Williams-Jones of McGill University** (McGill was also associated with the previous winners). The judges were Robert J. Cathro, MDD Treasurer, Hugh Squair, a Toronto Consultant, and Jean LaFleur of Placer Dome, Val'dor. An extended abstract of their papers is presented below.

Geochemistry of Procellanites from Northern Gaspe, Quebec: Application to Exploration for Copper Skarn Deposits

By: Robert P. Wares, Ixion Research Group, Montreal & A.E. Williams-Jones, McGill University

Porphyry copper-skarn deposits from the northern Gaspe peninsula, Quebec, are hosted by Early Devonian calcareous sedimentary rocks. The only economic deposits are those at Mines Gaspe, which have been mined since 1955 (Allcock, 1982; Procyshyn *et al.*, 1989). Many other skarn occurrences are known, notably in the area of the Sullipek deposit, located about 30 kilometres west of Mines Gaspe (Wares, 1988).

On a regional scale, all skarns are spatially associated with Late Devonian, hypabyssal quartz-feldspar porphyry plugs, sills and dike swarms. In all cases, contact metamorphism preceded the metasomatic events, producing light grey marble and calcsilicate hornfels. Prograde metasomatism of marble produced mostly andradite+clinopyroxene±quartz skarn, which has hosted the most productive ore deposits. At Mines Gaspe, one exceptional deposit (E-32 zone) consists of massive sulphide replacement of marble. In the Sullipek area, large volumes of skarn are essentially barren of sulphide mineralization. Metasomatism of calcsilicate hornfels produced porcellanite, which consists of pale-coloured, extremely fine grained assemblages of clinopyroxene+alkali feldspar±quartz. Although historically, the term *porcellanite* at Mines Gaspe has been used to describe any bleached lithology, the term is used here strictly to describe metasomatized hornfels. Porcellanite is spatially associated with skarn and hosts low-grade prophyry copper style of mineralization. Because the stratigraphy is dominated by calcareous pelitic rocks, porcellanite is far more abundant than skarn.

Whole-rock geochemical analyses of porcellanite from Mines Gaspe and the Sullipek area were corrected for mass change with immobile components TiO_2-Al_2O_3 (MacLean, 1990) and compared to unaltered protoliths. The mass correction factor is generally less that 5 percent, and the data indicate that porcellanite is the result of two types of alkali metasomatism: 1) mineralized procellanite, associated with cupriferous skarn, is potassic (orthoclase) and records up to 170 percent K_2O enrichment with respect to unaltered protoliths; 2) barren procellanite, associated with unmineralized skarn in the Sullipek area, is sodic (albite) and shows up to 230 percent Na_2O enrichment (Figure 1). All major elements show negligible change. Formation of procellanite from a model tremolite-anorthite-quartz hornfels can therefore be expressed by the following balanced reaction:

$Ca_2Mg_5Si_8O_{22}(OH)_2 + 3CaAl_2Si_2O_8 + 14SiO_2 + 6KCl + 2H_2O \rightarrow 5CaMgSi_2O_6 + 6KAlSi_3O_8 + 6HCl$

(tremolite + anorthite + quartz + aq. --> diopside + othoclase + aq.)

Consumption of quartz in the reaction is demonstrable with petrographic data showing far less modal quartz in porcellanite than in hornfels. Furthermore, hornfels commonly contains excess calcite, which neutralizes the acid produced by the reaction.

Homogenization data from primary fluid inclusions in skarn clinopyroxenes

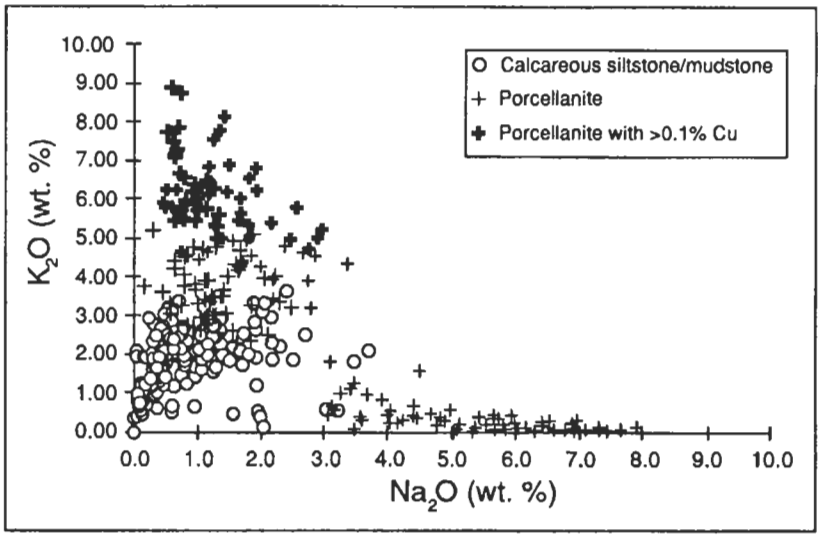

Figure 1. K_2O-Na_2O plot showing alkali enrichment in porcellanites relative to unaltered protoliths (calcareous siltstone/mudstone and hornfels). The cupriferous porcellanites at Mines Gaspé and at Sullipek are potassic. Sodic porcellanites, found south of the Sullipek deposit, are unmineralized.

from the Sullipek area and from skarn quartz at Mines Gaspe (Shelton, 1983) indicate that mineralized skarns formed in the 350-550°C temperature range. Temperature is therefore a key control of procellanite geochemistry. Assuming a constant K/(K+Na) ratio of 0.20 to 0.25 in the hydrothermal fluid (Roedder, 1984), high-temperature metasomatism favours albite whereas lower temperatures favour orthoclase (Lagache, 1984; Figure 2).

The lower temperature, mineralized systems are associated with potassic porcellanite and the latter is a useful exploration tool in the search for deep-seated copper-skarn deposits.

Acknowledgments

The authors are grateful to Mines Gaspe (Noranda Minerals Inc.) for financial support and for permission to publish this abstract.

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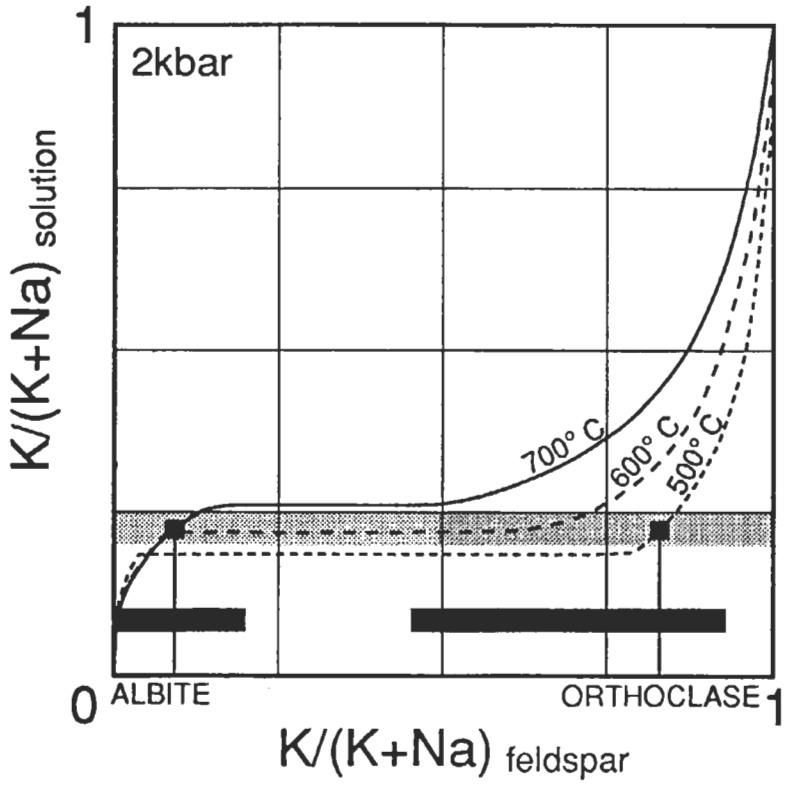

Figure 2. Molar K/(K+Na) equilibrium curves between a fluid phase and alkali feldspar for the 500-700°C range (Lagache, 1984). The shaded area represents the probable range of K/(K+Na) for a hydrothermal fluid associated with copper skarns (0.20-0.25). Such a fluid will stabilize albite at temperatures >600°C and orthoclase at <500°C. The black bars indicate the range of K/(K+Na) for feldspars in procellanites.

The Gangue, No. 41
January 1993

The Gangue is published quarterly by the Mineral Deposits Division, GAC, and is distributed to all members of the MDD as part of their membership fee.

Publication Schedule:

SUBMISSION DEADLINE	PUBLICATION DATE
December 15	January
March 15	April
June 15	July
September 15	October

Information for contributors:

The objective of this newsletter is primarily to provide a forum for members and other professionals to voice new ideas, describe interesting mineral occurrences or expound on deposit models. Articles on ore deposits, deposit models, news events, field trips, book reviews, conferences or other material which may be of interest to the economic geology community are welcomed. Reprints of presentations given to companies, mining groups or conferences are particularly welcome.

Manuscripts should be submitted on 5.25" or 3.5" IBM-formatted diskettes in any major word processor format. A printed version should be included. Illustrations must be in camera-ready format; photos should be of good quality. Short items dealing with news events or meetings can be submitted by FAX or mail.

Contributions may be edited for clarity or brevity.

Brian Grant
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The MDD encourages all geologists to join the division and contribute to the various programs and activities.

Our Founder's Views

Submitted by Bob Cathro, MDD Treasurer

Publications, field trips, awards and special sessions at GAC conferences - that's what MDD does and I believe it does it well .... Be a small, efficient organization that controls its future rather than writing cheques to other groups who don't do things as well.

