Discovery of a Jurassic Porphyry Copper Belt, Panguí Area, Southern Ecuador

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ABSTRACT

Grassroots exploration has led to discovery of 10 porphyry copper prospects in the previously unexplored Jurassic arc of southeastern Ecuador. The prospects are located in steep, wet, jungle-covered terrain in the Panguí area, part of the Cordillera del Cóndor. The exploration program, initially mounted in search of gold in the Oriente foreland basin, employed panned-concentrate drainage sampling. Follow-up of the resulting anomalies utilized soil sampling combined with rock-chip sampling and geologic mapping of the restricted creek outcrops. Scout and infill drilling of two of the prospects. San Carlos and Parianta, has shown hypogene mineralization averaging 0.5 to 0.7 percent Cu overlain by thin (averaging <30 m) zones of chalcocite enrichment or oxidized copper mineralization.

The prospects are centered on small, composite granodiorite to monzonite porphyry stocks that cut the Zamora batholith or, in one case, a satellite pluton. The batholith is emplaced into Jurassic volcanosedimentary
Corrections and Amplifications

The following footnotes for the "Discussions on Professional Ethics" column that appeared in the July 2000 issue of the SEG Newsletter were inadvertently omitted in the production process.

1 The JORC and VALMIN Codes can be found at www.australiancouncil.org/codes.

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THE UNIVERSITY OF ARIZONA.
TUCSON, ARIZONA.

The Department of Geosciences, University of Arizona, invites applications for this recently endowed Chair—a tenure-eligible faculty position to be filled in 2001. For further information contact:

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Laurentian University Department of Earth Sciences and Mineral Exploration Research Centre

Assistant Professor in Exploration Geochemistry

The Department of Earth Sciences and Mineral Exploration Research Centre (MERC) at Laurentian University invites applications for a tenure-track position at the Assistant Professor level in Geochemistry beginning July 1, 2001. Preference will be given to candidates experienced in exploration geochemistry and the candidate will interact with the mineral exploration industry in utilizing chemical data to model ore deposition and/or hydrothermal alteration associated with mineral deposits. In particular, experience in designing, conducting, and interpreting exploration lithogeochemical studies of mafic (Ni-Cu-PGE), VMS (Cu-Zn-Pb), lode gold, and or epithermal gold deposits is desirable. Teaching responsibilities will include courses in low- and high-temperature geochemistry at the undergraduate level, and exploration geochemistry at the graduate level. Supervision of graduate students within a vigorous, externally funded research program is expected. Information about the Department and MERC can be found at www.laurentian.ca/www/geochemistry.

A Ph.D. degree is required at the time of appointment. Applicants should send a curriculum vitae, examples of published work, a statement of teaching and research interests, and the names and mail/e-mail addresses of at least four (4) referees to: Faculty Search Committee, Department of Earth Sciences, Laurentian University, Sudbury, Ontario P3E 2C6, Canada. E-mail: DES@nickel.laurentian.ca, Fax: +1 (705) 675-4898.

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Contents

FEATURE ARTICLE
1 Discovery of a Jurassic Porphyry Copper Belt, Panguí Area, Southern Ecuador

NEWSLETTER COLUMNS
4 From the Executive Director: The SEG Website (www.segweb.org)—Current Status and Future Direction
5 PRESIDENTIAL PERSPECTIVE: Exploration, Research and the Information Highway: What Role for SEG?
6 From the Treasurer: SEG Foundations Extend Their Growth
7 SEG Report: Foundation Programs Provide Substance and Impact
8 Recent Contributors to SEG Foundation
9 SEG Student Research Grants Available in 2001

SEG NEWS
16 Global Exploration 2002—Integrated Methods for Discovery
17 SEG international Headquarters Dedicated
20 2000–2001 International Exchange Lecturer
21 Regional Vice President Report—South America
22 Report on ORE Deposits Mapping Course
23 Regional Vice President Report—Oceania: 15th Australian Geological Convention
24 Student Chapter News
29 SEG/University of Toronto Short Course: VMS Exploration
29 SEG/New Zealand Field Trip

SPECIAL FEATURE
30 A Record of the Early Years of Waldemar Lindgren (1878–1982) at the Freiberg Mining Academy, Germany

EXPLORATION REVIEWS
34 Mineral Exploration in Tanzania
37 Alaska
39 Western Canada
41 United States
42 Mexico

MEMBERSHIP
44 SEG Membership: Candidates and New Fellows, Members and Student Members
45 Personal Notes & News
50 SEG Membership Application Form

ANNOUNCEMENTS
2 "We've Moved!" (SEG Contact Information)
2 Corrections & Amplifications
2 J. David Lowell Chair in Economic Geology, University of Arizona
46 SEG-PDAC Meeting
46 Member Website Information Update
46 SEG-SME Annual Meeting in Denver, CO
46 SEG Web Page
47 NWMA Meeting
47 SEG FIELD TRAINING COURSE: Carbonate-hosted Zinc Deposits in High-Sulfidation Epithermal Systems, Central Perú
47 WEB Stable Isotope Fractionation Calendar

PUBLICATIONS
49 Publications of Interest
51 Publications Order Form

CALENDAR
45 ADVERTISERS—
45 Activation Laboratories, Ltd.
46 AECX
42 Anzaman, Joseph R.
20 Baltaev Colorado, Inc.
48 Barranca Resources
36 Cominco American
45 Ellis, B. Gerhard
20 Erickson, A.J.
38 Fuchs, William A.
48 Gencos, Inc.
48 James GeoAssociates P.C.
41 Larson, Lawrence T., Ph.D.
2 Laurentian University
43 Learning Curve
36 Mining Activity Update
38 MiningPro Files
40 Montgomery & Associates
48 Nut & Associates
38 Park, Gordon M.
45 Phelps Dodge
36 Pimco, Allen & Holt
8 Pollock, Roger
42 Recursos del Caribe S.A.
41 Sinclair Knight Merz
40 XRAL
39 Zonge Engineering & Research

DEADLINE FOR NEWSLETTER #44: November 30, 2000
The SEG Website (www.segweb.org)—Current Status and Future Direction

There are many issues that attract a diversity of opinions in the SEG, but none so great as the direction that the Society should be taking with regard to the Internet. Quantifying responses to the recent website questionnaire has provided a wealth of information, much of which will be used in setting priorities for future initiatives on the web. We sent out 2,185 e-mails and received 858 responses. This proportion equates to a return of nearly 40%, an encouraging response given the relatively high number of failed transmissions. Responses to questions 1–10 are summarized below (see page 4 of the April issue of the Newsletter for a copy of the questionnaire).

Q1: The vast majority (96%) of respondents used e-mail daily, although 3% were weekly users, and 1% only used e-mail on a monthly basis.

Q2: Internet usage was daily for 67% of those surveyed. 27% accessed the Internet on a weekly basis and 5–6% either did not respond or indicated that they never used the Internet.

Q3: With regard to the SEG website, 53% accessed the site on a monthly basis and 1% on a weekly basis, 13% indicated that they never accessed the site.

Q4: Responses to the reasons for not accessing the SEG website mostly listed “other” (51%), followed by 31% who were “not familiar/comfortable with it,” 14% had “no interest,” and 4% had “computer equipment too old/low/not available.”

Q5: The most relevant websites for economic geologists were voted to be: a—InfoMine (107); b—SEG (94); and c-USGS (91).

Q6: Features that could be added to the SEG website were ranked as follows based on the percentage of respondents who rated a feature as (1) “strong interest and frequent use,” (2) “moderate interest and occasional use,” or (3) “little interest”:

<table>
<thead>
<tr>
<th>Feature</th>
<th>#1 rating</th>
<th>#2 rating</th>
<th>#3 rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral deposit info (case studies/models)</td>
<td>88%</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>Downloadable versions of SEG publications</td>
<td>67%</td>
<td>20%</td>
<td>9%</td>
</tr>
<tr>
<td>Links (linked to other relevant sites)</td>
<td>62%</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td>Online (virtual) short courses/field trips</td>
<td>12%</td>
<td>43%</td>
<td>11%</td>
</tr>
<tr>
<td>Job board for members/employers</td>
<td>36%</td>
<td>40%</td>
<td>19%</td>
</tr>
<tr>
<td>Online registration for meetings/events</td>
<td>59%</td>
<td>43%</td>
<td>16%</td>
</tr>
<tr>
<td>Online membership dues payment</td>
<td>54%</td>
<td>29%</td>
<td>26%</td>
</tr>
<tr>
<td>Member profiles database (restricted access)</td>
<td>15%</td>
<td>45%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Q7: In terms of publications, website features were ranked as follows based on the same numerical system as above:

<table>
<thead>
<tr>
<th>Publication</th>
<th>#1 rating</th>
<th>#2 rating</th>
<th>#3 rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEG Newsletter</td>
<td>65%</td>
<td>20%</td>
<td>11%</td>
</tr>
<tr>
<td>Articles from Economic Geology</td>
<td>56%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Special Publications</td>
<td>54%</td>
<td>28%</td>
<td>15%</td>
</tr>
<tr>
<td>Monographs in Economic Geology</td>
<td>49%</td>
<td>29%</td>
<td>16%</td>
</tr>
<tr>
<td>Reviews in Economic Geology</td>
<td>43%</td>
<td>31%</td>
<td>22%</td>
</tr>
<tr>
<td>SEG Field Trip Guidebooks</td>
<td>38%</td>
<td>40%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Q8: The majority of respondents were either self-employed (30%) or corporate (30%), followed by academia (28%) and government (11%). About 1% did not enter any affiliation.

Q9: Regionally, the participants broke down as follows: North America (53%), Oceania (19%), Europe (11%), South America (10%), Asia (4%), and Africa (3%).

Q10: By age group, respondents were mostly 40–49 (30%), followed by 50–59 (26%), 60–69 (23%), 60 and older (11%), and younger than 30 (9%). About 1% did not enter any age group.

The comments and suggestions listed in response to the narrative-style Question 11 have turned out to be the most useful part of this survey. However, entering these free-format responses into our database has only recently been completed. Discussion of some 800 individual responses will be the subject of a future column. There is also much more to be gleaned from the existing responses, particularly in terms of preferences as related to region or affiliation.

This survey is extremely useful, but any conclusions relate to the current status of the SEG membership. The information provided by the survey must be considered within the context of changing demographics and what SEG might look like in the years to come. Consider in this regard that approximately three out of four new member applications are from outside of North America. Furthermore, many of the efficiencies to be gained from an increased presence on the Internet have more to do with cutting administrative overheads than providing wizardry that might be accessible to only those members who benefit from sufficient bandwidth. In this regard, we should also be looking to such initiatives as electronic poll-taking to cut the costs of postage, electronic transfer of paper proofs rather than using courier services, and processing of publication orders over the Internet. At the same time we must address the real needs of the membership—several members have alerted me to competitor websites that deliver more sophisticated services than SEG. Interestingly, as a member of other societies that have recently made large capital expenditures on their websites, I am evaluating my continued membership against an increase in dues. If this is a consideration to me in the USA, how much more so to a member based in a developing country where earnings are not in hard currency? The rule of the Internet has been that organizations need to deliver value, but typically not at increased cost. SEG needs to guard against overreacting to moves by competitors, especially in...
such areas as downloadable publications, where there are many different business models without any clear winner.

SEG is continuing to pursue the route of building alliances and leveraging the knowledge and experience of its volunteers. Erich Petersen, our webmaster in Utah, has been training SEG staff in Littleton to conduct website edits so that we can elevate our editorial standards to the same level as other SEG publications. In parallel, Sue Courtney (Membership Services) has been working hard to finalize SEG's online bookstore, now close to completion through the cooperative efforts of Chris Keane, Director of Development and Technology at the American Geological Institute (AGI). In order to accelerate these efforts, I have spoken with several members regarding future plans for such important areas as web-based mineral deposit information. One proposal is to harness the creativity of our Student Chapters through the guidance of their university advisors. This is only one of many possible proposals to address the needs of the SEG membership and I encourage members, and student members in particular, to continue communicating with me in this regard. We have much to do and our game plan is now much clearer with the results of the website questionnaire in hand. I would like to thank all of you who took the time and effort to respond to this questionnaire and to provide thoughtful comments.

**PRESIDENTIAL PERSPECTIVE**

**Exploration, Research and the Information Highway: What Role for SEG?**

Geologists at universities and government surveys generate new knowledge that ultimately may be used to develop new wealth, through resource discoveries, and improved life quality, through better understanding of natural processes and their potential effects on our well-being. Industry geologists generate and apply such knowledge in the quest for new resources or for developing new services for the consumers. New concepts (knowledge) and their underpinning observations, based on field and laboratory research, may be used in unexpected ways, perhaps long after they were published. Ready access to a large volume of high quality information, coupled with insight and innovation of individual geologists, has been the key to many exploration successes. For example, maps produced by W.H. Collins for the Geological Survey of Canada in 1925 were used 28 years later by Franc Joubin to discover the Elliot Lake, Ontario, uranium resources. Joubin also was aware of theories of paleo-stream concentrating processes for gold (from Witwatersrand studies) and other heavy minerals; putting these theories and Collins' excellent maps together, he successfully predicted the location of a majority of the resources near Elliot Lake.

Until the 1990s, our traditional means of obtaining geological information relied largely on the printed medium: maps, reports, and research papers that were available in libraries and personal or company files and archives. However, as part of the "information age," most of us have become increasingly reliant on digital technology. Field observations are now entered into geographic programs and spreadsheets, even in the most remote locations. Geological surveys and companies now produce GIS-ready maps in the field. For example, map publication delays at most geological surveys have been reduced from a six- to twelve-month period down to a few weeks following the field season. Data increasingly are being released digitally, and in some cases, such as the British Columbia Geological Survey, almost all new information is released via the Web. The B.C. Survey has discovered that not only can it provide new information to clients quickly, relative to the more traditional paper-based methods, it can also be provided at a fraction of the cost. Many surveys, realizing that geoscience information is key in the competition for new expenditures by exploration companies, are providing digital maps and reports at very low cost.

Industry has been leading the digital approach. In numerous client surveys conducted by geological surveys, industry's primary expectation from publicly funded organizations is always the same: "Provide new maps and geological descriptions, and provide them digitally." Starting with the major companies, but now commonplace with the juniors and even with prospectors, GIS has become a basic exploration tool. Now a new innovator has appeared: Robert McEwen, CEO of Goldcorp Inc., an important Canadian gold producer, challenged the geological community to find the next 6 Moz in Goldcorp's Red Lake Mine. Goldcorp made available virtually all of the mine data (drill logs, assays, sections, plans, and a time-limited version of a 3-D analysis software package, all free of charge) on the web and via CD, and asked for 8-page analyses that would target these new resources. Out of hundreds of responses, 50 proposals were reviewed independently by a panel of six experienced geologists (I was fortunate to be included in this group). Twenty-five of these received $10,000 each for innovative proposals, and were asked to revise their submissions for additional review in a few months. Top prizes of up to $100,000 have ensured a top-quality set of responses. McEwen has "tapped into the intellectual capital of the industry," and by using Internet technology, digitally collected data, and the innovative
SEG Foundations Extend Their Growth

Both the SEG Foundation’s Hugh Exton McKinstry Fund and the new SEG Canada Foundation have exciting news. The McKinstry Fund received the balance of the bequest from Elizabeth McKinstry’s estate, and the SEG Canada Foundation received tax exempt status from Revenue Canada. Canadians and Canadian corporations now can make contributions to SEG efforts via the Canadian entity and receive a tax deduction.

As noted previously, the SEG established the Society of Economic Geologists Canada Foundation as a corporation in 1999. However, it took many additional months for Revenue Canada to conter the all-important second half of the equation—tax exempt status. Thus, the SEGCF is now duly registered as a charitable entity entitled to receive contributions, and such contributions will be tax deductible to the donors. Individuals and corporations wishing to make such donations should send them directly to

Gerald C. Carbon, President
Society of Economic Geologists Canada Foundation
500-625 Howe Street
Vancouver, B.C., V6C 2T6
Canada

At the end of August, the McKinstry Fund received $50,931 from Elizabeth McKinstry’s estate, and shortly thereafter received a further $272 in interest for the previous month. Total funds received were $51,203. This recent bequest, plus the value of the original gift, the $1.5 million received in 1998 and current interest and dividends, brings the value of the Fund to in excess of $1.5 million. What this implies for the Foundation is that, in future years, the McKinstry Fund alone will be capable of providing grants for research in support of economic geology that are equal in value to the research funds provided recently from all SEGCF sources combined.