That was one response to a recent questionnaire sent to former Chairs, officers and field-trip & workshop organizers who comprise the founders of the MDD. Of the 27 who were contacted for their recollections and opinions, 25 responded in writing and another made verbal contact. Our thanks go to all of them, particularly those who took the extra time to append letters up to three pages long.

The questionnaire was prompted by the sense of responsibility that current executive members feel to manage the valuable nestegg that has been accumulated in the 14 years of MDD's existence. With the regular turnover in executive membership, it is difficult to maintain continuity of purpose when responding to new initiatives and changing financial circumstances. Among the main decisions facing the executive in recent years have been:

- how much priority to give to financial support of mineral deposit-related publications;
- whether publication funding should be in the form of recoverable seed money or outright grants;
- what other services are most useful to MDD membersp;
- and, how to maintain membership levels in a difficult economic climate.

MDD was created to ensure a good mineral deposit program at annual GAC meetings and provide other services that were not available from other sources. In the recollections of one respondent, early guidelines for project support included:

- had to be accessible to all or a large portion of the membership,
- had to be of educational or scientific merit,
- had to show a reasonable possibility of a profit.

One important early policy was to budget field trips and workshops at a slight profit in order to build up a small nest egg. Since none of these ever lost money, each contingency became profit. The nest-egg eventually became large enough that member's fees cover the costs of producing and mailing *The Gangue* and MDD operates on its interest income. As one founder put it:

"Money-making was no sin provided the funds were generated, invested and spent in the provision of timely and valuable services to participants and members".

MDD gradually progressed into publications as the most effective way of providing service to members and the earth-science community. Five GAC volumes have been published with MDD funding totalling $54,000:

- Geology and Ore Deposits of the Highland Valley Camp
- Gold and Copper-Zinc Metallogeny, Hemlo-Manitouwadge
- Volcanic Sulphide Districts of Central Newfoundland
- Yellowknife Guide Book
- Greenstone Gold and Crustal Evolution

About $34,000 has been recovered from sales. MDD has committed to support two new GAC publications, Volume 2 of *Ore Deposit Models*, and the *proceedings of the IAGOD Symposium on Mineral Deposit Modelling*.

In response to the questionnaire, 90% of the founders feel that publications continue to provide the most effective service. Some respondents pointed out that there is a chronic shortage of good papers or too many publications, and stressed that support should be restricted to high-quality work that members need.

On the question of funding policy, 72% favour recoverable seed money versus outright grants. When grants are necessary, it was suggested that MDD members should receive a substantial price discount. When asked for their opinion on other financing requests that MDD receives only 4% of the founders support funding for *Big Science* programs (such as Lithoprobe) and only 16% are in favour of Science Centre funding. On the topic of education, 28% would support such initiatives while many others are con-

MDD Arizona/Sonora Field Trip - February 1993

Geological Association of Canada - Mineral Deposits Division
Association Geologique du Canada - Division des Gites Mineraux

Time: February 18-28
Commences: Tucson, Holiday Inn, Feb 18 PM,
Terminates: Tucson Int. Airport, Feb. 28 approx. midday

Sites to be visited include:

Mission - *porphyry Cu*
Sierrita - *porphyry Cu*
Cananea - *porphyry Cu*
La Caridad - *porphyry Cu*
La Colorada* - *intrusion-hosted Au*
Oposura* - *Zn-Pb skarn*
San Antonia de la Huerta* - *Porphyry Cu-Au*
San Francisco* - *Qz-Au veins in altered granite*
Silver Bell - *porphyry Cu*
Johnson Camp - *oxide Cu*
Maria - *Cu breccia pipe*
Pilares Nacozari - *Cu breccia pipe*
Amelia* - *carbonate-hosted Au*
Verde Grande* - *skarn oxide Cu*

* *Confirmation from Company still to be received*

Field Trip Leaders:
Arizona - Prof. Spencer Titley, Univ. of Arizona
Sonora - John-Mark Staude, U.S.G.S./Univ. of Arizona

Cost: Approx. $125/day, Total of approximately $1,250 ($1,350 for non-MDD members)

Deposit: $250, to reserve place. Cheque payable to : MDD Field Trip

For further information & registration, contact James Macdonald at:

A.J. Macdonald - MDD
Mineral Deposit Research Unit
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Rapid Reponse Requested for Trip Planning

cerned that more isn't being done but feel MDD lacks sufficient funds to do anything effective. One interesting suggestion is for MDD to take the initiative in organizing field trips to operating mines and advanced exploration projects for science teachers.

It will come as no surprise that the founders are overwhemingly in favour of continuing to emphasize field trips and short courses or workshops. The current executive is already responding by organizing a field trip to Arizona/Mexico in February 1993, and a diamond exploration workshop in May-June. In addition, several short courses are also in the planning stage for late 1993 - early 1994 on such diverse topics as fluid inclusions, age dating and veins/structures. As always, ideas and volunteers are welcome.

Most of the founders feel that MDD should live within its means but continue to generate additional income by offering regular training and professional development opportunities through short courses and field trips. While some feel the the executive has a trustee responsibility to protect MDD assets, that view was not unanimous. In the words of one founder:

We should be part of the risk-taking community, not behaving like miserly bankers!

Bob Cathro

NWMA - SEG
1993 Convention

The Society of Economic Geologists will participate in the 98th annual Northwest Mining Association Convention, **New World of Minerals,** December 2-4, 1993, to be held in Spokane, Washington. The program will include a joint SEG-NWMA session in the geology section of Friday morning, December 4th. This is the first of what will be continuing SEG - NWMA sessions at the annual NWMA convention.

The convention will emphasize international minerals information and will present new development, exploration and operating facts from around the world. Specific topics will include the metallogenesis of far-eastern Russia, exploring skarn deposits, gold-bearing deposits of the Altiplano and Cordillera Occidental of Bolivia, precious-metal exploration in the eastern Caribbean, and a comparison of sediment-hosted copper deposit models.

For additional information regarding the joint session contact Ronald G. Worl, U.S. Geological Survey, Spokane, Washington. Tel: (509) 353-2639.

1992 1993 MDD EXECUTIVE

Following are MDD Executives and Directors for the 1992-1993 term. Please contact any of these individuals for enquires, or to suggest initiatives for MDD.

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LITHOGEOCHEMICAL EXPLORATION FOR VMS DEPOSITS

Identifying Metasomatic Zones Associated with Volvanic-hosted Massive Sulphide Deposits using Pearce Element Ratio Analysis

Hans E. Madeisky [1] and Clifford R.Stanley [2]

[1] Mining Geology Research Group, Royal School of Mines, Imperial College, Univ. of London
[2] Mineral Deposit Research Unit, Dept. of Geosciences, The University of British Columbia

Summary of a Student Poster presented at the Northwest Mining Association, 98th Annual Convention, December 2, 3 & 4, 1992, Spokane, Washington

A spatial, temporal and causal link between hydrothermal alteration and metasomatism of footwall rocks and volcanic-hosted massive sulphide (VHMS) mineralization is widely recognized. Chemical reactions between mineralizing fluids and footwall rocks frequently produce systematically zoned mineralogical and geochemical haloes around the deposits. Generally the footwall haloes are much larger than the deposits themselves and are, therefore, potential exploration guides to VHMS mineralization.

As a result, alteration mineral assemblages and geochemical zoning patterns in footwall rocks of VHMS deposits have been exploited by the exploration industry through the development of a variety of empirical geochemical indices and exploration parameters. Lithogeochemical techniques become especially important when exploring for deep targets, where geophysical prospecting procedures may have limited applicability.

The alteration mineralogy and the geochemical zoning patterns observed in the footwall rocks of VHMS deposits are the final product of the combined effects of rock forming processes (igneous fractionation, crystal sorting, and clastic deposition) and all other processes that further modify the chemistry of these rocks (seafloor metasomatism, hydrothermal metasomatism associated with the mineralizing event, metamorphism, and weathering). In most circumstances neither: i) the distribution of alteration minerals, nor ii) element concentrations, nor iii) empirical alteration indices can be relied upon to discriminate between these processes, and to identify hydrothermal discharge sites associated with VHMS mineralization. Selecting exploration targets by these means is often difficult, because mst of the alteration mineral assemblages and chemical zoning patterns are not unique products of any particular process. This is further exacerbated by the lack of stratigraphic continuity in many volcanic successions hosting VHMS deposits. When these successions have also suffered tectonic disruption, effective selection of VHMS exploration targets by direct observation of mineralogical or chemical patterns becomes very difficult.

Therefore, in order to exploit the widespread alteration mineral and geochemical haloes present in footwall rocks of many VHMS deposits as effective exploration parameters, it becomes necessary to identify and quantify the impact that hydrothermal fluids associated with the mineralizing event had on the geochemistry of these rocks, and to distinguish this from any pre-existing geochemical heterogeneity in these rocks, and from other geochemical variation introduced by unrelated processes.

The principal sources of geochemical variation observed in host rocks of VHMS deposits are:

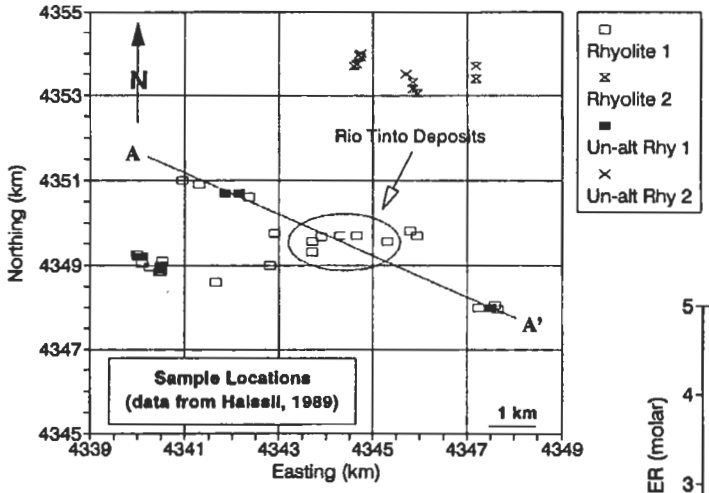
- **measurement error** - including errors introduced during sampling (the nugget effect) and analysis,
- **closure** - a mathematical artifact caused by the requirement that a rock composition must sum to 100%, thereby preventing the manifestation of differences in rock compositions from directly reflecting the actual changes that have occurred in the rocks,
- **fractionation** - systematic geochemical variations produced by crystal or volatile separation from a melt, and by crystal sorting; present before mineralizing fluids alter these rocks,
- **compositional mixing** - mechanical mixing of rocks of different genesis and composition (*e.g.* - volcanic fragmentals with exotic clasts), and
- **metasomatism** - material transfer associated with chemical reactions between mineralizing fluids and the host rocks.

Although measurement errors cannot be eliminated from geochemical data, their magnitude can be estimated through the use of reference materials, duplicate analysis and by rigorous error propagation. This will ensure that any resulting geochemical interpretation can be confidently supported by the data. Compositional mixing, produced by the inclusion of exotic clasts in fragmental volcanic rocks, can be avoided through careful sampling in the field or by separating the exotic clasts from the rock matrix during sample preparation.

The mathematical artifact of closure must be accommodated before any meaningful analysis of geochemical data can proceed. The impact of this source of variation has long been recognized and several authors have devised methods for dealing with the closure problem (Akella 1966, Gresens 1967, Pearce 1968, Grant 1986, MacLean 1990). Their methods are all based on the same fundamental equation that allows calculation of the actual material transfers that have produced the variations in rock compositions. In order to solve the material transfer equation, these methods rely on knowledge of how the size (mass, moles) of the rock (system) changed during material transfer, or on the presence of an element (conserved constituent) in the rock, which did not participate in any form of material transfer.

All of these methods overcome the problem of closure, but Pearce's approach, which involves the use of a ratio formulation, has an advantage over the others because his material transfer equation is expressed in molar terms using a conserved constituent (element) in the ratio denominator. This causes variations in Pearce element ratios (PER's) to be directly proportional to the amount of material transfer in the numerator element. Furthermore, by using mole instead of mass concentrations in PER analysis, the resulting material transfers can be related directly to mineral formulae and chemical reactions. This allows solid-solution mineral composition variations to be accommodated by simple addition of PER's. But most importantly, these features allow development of linear fractionation models which can represent the geochemical heterogeneity that may be present in volcanic rocks before the advent of metasomatism associated with mineralization. Thus, the use of PER analysis not only overcomes the effects of closure, but also allows the geochemical variations associated with fractionation and crystal sorting to be recognized and accommodated. PER's provide a specific strategy by which to decouple the effects of metasomatism and fractionation and/or crystal sorting by means of examining the nature of covariation of elements that have undergone material transfer. Those elements that have participated in fractionation or crystal sorting must undergo material transfer in ways consistent with the fractionating or sorting mineral stoichiometry, whereas elements participating in metasomatism may have no such restriction, and may not exhibit any predictable covariation. Thus, with linear models for fractionation and crystal sorting, the additional variations attributable to metasomatism may be identified and quantified by the residuals to the fractionation model line on PER diagrams.

The advantage of the PER method is that it can detect subtle geochemical variations that might otherwise be missed. For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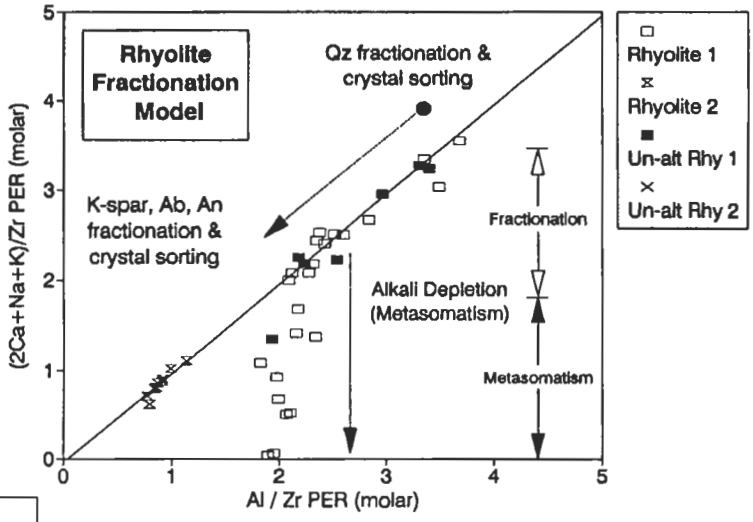
Rhyolite Fractionation Model
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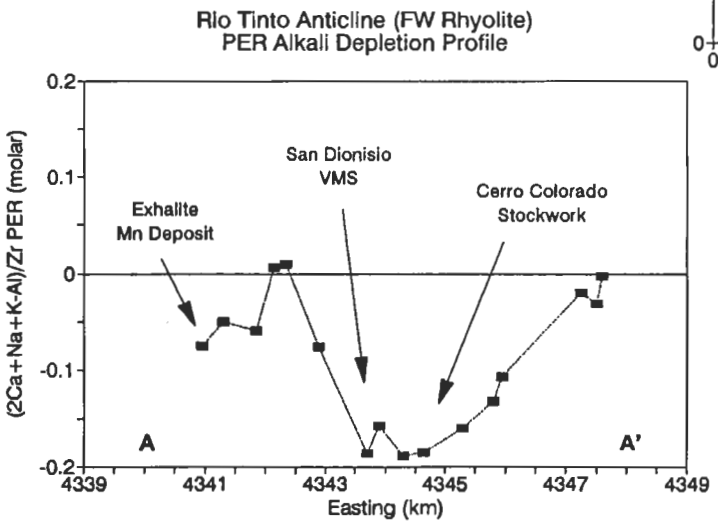
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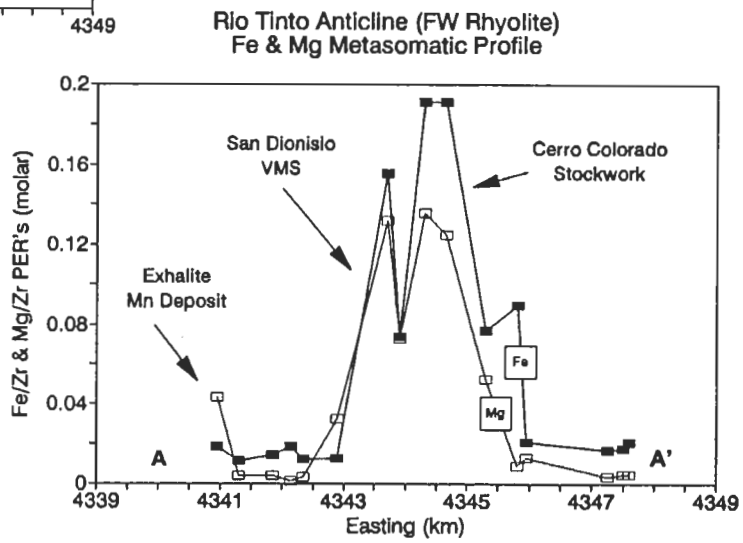
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PDAC - CALL FOR PAPERS

The Prospectors and Developers Association of Canada invites papers for presentation at its Open Forum to be held during the 1993 Annual PDAC Convention (March 28 to 31st, 1993, Toronto, Canada). The Open Forum, which runs concurrently with the main convention technical program of invited papers, will provide an opportunity for people in the mineral industry to report on any topic related to exploration and development. It is recommended that papers submitted for this session emphasize application rather than theory.

Abstracts of no more than 200 words should be submitted by January 29, 1993.

Authors whose abstracts are accepted by the adjudicating committee will be notified by February 12, 1993, and will be required to submit an extended six-page abstract for distribution at the convention by March 12, 1993. They will also be asked to make a 20-minute presentation at the Open Forum, on Tuesday, March 30, 1993.

Abstracts should be submitted in triplicate to:

Mrs. Saley Lawton - Co-coordinator, Open Forum
Prospectors and Developers Association of Canada
64 Victoria Street, Suite 1002, Toronto, Ontario, M5C 2A5

example, the near total loss of alkali metals, or the significant addition of Fe and Mg in the cores of feeder zones below VHMS deposits would be noticeable despite the effects of closure. However, minor variations in these elements may be totally obscured by closure or by geochemical heterogeneities produced by pre-existing fractionation or crystal sorting. These minor variations may prove to be important exploration guides to mineralization and may offer the explorationist a significant ability to navigate within the widespread footwall alkali depletion zones.

PER analysis can only proceed when these basic assumptions are met:

- the rocks under investigation are related to a common parent which at one time was homogeneous,
- at least one material transfer process has acted to create the geochemical variability observed in these rocks, and
- at least one constituent (element) of these rocks did not participate in (was conserved during) any material transfer process.

This paradigm involves a two phase approach to the investigation of geochemical variability in a suite of volcanic rocks. The question of whether these rocks are related must be determined first. This may be done using element ratios, which will be equal if the elements are conserved and if the rocks are cogenetic. Once this *conserved element and cogenetic rocks hypothesis* has been confirmed, PER analysis allows investigation of how these rocks are related through the formulation of linear fractionation and crystal sorting models on PER diagrams.