The flagship publications of both societies, the Geological Society of America and Geological Association of Canada, are available in digital form at low cost, facilitating literature retrieval as well as the searches. I encourage SEG to follow this trend as quickly as possible; the cost of digitizing back issues would be quickly recovered by sales, and as the leading journal in the field, Economic Geology is as basic a resource as a library of geological maps. Once the journal is established on a digital base, it can provide geological maps and large data sets as part of its routine publication stream; paper-based map publication has been prohibitively expensive, but digital maps cost virtually nothing to distribute. In addition, SEG will begin to develop an easily available set of deposit-type descriptions. This innovation, led by Larry Meinert and our ad hoc Internet Committee, will provide continually updated, map- and picture-rich descriptions of major deposit types that should be an outstanding aid to teaching and continuous learning.

Some have urged caution in moving into the digital world, citing changing technology, loss of editorial quality, new standards, the desire to have a paper version, and the continuing need for better hardware and new software. While these are legitimate concerns for any new technology, it’s time to recognize that the information revolution is progressing rapidly, and that use of digital technology is no longer an innovation, but a requirement. Increasing competition for investment funds will involve maximizing exploration efficiency, and that starts with improved access to information. We will always need the hand lens, the compass, and the expertise of the individual wielding those tools, but we will also need to communicate and compile our observations in a more accessible manner, so that better interpretations can quickly and efficiently lead to new discoveries.
Foundation Programs Provide Substance and Impact

2002 Conference Advance Planning. The Foundation is spearheading a campaign to raise seed capital funding for SEG 2002 Conference on Global Exploration—Integrated Methods for Discovery. This conference is a sequel to the highly successful 1993 Conference on Integrated Methods in Exploration and Discovery. Seed money is necessary to keep registration costs especially for students, as low as possible, to pay for printing and mailing costs, and to have funds available early to guarantee hotel and facility commitments.

Bruce Bailey is the general chairman for this Denver-based conference, which will include a full spectrum of geologic, geophysical, and geophysical tools used in today's exploration programs. Applied factual case histories, including both conceptual and philosophical positions that helped formulate successful exploration strategies, will be featured. Drill core and poster sessions are planned, along with three days of talks and field trips. The Foundation is proud to be part of the program. We are determined that the 2002 Conference remain affordable and that the ratio of benefits received to conference cost be maximized.

Based on requirements from the 1993 conference, our goal is to raise $100,000 and our Trustees are participating in raising these seed capital funds from mining companies, suppliers, and other friends of economic geology who recognize the importance of global mineral resources.

Student Grants Program. The Foundation provides support for Student Research Grants, and this year's support of $86,500 for 57 economic geology students represents a 44% increase in funding over last year's amount. As reported in the July 2000 SEG Newsletter, 51% of this year's recipients are from outside the United States. This funding increase was largely due to receipt of the McKinnon Estate funds, which illustrates the immediate impact and outreach these types of gifts provide.

The Foundation hopes that bequests and estate planning programs will continue to expand our resources for the Student Grants program.

Professional Ethics. The Foundation recognizes and reflects the membership's expressed concern regarding professional ethics, and the importance to SEG's reputation for high ethical standards. This issue was raised and rigorously examined by an SEG ethics ad hoc committee, which recommended increasing membership awareness of ethical issues. To this end, the Council agreed that an ethics column would be included in the SEG Newsletter. Two years ago, we were concerned about the Society's expressed stand on ethical issues, and now those issues are being addressed in the Newsletter.

Continuing Education. Programs dealing with Applied Topics of continuing education are important to SEG members and to the profession as a whole. The Foundation, in concert with the Society, is preparing to deal with funding for these programs. Many of us have benefited from strong and well-organized mentoring programs that were provided by our employers. However, many employers have either reduced or eliminated these mentoring programs. The SEG can play a valuable role in providing applied, skill-enhancing programs. Continuing education credits are frequently required to maintain and/or gain professional registration, and the Society, with funding from the Foundation, can aid interested members by providing courses that result in hands-on skill enhancement.

In summary, the Foundation is indebted to the devoted and far-sighted generosity of the SEG membership and its friends. The reasonable cost, an expanding geographic reach, and the high quality of SEG's resulting programs reflect the immense difference that adequate funding can make in economic geology's continuing global impact.
formations, which concealed Triassic extensional half-grabens before being incorporated into the Subandean fold-thrust belt along the western margin of the Oriente basin. North- and northwest-striking normal faults in the hanging wall of a major north-striking fault zone controlled the locations of most of the porphyry centers.

K-silicate and variably overprinted intermediate argillic alteration, containing chalcocite as the principal sulfide mineral, characterize the central parts of most of the porphyry prospects and grade outward to pyrite-dominated propylitic halos. Overprinted sericitic alteration is generally less widely developed, although apparently shallower erosion at the Warinza and Wawame prospects resulted in preservation of extensive pyrite-rich sericitic zones. All the prospects contain appreciable (60–250 ppm) molybdenum, but gold tenors are low except at Panaunta and Wawame (0.15 and 0.2 g/t, respectively). Supergene oxidation and chalcocite enrichment zones are immature because of inhibition by the rapid erosion prevalent in the Pangui area. Supergene profiles attain their maximum development on ridge crests but are essentially absent along major creeks.

Discovery of the Pangui belt, along with other recently defined porphyry copper systems in northern Peru, Indonesia, and the Philippines, underscores yet again the efficacy of drainage geochemistry as an exploration technique in tropical and sub-tropical arc terranes as well as the outstanding potential for additional exposed deposits in poorly explored parts of the circum-Pacific region.

INTRODUCTION

A previously unknown porphyry copper belt has been discovered in the Pangui area, a 1,600 km² area of Morona-Santiago and Zamora-Chincha Provinces, southeastern Ecuador (Figs. 1 and 2). The 10 porphyry copper systems and one copper skarn define a 70-km-long, north-south-trending belt (Fig. 3, p. 10) in the Cordillera de Cutucú and Cordillera del Cóndor, parts of the Subandean belt bordering the Oriente basin in Peru (Fig. 1).

The climate of the Pangui area is humid sub-tropical, with annual rainfall of 1,000 to 2,500 mm and average temperatures ranging from 18° to 22°C. Elevations range from 600 to 3,000 m, with the deeply incised Zamora River forming the main drainage within the area. Much of the area is covered by jungle and characterized by slopes steeper than 25°. Soil cover varies in thickness from 10 cm to 20 m, with a thick (~1 m) layer of black humus typically overlying a well-developed, orange to red B horizon composed mostly of clay.

Nine of the 10 porphyry copper centers are located within the mapped limits of the Zamora batholith and the tenth, Warinza, is approximately 13 km east (Fig. 3). The Zamora batholith, extending from 3°S to roughly 5°S, is bounded westward by Jurassic sedimentary and volcanic rocks and the Cordillera Real metamorphic belt, all cut by north-northeast-striking thrust faults (Figs. 1 and 2).

Until the mid-1990s, the Pangui area and its environs were largely unexplored. This article outlines the six-year exploration program initiated by Gencor Limited and continued, following corporate restructuring, by Billion plc. General geologic features of the Pangui area are highlighted, with particular reference to the initial discoveries, the San Carlos and Panaunta porphyry copper prospects.
EXPLORATION HISTORY

Gencon, through its subsidiary Cauto Ecuador Minera S. A., initiated the Panguí project in 1991. Exploration was designed to test the perceived gold potential of the Oriente foreland basin by means of a regional reconnaissance and concentrate geochemical sampling program. The results outlined a number of gold and base-metal targets for follow-up, during which the first porphyry copper-molybdenum prospect, San Carlos, was identified in April 1995. Nine more porphyry copper centers were discovered by follow-up of other regional-concentrate anomalies over the next four years (Fig. 3).

Ridge-and-spur soil sampling effectively delineated the porphyry copper prospects. The soil sampling was accompanied by detailed rock-chip sampling of all mineralized rock exposures along streams and rivers, and was followed by scout diamond drilling of three of the identified porphyry copper targets. Infill evaluation drilling was completed on two of these targets, San Carlos and Panantiza.

Airborne magnetic, electromagnetic, and radiometric data were collected over the Panguí belt and were complemented by ground induced-polarization surveys over most of the individual porphyry copper centers. Ground magnetic surveys were conducted solely at San Carlos and Panantiza.

In mid-1999, Billiton scaled back its generative exploration effort and, shortly thereafter, concluded an agreement for further exploration of the Panguí area with Coriente Resources Inc. of Canada. Since late 1999, diamond drilling of two more porphyry copper prospects, Wanantiza and Wawama, has been funded by Coriente Resources and managed by Lowell Mineral Exploration.

REGIONAL SETTING

Ecuador may be divided into three physiographic units: the Costa, Sierra, and Oriente, from west to east (Fig. 1). The Oriente, or eastern region, is part of a foreland basin between the Guyana Shield and the Andean Cordillera (Baldock, 1982). It comprises the upper reaches of the Amazon basin and the Subandean zone. The Subandean zone in Ecuador is a back-arc fold-thrust belt, which encompasses the Cordillera de Cutucú and Cordillera del Cóndor front and uplift (Fig. 1).

The Subandean zone was part of an Early Mesozoic rift system (Jaillard et al., 1990; Aspden and Litherland, 1992) characterized by north-trending, nested half-grabens (Balkwill et al., 1995). Interpretation of unpublished seismic records for the Cordillera de Cutucú and Cordillera del Cóndor (C. Spencer, unpub. rep., 1995) shows that normal faults in the extensional system are curvilinear in form, with a dominant north-northwest strike and downthrow mostly to the west. The normal faults terminate against, or merge with, northwest-striking strike-slip transfer zones that consist of transform or en-echelon fault sets. During the Early Jurassic, the rift basins were filled by marine limestone, sandstone, and shale (Santiago Formation), facies-equivalent red-bed sandstone and shale, with thin horizons of anhydrite, dolomite, and gypsum (Chiquina unit), and overlying arc-type basaltic and andesitic volcanic and volcanoclastic rocks (Misahualli unit, Fig. 3), as documented by Tschopp (1953), Baldock (1982), and Litherland et al. (1994).

Middle to Late Jurassic batholiths and volcanic rocks (including the Misahualli unit) along the eastern side of the Cordillera Real of Ecuador (Fig. 1) and in the Cordillera Oriental of Colombia are interpreted as remnants of a calc-alkaline volcanic-plutonic arc constructed at an Andean-type continental margin (Sillitoe et al., 1982; Aspden et al., 1987). Jurassic plutons in Ecuador and neighboring Colombia, including the large Zamora, Abitagua, and Cuchilla batholiths (Fig. 1), range in age from ~190 to 150 Ma (Aspden et al., 1992; Litherland et al., 1994). Jurassic intrusions in the Cordillera Oriental of southern Colombia are associated with porphyry copper systems (Sillitoe et al., 1982, 1984; Fig. 4); but no such mineralization of this
age had been documented further south in Ecuador prior to the discoveries described herein.

Epichronometrical quartzite of the Early Cretaceous Hulla Formation (Fig. 3) accumulated in a fluviatile environment over the cosmonastically planed Jurassic volcanosedimentary sequences and batholiths (Tschopp, 1953) following compressive tectonism induced by terrane accretion along the northern Andean margin (Aspden and Litherland, 1992). Back-arc extension during the late Early to Late Cretaceous allowed deposition of marine mudstone and limestone of the overlying Napo Formation (Tschopp, 1953). As a result of renewed collision along the northern Andean margin during the latest Cretaceous-Early Tertiary (aspen and Litherland, 1992), the Early Mesozoic extensional faults underwent partial tectonic inversion. The Cordillera de Cauca and Cordillera del Cóndor frontal uplifts were formed during this east-directed compression.

**LOCAL METALLOGENY**

Gold was exploited in pre-Colombian and Colonial times at several localities in the Cordillera del Cóndor. The Nambija and

**LOCAL GEOLOGY**

The Zama Batholith comprises I-type, calc-alkaline diorite, tonalite, granodiorite, and monzogranite intrusions characterized by a general lack of ductile fabrics and relatively low Sr, values (>0.7036–0.7051; Litherland et al., 1991). The batholith, dated at Middle to Late Jurassic (~190 to 150 Ma; Aspden et al., 1992; Litherland et al., 1994), cuts the Santiago, Chapiza, and Misahuallí sequences and is intruded by the stocks related to nine of the Panguiporphy copper centers (Fig. 3).
K-Ar ages of 15 ± 5 Ma (SERNAGEOMIN, Chile, unpub. rept., 1997) for a whole-rock sample of intensely sericitized porphyry and 157 ± 5 Ma for hornblende separated from a late intermineral porphyry (MEJ-PRODEMINGA, 2000a), both from San Carlos, confirm that the Pangui porphyry copper belt is also Late Jurassic in age (Fig. 4).

The Zamora batholith and associated stocks are unconformably overlain by the Hollín quartzite (Fig. 3), which attains a thickness of approximately 150 m in the Pangui belt where it forms flat-lying outliers. Mudstone and subsidiary limestone of the overlying Nava Formation are exposed on the western flanks of the Cordillera del Cóndor (Fig. 3).

The Zamora batholith is interpreted to have been intruded into the hanging wall of a north-striking zone of Jurassic normal faults that was tectonically inverted in the Tertiary to produce the Cordillera del Cóndor uplift (Fig. 3). Nine of the porphyry copper prospects are located adjacent to subsidiary faults cutting the batholith, especially those striking north and northwesterly.

The porphyry copper prospects identified through late 1999 are centered on composite granodiorite to monzogranite porphyry stocks. At San Carlos, Pamantza, and elsewhere, the porphyries are the foot of K silicate alteration and chalcopyrite mineralization. Intermediate argillic and sericitic alteration overprint the K silicate assemblages, except at Wariniza and Wakame, where sericitization is limited in extent. Propylitic alteration, containing anomalously high zinc, constitutes halos to all the porphyry centers. Quartz veins in are poorly developed in all the porphyry prospects compared to many such systems elsewhere. Sulfide zoning, from pyrite/chalcopyrite ratios as low as 1:10 in the cores to >10:1 on the peripheries, clearly defines the prospects.

**PORPHYRY COPPER PROSPECTS**

**San Carlos**

The composite granodiorite porphyry stock at San Carlos intrudes equigranular monzogranite of the Zamora batholith. The porphyries contain prominent plagioclase and hornblende with subordinate quartz phenocrysts. Early, intermineral, and postmineral phases are recognized, each with its own diagnostic copper content. Progressively younger porphyries truncate veins in earlier phases (cf. Kirkham, 1971).

The early porphyry is characterized by relatively low intensities of quartz veining and typically 0.5 to 0.7 percent hypogene Cu, mainly in the form of dispersed grains and fracture coatings of chalcopyrite. The intermineral porphyries are subdivided into three phases containing progressively lower copper contents (Figs. 5 and 6). These three phases also display progressively lower fracture and veinlet intensities, with the last two lacking molybdenite-bearing B veins (as defined by Gustafson and Hurn, 1975). The intermineral porphyries constitute two north-northwest-striking dike-like bodies, the western one possessing a shallowly southeast-dipping roof (Figs. 5 and 7). The postmineral porphyry is volumetrically minor, comprises narrow northeast-striking dikes, and lacks veinlets and sulfides.

A northwest-striking fault separates the early porphyry in the south from the intermineral porphyries farther north (Figs. 5 and 7). The fault is observed to have been active during mineralization and to have undergone north-side-down, postmineral displacement approaching +100 m (Fig. 7).

The early porphyry and the first of the intermineral porphyries, along with the adjoining host monzogranite, were subjected to K silicate (biotite-K feldspar) alteration and associated chalcopyrite mineralization. The two latest intermineral porphyries were emplaced after the completion of K silicate alteration (Fig. 6), as shown by direct
replacement of hornblende phenocrysts by chlorite rather than biotite. Alteration as well as mineralization intensities diminish as the porphyry phases become younger. The central copper-bearing parts of the system are characterized by pyrite/chalcopyrite ratios of 5:1; ratios increase abruptly outward to exceed 10:1 in the southwest and 50:1 in the northeast, where peripheral sericitic alteration is located.

Intermediate argillic alteration overprints all the intrusive rocks, excepting the postmineral dikes (Fig 6). This alteration event is characterized by partial transformation of mafic minerals to chlorite, replacement of plagioclase by ilite or smectite, hematite pseudomorphs (martite) after magnetite, and some pyrite and calcite introduction, but does not appear to have materially changed the overall copper content. Small, irregularly distributed patches of K silicate alteration remain within the predominant intermediate argillic assemblages, but larger remnants also occur locally (Fig 7). The barren postmineral porphyry dikes display only weak propylitic (chlorite-epidote) alteration.