PER analysis has been applied to geochemical data from a dissertation on *Intrusive Magmatism, Volcanism and Massive Sulphide Mineralization at Rio Tinto, Spain* (Halsall, 1989). Whole-rock major oxide and trace element geochemical analyses of samples collected from massive and laterally extensive footwall rhyolite and basalt flows, exhibiting varying degrees of hydrothermal alteration, were investigated. Samples were collected from an 8 by 6 kilometre area, elongate with the strike of the Rio Tinto anticline. The footwall rhyolite and basalt flows lie from 150 to 500 metres stratigraphically below the massive sulphide and stockwork mineralization. PER analysis of the data from Rio Tinto has led to the following observations:

- two separate and spatially coherent cogenetic groups of rhyolites occur at Rio Tinto. Both rhyolite groups underwent quartz and alkali feldspar fractionation and crystal sorting,
- all of the basalt flows appear to belong to a cogenetic group. Their magmatic evolution involved olivine and plagioclase fractionation and probably crystal sorting,
- metasomatic additions and losses of elements can be recognized up to 3 km from the centre of the mineralization (Cerro Colorado open pit). The behaviour of elements differs in each lithology,
- the magnitude of material transfer resulting from igneous fractionation and crystal sorting is equal to, or greater than, that due to hydrothermal metasomatism in both lithologies, except for elements that did not participate in fractionation and crystal sorting (*e.g.* - Fe, Mg in rhyolites),
- the rhyolite directly underlying the mineralization is a highly evolved melt and only the most evolved portions of this rhyolite are metasomatized, suggesting a genetic link between these highly evolved rhyolites and the presence of VHMS mineralization, and
- in contrast to this rhyolite, both evolved and primitive basalts have suffered metasomatic losses and gains, suggesting that the basalts are unrelated to the genetic processes responsible for mineralization.

The PER exploration technique is theoretically based on a fundamental material transfer equation, and rests on well understood petrologic principles. As such, it is applicable to many hydrothermal mineral deposits in a variety of geological environments, and may not suffer the application limitations typically associated with empirically developed geochemical alteration indices. Also, the PER approach is very simple to use, and is cost effective, requiring only careful sampling, competitive analytical quality, and currently available data manipulation technology (*i.e.* - a simple spreadsheet program). As a result, this lithogeochemical method can be readily incorporated into most VHMS exploration programmes. Furthermore, the technique can be optimized to detect and respond to specific conditions that may exist in a particular VHMS environment, or to unique conditions associated with other mineral deposit environments where metasomatism has accompanied emplacement of mineralization.

* * *

TABLE

Summary of Metasomatic Element Additions and Losses at Rio Tinto

Lithology	Element	Detectable Distance from Mineralization(km)	Material Transfer (M = Metasomatism) (F = Fractionation)
Rhyolite	Fe, Mg, Mn	1.5	Addition (M)
	Ca, Ba, Rb, Sr	3.0	Loss (M)
	Si, Al	3.0	Loss (F)
	Alkali Alteration Index (Na, K)	2.0	Loss (F, M)
	Silica Alteration Index (Si)	2.0	Addition (M)
Basalt	Mn	3.0	Addition (M)
	K, Ba, Rb, Sr	2.0	Loss (M)
	P, Ti	0.5	Loss (M)
	Y	0.5	Addition (M)
	Mafic Alteration Index (Mg)	2.0	Addition (F, M)
	Mafic Alteration Index (Na, Ca)	2.0	Loss (F, M)
	Mafic Alteration Index (Fe)	2.0	Addition (M)

Summary of Pending MDD Activities and Future Plans

James Macdonald
MDD Chairperson

Following is a brief summary of activities and planned activities in which MDD is involved for 1993 and beyond:

1. Field Trip to Arizona/Sonora

- February 18-28.
- 3 Days in Tucson area, 6 days in Mexico before returning to Tucson.
- for details - see elsewhere in this issue of *The Gangue*

2. GAC/MAC Symposia

MDD is sponsoring two symposia at the GAC/MAC Annual Meeting to be held in Edmonton, May 17-19:

- **Diamonds** Symposium (organizer: Malcolm Gent)
- **Arc Metallogeny** Symposium (organizers: Dani Alldrick & John Thompson)

3. Pending Publications

MDD is committed to financial assistance for two publications which we hope will be available in the near future:

- Mineral Deposit Models Volume (from IAGOD, Ottawa 1990);
- Volume II of Ore Deposit Models, edited by P.A. Sheahan and M.E. Cherry

4. Workshops - First Half 1992

- **Structural Analysis of Shear Zones and Veins in Gold Districts:** Francois Robert & Howard Poulsen (GSC, Ottawa) will offer this practically oriented workshop with case-study discussions on **March 15 & 16 in Vancouver** (Simon Fraser University's Downtown Campus). Topics to be discussed during the two-day workshop include: Structural aspects of gold deposits; structural elements of shear zones and veins; analysis of shear zones and vein networks; complicating factors (non-conjugate behavior, anisotropy, reactivation, deformed deposits); role of fluids (hydraulic fracturing, brecciation, etc.)
  Practical applications to exploration will be emphasized, drawing upon examples from across Canada.
- **Diamonds:** Velma Sterenberg is investigating the possibility of diamonds workshop to be held in Vancouver in late May, with a hands-on emphasis, opportunities to examine drill core and rock samples, *etc.*; if sufficient interest is expressed, the workshop could be held also in Central Canada, probably at an earlier date.

Every effort will be made to offer these workshops at an attractive cost to MDD membership. Please note, however, that workshops will be held only if a significant level of interest is provided by MDD members; if you may be interested in attending either workshop please indicate this on the response sheet at the end of this issue of The Gangue.

5. Potential Future Short Courses

We are currently investigating the viability of arranging additional Short Courses and Workshops for MDD members in late 1993 or 1994. Two possibilities are under current consideration:

- **Geochronometry and Mineral Deposits,** led by Jim Mortensen (on leave from GSC, Ottawa, visiting Professor at UBC, Department of Geological Sciences). This would be a brand new course, of interest to any economic geologist wishing to unravel the relative and absolute ages of host rocks, alteration and ore minerals. Emphasis would be placed upon case studies and new methods.
- **Fluid Inclusions and Mineral Deposits** led by Jim Reynolds (Fluid Inc., Denver) and Bob Bodnar (Virginia Polytech). This course has been given around the world; One reviewer (Prof. A.E. Scoch) in Johannesburg described it as "One of the best workshops this reviewer has ever attended".

If you have any feelings about the attractiveness of either of these courses, please indicate them on the questionnaire included in this issue of The Gangue.

6. GAC/MAC 1994 Waterloo - Planned Short Course

Alteration and Alteration Processes Associated with Ore-Forming Systems, organized by David Lenz (GSC, Bathurst) and Craig Jowett (Waterloo).

7. EXOTIC Field Trip

At a recent meeting of some of MDD's Director's and Executive in Vancouver, Tom Schroeter suggested that it would be an opportune time to commence planning for an *Exotic* MDD Field Trip outside North and Central America, and preferably to an area not visited before by MDD members. Locations suggested included:

Turkey	Argentina
Russia	Southern Africa

A trip of this type, to a location not on our back door, would take some considerable planning and organization. If a decision on location is taken in the near term, it will probably take at least 12-18 months to fully orchestrate; *i.e.*, the trip could take place in Spring of 1994, at the earliest. Let us know on the response form of a preferred location for such a trip and whether you are able to assist in the organization.

The success of all the plans and activities described here depends heavily upon participation of the Division's membership. The MDD Directors and Executive require your feedback during the organizational stages in order to assess whether a particular event is going to be of use to our members. For this reason, a response sheet is attached to this issue of *The Gangue* to give you that chance; let us know if you may be interested in a particular workshop, field trip, *etc.* Also, let us know if you would rather see other types of course, publication or whatever.

Please fill in the questionnaire included in this issue and either mail or FAX your response to James Macdonald, MDD Chairperson, at The University of British Columbia.

International Mining Highlights

Information courtesy of: Ontario Ministry of Development & Mines,

- Tasmania's newly elected government is reviewing the country's mining act as part of its approach to encourage mining. It will also allow mining in national parks and plans to determine the industry's environmental responsibilities for operations within the parks. State assurances of long-term access to resources will be examined. The state also plans to provide financial incentives to the mining industry. Prime Minister, J. Groom stated at a recent Australian Mining Industry Council seminar, that *"Tasmania's 2.5 year flirtation with environmentalism at the expense of economic common sense, has cost the state and the mining industry dearly."* Exports by Tasmania's mining industry are responsible for earnings of 1 billion Australian dollars (about C$880 million) annually - half of Tasmania's export earnings.

- A Russian consortium is competing with over 20 western companies in a tender to develop the Udokan copper deposit in Siberia. Udokan has ore reserves estimated at 1,200 million tonnes containing about 18 million tonnes copper. The deposit, discovered in the 1940s, is situated in mountainous terrain and will require an estimated $1 billion for development. Western companies bidding include BHP Minerals, RTZ Corp., and Phelps Dodge

- A study of the international gold industry by AME Mineral Economics of Australia concludes that the gold boom is over and gold prices are unlikely to rise this decade. Investment interest in gold has diminished because of low inflation, high interest rates, falling asset prices and low demand. Demand for gold in the official reserves of countries has diminished because of trading blocks and new currency areas such as the European Economic Community.

- Argentina's Congress is considering two draft bills which are expected to provide new incentives for investment in the country's mineral sector. The proposed laws contain measures to provide: long term fiscal guarantees for mining; tax relief on minerals, mining and environmental protection costs; the right to import capital equipment for mining; and preferential tax treatment for investments in mining and infrastructure. In addition, the bills propose lifting restrictions on operations by foreign companies in border areas and with respect to strategic minerals. Local authorities will be empowered to retain a 3% royalty on minerals extracted.

- Current low platinum prices may be due, in part, by heavy Russian sales of inventory but it is unlikely such sales can be maintained. Demand for platinum went from 2.8 million ounces in 1990 to 3.25 million ounces in 1991; demand is expected to exceed 4 million ounces by 1995 according to RTZ Corp. predictions. Demand is due to a growing industrial base, low stock levels and jewellery.

- The US Advanced Battery Consortium have let $42 million in contracts for the development of two advanced battery technologies for use in electric vehicles: lithium-polymer electrolyte and lithium iron-sulphide. A further $12.2 million is earmarked for research by the US Dept. of Energy. The Consortium was formed by the "big three" automakers and the Electric Power Research Insititute.

- The Prime Minister of Papua New Guinea announced that his government intends to review & renegotiate resource agreements with mining companies. The government intends increasing its share of the Porgera gold project from 10% to 30%. The PNG government alleges that other partners in the project misled it on the project's reserves and profit potential. Apparently the PNG government is also considering increasing its share of RTZ Corp.'s Lihir gold deposit but it is uncertain whether it could fund 30% of the estimated US$700 million development costs. In addition direct international flights from Australia to mining/exploration sites are now banned and flights must go through Port Moresby.

- Marxist guerrillas blew up Columbia's largest copper mine at the beginning of November. The blast destroyed the mine and operations are suspended indefinitely.

- The Prensa Latina news agency reported that Chile's Ministry of Mining is planning to invest some $7,000 million in various projects during the period 1992-1994. These projects will cover geological prospecting, the exploitation of new deposits and the development of existing ones. Chile's mining sector accounts for around 6% of total investment in the country.

- The Northwest Mining Association predicts that with the election of Bill Clinton Democratic mining reform legislation will increase the cost of doing business in the US and force mining companies to go elsewhere.

- A development of a major lead-zinc deposit located in Lanping County, Yunnan Province, China, is expected to be the largest lead-zinc mine in China and one of the world's 10 largest. Reserves are estimated at 150 million tons. Production is scheduled to begin in 1995.

- A report on the environment published by Mines and Metals Research Services indicates that as environmental lobby groups gain wealth, life will become more difficult for metal producers. The report indicates that environmental law is no longer based on scientific principal but rather on the behest of public opinion. The stringent standards being requested could cost the copper, lead and zinc industries of the western world over $6 billion. Much of the public pressure is being applied by environmental lobby groups that have become very wealthy. The largest environmental lobby group in the US is now Nature Conservancy with over $253 million in revenue and almost 8 million members.

- Six of Canada's top 10 gold producers are in Ontario. The top three producers in 1991 were the Williams Mine, the Golden Giant Mine and the David Bell Mine, all at Hemlo.

- New mining legislation in Mexico is expected to attract greater investment. Foreign investors will now be permitted up to 100% direct investment in exploration for a period of 6 years and in excavation activities for 20 years. Restrictions on surface land concessions for mining has been eliminated.

- A report recently published by Metals & Minerals Research Services concludes that copper, lead and zinc producers in the established market economy countries are spending in excess of US$6,000 million to comply with environmental legislation. The report also notes that some producers will be unable to meet the requirements and because of cost or technical reasons numerous mines and processing facilities around the world are at risk.

- The total value of Canadian mineral commodity exports in 1991, as defined by the Harmonized System, was $36.97 billion, according to the Mining Association of Canada's *Mining in Canada: Facts and Figures*, 1992 edition. This is 26.8% of the total domestic exports of $138.08 billion in 1991.

MDD Questionnaire

Please respond to
James Macdonald, Chairperson,
FAX (604) 822-6088

	Not interested	Require further information	Wish to participate
FIELD TRIP - FEBRUARY 1993			
☑ Arizona - Sonora - see details elsewhere in this issue			
PLANNED WORKSHOPS 1993			
☑ Structural Analysis of Shear Zones and Veins in Gold Districts			
☑ Diamonds			
POTENTIAL WORKSHOPS/SHORT COURSES 1993/94			
☑ Geochronometry & Mineral Deposits		■	
☑ Fluid Inclusions & Mineral Deposits		■	

WORKSHOP/COURSE SUGGESTIONS ?

SUGGESTIONS FOR GEOLOGICAL SITES WORTHY OF CONSERVATION ?

EXOTIC Field Trip Suggestions ?

To: Time:

Can YOU organize a trip? YES ☐ No ☐

Your Name:

Address:

Tel:( ) FAX:( )

Conservation of Geological Sites

As a result of the First International Symposium on the Conservation of our Geological Heritage, held in Digne, France, in 1991, it has been suggested to the GAC that a network of geological sites across Canada be established to meet the following objectives:

- maintenance of key reference sites should be perpetually maintained for geological research; *e.g.*, key fossil/mineral sites *etc.*
- access to appropriate sites is essential for the proper training of future generations of geoscientists
- good, well preserved sites are valuable for public education, and therefore are good for the visibility and profile of geology, and related industries, as a whole.

If you have any suggestions of key geological sites that could be targeted for conservation, particularly if the site has relevance to the mining and exploration industries, please put you suggestion on the Questionnaire at the end of this issue of *The Gangue*.

MDD - GAC Memberships 1993

The Gangue newsletter is distributed quarterly to all Mineral Deposits Division members of the GAC. Members are hereby reminded that membership fees must be paid as soon as possible to ensure you receive all issues of *The Gangue* during 1993. The MDD is distributing this issue to all Division members for the 1992 calendar year but the next issue will only be mailed to paid-up members for 1993. **Please Renew Now** to ensure we all stay in touch!

Encourage your friends to join the MDD! Pass *The Gangue* to geoscience associates to encourage their membership.

Mineral Deposit Division memberships are available to all Geological Association of Canada members with the additional payment of the $10 MDD annual fee.

GAC Memberships are available from:

Geological Association of Canada
Dept. of Earth Sciences
Memorial University of Newfoundland
St. John's, Newfoundland
Tel: (709) 737-7660

Basic fee (Fellow) including subscription to GEOLOG newsletter = $55.00
Student fee = $25.00
Retired member (age 65 or over) = $25.00
Unemployed members = $25.00

A Norm-Based Classification for Coarse-Grained Igneous Rocks

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[1] *Current Address: AECL Research, Whiteshell Laboratories, Pinawa, Manitoba R0E 1L0*

Summary

Ironically, the coarser-grained an igneous rock is, the more difficult it may be to identify. The standard IUGS classification is based upon modal proportions of minerals, but samples of very coarse-grained or megacrystic rocks generally are not representative on the scale of a thin section. Point counts of large slabbed surfaces may be impractical, particularly if a study involves many samples. In contrast, representative chemical data are relatively easy to obtain.

A mesonorm-based classification, adapted to the conventional IUGS classification method, was developed for a set of coarse-grained, porphyritic samples from a metaluminous pluton in northeastern Brazil. **The method converts norm-based mineral constituents (q, an, or, ab) to the relative proportions of IUGS modal parameters Q, A and P.** An estimated small percentage of albite (ab) constituent that would be contained within solid solution in alkali feldspar is assigned, with all of the orthoclase (or), to the parameter A. The remaining ab is combined with all of the anorthite (an) constituent to P and the sample is classified by the IUGS criteria as if the data were from a modal analysis. The **mesonorm** is recommended instead of the CIPW norm for all samples, including those that may not contain substantial amphibole or biotite, because it better approximates the mode for silicates by expressing its results in cation percentages rather than in weight percent.

The mesonorm-based classification method was tested with a second set of samples from the pluton from a mineralogically similar but finer-grained facies from which reliable modal data were available. The norm-based classifications correspond closely to results based on modal proportions, in contrast to other chemically-based classification methods such as Q'/ANOR or R_1/R_2 multicationic parameters.

What is a Rock, That It Should Have a Name?

As an international effort to standardize the names of igneous rocks, a subcommittee of the IUGS (International Union of Geological Sciences) headed by A.L. Streckeisen developed recommendations for the classification and nomenclature of plutonic rocks (Streckeisen, 1967; IUGS, 1973). The IUGS classification is based on the modal percentages of quartz (Q), alkali feldspar (A), plagioclase (P), and/or feldspathoids (F).

The Problem

The conventional IUGS classification is a convenient and reliable method for identifying igneous rocks with a grain size greater than 1 mm. But what happens when the sample is too coarse-grained to estimate the mode from thin sections, or when it is not possible to grid and point count large, representative slabs?

This was the problem with the Bodoco Pluton in northeastern Brazil, a coarse-grained and megacrystic intrusion that defied simple modal analysis. The typical lithology of this pluton consists of megacrysts of alkali feldspar in a coarse-grained matrix of plagioclase, hornblende, biotite, quartz, and titanite. Individual megacrysts commonly are larger than standard petrographic thin sections.