A roughly 600 x 600-m zone in the south-central part of the San Carlos prospect contains >0.7 percent hypogene copper in the early granodiorite porphyry and its host monzogranite (Fig 5). Hypogene copper content decreases progressively outward, although the decrease is modest toward the north. Emplacement of the intermineral porphyries partly destroyed this higher-grade hypogene core zone.

An immature supra-igneous profile, thickest beneath ridge crests and essentially absent from creek beds, is developed at San Carlos. The chlorite enrichment zone, which averages ~25 m thick, is best developed where high hypogene copper values and pyrite/chalcopyrite ratios of 2:1 in monzogranite underlie the main ridge (Figs. 5 and 7). The best vertical drill intersection of enriched material is 1.34 percent Cu over 68 m. A thin mixed zone of chlorite partly transformed to copper oxide minerals separates the enriched zone and the overlying 50- to 150-m thick goethite leached capping (Fig 7).

Where pyrite/chalcopyrite ratios are <1:1, insufficient acid was generated to mobilize much copper. Neotectate (amorphous copper-manganese-iron silicate), copper clay (fine-grained chrysocolla impregnating hypogene kaolinite plagioclase phenocrysts), and minor pitch limonite (cuprous iron goethite) and chrysocolla developed extensively in the oxidized zone. The relatively high neutralization capacities of the intermineral porphyries resulted in fixation of exotic copper, mainly as copper clay, in the oxidized zones.

**Panantza**

The Panantza prospect is characterized by a suite of intrusive rocks similar to those at San Carlos. An equigranular monzogranite host rock, intruded by aplite, is cut by an early and two intermineral monzogranite porphyries. The three porphyries have grade signatures of 0.6 to 0.8, 0.3, and 0.15 percent hypogene Cu, respectively. All the porphyries contain prominent plagioclase and hornblende phenocrysts plus variable amounts of quartz phenocrysts and orthoclase megacrysts. The early porphyry has notably less phenocryst quartz and orthoclase than the early intermineral phase. The early porphyry constitutes an elongate, northwest-trending body (Fig 8). Several narrow, barren postmineral porphyry dikes were intersected in the drilling, all suspected to be genetically unrelated to
porphyry copper formation. An earlier dike generation is andesitic (microdioritic), a later one dacitic or rhyodacitic.

Monzogranite and aplogranite host rocks early porphyry, and early intermineral porphyry all underwent K silicate alteration, accompanied by chalcopyrite as disseminated grains in mafic sites and fracture fillings. Pyrite/chalcopyrite ratios in the central parts of the system do not exceed 1:1, but pyrite content increases appreciably as the periphery of the system is approached.

K silicate alteration in the core of the system passes outward to a partial halo of sericite alteration which is deficient in chalcopyrite. The K silicate core is patchily overprinted by intermediate argillic and less widespread sericitic alteration. Although the intermediate argillic overprint caused local redistribution of copper and addition of pyrite, it does not have any consistent effect on the average copper content of the pre-existing K silicate alteration. It does, however, cause a 30 to 60 percent reduction of the initial (~0.15 g/t) gold content.

The most southerly drill hole intersected a major, possibly northwest-striking fault zone defined by sheared and brecciated monzogranite. The fault zone is characterized by pervasive sericitic alteration and contains late-stage spherulite (up to 0.8% Zn), from which it is inferred that the faulting was active at least during late-stage hydrothermal activity.

The highest hypogene copper values, >0.75 percent are concentrated in and immediately surrounding the early porphyry body in a northwest-trending zone some 800 m long and 200 m wide (Fig. 8). Copper values decrease progressively outward beyond this early porphyry zone, which is confined to the southern half of the Panamitza copper-in-soil anomaly (Fig. 8).

Chalcocite enrichment is weakly developed at Panamitza as a result of either unduly low pyrite/chalcopyrite ratios or insufficient initial copper content in the intermineral porphyries. The oxidized zone at Panamitza averages only about 50 m thick because the system is centered on the broad Rin Panamitza valley (Fig. 8). Where pyrite/chalcopyrite ratios are ≤1.1, copper oxide mineralization, underlain by a thin zone of chalcocite-bearing mixed mineral, is developed. The main copper oxide minerals are copper clay, malachite, chrysocolla, and pitch limonite.

**Other prospects**

More recently discovered porphyry copper prospects in the Pangui belt include Warintza and Chanocho-Wawamne (Fig. 3). The Warintza area is underlain by an equigranular granodiorite pluton located east of the Zamora batholith. The pluton intrudes a sequence of andesitic volcanic and minor intercalated sedimentary rocks, locally calcareous in composition, the affiliation of which remains uncertain (Fig. 3). Part or the contact between the pluton and its host rocks is cut by a composite granodiorite or monzogranite porphyry stock, the focus of the main Warintza porphyry copper system. Small volumes of hydrothermal breccia occur locally. The Warintza prospect is characterized by a 10-km² zone of intense and pervasive sericitic alteration. The sericitic zone is interpreted to be underlain by K silicate alteration, which is exposed at the lowest elevations around the margins of the prospect. On the basis of the results of rock-chip sampling along creeks, the high pyrite content (pyrite/chalcopyrite >5/1), and the existence of a broad high ridge at Warintza, chalcocite enrichment is predicted to be as good as, if not better than, that at San Carlos. Results announced (May 2, 2001) by Cominco Resources suggest a broadly similar thickness and degree of enrichment beneath the area selected for initial drill testing.

At the Chanocho-Wawamne porphyry copper prospect, granodiorite of the Zamora batholith intrudes Miocene andesitic volcanics and siltstone and is overlain by Hollin quartzite. The granodiorite and its host rocks at Wawamne are cut by several porphyry phases, the most important of which is tentatively assigned a quartz diorite composition. Smaller intermineral diorite porphyries are also observed, along with bodies of hydrothermal breccia. Sericitic alteration is predominant, although remnants of K silicate alteration are present. Rock-chip sampling along the numerous creeks at Wawamne suggests that the mineralization consists of >0.5 percent hypogene Cu and 0.2 g/t Au, values that were confirmed (July 6, 2000) by Cominco Resources’ initial drilling results.

**RESOURCES**

San Carlos was tested by 26 diamond drill holes totaling 5,933 m, from which an inferred hypogene mineral resource of about 850 million tonnes at 0.5 percent Cu was estimated (R. Kirk and J. Ford, unpub. repts., 1999). Although a zero cutoff grade was applied, the calculation refers only to the higher-grade early porphyry and contiguous monzogranite, with the lower-grade intermineral and late-mineral porphyries being excluded from consideration. Supergene sulfide and copper oxide resources are far more limited, although higher in grade, with the main chalcopyrite enrichment zone averaging >0.7 percent Cu.

At Panamitza, a total of 2,983 m of diamond drilling was completed in 11 holes, but data are insufficient to estimate mineral resources. Drill holes in the central part of the prospect cut hypogene mineralization averaging about 0.7 percent hypogene Cu, similar to that in the higher-grade zone at San Carlos. Copper oxide mineralization in two holes averages about 1.2 percent Cu over 27 to 50 m vertically, although continuity of the mineralization remains to be determined. No significant chalcocite enrichment was encountered at Panamitza.

**EXPLORATION REVIEW**

When exploration commenced in the Pangui area, a lack of suitable topographic and geologic maps provided the rationale for an aerial photographic interpretation in 1994. This interpretation identified a number of the principal north- and northwest-striking faults that later proved to control the locations of porphyry copper prospects. Our experience suggests that aerial photography, RADARSAT (synthetic aperture radar imaging), and Landsat TM imagery may be used as effective aids to selecting prospective ground in the Pangui area.

Panned-concentrate sampling was the main technique used during the reconnaissance exploration stage, and proved to be the critical element in the program. Sample density, at one per ~0.4 km², was high. Panned-concentrate samples were analyzed for gold (30–50 g fire assay with AA finish) and a suite of 34 elements by ICP at Bondar Clegg’s laboratory in Vancouver, Canada. Geologic mapping during the reconnaissance phase also proved useful, but cannot be relied upon as a basic exploration tool because of the lack of nuclip.

Orientation studies, which had the specific aim of detecting new gold, showed that panned-concentrate sampling was the most suitable geochemical method for regional screening. A further orientation study was
undertaken following recognition of the first porphyry copper prospect at San Carlos. This reorientation sampling revealed no significant difference between anomaly definition achieved using -80° and -150° silt fractions and the panned concentrates (Fig. 5). Both stream-sediment and panned-concentrate sampling would have showed the San Carlos drainage to be anomalous with respect to a suite of elements, including Cu (Fig. 5), Mo, Zn, Pb, As, and Au.

Follow-up work, comprising semidetailed geologic mapping and ridge-and-spur soil sampling, outlined the general extent and characteristics of the porphyry copper prospects. Subsequent infill soil sampling on lines 200 m apart is sufficient to fully delineate the mineralization. The main prospects are outlined by >500 ppm Cu and >50 ppm Mo in soil (Figs. 5 and 8). Several orientation studies were conducted to define the optimal soil-sampling procedure. This involved collection of samples from the B horizon at a depth of 50 cm to 1 m and at 50- to 100-m intervals along lines. Duplicate samples were taken at every 200th site. No augering was necessary for sample collection. Soil samples weighing 500 to 1000 g were collected for shipment to Intek Testing Services, Bondar Clegg's preparation facility in Quino, where the samples were dried, disaggregated with pede and mortar, and sieved to -80%. The -80% fraction was analyzed for Au and a suite of 34 elements in the same manner as described above for the panned-concentrate samples.

During target definition using grid soil sampling, detailed chip-channel sampling of all well-mineralized outcrops along creek beds was carried out at 5- to 20-m intervals (Figs. 5 and 8). Where samples were largely free of sericite alteration, the analytical results approximate the hypogene copper content of underlying rocks. Generally, where mineralization crops out and possesses pyrite/chalcopyrite ratios of ≤1, the core of the system is exposed. This conclusion would be confirmed by mapping K silicate-altered early porphyry intrusions. In contrast, if a creek displays pyrite/chalcopyrite ratios substantially >1, it suggests that the high-grade core of the system may be concealed elsewhere in the soil anomaly, and hence, requires scout drilling to locate it. Alternatively, the K silicate core may underlie pyrite-rich sericite alteration.

Airborne electromagnetic and magnetic surveys are useful in recognizing porphyry copper alteration zones within the Zamora batholith and satellite plutons. High conductivity responses are obtained over sericitic and propylitic halos of the San Carlos, Satus, and Pamanta prospects. Whereas at Warintza a high conductivity anomaly outlines the main mineralized zone characterized by sericitic alteration. Analytical signal lows due to magnetic destruction define porphyry centers where intermediate argillic or sericitic alteration is intensively developed (P. Mills and B. Kirk, unpub. rep., 1999). The ground and airborne geophysical results were not used for locating the initial scout drill holes, but proved a valuable backup to geochemistry when siting the subsequent infill holes at San Carlos and Pamanta.

**DISCUSSION**

The Jurassic metamorphic belt along the eastern edge of the Andean Cordillera, host to the Zamora batholith and Pangui porphyry copper systems, is well-defined southward from Colombia to the vicinity of the Ecuador-Peru border, where it appears to terminate (Fig. 4). The cessation of Jurassic magmatism at this position, coincident with the change in Andean strike from northeast to northwest at the Huancabamba Deflection, may be attributed to the fact that subduction of oceanic lithosphere was directed southeastward (Aspden et al., 1987; Jaillard et al., 1999). Hence, orthogonal subduction with associated magnetism and copper mineralization along the northern Andes gave way to roughly trench-parallel motion and anamorphic conditions along the central Andes of Peru.

The available radiometric ages suggest that the Pangui porphyry copper stocks were intruded during the final stages of Zamora batholith emplacement. Hence, the confinement of the porphyry copper systems to the Zamora batholith. However, at Warintza, an equigranular dioritic pluton suggests that batholith stock intrusion and copper mineralization took place during—and followed by—uplift and erosion. The postriftal erosion must have largely predated deposition of the uncontemporaneously overlying Holocene Formation and, therefore, been a consequence of the latest Jurassic collisional event (Aspden and Laiher, 1992). Notwithstanding the typical small sizes of the mineralized stocks (Figs. 5 and 8), the predominance of pyrite-poor K silicate alteration and paucity of sericite alteration and hydrothermal brecciation at most prospects may be taken to suggest that a relatively deep (say, >3 km) environment is exposed.

Nevertheless, the predominance of pyrite-rich sericite over K silicate alteration at both Warintza and Pamanta, as well as at the Jurassic Mocoa prospect in southern Colombia (Silinorte et al., 1984; Fig. 4), implies that erosion levels may be substantially shallower locally. Preservation of these shallower systems, as well as the Pangui belt in general, owes much to concealment in a back-arc setting beneath the Cretaceous Holmin and Napo Formations as well as now-eroded younger formations.

Hydrogen copper content of 0.7 to 0.8 percent in the cores of the best-studied prospects—San Carlos and Pamanta—is relatively high by world standards. Such high values are somewhat surprising when the relatively low intensity of quartz-veinlet stockworks is recalled. Most of the Pangui prospects contain 60 to 70 ppm (and, at Warintza, 250 ppm) Mo and, hence, are classifiable as copper-molybdenum systems, although none has a molybdenum content approaching that of Mocoa (600 ppm; Silinorte et al., 1984). Low-grade gold (<0.1 g/t) is generally present except at Pamanta and Warintza where available analyses suggest averages of 0.15 and 0.2 g/t, respectively.

The steep terrain, copious rainfall, and consequent high erosion rates in the Pangui area seem to have inhibited development of deep supergene profiles and generation of thick leached, oxidized, and attendant chalcocite enrichment zones like those in southern Peru and northern Chile (e.g., Silinorte, 1990). Rather, supergene profiles are relatively thin and immature, ranging in thickness from 150 m beneath ridge crests to zero beneath major drainages. Such modest supergene profiles typify porphyry copper systems in similar geomorphic and climatic regimes elsewhere in the northern Andes (e.g., Mocoa; Silinorte et al., 1984; Río Blanco; Braun et al., 2000; Fig. 4). Nevertheless, substantially thicker zones of chalcocite enrichment locally developed rapidly under comparable conditions (e.g., Ok Tedi, Papua New Guinea; Bamford, 1972), thereby implying that the full supergene potential of the Pangui belt must await completion of further drilling. Any supergene profiles developed before Holmin sedimentation in the Early Cretaceous appear to have been eroded, although this remains to be ascertained at Chandu, which is partially concealed beneath flat-lying quartzite.
CONCLUDING REMARKS

Discovery of the Panguí porphyry copper belt was an unexpected outcome of a somewhat unorthodox gold exploration program. Panneled-concentrate sampling proved to be extremely effective in identifying copper and molybdenum anomalies associated with the porphyry copper centers, although this sample medium would not be the one normally selected for base-metal exploration. The difficult terrain, limited access, and extreme climatic conditions were the main challenges to both the regional geochronological sampling and subsequent follow-up work, as they are in some other jungle-covered arcs throughout the circum-Pacific region. Mapping and sampling of creek outcrops combined with soil geochemistry proved an efficient means of delimiting the porphyry copper systems and selecting drill targets — procedures used widely in similar environments elsewhere.

The Panguí discoveries emphasize yet again the effectiveness of grassroots exploration using tried-and-tested geologic and geochronological techniques in poorly explored areas. In the case of the Panguí area, proximity to the disputed frontier with Peru hindered exploration activities for 57 years. It is hoped that the persistent settlement of the border dispute in 1999 will promote exploration and lead to further discoveries both in southern Ecuador and neighboring northern Peru. Furthermore, the success of the Panguí project should encourage application of similar basic grassroot programs elsewhere in underexplored tropical and subtropical regions around the Pacific Rim. Comparative programs, based on drainage geochemistry, have resulted in discovery of porphyry copper systems in steep jungle terrain at Rio Blanco in northern Peru (Braun et al., 2000), Bato Hija in Indonesia (Meldrum et al., 1994), and Tanzania in the Philippines (Rohrbach et al., 1999) during the last decade. Rio Blanco and Bato Hija, like the Panguí porphyry copper systems, were the unplanned outcomes of exploration for gold.