A Mesonorm-based Approach

The objective of this study was to develop a simple classification method that would use whole-rock geochemical analyses to approximate the standard IUGS modal classification. The method was designed to permit relatively rapid identification of the most com-

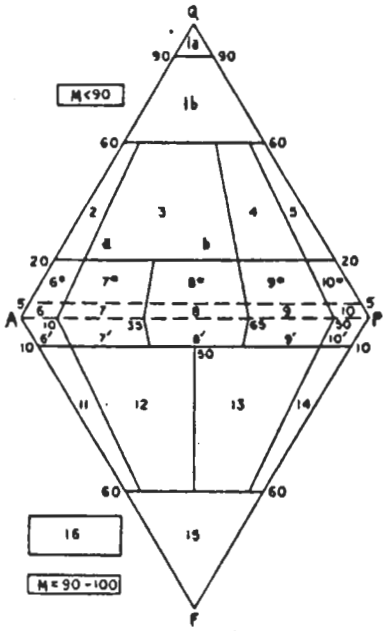

Figure 1: The standard IUGS classification diagram for plutonic rocks (from IUGS, 1973)

Minerals & mineral groups

Q - quartz
A - alkali feldspars (orthoclase, microcline, perthite, anorthoclase, albite
P - plagioclase, scapolite
F - feldspathoids or foids (leucite and pseudoleucite; nepheline, sodalite, nosean, hauyne, cancrinite, analcime, *etc:)*
M - mafic and related minerals (micas, amphiboles, pyroxenes, olivines, opaque minerals, accessories (zircon, apatite, titanite, *etc.),* epidote, allanite, garnets, melilites, monticellite, primary carbonates, *etc.*)

$$Q + A + P = 100 \quad \text{or,} \quad A + P + F = 100$$

Classification and nomenclature according to modal mineral content (measured in volume percent)

1a	Quartzolite (silexite)
1b	Quartz-rich granitoids
2	Alkali-feldspar granite
3	Granite
4	G ranodiorite
5	Tonalite
6*	Alkali-feldspar quartz syenite
7*	Quartz syenite
8*	Quartz monzonite
9*	Quartz monzodiorite/ quartz monzogabbro
10*	Quartz diorite/ quartz gabbro/ quartz anorthosite
6	Alkali-feldspar syenite
7	Syenite
8	Monzonite
9	Monzodiorite/ monzogabbro
10	Diorite/ gabbro anorthosite
6'	Foid-bearing alkali-feldspar syenite
7'	Foid-bearing syenite
8'	Foid-bearing monzonite
9'	Foid-bearing monzodiorite/ monzogabbro
10'	Foid-bearing diorite/ gabbro
11	Foid syenite
12	Foid monzosyenite (syn. foid plagisyenite)
13	Foid monzodiorite/ Foid monzogabbro (both syn. essexite)
14	Foid diorite/ Foid gabbro (syn. Theralite)
15	Foidolites
16	Ultramafic rocks (ultramafites)

mon types of plutonic igneous rocks. Whole-rock chemical analyses of the Bodoco samples were converted to ***normative minerals*** that were used to classify the rocks by the IUGS method as if they were modal data.

Like many plutonic rocks, the Bodoc samples contained abundant hornblende and biotite, so the mesonorm (Barth, 1959) was determined instead of the CIPW norm. The chief difference between the CIPW norm and the mesonorm is that the mesonorm includes standardized compositions of several hydrous minerals (hornblende, biotite, actinolite, and barkevite). Additional confidence in the use of the mesonorm for the Bodoco samples was provided by the fact that actual compositions of hornblende and biotite, obtained by electron microprobe, were similar to the standardized compositions of the mesonorm. This resulted in relatively accurate predictions of the proportions of feldspar in the samples, a critical parameter of the IUGS classification.

Another advantage of using the mesonorm instead of the CIPW norm, even for rocks that do not contain much amphibole or mica, is that the mesonorm is calculated and reported on the basis of cation percentages, which for silicates correspond approximately to the mode (Barth, 1955).

An Example of the Mesonorm-based Classification

The mesonorm-based classification is demonstrated with a step-by-step classification method using a typical megacrystic sample, MEG-57A (Table 1), from the Bodoco pluton. Sample MEG-57A contains megacrysts of perthitic alkali feldspar in a coarse-grained matrix of plagioclase, hornblende, biotite, quartz and titanite.

Table 1: CHEMICAL ANALYSIS FOR SAMPLE MEG-57A

Oxide	Oxide Wt %	Cation	Normalized Cation %
SiO_2	63.56	Si	59.18
TiO_2	0.67	Ti	0.47
Al_2O_3	15.61	Al	17.13
Fe_2O_3	1.29	Fe3+	0.90
FeO	2.82	Fe2+	2.20
MnO	0.06	Mn	0.05
MgO	2.23	Mg	3.10
CaO	3.39	Ca	3.38
Na_2O	3.95	Na	7.13
K_2O	5.14	K	6.11
P_2O_5	0.46	P	0.36
TOTAL	99.18		100.01

Part 1. Convert chemical analysis to mesonorm

(*see* Barth, 1955, for full details of how to calculate the mesonorm)

1. Convert weight percent oxides to cation percentages (as above).
2. Consume all Ti, Fe3+, and P by making tn , mt and ap.
   titanite = 0.47 [Ti] + 0.47 [Ca] + 0.47 [Si] = 1.41
   magnetite = 0.90 [Fe3+] + (1/2 x 0.90) [Fe2+] = 1.35
   apatite = 0.36 [P] + (5/3 x 0.36) [Ca] = 0.96
3. Consume all Na to make ab .
   albite = 7.13 [Na] + 7.13 [Al] + (3 x 7.13) [Si] = 35.65
4. Consume all K to make provisional or .
   prov. orthoclase = 6.11[K]+6.11[Al]+(3.6 x 6.11)[Si]= 30.55
5. Consider sum of remaining Fe2+, Mn, & Mg as Mg .
   Mg = 1.75 [Fe2+] + 0.05 [Mn] + 3.10 [Mg] = 4.90
6. Procedure varies depending on the percentages remaining of Ca, Al, and Mg :
   At this point in the mesonorm, totals remaining for MEG-57A are:

Al = 3.89	2Ca = 4.62	2Ca - 0.5 Mg = 1.95

Case A: Al > 2 Ca	Case A: 3.89 > 4.62 = false
Case B: Al > 2 Ca - 0.5 Mg	Case B: 3.89 > 1.95 = TRUE
Case C: Al < 2 Ca - 0.5 Mg	Case C: 3.89 < 1.95 = false

Therefore, go to STEP 6, Case B (re. Barth, 1955).

STEP 6, Case B: Distribute remaining Ca between an and ho , then unmake some or to make "bi".

% Ca in anorthite : Al - Ca

% Ca in hornblende : 2Ca - Al

anorthite = 1.58 [Ca] + (2x1.58)[Al] + (2x1.58)[Si] = 7.90
hornblende
= 0.73[Ca] + (2x0.73)[Mg] + 0.73[Al] + (7/2x0.73)[Si] = 5.48
biotite = 3.44[Mg] + (5/3x3.44)[or'] = 9.17
revised orthoclase = 30.55 [or] - (5/3 x 3.44) [or] = 24.82

7. Assign all remaining Si to q . If q > 0, the mesonorm calculation is complete. (Mineral percentages should total 100% - Table 2.)

quartz = 13.28 [Si] = 13.28

Table 2: MESONORM FOR SAMPLE MEG-57A

Normative Component		Percent*
quartz	q	13.28
orthoclase	or	24.82
albite	ab	35.65
anorthite	an	7.90
hornblende	ho	5.48
biotite	bi	9.17
magnetite	mt	1.35
titanite	tn	1.41
apatite	ap	0.96
		100.02

** Distribution of cations (%)*

Part 2. Adapt the Mesonorm to an IUGS-type classification

Use the mesonorm calculated in Part 1 to adapt the normative constituents to the IUGS-type parameters Q , A and P :

Step 1. **Quartz.** Assign mesonorm quartz (q) constituent to Q .

Q = q = 13.28

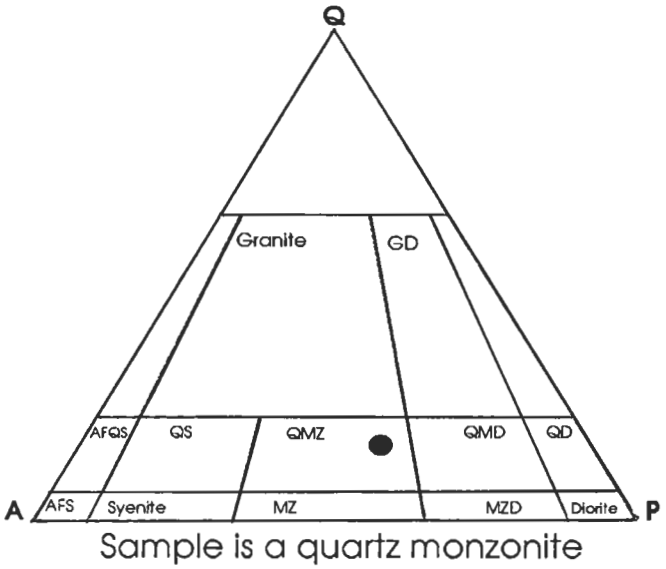

Figure 2. QAPF Diagram.

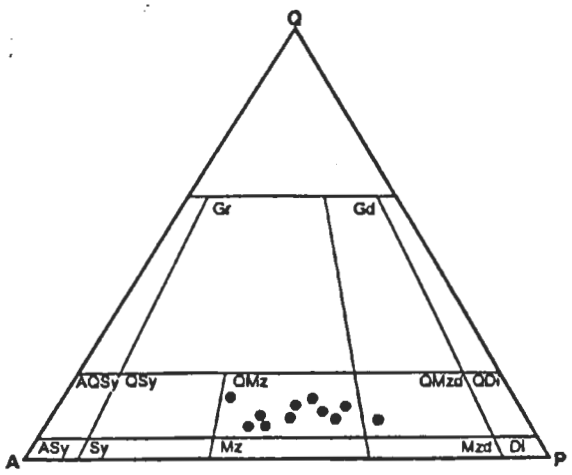

Figure 3a. Modal classification (IUGS) based on petrographic point counts of fine-grained and medium-grained samples from border facies of the Bodoco pluton. Most samples are classified as quartz monzonite.