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REFERENCES


Global Exploration 2002
Integrated Methods for Discovery

The Society of Economic Geologists, in collaboration with the Society for Geology Applied to Mineral Deposits (SGA) and the Association of Exploration Geochemists (AEG), will convene Global Exploration 2002—Integrated Methods for Discovery in April 2002. The meeting is a sequel to the highly successful 1993 Integrated Methods in Exploration and Discovery conference. The 2002 meeting, like its predecessor, will emphasize the effective integrated use of a variety of exploration tools and techniques for discovery. The venue will be Denver, Colorado, USA.

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TECHNICAL SESSIONS
The 2002 meeting promises an exceptional technical program with select speakers discussing some of the great mineral deposits and districts of the world. All technical papers will be invited. There will be a single-track program, with fewer papers of better quality and greater length than at most meetings. Emphasis for all presentations will be the integration of geology, geochemistry, and geophysics. Four keynote addresses will highlight some of the best new thinking in mineral exploration. Technical sessions have been organized around six half-day theme sessions entitled:

- Four-Dimensional Portraits of Giants
- In the Shadow of Headframes—Exploration in Old Districts
- Under the Covers—Exploration for Hidden Deposits
- The Dollars and Sense of Exploration
- Case Studies—Regional Exploration
- Case Studies—District Exploration

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POSTER AND CORE PRESENTATIONS
These will be integral to the technical program. Presentations will be given during dedicated time periods to maximize the exchange between presenters and meeting participants. Poster presentations will be selected with an emphasis upon attracting contributions from students. Core displays will complement many of the technical and poster presentations.

FIELD TRIPS
Field trips will be conducted in connection with the conference and include:

- Carlin Trend Gold Deposits, Nevada
- Porphyry Copper Deposits, Arizona-Sonora
- Sudbury, Ontario
- Zacatecas Mineral District, Mexico

The Carlin Trend and Arizona-Sonora porphyry copper field trips will highlight the use of integrated data sets in the field.

WORKSHOPS
Several workshops relating to the theme of the conference will be offered.

PUBLICATION
A high-quality volume of technical papers will be distributed to participants at the conference. Authors will be required to submit an extended abstract for the meeting program and a complete manuscript for the conference volume.

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For further information, go to our website at www.seg2002.org, or contact us at seg2002@segweb.org

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SEG International Headquarters Dedicated

More than 200 SEG members and guests attended the Grand Opening Ceremony held at SEG's new International Headquarters Building in the Ken Caryl Business Center in the greater metropolitan area of southwest Denver, Colorado, on Saturday, June 10, 2000, beginning at 3:30 pm. The occasion began with an open house that allowed those in attendance to circulate through the spacious facility and observe its custom-designed features. The two-level "prairie-style" structure, with a long and relatively low profile, is ideally suited for the site and the surrounding topography. A total of 17,500 square feet is evenly divided between the main level and a lower, walk-out level. The main level consists of administrative offices, conference rooms, and a library. As described in the October 1998 issue of the SEG Newsletter, the distinctive feature of the building is the front entrance-lower-conference room combination, with its ever-widening sight lines from the front entrance through the window wall—34 feet wide by 16 feet high—at the far end of the conference room, and then beyond to capture a panorama of Colorado Front Range scenery. The total visual effect is spectacular. Approximately one-third of the lower level of the building is partitioned off and utilized for storage of SEG and PUCO publications. The remainder, a large, unfinished open room, hosted the Grand Opening Ceremony and the reception and buffet dinner that followed.

Shortly after 4:00 pm, former Executive Director John A. Thomas opened the ceremony by welcoming those present and spoke briefly on the origin of the building, noting that SEG's Anonymous Donor had provided four separate gifts of stock to a total market value of over $4.6 million, and that the Society realized an additional $400,000 in capital gains on stock sales, bringing the total value of the gifts to over $5.0 million. These gifts completely covered the cost of the building, including design and construction, land acquisition, landscaping, and all other associated costs such as legal, permits, office furniture, and computer and telephone systems. These costs came to approximately $3.5 million, the balance—$1.5 million—has been placed in an endowment fund that will provide a future income stream to offset the operating and maintenance costs for the building. Thus, the entire project, including future operating and maintenance costs, should not require any direct financial support from the Society.

Following the introductory remarks, the program included the following sequence of speakers: John Gagnon, Project Architect, and Scott Frick, Project Manager, of the Buchanan Yonushushi Group (BYG)—the architects/builders, in representation of Brad Buchanan, BYG Principal. Gagnon briefly discussed the architectural concepts on which the building was designed, and Frick summarized its construction history. James M. Franklin, SEG President, then added his welcome and considered the building as a threshold to the future, symbolizing the change in SEG to an expensive, multidimensional Society while continuing to serve the mining industry—the essential backbone industry of both the "new" and "old" economies.

Roger Newell, President of the SEG Foundation, remarked on the role of the Foundation as a source of funds for Society programs, the stewardship of those funds, and the importance of volunteers to both the Foundation and the Society. Karen Freitag, past President of the SEG Student Chapter at the Colorado School of Mines, brought a student's perspective on SEG and the minerals industry to the program, noting that SEG and its Foundation have been very supportive of students through individual research grants, financial aid for student chapter activities, low-priced quality publications, etc., but that employment opportunities for recent graduates are fewer and students are forced to change professions in order to secure employment. She added that the mining industry should be concerned about this loss of talent and that perhaps the Society could somehow work with industry to develop employment opportunities for students.

Stephen E. Kesler, past President of the Society, looked at the new building from an academic perspective and considered it a promise that research in economic geology is here to stay and will continue to be an important part of academic activities for a long time: in the education of young geologists, with regard to the importance of mineral resources to society; the importance of ore deposits to the entire spectrum of geology in the planet and the degree to which mineral deposit-forming processes actually affect the chemistry or our environment, and that this will lead to a better informed public and, in turn, a better informed government.

Samuel S. Adams, past President of both the Society and the American Geological Institute, initiated his comments by stating that the building exemplifies the greatest imaginable changes in the Society and that its commanding presence will facilitate a far greater role for economic geology than was ever contemplated. His further comments were threefold: Why has SEG been successful? What is shifting underneath us and all around us? And, what will the building see and what special role will it play? Future decisions affecting the minerals industry will involve "value balancing" and economic geologists will need to understand this concept. With SEG's comprehensive patronage, the building will be a landmark for exploration progress and the evolving schools of value balancing that will frame how and where exploration is conducted. He concluded that the building is headed for greatness, as the donor (expectedly) intended.

Brian J. Skinner, President of the Economic Geology Publishing Company, and a past President of both the Society and the Geological Society of America, provided the closing remarks for the Ceremony. He commented that occasions such as this one are a time to reflect on the past events and activities that brought us to where we are today. He then briefly recounted the origin of the (relatively young) profession of economic geology, the founding of the journal, Economic Geology (in 1905), the subsequent founding of the Society (in 1920), and the significant developments in the profession and the Society since then. He further noted that in the past several years, the Society has grown rapidly and become the focus of the international community of economic geologists. As a result, the Society is now poised to become one of the great professional-scientific societies of geology. After acknowledging the wisdom, foresight, and generosity of the Anonymous Donor, he concluded that the handsome headquarters building will bring added focus and momentum that will serve to spur the accomplishments of the Society and its members to greater heights, with the challenge being to create an environment in which all members of the larger geological community come to understand how their specialties, no matter how disparate, can add to our understanding of the genesis of mineral deposits.
SEG International Headquarters

1. Guests arriving for the grand opening of SEG's new International Headquarters.

2. Some of the more than two hundred members and guests who attended the Grand Opening Ceremony mingle in the lobby area of the new building.

3. Looking to the southeast through the conference room, along the length of the conference room table, and a partial view of the panoramic Colorado Front Range scenery. The oval-shaped table, with a "boat tail" at the far end, is 26 feet long and 9 feet 4 inches wide at its widest point. The perimeter is natural cherry wood, with inset dark "granite granite" panels radiating from the SEG logo, which is etched in a single piece of finely crystalline, black gabbro. The total weight of the table is 4.5 tons; power and modem connections, 6 each per side, are installed just under the lip of the perimeter of the table.

4. At one side of the conference room, (L to R) Scott Fracke—BYG Project Manager, Doug Silver—SEG member, Art Coury—Chairman of the SEG Architectural Committee, and Brian Faselt—SEG's legal counsel, exchange comments about the building.
headquarters Dedication

5 Fred Graybaek (left)—member of the SEG Finance Committee, with César Vidal (center)—SEG Regional Vice President for South America, and Brian Skinner—President—Economic Geology Publishing Company, renewing acquaintances prior to the Grand Opening Ceremony. César came from Lima, Peru, just to attend the ceremony.

6 (L to R) Gary Huber—Chairman of the SEG Finance Committee, with his guest Shirley Swanson, and Art Pante—SEG member with his wife, Trish, obviously enjoying the occasion.

7 SEG President Jim Franklin welcomes members and guests at the Grand Opening Ceremony.

8 The lower ("garden") level of the building provided an ideal setting in which to accommodate the more than 200 members and guests who attended the Grand Opening Ceremony. (The caterers in the background are "at the ready" to commence the reception and buffet dinner service that followed the ceremony.)

9 At the conclusion of the Grand Opening Ceremony, past presidents Phil Bethke (L) and Steve Kesler unveil a replica of the bronze plaque that will be mounted in the entry foyer of the building to honor the Anonymous Donor.
2000–2001 International Exchange Lecturer


Constantino Mpodozis was born in Los Angeles, Chile, in 1950 and studied geology at the Department of Geology, Universidad de Chile, Santiago, where he obtained an M.Sc. degree in geology in 1974. He continued his graduate studies at the Université Pierre et Marie Curie (Paris VII), France, under the supervision of Dr. Jean Aubouin, who later became president of the French Academy of Sciences. The subject of his doctoral dissertation was a study on the structure and tectonics of northern Greece (Agrapha Region, Pindus Mountains).

After receiving his Ph.D. degree in 1977, Mpodozis returned to Chile and became an assistant professor at the Geology Department, Universidad de Chile, Santiago. He also began his research career, studying the regional geology and tectonics of the western Patagonia fjord land region and the island of Tierra del Fuego. In 1981, he joined the Chilean Geological Survey (Servageomin), where he was put in charge of diverse regional mapping projects in the main Andean Range of Northern Chile. In 1987, he was awarded a J. S. Guggenheim Fellowship that allowed him to spend a year as a visiting scientist at Cornell University, Ithaca, New York. There, he interacted with scientists of the Cornell Andean Project, especially Dr. Suzanne M. Kay, with whom he has established a long-lasting research collaboration.

In 1990, he was appointed head of the Regional Geology Department, and in 1994, was named Director of Geology in the Chilean Survey. Also in 1994, the Colegio de Geólogos de Chile awarded Mpodozis the Premio Nacional de Geología (National Geology Award). He has also been a member of the Scientific Committee of the International Geological Correlation Program (IDG-UNESCO, 1990–1995) and editor of the Revista Geológica de Chile.

At the Universidad de Chile, Mpodozis lectured on structural geology and directed many undergraduate research projects. In addition, he has presented short courses and seminar lectures on the tectonics of the Central Andes at the University of British Columbia, the University of Buenos Aires, the Geological Society of Nevada, and Freie Universität Berlin.

Mpodozis has a long experience in the geology of the Central Andes. He is author and/or co-author of about 160 papers, bulletins, geologic maps, and congress presentations published in the Chilean and international geologic literature. Subjects include such topics as the regional structure and petrology of the Paleozoic basement of the Patagonian Andes; the evolution of the Late Paleozoic Gondwana batholiths in central Chile; the Cretaceous extensional deformation of the Copiapó region; the volcanic stratigraphy, geochemistry, and structure of the Mariquina and El Indio mineral belts; the Ojos del Salado volcanic region; and the southern Argentine Puna.

In recent years he has overseen, or been involved in, major geologic mapping programs resulting from collaborative agreements between Codelco-Chile and the Servicio Nacional de Geología y Minería to study the Domeykof fault system and the tectonic setting of the giant Eocene-Oligocene porphyry copper deposits of northern Chile. This work, carried out with colleagues Paula Comejo and Andrew Tomlinson of the Chilean Survey, as well as the collaborative research with Suzanne Kay on the Oligocene-Miocene Mariquina and El Indio mineral belts, has resulted in a new understanding of the relationships between mineralization events, tectonic history, and the crustal evolution of the Central Andes.

PROPOSED TALKS BY MPODOZIS FOR SEG LECTURE TOUR, MARCH 2001

1. Tectonic setting and structural controls of the giant Eocene-Oligocene porphyry copper deposits of Northern Chile.
2. Late Cenozoic mineralization and crustal evolution in a thickening arc: the Mariquina and El Indio mineral belts in Northern Chile.
Regional Vice President Report—South America
Informe del Vice Presidente—Sud América

CÉSAR VIDAL (SEG 1992)

SEG continues to increase its activities in South America and had a strong presence at the X Congreso Peruano de Geología held July 17–22, in Lima, Perú. The Congreso attracted more than 700 participants, including a relatively large number of students.

Dr. Constantino Mpodozis, Deputy Director of SERNAGEOMIN, Chile, and an SEG International Exchange Lecturer for 2000, gave the keynote presentation. He reviewed theories on Central Andean tectonics and metallogenesis, and suggested that crustal thickening in the 40 to 50 km transition range was a major cause for massive dehydration and generation of hydrothermal fluids. The ore metal budget, however, remains to be addressed.

During August, several SEG representatives attended the 31st International Geological Congress in Rio de Janeiro. At a special symposium on Andean ore deposits, César Vidal gave an invited presentation, “Unknown and Missing Links in the Metallogenic Framework of the Peruvian Andes.”

Dr. Miguel Cardozo G., Exploration Manager—Americas for North Compañia Minera, S.A., has been selected as the SEG Regional Vice President lecturer for South America. He was involved in the early delineation of the Yanacocha gold deposit, and will offer two lectures: (1) Andean Metallogenesis, and (2) Yanacocha Discoveries and Laskalikes. These lectures will be presented in 5 or 6 different venues in South America in January 2001. Universities, institutions, and other organizations wishing to request a lecture should contact Dr. César Vidal, Vice President—Exploration, Cia. de Buenaventura, S.A.A., Lima, Perú; e-mail cesarv@buenaventura.com.pe.

SEG aumentan las actividades del Society of Economic Geologists (SEG) en Sud América, notablemente con una presencia importante en el X Congreso de Geología que tomó lugar durante el 17 a 22 de Julio del presente en Lima, Perú. Este Congreso atrajo más de 700 participantes, incluyendo más de 200 estudiantes.

El Dr. Constantino Mpodozis, Director Diputado de SERNAGEOMIN, Chile y el International Exchange Lecturer del SEG por 2000–2001, fue invitado al Congreso para dar el Keynote Address (la “lectura clave”). El Dr. Mpodozis discutió las teorías sobre la tectónica y metallogenesis de los Andes Centrales; él sugiere que el aumento en el espesor de la corteza en el rango de transición de 40 a 50 kilómetros causado mayormente la disfunduración masiva de sedimentos y, consecuentemente, la formación de fluidos hidrotermales. El problema del origen y cantidad total de metales económicos aún sigue siendo un misterio.

Otras actividades en el Congreso incluyeron la presentación de una conferencia que trató de Procesos Superógenos por el Dr. William X. Chávez, Jr. (SEG 1990), aprovechando de la publicación de su artículo sobre el mismo tema en el SEG Newsletter de Abril 2000. SEG también hizo una “mesa de información” que trató con las actividades profesionales del Society of Economic Geologists. Había muchos interesados, especialmente en las publicaciones nuevas y en participando en las actividades del SEG por ser miembros en nivel profesional o de estudiantes.

Durante el mes de Agosto, representantes del SEG participaron en el 31º Congreso Internacional de Geología en Rio de Janeiro, Brasil. En un simposio especial que trató con yacimientos metales de los Andes. Dr. César Vidal dio una conferencia invitada sobre “Unknown and Missing Links in the Metallogenic Framework of the Peruvian Andes.”

REPORT ON ORE DEPOSITS MAPPING COURSE

Cerro Verde Porphyry Copper Deposit, Arequipa, Perú

AUGUST 13–16, 2000

The Society of Economic Geologists, in collaboration with Sociedad Minera Cerro Verde, S.A.A., offered an ore deposits mapping course at the Cerro Verde open pit copper mines near Arequipa, southern Perú. Course instructors David P. Braxton (Project Geologist with Minera Phelps Dodge del Perú, S.A.C.), Erich U. Petersen (University of Utah), and William X. Chávez, Jr. (New Mexico School of Mines) organized the course along with Superintendent of Geology Ing. Walter Fernandez, Senior Geologist Ing. Jorge Guillen, and Chief Geologist Ing. Jim Jones.

The 25 participants included two students and 23 professionals; the professionals represented six mining and exploration companies, with participants from Ecuador, Chile, Argentina, Perú, Bulgaria, and the United States. Sociedad Minera Cerro Verde, S.A.A., provided scholarship support for local students who attended the course, and made organization of the course very easy by providing excellent logistical support before and during the mapping sessions.

Bench-scale mapping took place in various areas of the Cerro Verde hydrothermal system, including the Cerro Verde and Santa Rosa open pit mine areas, with a review of hydrothermal breccias in the Cerro Negro prospect area. Also discussed in detail were the mineralogy and interpretation of iron oxide assemblages during extended visits to the Cerro Verde and Santa Rosa leached cupping areas.

The SEG would like to thank the staff of Sociedad Minera Cerro Verde, S.A.A., especially Ing. Jon Jones and Sr. Gabriela Pont and David P. Braxton of Minera Phelps Dodge del Perú, S.A.C., for their tremendous efforts and assistance with this course.
The 15th Australian Geological Convention (AGC) was held in Sydney in early July at the University of Technology and attracted some 650 delegates. The largest lecture theatre was used for economic geology sessions that continued all week. SEG sponsored a session on skarns and porphyry deposits. The program also included a symposium entitled, "Area Selection in Exploration." This symposium consisted of outstanding economic geology papers and highlights from selected papers are summarized below.

Doug Haynes of BHP presented an original and ground-breaking approach to conceptualization of preferred locations for large ore deposits. Strategy for seeking large deposits can be optimized by examining technically comparable areas that have been under-explored, with follow-up of known ore and where geology and geochemistry are used in preference to geophysics. Haynes advocates looking for major common features that empirically apply to the spectrum of large deposits within a broad ore regime, such as a major basin, and believes that this approach can encompass as yet "undiscovered" areas that do not fit conventional models. Sensitive geochemical techniques can then be used in under-explored areas that fit the generalized model. He gives emphasis to understanding the upper crustal successions and oxidation states in a regional and district sense, and also true the metal source, heat pumping/plumbing transport system, and deposition agents and sites that, in effect, form large ore deposits. He outlined his understanding of oxidation states in a way that I have not heard before. Well-oxygenated, mixed, and reduced regions are key elements to a range of ore deposit types; without the right of domain, the ore type is not found. Research has tackled oxidation/reduction chemistry in ore deposit settings, but rarely on a district scale as the key to understanding processes that control ore formation. Haynes requires lithological and structural entities to be large scale and with bold geometries. His progenitor "comparative" theory encompasses the grabbing of more than 1,000 km in area, several kilometers thick, with uniform oxidation states, bounded by major faults, perhaps later deformed, and with relatively simple structure. It is a view that makes a lot of sense as the place to find the big ones. He proposed the drawdown of salty fluids from near surface during active extension tectonics and mixing with methane-rich fluid up-flow as being linked to high metal concentrations in deposits such as pyrophyllite copper.

A couple of papers advocated that exploration should be guided by "risk-analysis" of the type used in the petroleum industry. Although exploration programs should be continually tempered by assessment of relative risk, strict numerical quantification of the process is highly dubious. Mineral exploration has more variables than petroleum exploration, and this is the problem in quantifying risk. Exploration geologists have always considered risk-assessment as an analogue rather than digital process.

Greg Hall discussed Place's approach to area selection and the discovery of the Granny Smith gold deposit in WA, involving the application of conceptual analogues (e.g., Transvaal conglomerates implying linked faults), and structural geology combined with the local knowledge of the prospector. He also reviewed the Kalgoorlie region and the concept of deep crustal faults being downward conduits for solutions from the surface and up-flow faults carrying gold mineralization, particularly where they are at a high angle to the regional wrench faults. Area selection can be biased towards regional cells, of perhaps 20 km in diameter (centered on a buried heat influence), where mineralization opportunities are maximized beyond the known showings. He noted the potential importance of paired metamorphic belts as reflecting major crustal discontinuities and directions of heat-gradient driven fluid flow and suggested that a regional "spacing" of major deposits, together with low mean-stress above plutons, can be used to select good areas.

David Graves talked on the use of computerized weights of evidence, fuzzy logic, and artificial neural networks to examine GIS-type data for area selection. On input criteria, comparative shape analysis is useful in finding areas that are domed or have antinomies in uplifted areas as a guide to gold mineralization. He suggested that relatively flat structures produce unusual closures that may enhance gold capture, such as at Kambalda, especially where the flat structures intersect steep wrench faults. In the case of Archean gold, the ores are localized during late tectonic disturbance. Consequently, computer-based "stress mapping" can be used for area selection: where you see is what you told! This shows areas of dilatation (flow minimum stress coincident with gold-prone areas.)

Ross Large discussed research on McArthur basin Pb-Zn ores and emphasized the combination of permeability, porosity and heat flow to set the scene for good deposits. The model Pb-Zn deposit process started as the result of downward flowing sea water moving into the basin along diastrophic faults, perhaps dissolving evaporites, minerals, to enhance solubility. These solutions moved by convection and by lateral gradients to collect Pb-Zn from the permeable aquifer (partly derived from the weathering of the underlying metavolcanic volcanics), and then migrated up along syndepositional faults and proximal outflow faults. This is a type of a cyclical recharge/depletion-seal-discharge concept with fluids following key lithological aquifer seal pathways. Like Haynes, Ross noted the importance of the aquifer of hematin that buffers fluids to high oxidation levels, ideal for Pb-Zn transport. Then, at the site of deposition, reaction with water affected by reduced organic-rich shale, causes precipitation of ores. Work has shown that, as with several other world-class zinc deposits, manganese is wide halo to the ores and diabase is enriched; some new data on oxygen and carbon isotopes were given as assisting vectorial relationships.

John Parker indicated that area selection has become a matter of dealing with more complex data sets integrated by a GIS approach. He discussed the new use of ore geochronology as a detection tool in the Gawler Craton and emphasized the favorable high-oxide nature of certain mineralized granites.

Several successful exploration geologists were somewhat negative about the cost-effectiveness of elaborate modern digital techniques used to select areas, and cited the success of conventional exploration of a more low-tech type.

The revitalized approach of the State and Territory geological surveys was comprehensively tackled by Dennis Gee. He emphasized the new role of the surveys, not only to collate and provide functional and freely available datasets but also, in these times of contracting corporate grass roots activity, to promote exploration by having staff operate in a project generation mode. Under Gee's driving force, the Northern Territory geological survey is the first to provide digital base data free of charge, and he hopes this provides a precedent to encourage grass roots exploration.

Overall, the symposium was very stimulating. An Abstract Volume (Number 99) of 577 pages is available from the Geological Society of Australia, <gsoa@gsa.org.au>.
On January 8, 2000, the Board of Governors approved Carleton University's application for an SEG Student Chapter. The newly formed chapter, CUSEG, got underway with a lecture from C. G. Farrow, of INCO Ltd., concerning the role of volatiles in the formation of Cu-Ni-PGE deposits from mafic-ultramafic systems. Two more lectures were scheduled to complement the proposed spring field trips, first to Timmins/Kirkland Lake to examine VMS and shear zone gold deposits, and second to Hungary to study epithermal gold environments. Brian Lunnstra, of Ottawa University, described the Barick and Holloway gold mines. Jeff Hedenquist, consultant, spoke on the role of volcanism and associated fluid systems in epithermal gold environments. The chapter was excited at the degree of interest shown toward these inaugural lectures. CUSEG has 20 members ranging from 2nd year to graduate-level students.

The first CUSEG field trip was a visit to the mining district of Timmins and Kirkland Lake, April 11–13. Seven students from Carleton University participated, together with David Wankins, of Carleton University, and Jeffrey Hedenquist. The group visited the world-class Kidd Creek mine, one of the deepest mines in Ontario (9,800 ft). Kidd Creek, is an Archean volcanogenic Cu-Zn-Ag massive sulfide deposit, is located in the Abitibi Greenstone belt. The first stop was at the 6,000-ft level, where the ore is Zn-rich massive sulfide at the contact of mafic and felsic rocks, typical of this deposit. At level 7,000, we observed in the Cu stringer zone in rhyolite, surrounded by strongly altered rock. In the afternoon the group visited the crushing and concentrator facilities of the mine.

On April 12, we visited the Dome mine—a typical shear-zone-hosted Au deposit in the Abitibi Greenstone belt. It is located in the vicinity of two major faults (Dorset-Porcupine and Dome fault zone). The Au-bearing fluids traveled along faults and contacts between rock units and precipitated the Au in the nose of a major fold (“Greenstone Nose”). Free Au occurs in different types of veins, however, some is trapped in pyrite.

On the last day, part of the group visited the Holt McDermott mine, owned by Barrick Gold, and the other part went underground at the Holloway mine, owned by Battle Mountain Gold. Both deposits are shear-zone-hosted Au, also located in the Abitibi Greenstone belt. Although only separated by a highway, there are differences in host rock alteration mineralogy; in both deposits Au occurs within pyrite.

In the afternoon, we visited the Kirkland Lake museum. At the beginning of the century, Kirkland Lake was a very rich gold mining community that attracted unique and eccentric people from all over the world.

We would like to thank everyone who helped organize this trip, and our guides in the mines and at the refinery.

The field trip to Hungary and Slovakia, April 25–May 1, was the most exciting activity of CUSEG this term. The trip was led by Ferenc Molnár, a professor at Eötvös Loránd University, Budapest, Hungary. Our guides in Slovakia were Jaroslav Leca, a professor at the university in Bratislava, and Peter Koderka, his Ph.D. student.

The field trip emphasized epithermal Au mineralization in the volcanic fields of Northeastern Hungary and Central Slovakia, where porphyry- and skarn-type mineralization was observed. A petrified mine and an abandoned bauxite mine in Hungary were also visited.

The ore deposits of the Carpatho-Pannonian region were known at the time of the Celtic and Roman empires. The area is enriched in precious metals, Cu, and other base metals. Mineralization is related to andesite stratovolcanoes, dacite-diorite flow domes, and subvolcanic intrusive complexes in regions of continental margins and island arcs. Au is spatially associated with K alteration.

On the first two days, we visited the Tokaj Mountains in northeastern Hungary, which is famous not only because of the famous “Tokaji Aszu” wine, but also because it is the oldest Au-Ag base-metal mining district in the Tertiary-Quaternary volcanic arc of the Carpathians. The Tokaj region is a great, bounded by major faults. It represents the shallow levels of a low-sulfidation-type system. We observed several locations showing the boiling horizon where the Au in epithermal systems is usually found. At Bamboly Hill, some quartz veins carry up to 10 g/t Au. In Telkibánya and Király Hill, a steam-heated alteration zone has been recognized, and near Fony, a hydrothermal stream at the edge of a caldera contains hydrothermal breccia with chalcocite, cuprite, and cinnebar. Fossiiferous lacustrine silica, which is related to a late stage of volcanic activity, was also observed.

The first stop of the field trip: Király Hill (steam-heated alteration).

On the third day, we visited the Mátra Mountains, another volcanic region in northeastern Hungary, where Bélla mine and Láhőcs Hill are typical examples of high-sulfidation environment. At Sandorset, we saw evidence for a low-sulfidation assemblage overprinting a high-sulfidation environment. Other types of mineralization in the Mátra Mountains include porphyry Cu, Cu-Zn-Fe skarn, and metasomatic Pb-Zn, found in Reck-Lahöcs.

The next three days were spent in Slovakia visiting two major caldera systems of the central Slovakian volcanic field—Síavnica and Kremnica. The volcanic activity in the area started at 15 Ma and ended at 9 Ma. Most of the mineralization is hosted in volcanic and subvolcanic complexes. Stops near Hronská included the All Saints vein, which is 8 km long and 2 km deep and contains Cu and base metals along the center of the vein and Au-Ag toward the walls. The Schopler and Klementia veins contain Au, precipitated during boiling of
fluids. The Spitaler vein is another major vein containing Au, Ag, and base metals. Also near Hradiska, a magnetite skarn occurs at the contact of a granodiorite intrusion and limestone.

In the last day, we visited the Velencei Mountains in the central part of Hungary. The Au mineralization in this region is related to paleogene andesite that intrudes older granitic rocks. Czesos Mountain hosts a high-sulfidation environment, with silicified brecciated rocks and ampicite, kordyakite, and pyrophylite as alteration minerals. The conical shaped hills (silicified bodies) outline a former caldera.

We would like to thank Ferenc Molnár for the time and effort he put into the organization of this field trip, as well as Jaroslav Lesa and Peter Kudera for their patient explanation of the complicated geology of central Slovakia. Our thanks extend to everyone in Hungary and Slovakia: they made our trip unforgettable.

All members are thanked for their work in getting the chapter up and running. Special thanks to David Watkinson, internal sponsor; and Mark Hannington, external sponsor, for their support and advice. Thanks to INCO Ltd. and Falconbridge for their generous donations, which made all of our events possible. Thanks also to the Carleton University Department of Earth Sciences for moral and financial support toward the formation of CUSEG. Finally, thanks to the SEG! We look forward to submitting our next report.

--- Zsuzsanna Magyarni and Matthew Stewart, CUSEG

--- McGill University ---

The McGill University Student Chapter of the SEG held a two-week field trip to Arizona and Nevada in mid-February. Seven Chapter members and two industry representatives participated. The main objective of the trip was to give participants exposure to classic porphyry Cu-Mo deposits of the American Southwest, as well as to other environments such as low-sulfidation gold and volcanogenic massive sulfides (VMS) deposits. An ambitious 4,700-km route was planned to take in as many ore deposits and spectacular geological features as possible.

The first ore deposit visited was the ASARCO's giant (3.2 km long by 2.8 km wide) Mission Complex mine, located 30 km south of Tucson. Mineralization at Mission occurs as disseminated and vein-like sulfides almost entirely in a wide variety of calc-silicate-altered sedimentary rocks (tectonites). Since 1959, 700 Mt of ore grading 0.67% Cu, 0.01% Mo, and 0.1% Au have been mined, with a reserve of 400 Mt, grading 0.65% Cu. Five stops were made in the pit to view the various rock types and stratigraphic features, including the following: diopside-autotactic tectonites and quartzites (Scheffer Fm.); epidote, garnet, and garnet-wollastonite tectonites (Concha Fm.); garnet and diopside tectonites (Epithof Fm.); quartz monzonite porphyry (mineralizing intrusion), and argillites (Rodillo Fm.).

The following day, the group visited the historic mining town of Bisbee, 130 km SE of Tucson, and viewed the abandoned Lavender open pit, formerly mined by Phelps Dodge. The Lavender pit was developed in a fluidized breccia pipe and is Nevada (130 Mt) in age, not granodiorite, as are all other porphyry copper deposits in Arizona. Mineralization occurs as a sulfide-oxide matrix in exo-sedimentary and metamorphic clasts. A large supergene blanket is still visible in the pit walls. An estimated 151.7 Mt of ore, grading 2.35% Cu, 20.9 g/t Ag, and 0.58 g/t Au, was mined in the Bisbee area. It is interesting to note that Quebec and Bisbee share a common bond in the form of the Dr. James Douglas. Douglas, born in Quebec City and educated at McGill, was the head geologist for Phelps Dodge in 1881, and it was his discovery of the Copper Queen mine that propelled an established mining firm (Phelps, Dodge, and Company) into one of the greatest copper producers in the world. A short underground visit was made to the Copper Queen mine on an organized tour. The tour gave a good overview of historic mining practices and the form of the mineralized breccia, which showed heavy overprinting by secondary minerals (malachite and azurite) formed by percolating surface water.