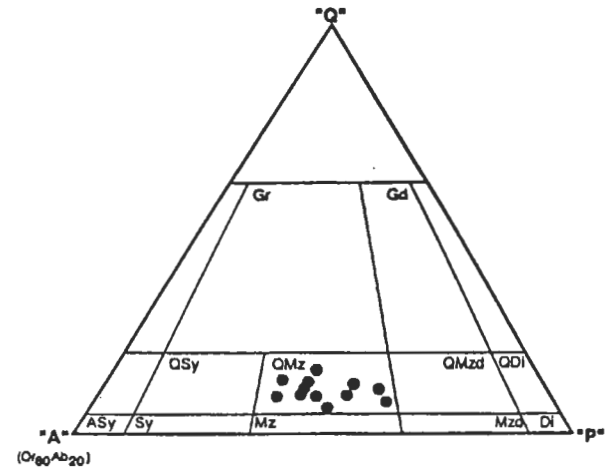

Figure 3b. Mesonorm-based adaptation of the IUGS classification, using whole-rock chemical analyses of fine-grained and medium-grained samples from the border facies of the Bodoco pluton. Results correspond well with the modal classification; most samples are quartz monzonite.

Figure 3 Abbreviations

AQSy	Alkali Feldspar Quartz Syenite
ASy	Alkali Feldspar Syenite
Di	Diorite
Gd	Granodiorite
Gr	Granite
Mz	Monzonite
Mzd	Monzodiorite
QDi	Quartz Diorite
QMz	Quartz Monzonite
QMzd	Quartz Monzodiorite
QSy	Quartz Syenite
Sy	Syenite

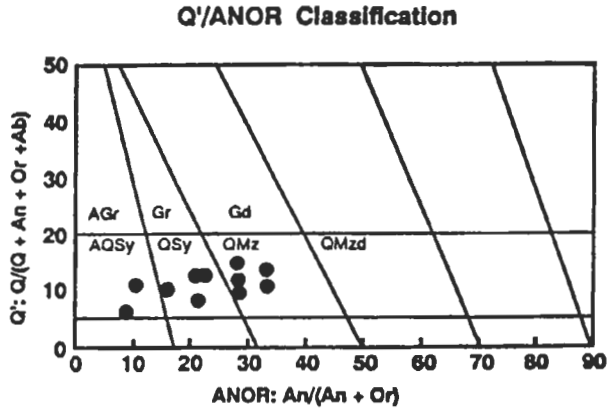

Figure 4: Q'/ANOR classification (Streckeisen & LeMaitre, 1979). In the Q'/ANOR classification of these samples, the relative proportions of plagioclase and alkali feldspar are misrepresented. According to this method, the analyzed samples are more syenitic than the modal data indicate.

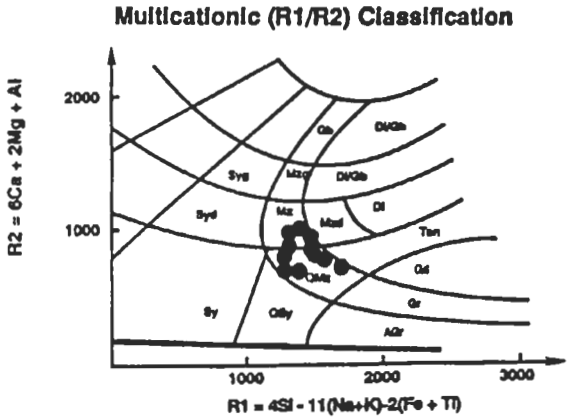

Figure 5: R_1/R_2 Multicationic Parameters (De la Roche and others, 1980). This method underestimates the proportion of modal quartz in the samples. Modally, most of the samples in this set are quartz monzonite, but the R_1/R_2 multicationic classification describes many as monzonite.

Figure 4 & 5 Abbreviations

AGr	Alkali Feldspar Granite
AQSy	Alkali Feldspar Quartz Syenite
Di	Diorite
Di/ Gb	Diorite/ Gabbro
Gb	Gabbro
Gd	Granodiorite
Gr	Granite
Mz	Monzonite
Mzd	Monzodiorite
Mzg	Monzogabbro
QMz	Quartz Monzonite
QMzd	Quartz Monzodiorite
QSy	Quartz Syenite
Sy	Syenite
Syd	Syenodiorite
Ton	Tonalite

Step 2. **Alkali feldspar.** Alkali feldspar contains orthoclase (or) plus a small amount of albite (ab) in solid solution. Use microprobe data, if available, or petrography to estimate the amount of albite constituent to apportion to alkali feldspar. For example, analytical data for the Bodoco pluton indicate that the average composition of alkali feldspar is $Or_{92}Ab_8$. In addition, the megacrysts are coarsely perthitic; about 10-15 percent of each megacryst consists of albitic exsolution lamellae. To compensate for the albite constituent in the alkali feldspar, it is estimated that the original (unexsolved) composition of the Bodoco megacrysts was approximately $Or_{80}Ab_{20}$. Therefore, or and ab are apportioned to A as follows:

ab* = 20 x (or/80)
A = or + ab*
= 24.82 + 6.21
= 31.03

Step 3. **Plagioclase.** Combine the remainder of the albite (ab) constituent with all of the anorthite (an) constituent and assign to P.

P = an + (ab - ab*)
= 7.90 + (35.65 - 6.21)
= 7.90 + 29.44
= 37.34

Part 3. Plot Q-A-P data and identify the rock type

Normalize Q, A, and P to 100 percent, and plot on a QAPF diagram to identify the rock type (Figure 2).

Q = Q / (Q + A + P) x 100
= 13.28 / 81.65
= **16.3**
A = A / (Q + A + P) x 100
= 31.03 / 81.65
= **38.0**
P = P / (Q + A + "P") x 100
= 37.34 / 81.65
= **45.7**
Q + A + P = (16.3 + 38.0 + 45.7)
= **100.0**

Test Case

The mesonorm-based approach was tested on a subsidiary set of samples. These were from a finer-grained but compositionally similar border facies of the pluton for which modal analyses were available. The norm-based classifications corresponded closely to results based on the conventional IUGS modal classification (Figures 3a and 3b).

Other Methods

The samples in the test case, for which both modal and chemical data were available, were used to test several other classification methods that rely on chemical analyses. The other methods tended to misrepresent the rock types that were indicated by the modal data (Figures 4, 5).

Summary

A mesonorm-based adaptation of the conventional IUGS classification can provide a reasonably reliable prediction of rock type for very coarse-grained igneous rocks or for other samples for which there are chemical analyses but no modal data. The method has been tested successfully with quartz-bearing plutonic rocks of intermediate composition. If analytical data of the mineral phases are available, the norm-based calculations may be improved by incorporating small percentage of albite component into alkali feldspar.

Acknowledgments

This study was funded in part by a Grant-in-Aid of research by Sigma Xi. Microprobe analyses were supported by NSF grant EAR-8720141 to Dr. Calvin Barnes, Texas Tech University. Anthony Kost and Rick McKee are thanked for preparing the illustrations.

The paper was originally presented as a poster, GAC/MAC Annual Meeting, 1992, Wolfville, Nova Scotia.

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Streckeisen, A.L. (1967): Classification and nomenclature of igneous rocks (final report of an enquiry); *Neues Jahrbuch fur Mineralogie Abhandlungen*, Vol. 107, p. 144-240.

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MEETINGS, WORKSHOPS & FIELDTRIPS

[Editor's Note: If you are sponsoring or are aware of a meeting or event of potential interest to economic geologists please FAX me a note at (604) 356-7413 so that it may be included in the next issue of The Gangue. Notices must include a contact address or phone number. Thanks!]

JANUARY 1993

26 - 29 **Cordilleran Roundup 1993.** Vancouver, B.C. The major mineral exploration convention in Western Canada. Sessions on economic geology & ore deposit models, geological poster sessions, trade show, core shack, *etc.* Organized by the BC & Yukon Chamber of Mines in cooperation with the British Columbia Geological Survey Branch and Geological Survey of Canada. For details: Jack Patterson, Managing Director, 840 West Hastings Street, Vancouver, B.C., V6C 1C8. Tel. (604) 681-5328; FAX (604) 681-2363.

FEBRUARY 1993

15 - 17 **SEG Winter Meeting and SME Annual Meeting 1993.** Reno, Nevada. Society for Mining, Metallurgy and Exploration, Inc. For details: J.E. Cross, SME - Meetings Department, P.O. Box 625002, Littleton, Colorado 80162.

18 - 28 **MDD-GAC Field Trip to Arizona and Northern Mexico.** For details: J. Macdonald, Chairperson, MDD, c/o Mineral Deposits Research Unit, Department of Geological Sciences, The University of British Columbia, 6339 Stores Road, Vancouver, B.C., V6T 1Z4, Canada. Tel. (604) 822-4563; FAX (604)

822-6088. See elsewhere in this issue for further details.

MARCH 1993

28 - 31 **PDAC 1993 International Convention on Mineral Exploration and Development.** Toronto, Ontario, Canada. Sponsored by the Prospectors and Developers Association of Canada. Will include a short course on exploration and evaluation of **diamond deposits**, a technical program focussed on diamonds in North America, a session on CIS and Eastern European opportunities, standards for ore reserves and metallurgy, and a day devoted to new discoveries and developments. Information contact: PDAC, 74 Victoria Street, Toronto, Ontario, Canada, M5C 2A5. Tel: (416) 362-1969, FAX: (416) 362-0101.

APRIL 1993

Date to be announced. **Volcanoes and Ore Deposits.** Short Course No. 13, Mineral Deposits Research Unit. Vancouver, British Columbia. For details: S. Tietjen, MDRU, Department of Geological Sciences, The University of British Columbia, 6339 Stores Road, Vancouver, B.C., V6T 1Z4, Canada. Tel. (604) 822-6136; FAX (604) 822-6088.