The party traveled 200 km to spend the afternoon touring Phelps Dodge's Miami-Inspiration mine. Mineralization at Miami is hosted within metamorphosed rocks of the Precambrian Final schist, which was intruded at 612 Ma by the Schullize granite (actually a quartz monzonite), and subsequently intruded by other quartz monzonite intrusions (593 Ma) responsible for the copper mineralization. The original mineralization consisted of pyrite and chalcopyrite, with a grade of 0.30 to 0.40% copper. Minor amounts of molybdenite, bornite, chalcocite, and galeana are also present. Tertiary to Recent weathering of the Miami-Inspiration orebody has led to the development of extensive oxidation and supergene zones. The leached cap attains a thickness of 120 m, and is composed of limonite, hematite, and remnant chrysocolla. Beneath this cap occurs a 60- to 120-m-thick copper oxide zone, which grades into 6-m-thick blanket composed of chalcocite, with lesser covellite and digenite. The grade of the supergene ore ranges from 0.8 to 1.3% Cu. Hypogene alteration has been masked by supergene effects. At the present rate of extraction, the Miami-Inspiration mine life is expected to be five years.
wt % Cu. Recent exploration has focused on an 18 Mt lens of ore containing 0.4% Zn and <1% Cu.

At the United Verde open pit, a variety of diagnostic features of VMS mineralization is displayed in the pit walls. Features observed include the dacitone bed (representing a post-orogenic extension horizon), intense Mg-chlorite alteration of the Lower Cretaceous rhyolite, chalcopyrite veins and stockworks cutting the footwall “black schist,” and bedded pyrite containing black smoker chimney fragments. A tour of roadside outcrops in the immediate vicinity of the mine concentrated on structural and stratigraphic relationships.

Following visits to the Grand Canyon, Meteorite Crater, and Death Valley was a visit to Round Mountain mine—a vast heap-leach, low-sulfidation gold deposit located 80 km north of Tonopah, Nevada. The orebody is housed in tuff units associated with a 26.5 Ma caldera that formed in and on Paleozoic metasediments overlying Cretaceous granite. The ash-flow tuff attains a thickness of over 1,000 m and is composed of ash, pumice, volcanic glass, and rock fragments. Rapid cooling in the upper (T1) and lower (T2) part of this tuff unit preserved the porosity, whereas welding occurred in the middle section (T3), due to heat and the pressure of the overlying tuff. Fracturing associated with caldera collapse led to the upward movement of mineralizing fluid, precipitation of gold and silver, and quartz-adularia alteration in the permeable tuff. Late-stage faulting due to Basin and Range tectonics 10 m.y. ago caused part of the orebody to be down-dropped into the valley, and subsequently covered by alluvium. The ore occurs as four different types: veins within the intrusive bedrock (Type 1), disseminated mineralization within highly porous and permeable non-welded tuff (Type 2), fracture-controlled and disseminated mineralization within the basal intrusive tuff unit (Type 3), and fracture-controlled mineralization within the metasedimentary unit (Type 4). Most of the ore currently being mined is Type 2, and it has an average grade of 0.58 g/t Au. It is estimated that 3.7 Moz of gold is present as Type 2 ore. Also present are hematite veins that contain between 5 and 205,000 oz per pocket! This material is taken directly to the smelter.

An informative computer presentation on the mine wrapped up the offsite tour before a visit to the open pit to witness a routine blast from the dispatch tower. Unfortunately, we were unable to visit the floor of the pit and after briefly looking at the large cyanide heap-leach pads, we examined samples from the core-shed.

The final mine visit was the Bagdad Cu-Mo porphyry deposit, also operated by Phelps Dodge. Having visited two other Cu-Mo porphyry deposits, we had developed a preconceived set of ideas about porphyry mineralization that was dashed when we found that all the ore at Bagdad is present within the potassic zone.

The Bagdad mine is situated at the intersection of the north-trending Spring Mountain fault zone and the EN-striking Laramide intrusive belt. The emplacement of a 71 Ma, porphyritic quartz-monzonite dike into the surrounding quartz monzonite complex led to the main mineralizing event. The Cu-Mo mineralization is generally associated with moderate to strong potassic alteration that occurs within a phyllitic alteration shell. Since mining first began at Bagdad in 1927, 3.5 Mt of ore have been mined with a grade of 0.49% Cu. Reserve calculations estimate that 750 Mt of ore remain with a grade of 0.37% Cu and 0.02% Mo, which amounts to a mine life of 25 years at the current extraction rate. The mine has also produced 12 Moz of silver. In the pit, several stops were made to compare different styles of mineralization in the potassically altered quartz monzonite and porphyritic quartz monzonite intrusives. Of the three porphyry Cu-Mo mines visited during the field trip, Bagdad had the richest hypogene ore, where chalcopyrite was particularly abundant in stockwork veins, accompanied by minor supergene chalcocite.

The McGill Student Chapter would like to thank the Society of Economic Geologists, Cominco Ltd., Noranda Ltd., Barrick Gold Corp., and Quebec Mining for their generous support, which made this trip possible. We would also like to extend our thanks to Phelps Dodge, ASARCO, and Round Mountain Gold Corp., and their personnel, who facilitated our mine visits in Arizona and Nevada.

On March 27, in conjunction with the Department of Earth and Planetary Sciences, the Chapter held a successful one-day symposium entitled, “VMS Mineralization Associated with Submarine Volcanism.” The goal of the symposium was to relate volcanological processes of calderas with the formation of VMS deposits. Over 80 delegates (including members from UQAM, Carleton, Laurentian and the University of Western Ontario SEG Student Chapter) attended this free event. The first speaker of the morning was John Six, McGill University, who presented “An Overview of Caldera Systems: Current Knowledge, Unresolved Problems, and Future Prospects.” Ben Kennedy, McGill University, then spoke on “Experimental Studies Related to Fault Development in Calderas.” Jim Franklin of Franklin Geosciences presented, “A Tectonic Overview of VMS Settings,” and was followed by Mark Hannington, Geological Survey of Canada, who spoke on “Sea-floor Hydrothermal Systems in Modern Submarine Calderas: A Global Perspective.” He showed many examples that demonstrated associations between calderas and VMS and epithermal gold deposits.

Richard Fiske (Smithsonian Institute) started the afternoon session with a talk on “Submarine Silicic Calderas South of Japan: Targets for Volcanological Studies and Economic Breakthroughs.” He showed many examples of felsic calderas containing appreciable mineralization. Harold Gibson, Laurentian University, introduced the audience to ancient examples of VMS mineralization from the Abitibi district of Canada in his talk entitled “Calderas, Calderon and Volcanogenic Subsidence Structures in Ancient Successions: Recognition, Problems and Relationship to VMS Deposits.” The final speaker was Wolf Mueller, University of Quebec at Chicoutimi, who also spoke about ancient examples in his talk entitled “Mineralized Central Calderon Structures: Examples from the Hunter Mine and Notemal of the Archean Abitibi Greenstone Belt.”

Given the success of the conference and the enthusiasm displayed by the participants, the McGill Student Chapter hopes to hold similar events in future years. We would like to thank the delegates who attended the symposium and especially the invited speakers who made this event so successful. Financial sponsorship and support was provided by the Department of Earth and Planetary Sciences and the Faculty of Graduate Studies and Research at McGill University, by the Géotechnique Research Group at the University of Montreal/Ecole Polytechnique, and personal donations by professors J. Six and A.E. Williams-Jones.

OTHER TALKS

The Chapter also hosted three visiting lecturers. In late January, Michel Gauthier, Universite du Quebec a Montreal (UQAM), presented “Mineral Deposits of the Eastern Townships, Quebec.” This talk focused on different styles (e.g., VMS, MVT, red-bed copper) and potential of mineralization in an area of Quebec familiar to many of the attendees. In mid-March, Terri Kunkler, from SOQUEM Ltd., spoke on Cu-Au-Sn Olympic Dam—Kintian-type deposits, and their
exploration potential in Canada. Our final speaker of the year was Jeff Hedengquist, a consultant geologist, who presented “Volcanoes, Geothermal Systems and Ore Deposits: Processes to Products.” The lecture featured examples of high- and low-sulfidation precious metal deposits and their link to volcanic and geothermal systems in the circum-Pacific region. The McGill Student Chapter hopes to maintain the quality of our guest speakers for the next academic year.

For more information and pictures of the field trip and other McGill Chapter news and upcoming events, please visit us on the web at http://www.cps.mcgill.ca/~seg.

— Sandy Archibald

ON SUNDAY, MAY 7, GEOLOGISTS representing numerous companies and students from the combined SEG student chapter of The University of Utah (CMES), New Mexico Tech, and the University of Texas, Austin, gathered in Lima, Peru, for the first leg of two Andean transects. This transect would take the group from the Coastal batholith at Lima to the field and thrust belt between Yauli Yacu (formerly Casapalca) and San Ramon. In one day, we crossed the entire Cordillera, rising from sea level to 4,816 m elevation and descending again to 900 m.

The first mine visited was the San Vicente zinc mine (SVMS), the twelfth largest in Peru, with 1989 production of 940,000 tons of ore at 8.9% Zn. The San Vicente ores are considered Mississippi Valley-type analogues and are famous for their rhythmic banding. The tailings area is very small, as over 80 percent of the mined material is used as backfill.

The next stop was at the La Oroya custom smelter (4700 m elev) operated by Doe Run Peru. The smelter, which is undergoing a thorough modernization process, produces 20 products of polymetallic ores recovered from the mines of central Peru. Doe Run Peru has initiated a far-reaching program of education and environmental restoration at La Oroya.

Yauli Yacu at 4,250 m elevation, is a Zn-Cu-Pb-Ag district that is undergoing major expansion as a result of investments by Glencore Corporation. Polymetallic veins, limestone replacement ores, and conglomerates, in which sphalerite replaces carbonate class, were discussed during an underground tour. The polymetallic veins have been explored over a strike length of 4 km and a 2,000 m vertical interval. Mining has taken place in the area since colonial times.

VMS deposits occur 60 km east of Lima. These deposits initially were mined for barite. Today, Perubarr is interested in the zinc mineralization. Mined orebodies and smaller smaller ones occur in a zone extending in the Coastal batholith. The rocks and ores have been recrystallized as a result of contact metamorphism. Two near-surface orebodies, Jumilla and Guechola, have been mined out. Underground mining continues at Cecilia Norte and Cecilia Sur, with a projected production of 540,000 metric tons in 2000.

One hundred kilometers south of Lima, we visited the Raul-Condable copper district. These ores have been variously described as VMS deposits and as skarns. Lower Cretaceous volcanosedimentary sequence is intruded by dacitic-andesitic dikes and sills and a granodiorite stock with associated dolerite dikes. Mineralization occurs in late crosscutting veins, as replacements of calcareous units, and in skarn-bound breccias. Mineralization consists of chalcopyrite, pyrrhotite, pyrite, and magnetite. Metasomatism accompanying mineralization converted actinolite to scapolite. More than 25 Mt of 1.7% Cu, 0.295 g/t Au, and 0.194 oz/t Ag have been mined to date in the district. The Tail pit is inactive.

The Southern Andean transect and tours of the porphyry copper district began at Arequipa, the second largest city in Peru. The trip from Arequipa to Maquepuca crossed the Incapuquio fault zone, thought to be an extension of the Falla de Dorneycio in Chile.

The Casapalca deposit, operated by Southern Peru Copper Corporation, is located between 3,100 and 3,800 m elevation. Leaching and supergene enrichment was interrupted after initiation by the eruption of the Huayllas tuffs. As a result, only 15 m of oxidized and 20 m of enriched material were developed. Reserves are 1.24 billion tons at 0.64% Cu. Another 2.1 billion tons of deep ore have been outlined.

At Taqapalca, the ignimbrite cover is absent and enrichment is more extensive. Tourmaline breccias are common. Today, 519 Mt of ore grading 1.0% Cu have been mined, and reserves are 700 Mt of 1.74% Cu, with an additional 1.1 billion tons of leachable ore at 0.20% Cu. Hypogene mineralization consists of pyrite and chalcopyrite. Anhydrite/gypsum veins are common.

The last stop was the Cerro Verde (Phelps Dodge) deposit just 30 km south of Arequipa. The first shipments of cathode copper were made in 1977. Ore is mined from the Cerro Verde and Santa Rosa pits. The breccia-hosted ores of Cerro Negro are yet to be developed. The Cerro Verde and Santa Rosa porphyries have been dated at 58.3 Â± 2.3 Ma. Hypogene mineralization consists of chalcopyrite + pyrite. The highest grades are in the potassic core where chalcopyrite nearly always exceeds pyrite.

Participants in the University of Utah–New Mexico Tech–University of Texas field trip to Peru. BACK ROW: Nick Hawkes, Nancy Davis, Amy Gilmer, Ryan Mathur, Jennifer Hoad, Dan Alkon, Richard Pez (at back), Kaydee Roberts, Andrew Mioduchowski, Gerry Ray FRONT ROW: Ralph Hafen, Chris Martin, Gabriel Saporiti, William X. Chávez, Jr., Erich U. Peterson, Thad Roberts, Hector Suarez.

We wish to thank the Society of Economic Geologists for making this trip possible through their field trip fund, the Companies that provided support, and our hosts in Peru for a truly educational trip.

Please visit our website for a virtual experience http://www.mines.utah.edu/pyrite/peru2000/Penweb/penweb.html.

— Erich U. Peterson • William X. Chávez, Jr.
THE OREGON STUDENT CHAPTER of SEG wishes to thank SEG for support of the Hydrothermal Systems field trip to New Zealand in March of 2000. Two members from Oregon State University, Corvallis, Oregon joined a group of twenty-two students from University of Arizona, Tucson, Arizona; Stanford University, Palo Alto, California, and the University of Nevada, Las Vegas, Nevada. Dr. Stuart Simmons from the Geothermal Institute, University of Auckland in Auckland, New Zealand led the field trip. The field trip would not have been possible without the excellent organization provided by Dr. Simmons in New Zealand, and Stuart Gibbons at the University of Arizona. The trip was an excellent overview of both active and fossil epithermal systems on the North Island of New Zealand. The trip started on the Coromandel Peninsula, where Au-Ag prospects near the historic mining district of Thames were examined. Further to the south, the Martha Hill gold mine in Waifu, and the historic mining district of Karangahake were visited. The Martha mine, with reserves of 8.1 Mt at 3.1 g/t Au, and 28 g/t Au, is expected to be in production until 2007. Karangahake is where the first cyanide leaching techniques were pioneered during the late 1800s. A day trip by helicopter to White Island was one of the many highlights. This active volcano, located about 50 km offshore of the North Island, represents the northern extension of the Taupo Volcanic Zone. White Island offers an excellent view of an active degassing arc volcano, thought to be a high-sulfidation epithermal environment. We observed the crater at sea level, witnessed some of the highest SO₂ flux being released to date, and missed an ash eruption by only a few weeks. Several hydrothermal systems, in the Park, steamiest Rotorua, as well as some of the beautiful beaches of New Zealand, were also visited. The grand finale at Ohakuri included a mapping exercise, in which we defined alteration assemblages and targeted epithermal gold mineralization. We thank Stuart Simmons for an excellent trip.

The Oregon Student Chapter would also like to recognize and thank the 1998 and 1999 SEG International Distinguished Lecturers. Dr. Chris Heinrich from ETH, and the University of Zurich, Zurich, Switzerland and Dr. Noel White, a consultant from Brisbane, Australia. Both lecturers spoke during September and October of 1999 at Oregon State University and at the University of Oregon. Dr. Heinrich spoke on the techniques of the ETH-designed micro-analytical system combining the Excimer Laser with an ICP-MS, and its application to geochronology of fluid inclusions in porphyry copper and tin-tungsten ore deposits. Dr. White discussed contrasting styles of epithermal alteration, mineralization, and high-sulfidation vs. low-sulfidation Au-Ag ores. Their lectures were informative and greatly appreciated.

The Student Chapter hosted two invited speakers during the spring of 2000 at Oregon State University. They were Dr. Mark Reed from the University of Oregon, and Dr. Koichiro Watanabe, a visiting professor from Kyushu University in Hakoizaki, Japan. Dr. Reed spoke on hydrothermal systems at Butte, Montana and advances on the CHILLER program. Dr. Watanabe spoke on the Kuju and Unzen volcanoes near Kyushu, Japan.

The Chapter's officers for the 2000-2001 school year are: Brian Runk (UOO), Secretary; Joanna Lipke (OSU), Treasurer; Mike Winkler (OSU), Vice President; and Alex Raab (OSU), President. Contact numbers for the Oregon Chapter are (541) 737-1201 and Dr. John Dilles at (541) 737-1245. E-mail contact is raab@geo.orst.edu or dilles@geo.orst.edu.