6 - 8 **Symposium on Mineral Resource Evaluation.** Sponsored by the Dept of Geology, Univ of Leicester in conjunction with the Institution of Mining and Metallurgy (Midlands Section), the Geosciences Information Group, and the Mineral Deposits Study Group. For information contact: Mike Whateley or Peter Harvey, Dept of Geology, Leicester Univ. University Road, Leicester LE1 7RH, United Kingdom. Tel: (0533) 523922 or 523796 FAX: (0533) 523918.

4 - 8 25th **International Symposium on Remote Sensing and Global Environmental Change.** Graz, Austria. Contact: ERIM/International Symposium, PO Box 134001, Ann Arbor, MI 48113-4001, USA. FAX (313) 994-5123.

17 - 20 **Integrated Methods In Exploration & Discovery. SEG 1993 Spring Conference.** Red Lion Hotel, Denver, Colorado. Sponsored by SEG, Soc. of Expl. Geophysicists, Assoc. of Expl. Geochemists, and the U.S. Geological Survey. For details: Richard L. Nielsen, 13741 Braun Drive, Golden, Colorado 80401, USA. Tel: (303) 279-3118, FAX (303) 674-3885.

MAY 1993

17 - 19 **Edmonton 1993. GAC/MAC Joint Annual Meeting.** Edmonton, Alberta. University of Alberta. For details: J.W. Kramers, Alberta Geological Survey, P.O. Box 8330, Station F, Edmonton, Alberta, T6H 5X2. Tel. (403) 438-7603; FAX. (403) 438-3364.

Date to be announced. **UBC - Industry Chilean Field Trip.** UBC graduate students with Dr. C. Godwin are organizing a field trip to mineral deposits in northern Chile between Santiago and Calama. Focus is on about 12 copper-gold mineralization. Cost est $3800. Only 15 places available - Reserve a spot by sending $500deposit payable to Univ of B.C. by February 1, 1993 to: Chile Field Trip 1993, c/o Sonya Tietjen, Dept. of Geological Sciences, 6339 Stores Road, Vancouver, BC, Canada, V6T 1Z4. Tel: (604) 822-6136 FAX (604) 822-6088. Be sure to include your full name, address, telephone & FAX number for contact.

AUGUST 1993

5 - 7 **Remote Sensing Methods for Tectonics and Prospecting Workshop.** St. Petersbury, Russia. Organized by the Mining Institute (Gornyi Institut) and the Scientific Center of the Russian Academy of Sciences. Focus will be on types of surveys using satellite data and methods of digital processing; geological models of major ore deposits and the patterns of their manifestation in satellite images, and the integration of remote sensing, geophysical and geological data to predict ore mineralization. For information contact: VIKKNAM - Institute of Remote Sensing for Geology, Birjevoy proezd 6, St. Petersburg, 199034, Russia. In the U.S.A. Tel: (812) 218-2801 FAX (812) 218-3916.

18 - 20 **International Conference - Mineral Exploration '93.** Cape Town, South Africa. Organized by the Camborne School of Mines. For information contact: Mineral Exploration '93, c/o Richard Edwards, Camborne School of Mines, Redruth, Cornwall, England. Tel: (0209) 714866 FAX: (0209) 716977.

SEPTEMBER 1993

1 - 3 **International Symposium of Mineralization Related to Mafic and Ultramafic Rocks.** Sponsored by: CODMUIR, IAGOD, SGA and SEG. Orleans, France. For details: D. Ohnenstetter, CRSCM, 1A rue de la Fnrolloerie, 45071 Orleans Cedex 2, France. Tel; 33-38-51-54-01; FAX. 33-38-63-64-88.

1 - 5 **16th International Geochemical Exploration Symposium.** Beijing, China. For information contact: Mr. Xu Li, 16th IGES Office, 26 Bai Wan Zhuang Dajie, Beijing 100037, China. Telex 22531 MGMRC CN, FAX: 86-1-420628.

Mid-September **Alaska Mineral Deposits.** Sponsored by the Society of Economic Geologists. Eight-day excursion will commence in Fairbanks and end in Juneau. Further details contact: Will White, U.S. Geological Survey, 4200 University Drive, Anchorage, Alaska, 99508-4667.

21 - 23 **Second International Symposium on Andean Geodynamics (ISAG 93),** Oxford, England. For details: Dr. P. Soler, ISAG 93, ORSTOM, CSI, 213 Rue Lafayette, 75480 Paris Cndex 10, France. FAX. 33-1-48-03-08-29.

25 - Oct. 1 **Ancient Volcanism and Modern Analogues,** Canberra, Australia. IAVCEI General Assembly 1993. For details: IAVCEI ACTS, GPO Box 2200, Canberra, ACT 2601 Australia. Tel: (616) 257-3299; FAX: (616) 257-3256.

OCTOBER 1993

25 - 28 **SEG Fall Meeting and Geological Society of America Annual Meeting.** Boston, Massachusetts. For details: Half Zantop, SEG Program Chair, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire, 03755, USA.

NOVEMBER 1993

Date to be announced. **Geology and Ore Deposits of the Southern Andes.** D. Sillitoe, C. Mpodozis and F. Camus, Short Course No.14, Mineral Deposits Research Unit. Vancouver, British Columbia. For details: S. Tietjen, MDRU, Dept of Geological Sciences, The University of British Columbia, 6339 Stores Road, Vancouver, B.C., V6T 1Z4, Canada. Tel. (604) 822-6136; FAX (604) 822-6088.

Date to be announced. **Structural Geology in Mineral Exploration.** Presented by K. McClay. Short Course No.14, Mineral Deposits Research Unit. Vancouver, British Columbia. For details: S. Tietjen, MDRU, Dept of Geological Sciences, The University of British Columbia, 6339 Stores Road, Vancouver, B.C., V6T 1Z4, Canada. Tel. (604) 822-6136; FAX (604) 822-6088.

DECEMBER 1993

2 - 4 **SEG - NWMA Northwest Mining Association 99th Annual Convention - New World of Minerals.** Spokane, Washington. For details: K.W. Mote, Executive Director, NWMA, 10 North Post, Suite 414, Spokane, Washington, USA 99201-0772. Tel. (509) 624-1158; FAX (509) 623-1241. See further details in this issue.

OCTOBER 1994

24 - 27 **SEG Fall Meeting and Geological Society of America Annual Meeting.** For details: Eric S. Cheney, 1994 SEG Program Chairman, Department of Geological Sciences, University of Washington, AJ-20, Seattle, Washington, WA 98195, USA.

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MITEC

Dear Editor:

I wish to update the Mineral Deposits Division of the GAC on the Exploration Technology Division of MITEC. The Mining Industry Technology Council of Canada (MITEC) is a national non-profit organization created and funded by industry for the promotion and coordination of research and technology in exploration, mining and processing technologies. MITEC neither performs research itself nor funds R&D directly; its operations are to assemble research projects to meet industry needs.

The Canadian mining industry is concerned about the declining reserves of base metals in Canada, and the low discovery rate in recent years from mineral exploration in Canada. A meeting of concerned geoscientists primarily from industry, by including government and universities, resulted in the formation of the ETD. The mission, objectives and the founding corporations are listed below. The administrative arrangements for ETD allow it to cooperate and work with all companies in Canada as well as with foreign institutions and researchers wherever suitable to achieve ETD objectives.

Discussions have been held with each company supporting the ETD. These consultations have established three broad research directions as priorities for the bulk of Canadian mining companies. They are:

- improved geochemical techniques in areas of thick glacial cover;
- deep penetrating geophysical systems, which includes airborne, surface and borehole EM and surface seismic techniques; and,
- improved multidisciplinary analyses of Canadian ore deposits.

Additional areas of concern include:

- the use of remote sensing in the Canadian Shield environment;
- improved integration of exploration techniques;
- tectonic settings and search parameters of World Class Ore Deposits.

Three informal committees have been formed to examine the three main directions with the mandate to develop projects and to evaluate unsolicited projects that are consistent with our mandate. We expect to solicit funding for several projects before the end of the year.

The Exploration Technology Division would be pleased to hear of ongoing research endeavours which are in the public domain. It is our wish to draw on the most knowledgeable and capable sources in the global research community for work done under the auspices of ETD.

Yours truly,
Richard L. Moore

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Mining Industry Technology Council of Canada
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--- *ATTACHMENT* ---

MITEC Mission

- To contribute to the survival, profit and growth of the Canadian mining industry by improving the efficiency and effectiveness of mineral exploration through the development of innovative technology and methodology by managing and coordinating applied cooperative research.
- To become the principal agency by which cooperative exploration research funds are transferred to researchers (institutions, private or public companies, individuals, *etc.)* from the mining industry.

Objectives

- To define the agenda of breakthrough exploration issues required to increase the probability of discovering "world class deposits", particularly in Canada.
- To identify specific priority needs of exploration which can be achieved in both the short and long-term, through focussed high quality research.
- To select research groups and facilities most likely to achieve positive results within budget and time constraints.
- To solicit financial and technical support from industry on an individual project basis.
- To manage the implementation of selected projects.
- To monitor and manage the dissemination of information on all mineral exploration related research of relevance to Canada and to facilitate the distribution of progress reports and results.

Supporting Members:

American Barrick Resources Corp.
BHP Minerals
Billiton Minerals Canada Inc.
Brunswick Mining and Smelting Corp. Ltd.
Cambior Ltd.
Cominco Ltd.
Falconbridge Ltd.
Hemlo Gold Mines Inc.
Inco Ltd.
International Corona Corp.
Kennecott Canada Inc.
Lac Minerals Ltd.
Minnova Inc.
Noranda Exploration
Placer Dome Inc.
Rio Algom Exploration Inc.
Strathcona Mineral Services Ltd. (Nanisivik Mines)
Teck Exploration Ltd.
Westminer Canada Ltd., Exploration Division