— Alex K Raab
President, Oregon Student Chapter

THE UBC STUDENT CHAPTER has had an active and successful 1999-2000 year. The chapter has a core group of 10 students and has been successful in continuing the lecture series initiated in 1998-99, with three lectures that were well attended by students, faculty and industry. The first lecture of the 1999-2000 year was the SEG International Exchange Lecturer, Noel White of BHP Minerals, who presented a lecture on, “Convergent Evolution and Ore Deposits” in early September 1999. In October, a second SEG International Exchange Lecturer, Christoph Heinrich of ETH Zürich presented a lecture on, “Magmatic-Hydrothermal Ore Formation: New Insights from Fluid-Inclusion Micro-Analysis.” In February 2000, Barry Smee of Smee and Associates Consulting Ltd. presented a lecture on, “The Use and Abuse of Weak Extraction Geochemistry in Mineral Exploration.” In late February, Michael Michaud of SRK Consulting presented a talk on, “The Geology, Petrology, Geochemistry, and PGE+Au-Cu-Ni Ore Assemblage of the Roby Zone, Lac des Iles, Northwestern Ontario.” In early March, Bill Wenzelnski, Expatriate Resources Ltd and Lee Groat, Earth and Ocean Sciences, University of British Columbia, presented a lecture on, “Recent Emerald Discoveries of the Great Net Property, Yukon Territory.” In late March, the final lecture of the year was the SEG Thayer Lindsey Lecturer for 1999-2000, John Thompson of Teck

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White Island is the site of an active degassing arc volcano, which is thought to be a high-sulfidation epithermal environment.
Corporation, who presented a lecture entitled, “Research and Mineral Exploration.”

In May 2000, the UBC Student Chapter organized and undertook a five-day field trip to the Great Basin in conjunction with the Geological Society of Nevada 2000 conference. The field trip was attended by five student chapter members, one member of the University of Victoria SEG student chapter, and one geologist from the British Columbia Geological Survey. Field trip leaders were Dick Tosdal and Shane En bert of the Mineral Deposit Research Unit at UBC. The purpose of the field trip was to study various aspects of the geological and metallogenic history of the Great Basin. Day one included numerous informal stops to view the Paleozoic to Cenozoic geology in the region between Reno and Elko, including the Paleoarchean geology of the miogeoclinal, the upper Paleozoic overlap assemblage to the Anthracite Orogen, rocks of the Ruby Mountains core complex, and Eocene clastic and basaltic rocks proximal to the town of Elko. Day two of the field trip included two mine tours to Carlin-type Au deposits near Elko. The first was a tour of Barrick Gold’s giant open pit Betze-Post mine. This tour was followed by an underground mine tour of Barrick’s high-grade Meikle deposit. Day three of the field trip involved a tour of Homestake Mining Company’s West Archimedes Carlin-type Au deposit near Eureka, as well as an informal tour of the geology associated with porphyry Mo mineralization in the Mount Hope igneous complex. Day four of the trip entailed a detailed mine tour of the low-sulfidation epithermal Au deposit of Round Mountain Gold Corporation, and was followed by informal stops to view Pb-Ag veins in Jurassic granites at Austin, Nevada, and Cenozoic volcanic rocks in the Great Basin. The final day of the tour involved a mine tour of the Crooked-Lewis low-sulfidation epithermal Au deposit. The group then attended the Geological Society of Nevada 2000 conference. We wish to thank everyone who made our trip enjoyable, especially our tour guides and mine staff. This trip was funded by grants from the Department of Earth and Ocean Sciences at UBC and from the SEG.

The 1999–2000 year culminated with the election of a new executive for 2000–2001: Scott Hefferman—President, Carl Deyell—Vice President, Simon Haynes—Secretary, and Nancy MacDonald—Treasurer. Dick Tosdal will remain as the faculty sponsor. We thank all those who gave talks, those who donated their time, and the SEG for their support of the UBC student chapter in 1999–2000.

— Steve Piercey, UBC Student Chapter President (1999–2000)
A Record of the Early Years of Waldemar Lindgren (1878–1882) at the Freiberg Mining Academy, Germany

Circa 1878. General George Custer has just lost the battle of the Little Big Horn. Mark Twain publishes the Adventures of Tom Sawyer. Gold is discovered in the Black Hills of South Dakota. Waldemar Lindgren arrives at the Freiberg Mining Academy.

Waldemar Lindgren is widely recognized as one of the founders of modern economic geology. Many of the basic theories and classifications of mineral deposits used today were first published in his landmark textbook entitled Mineral Deposits. In 1905, he also led the group that established the journal of Economic Geology. Lindgren eventually published more than 30 papers in the journal, beginning with volume 1.

Lindgren received his early training in geology at the Freiberg Mining Academy between 1878 and 1882. Founded in 1765, the Freiberg Academy is the world’s oldest mining school. It is situated in the heart of the Ag-Pb-Sn mining district of Erzgebirge (Ore Mountains) in Saxony. Silver was first mined extensively in the region in 1168, and this led to the gradual industrialization of the area and the establishment of a mining center in the medieval city of Freiberg (from Freyen Berge, meaning “free mining”). The Mining Academy was established at the suggestion of the general mining commissioner of the region, to provide practical training in geology, mining, and metallurgy. It remains one of Germany’s most important postsecondary research institutions.

The original buildings of the institution are enclosed by the inner walls of the city and include the administrative center and the Institute of Mineralogy. The institute houses a large, permanent mineral collection that is among the oldest and finest in the world. The emphasis of the early mining school was on engineering and many of the teaching implements are preserved in the Academy Museum. These include an amazing collection of handcrafted working models of underground mining operations and equipment from the past 200 years (steam engines, stamp mills, pumps, etc.). Students received training in the local mines, one of which was taken over by the Academy in 1919 and is now maintained as teaching facility (Himmelsfahrh Fundgrube). One of the features of the older buildings is a detention cell for unruly students. Cited offenses included laughing aloud at the opera or hurling insults at the city’s lamplighters. There is no record of Lindgren ever having spent time in the cell.

A key figure in the founding of the Academy was Abraham Gottlob Werner (1749–1817). Werner was professor of mineralogy and mining engineering beginning in 1775 and was famous for his theory of Neptunism—the idea that water was the source of most rocks, and particularly, basalt. Application of this theory to ore genesis dominated the thinking on mineral deposits at the time and was not seriously challenged until James Hutton introduced the theory of Plutonism in 1788. Other well known professors at the Academy were Carl Friedrich Mohs (1818–1826) and Johann Friedrich Breithaupt (1826–1866). Albert Julius Weisbach succeeded Breithaupt in 1866 and taught mineralogy and crystallography during Lindgren’s tenure.

By the time Lindgren attended Freiberg, it was already a 100-year-old institution, attracting students from across Europe and the Americas. The Academy’s graduates included the famous natural scientist Alexander von Humboldt (1791) and the geochemist Victor Moritz Goldschmidt (1871–1874), whom Lindgren must have just missed. The records of its former students are housed in the extensive archives of the Mining Academy. From these records, we
have reproduced Lindgren's transcript and list of courses that were taken for his degree (Figure 1).

The courses being offered in 1878 were similar to many of those in engineering programs being offered at universities today. The record shows that Lindgren had a special command of the sciences, and especially of chemistry and engineering. His performance in law and economics seems to have been less impressive. Lindgren's strong background in chemistry was established in courses taught by Hieronymus Theodor Richter, then Rector of the Academy, and by Clemens Winkler-Richter and his colleague Ferdinand Reich were well known for their discovery of indium in sphalerite from one of Freiberg's silver mines in 1863. Winkler gained recognition in 1886 for the discovery of germanium, which he separated from the mineral argyrodite collected from the nearby Himmelsfahrt silver mine. His laboratory is still preserved as a museum across the street from the Institute for Mineralogy.

The courses by Alfred Wilhelm Stelzner on economic geology and petrology no doubt influenced Lindgren's career path. Stelzner emphasized the application of the petrographic microscope to the study of rocks and minerals. He was also one of the main critics of the then popular theory of lateral secretion in the formation of ore deposits. Stelzner promoted the idea that hydrothermal fluids and their dissolved metals were derived from deep-seated igneous sources—something that Lindgren later established in his landmark paper of 1901, "Metamorphic processes in fissure veins."

Lindgren graduated from the Freiberg Academy as a mining engineer in 1882, having completed 53 courses. Before leaving Freiberg, he published his first two scientific papers on mineral deposits, which dealt with the mineralogy of the Langban deposits of Sweden.

An excellent account of Lindgren's subsequent career is given by J.C. Graton (1933) in the AIME Lindgren Volume, Ore Deposits of the Western States. Following graduation, Lindgren remained in Freiberg for another year and undertook graduate work in metallurgy and chemistry. In June 1883, he sailed to America and joined the North Transcontinental Survey, which was engaged in building the Northern Pacific railway from St. Paul to Portland, Oregon. After a brief period as a mining engineer and metallurgist at Helena, Montana, and later at Anaconda, Lindgren joined the U.S. Geological Survey in late 1884. For more than 25 years, he carried out extensive field studies of the mineral deposits on the western United States, eventually becoming Chief Geologist of the Survey. In 1912, Lindgren became professor and head of the Department of Geology at the Massachusetts Institute of Technology. The first edition of Mineral Deposits appeared shortly thereafter. Four editions of the textbook were eventually published, in 1913, 1919, 1928 and 1933.

Contributed by Mark Hannington, Peter Herzog, Jan Jonasson and Thomas Monckoff, with details from a variety of published sources. Special thanks to Hans Hofmann.

Director of the Freiberg University Archives.
Table 1. A Translation of Lindgren’s Undergraduate Courses from 1878 to 1882

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<td>Markenscheidekunde Praktikum</td>
<td>Surveying Practical</td>
</tr>
<tr>
<td>Geodasie II</td>
<td>Geodesy II</td>
</tr>
<tr>
<td>Bem. und Hüttene. Rechnungswissenschaft</td>
<td>Accounting in Mining and Metallurgy</td>
</tr>
<tr>
<td>Probierkunde</td>
<td>Analytical Chemistry of Ores and Metallurgical Products</td>
</tr>
<tr>
<td>Bauzeichnen</td>
<td>Architectural Drawing</td>
</tr>
<tr>
<td>Eisenhüttenkunde</td>
<td>Metallurgy of Iron Ores</td>
</tr>
<tr>
<td>Elektrotechnik</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Maschineneichen II</td>
<td>Mechanical Drawing II</td>
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<tr>
<td>Mikroskopisches Praktikum</td>
<td>Microscopy Practical</td>
</tr>
<tr>
<td>Entwurf von Aufbereitungsanlagen</td>
<td>Design of Processing Plants</td>
</tr>
<tr>
<td>Meteorologie</td>
<td>Meteorology</td>
</tr>
<tr>
<td>Mikroskopisches Übungen</td>
<td>Exercises in Microscopy</td>
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</tbody>
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EXPLORATION REVIEWS

Special Report:
MINERAL EXPLORATION IN TANZANIA

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Although the Republic of Tanzania is one of the world’s poorest nations as a result of socialist policies introduced after its independence in 1963, its mineral wealth has been recognized from much earlier gold and diamond production. However, unlike some other African states, Tanzania has remained politically stable. In 1989 and 1990, the government commenced an economic readjustment program, which eased restrictions on the ownership of operating mines, increased profit remittance, and reduced levels of taxation. This program fostered a mineral exploration boom that started with the arrival of a few courageous players in a country then characterized by poorly developed infrastructure and minimal skills and experience in mining and exploration. The early arrivals included PORTRAT Mining (now East African Gold), Sutton Resources (Romanex), Tancan Gold (now Tan Range), Dar Tadine, and Cluff Resources and Samax, both of which have been merged into Ashanti Goldfields.

Since 1991, mineral exploration has continued at a rapid pace. From 1993 to 1997, many Australian and Canadian juniors arrived in the country, including Maiden Gold (Aus), Tanganyika Gold (Aus), Pangea Goldfields (SA), Serengeti Diamonds (Can), Patrick Gold (Can), Blue Sky Resources (later Princess Resources, Can), Ormonde Mining (Ireland), and East Africa mines (becoming Afrika Mashariki, Aus). They were accompanied by a smaller wave of major companies looking for joint ventures or acquisition of larger deposits discovered by the juniors. These included Ashanti Goldfields (through the acquisition of Cluff Resources), Barrick, BHP, Newmont, and several South African majors: JCI, ISCOR, Anglo American, Randgold, and Avgold.

Tanzania’s geology is summarized in Table 1 and essentially covers the entire geologic span.

Table 1. Simplified Geological and Mineralization Events in Tanzania

<table>
<thead>
<tr>
<th>AGE</th>
<th>MAJOR LITHOLOGIES</th>
<th>MINERALIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent</td>
<td>Beach sediments, inland lakes</td>
<td>Ti-Zr (heavy minerals)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soda ash deposits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laterite Ni in NW Tanzania?</td>
</tr>
<tr>
<td>Neogene</td>
<td>&lt;3 m.y.</td>
<td>Nb, phosphate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Limestone</td>
</tr>
<tr>
<td>Cenozoic</td>
<td>Marine and terrestrial basins (Rukwa trough)</td>
<td>Gas, evaporite minerals, kaolin</td>
</tr>
<tr>
<td>Mesozoic</td>
<td>120-60 m.y.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jurassic to Cretaceous sandstones, carbonates and evaporites in coastal basins</td>
<td></td>
</tr>
<tr>
<td>Mesozoic</td>
<td>250-120 m.y.</td>
<td>Coal, uranium?</td>
</tr>
<tr>
<td>Bozobain</td>
<td>550-650 m.y.</td>
<td>Minor Cu?</td>
</tr>
<tr>
<td></td>
<td>Shallow dipping, unmetamorphosed clastic sediments, minor dolomites and basalts. Largely confined to western Tanzania</td>
<td></td>
</tr>
<tr>
<td>KIBARAN OROGENY</td>
<td>(1100-1400 m.y.)</td>
<td>Ni-Cu-Co with layered intrusions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fe-Ti-V with layered intrusions</td>
</tr>
<tr>
<td>Kabanga</td>
<td>1275 m.y.</td>
<td>Sn, W+/−Ta associated with granites</td>
</tr>
<tr>
<td></td>
<td>Layered mafic-ultramafic intrusions (Kabungo-Musongati-Kabanga)</td>
<td></td>
</tr>
<tr>
<td>Karagwe-Ankoleanan</td>
<td>1300 m.y.</td>
<td>Graphite, gemstones, minor Au and Cu</td>
</tr>
<tr>
<td></td>
<td>Phyllites, sericite schists, meta-argillites, quartzites; granitic (diapiric?) domes</td>
<td></td>
</tr>
<tr>
<td>Usagaran (E Tanzania)</td>
<td>1720-1800 m.y.</td>
<td>Cu-Au (Ernest Henry?)</td>
</tr>
<tr>
<td></td>
<td>Biotite gneisses, granulites, quartzites and minor amphibolites and marbles; may include remnants of Archean greenstone</td>
<td>Lode gold (Lupa)</td>
</tr>
<tr>
<td></td>
<td>Bioite gneisses, quartzites (including magnetite quartzites), minor amphibolites and marbles; late granites; minor ultramafic and mafic intrusions; more common remnants of Archean greenstone</td>
<td>Pb-Cu-Au (Mpenda)</td>
</tr>
<tr>
<td>Rubidian (W Tanzania)</td>
<td>2200-2300 m.y.</td>
<td></td>
</tr>
<tr>
<td>ARCHEAN</td>
<td>Kavironian</td>
<td>Coarse clastic molasse sediments</td>
</tr>
<tr>
<td></td>
<td>2.65 b.y.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mafic volcanics overlain by minor felsic volcanics, thick-banded iron formations and minor clastic sediments; appears largely deficient in extrusive and intrusive ultramafic lithologies</td>
<td>Au (shear zone and replacement)</td>
</tr>
<tr>
<td></td>
<td>2.70 b.y.</td>
<td>VMS (unconfirmed, Migori in Kenya)</td>
</tr>
<tr>
<td>Granite gneiss terrane</td>
<td>Varies between younger (ca. 2.8 b.y.) post-orogenic ademelites to older tonalite basement (ca. 3.0 b.y.)</td>
<td>Au (Chocolate Reef/Bozvagi)</td>
</tr>
<tr>
<td>Dodoman</td>
<td>&gt;3.0 b.y.</td>
<td>Migmatized and highly metamorphosed largely gneissic rocks</td>
</tr>
</tbody>
</table>
from early Archean gneisses to recent Neogene volcanics related to
the on-going evolution of the Great African Rift.

Most mineral exploration has focused on three commodities:
gold, diamonds, and nickel. Some adventurous companies,
however, are investigating other targets such as heavy minerals,
evaporites and base metals (Cu-Zn).

Gold exploration has centered on the Lake Victoria greenstone
belts with some emphasis on the smaller Lupa gold field, and minor
activity in the Mbanda Cu-Pb-Au field. Also, new discoveries have
been made in the Niassa area—a strike extension of the Niassa
province in Mozambique—adjacent to Lake Malawi (Fig. 1).

The increase in activity is responsible for the discovery of several
major deposits, six of which have resources of over 1 Moz (Fig. 2)
within the Lake Victoria gold fields where mineralization is hosted
by Archean metavolcanics and sediments.

Table 2. Recent Major Discoveries in the Lake Victoria Goldfields.

<table>
<thead>
<tr>
<th>DEPOSIT</th>
<th>OWNER</th>
<th>SIZE (MOZ)</th>
<th>GRADE (G/T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulyanhulu</td>
<td>Barrick Gold</td>
<td>7.7</td>
<td>13.2 1</td>
</tr>
<tr>
<td>Gesta (incl. Kukuluma)</td>
<td>Ashanti / Samax</td>
<td>5.4</td>
<td>2.5 2</td>
</tr>
<tr>
<td>Nyamakulina/Ridge 8</td>
<td>Anglo American</td>
<td>2.0</td>
<td>?</td>
</tr>
<tr>
<td>Golden Ridge</td>
<td>Pangea / Barrick</td>
<td>1.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Golden Pride</td>
<td>Resolute</td>
<td>1.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Mobrama</td>
<td>Afrika Mashiriki /</td>
<td>1.2</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Anglo American</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kahama 3</td>
<td>Pangea / Anglo American</td>
<td>1.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>

1 In December 1998, further resources were identified in a blind
targeting to an existing mineralized zone.
2 Includes the Kukuluma resource at a higher grade of 4.5 g/t.
3 Also known as Chocilali Reef or Buzwagi; contains approx 0.11% Cu.

---

Figure 1. Simplified geological map of Tanzania
In the Geita region (with historical production of >280,000 oz), several smaller deposits occur as replacement zones within banded iron formations (Brog, 1994), or in altered rocks along the contacts of the banded iron formation. At Bulyanhulu, at least one mineralized zone occurs along the contact between pyritic felsic pyroclastic rocks and andesitic volcanics within a carbonate-rich stock. Golden Ridge is hosted largely by banded iron formations and associated greywackes. The Golden Pride is similarly hosted by greywackes. The relatively common discoveries of mineralization in banded iron formation (three out of six at Geita, Nyamakulima, and Golden Ridge) are a function of outcrop. Most of the greenstone terrain is covered by weathering with outcrops usually limited to ridges of banded iron formation.

Several other deposits in the 100,000 oz to <1 Moz range have been identified and have potential for increased resources. The most significant of these deposits are given in Table 3.

**Table 3. Deposits with 100,000 to <1 Moz Gold with Potential for Increased Resources**

<table>
<thead>
<tr>
<th>DEPOSIT</th>
<th>OWNER</th>
<th>SIZE/OZ AU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buhembra – Nyasagoro</td>
<td>Tanganyika Gold</td>
<td>750,000</td>
</tr>
<tr>
<td>Mgusu</td>
<td>Ormonde/Pangea Goldfields</td>
<td>271,000</td>
</tr>
<tr>
<td>Usirumbo</td>
<td>Samas/Ashanti</td>
<td>?</td>
</tr>
<tr>
<td>Buck Reef</td>
<td>East African Gold/Spinifex Resources</td>
<td>369,000</td>
</tr>
<tr>
<td>Myakafuru</td>
<td>East African Gold/Spinifex Resources</td>
<td>135,000</td>
</tr>
<tr>
<td>Kitongo</td>
<td>East African Gold/Spinifex Resources</td>
<td>479,000</td>
</tr>
<tr>
<td>Kungu</td>
<td>Patrick Gold</td>
<td>186,000</td>
</tr>
<tr>
<td>Buziba</td>
<td>Tanganyika Gold</td>
<td>?</td>
</tr>
<tr>
<td>Tulawaka</td>
<td>Pangea Goldfields/Union du Nord</td>
<td>&gt;500,000</td>
</tr>
</tbody>
</table>

1 Resource size likely to have increased with current or recent drilling programs.

Due to the paucity of outcrops, especially in the greenstone terrain south and west of Mwanza, remote sensing and geophysical techniques are being used extensively to identify potentially mineralized structures, with follow-up RAB/RC drilling through laterite cover up to 20 m thick. This technique has been very successful in Western Australia.

Exploration in the Luapula gold field, characterized by reworked Archean rocks with a strong Cretaceous overprint, (Nutt and Nhutara, 1994; Sango, 1988) has concentrated around the Sazu shear zone (30-km strike) and in greenstone remnants. Companies active here include Anglo American (through a joint venture with Tanganyika Gold), Ormonde Mining, and Princess Resources. No significant resources have been published, but exploration successes have been reported. Mineralization styles reported to date include the following:

- Replacement/sulfidation of banded iron formations.
- Quartz veining within or along granite-greenstone (metabasite) contacts, within granite gneisses.
- Stockworks associated with silicification in granitic rocks within the Sazu shear zone.

The potential for epithermal mineralization associated with Cenozoic and younger sediments and rift-faulting along the Tanzanian coastline has been identified at Winyaronga, where very young hydrothermal activity has been identified. Additional evidence of post-Karoo alteration of fault zones has been recognized, but no gold sampling data are available.

Only one modern gold mine (Golden Pride) is currently in production, but at least two major mines are scheduled to be opened: Bulyanhulu at 500,000 oz/yr, and Geita, which was placed in production in July, at 300,000 to 400,000 oz/yr. Mobrama, Kahama, and Nyamakulima are all at feasibility study stages.

**Western portion of Lake Victoria Goldfields:**

**Tectonic corridors and gold mineralization**

**Figure 2.** Major gold deposits in the Lake Victoria Goldfields area.
Exploration and Mine Development Throughout the United States

 Seeking Quality Mineral Properties

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Nickel exploration has focused entirely on a series of layered mafic to ultramafic intrusions at Kabanga and Kagera in northwest Tanzania. Mineralization is related partially to deformation and remobilization of the sulfides. At least one of the intrusions shows strong evidence of sulfide injection into the enclosing hornfelsic rocks. Resources reported in 1998 for Kabanga and Kagera are as follows:

<table>
<thead>
<tr>
<th>M tonnes</th>
<th>% Ni cut off</th>
<th>Ni (%)</th>
<th>Cu (%)</th>
<th>Co (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.0</td>
<td>0.50</td>
<td>1.50</td>
<td>0.22</td>
<td>0.13</td>
</tr>
<tr>
<td>19.8</td>
<td>1.19</td>
<td>2.36</td>
<td>0.31</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Numerous other mafic to ultramafic bodies have been traced in a large arcuate zone trending from Burundi through Tanzania and into southwestern Uganda. But only Kabanga has economic sulfide nickel grades, although lateritic deposits have been explored in Burundi.

Other exploration in Tanzania has been targeted at beach sands, evaporates, graphite, kaolin, and carbonatites (for phosphate and mohobium).

Tanzania has a rich and diversified mineral inventory, and following the government’s economic readjustment program, has attracted a wide range of mining and mineral exploration companies. Given the current stability, the opportunity for Tanzania to become a giant in African mining is great.

ACKNOWLEDGMENTS

During the nine years I have been visiting and working in Tanzania, I have received considerable help from many of the companies named above. In addition, a number of people have been enormously helpful and supportive of both myself and—more significantly—Tanzanian exploration, with the most important being Brian Hester, Kevin Schulz, and Mark Parker. Asante sana!

REFERENCES


**ALASKA**

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E-mail: arakon@arakon.com
Website: www.arakon.com

News is beginning to stream in from field programs and the results suggest the drill contractors and helicopter companies plan to be busy. The most active areas of the state are the Goodpaster, Fairbanks, Circle, Ketchikan and Nome districts.

**WESTERN ALASKA**

Cominco announced that drilling at its Anarraq prospect has delineated the eastern and southwestern limits of the deposit, but mineralization remains open elsewhere. Significant results thus far this year include 197 feet grading 20% Zn, 6% Pb and 1.9 oz Au in hole 923, and 65 feet grading 18% Zn and 6% Pb in hole 929. Drilling will continue as long as weather conditions permit.

NovaGold Resources announced additional drilling results from its 30-hole infill drilling program at the Rock Creek gold deposit near Nome: hole RR-008 Q45 intercepted 36.6 meters grading 2.7 g/t Au, hole RR-017-16.8 meters grading 5.0 g/t, hole RR-025-29 meters grading 2.3 g/t, hole RR-026-10.7 meters grading 5.1 g/t, and hole RR-038-15.2 meters grading 5.6 g/t.

Viceroy Resources has declined its option to restart production at the Illinois Creek deep leach mine near Galena; the property was returned to the State of Alaska.

**EASTERN INTERIOR**

Kinross Gold announced second quarter results from the Fort Knox mine. The mill processed 3.4 million tonnes of ore grading 0.89 g/t Au yielding 83,825 ounces of gold at a total cash cost of $214 per ounce compared to $238 per ounce during the first quarter of 2000. Gold recovery was 88%. Total production costs dropped to $304 per ounce. The mine is expected to increase production in the second half of the year as it accesses higher grade material.

Kinross Gold continued permitting at its True North deposit and exploration at its nearby Soo, Diorite and Amanaitzville prospects.

International Freegold Mineral Development announced commencement of core drilling and reclamation work on its Golden Summit project in the Fairbanks District. A single 1,000-foot-core hole will be collared south of the Wyoming vein and terminated in the footwall of the California vein. Drilling will target high-grade vein and disseminated bulk-tonnage gold mineralization in the vicinity of the old Cleary Hill mine.

Teck Corp. and partner Sumitomo Metal Mining released a draft scoping document for the EIS at their Pogo deposit. The document can be viewed at www.pogominesinc.com. The document outlines an initial production rate of 2,500 tons per day increasing to 3,500 tons per day. Annual gold production of 375,000 ounces increasing to 500,000 ounces (back-calculated recovered grade of 0.41 oz/ton). Mining would be via a 1,750-foot-deep shaft using primarily cut-and-fill methods. A total workforce of 510-585 employees will be housed in permanent on-site facilities. Milling would consist of crushing and a gravity circuit followed by sulfide flotation followed by cyanidation. The gravity circuit is expected to recover 30% of the gold, with the cyanide circuit recovering the remaining 70%. Detoxified cyanide-treated tails would be backfilled underground. Mine electrical power demand of 10-14 MW will be supplied by a 45-50-mile 137 kV power line from the existing commercial grid. Projected construction start-up is estimated for the first quarter of 2002, with initial production in early 2004. The estimated capital cost is $200-250 million.

Also, 12 holes have been drilled into the L3 quartz body, where previous drilling had intercepted high-grade gold mineralization. Although high-grade intercepts have been encountered, L3 apparently is not as continuous as L1 and L2. L3 remains open to the northeast, where additional drilling is planned. Meanwhile, surface exploration continues on other prospective areas of the property, where 25,000 feet of core drilling is planned for 2000.

Copper Ridge Explorations completed field work on its Ogopo prospect in the Goodpaster District. Detailed geologic mapping, grid soil sampling and prospecting were completed in late August. Assays are pending.

Western Keltic Mines and Rimfire Minerals announced a four-hole, 600-meter drill program on their Boundary prospect in the Goodpaster District. The drill target was defined by field work conducted earlier this season, including 360 soil samples, 24 km of ground magnetic surveys and 14 km of ground VLF. Soil sampling outlined a 1,800 m by 1,300 m Au-Bi anomaly cored by a 900 m by 300 m Au anomaly. A magnetic high is associated with these anomalies. At the nearby Southeast Surf prospect, completed work included 250 soil samples, 17 km of ground magnetic surveys and 10 km of ground VLF. Soil sampling outlined a 2,000 m by 1,500 m Au-Bi anomaly cored by a 1,300 m by 1,000 m Au anomaly. The anomaly straddles or lies within a porphyritic intrusive. A magnetic low is associated with the Southeast Surf anomalies.

International Bravo Resource Corp. completed three core holes on the East Divide prospect to test gold-bearing quartz vein occurrences that yielded up to 5.63 g/t over 10 m. The sheared vein system measures 250 m wide by at least 500 m long and is open along strike. Individual veins are hosted in intrusive rocks, strike east-west and vary in width from 1 to over 30 m. A second parallel vein swarm returned values from three continuous chip samples of 2.53 g/t Au over 10 m, 1.61 g/t Au over 18 m and 1.5 g/t Au over 16 m. The third vein swarm returned 2.51 g/t Au over 8 m. Gold mineralization is associated anomalous silver, copper and bismuth.

Canada Fluorspar (formerly Blue Desert Mining) announced that it has finalized an agreement with AngloGold whereby AngloGold will conduct up to $300,000 worth of field work on Canada Fluorspar’s Goodpaster District holdings. Work will concentrate on the Sevenmile, Portal and South Boundary prospects.

Hyder Gold and Rimfire Minerals announced that a 1,200-foot drill program will be conducted in early September on the Eagle prospect southwest of Pogo. The program will consist of 7 diamond core holes to test 3,000 m by 1,500 m gold anomaly hosted in intrusive rocks.

Abacus Minerals announced that it has signed a letter of intent with Engineer Mining Corp. whereby Abacus can earn up to 70% interest in the ER prospect west of Pogo. Abacus can earn 51% interest in the property by issuing 200,000 shares and making cash payments of $30,000 over three years. Engineer Mining will retain a 0.5% net smelter return royalty that can be purchased by Abacus at any time for
$500,000. Absorbs also gains the rights, through Engineer Mining's underlying deal with property owner Runfire Minerals, to earn an additional 19% interest by conducting $750,000 in exploration work before December 31, 2001.

Alaska newcomer El Niño Ventures announced that it has acquired a lease-purchase option from Anglo Alaska Gold Corp. on the 2,600 acre Sassy prospect adjacent to Teck/Sunutomo's Pogo claim block. The Sassy prospect is underlain by intrusive rocks of the Geodpasty Kutiloob and granitic rocks similar to those that host the Pogo deposit. El Niño must expend $80,000 on the property over 3 years, make cash payments of $40,000 and issue up to 200,000 shares of its stock. El Niño can acquire 100% interest in the claims, subject to a 3% net smelter return (NSR) royalty, by making cash payments totaling $500,000.

Ventures Resource announced that it had staked 13 new claim blocks covering approximately 30,000 acres of land adjacent to their Veta property east of the Goodpaster District. The claims cover a series of gold anomalies defined by stream sediment and pan concentrate sampling. Pan concentrate samples from the Willow Creek prospect returned values up to 11.5 g/t Pt + 11.9 g/t Pd, 4.5 g/t Pt + 4.6 g/t Pd, and 2.4 g/t Pt + 2.1 g/t Pd. Freegold acquired the properties through an option agreement with Alta Mines Inc.

Grady Resources announced additional high-grade gold mineralization on their White Gold Trend on the Rumble Creek JV in the Delta District. A hand trench on the Shalosky prospect returned 4 g/t Au over 17 meters.

Shear Minerals Ltd. has completed the first phase of field work on its Shulin Lake diamond prospect in the Chilina District, including 30 glacial till samples, 26 rock samples, 40 heavy mineral

**ALASKA RANGE**

International Freegold Mineral Development initiated a Phase One US$12,000 exploration program on its Tonsina platinum-group-metal prospect in south-central Alaska. Field work will concentrate on defining the extent of platinum-group-element mineralization in the vicinity of previous sampling, which returned values including 8.9 g/t Pt + 11.7 g/t Pd, 4.6 g/t Pt + 4.8 g/t Pd, and 2.4 g/t Pt + 1.8 g/t Pd. Freegold acquired the properties through an option agreement with Alta Mines Inc.

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Shear Minerals Ltd. has completed the first phase of field work on its Shulin Lake diamond prospect in the Chilina District, including 30 glacial till samples, 26 rock samples, 40 heavy mineral
mineralization has been discovered in the West Adit area and on North Pole Hill. The company will conduct underground and surface sampling in early September.

**International Freegold Mineral Development Inc.** has acquired 100% interest in 105 unpatented Federal lode mining claims covering 2,100 acres on the Union Bay platinum group metal prospect. The Union Bay prospect is located near tidewater on the Cleveland Peninsula of mainland southeast Alaska, approximately 35 miles northwest of Ketchikan. The Union Bay prospect is composed of a zoned ultramafic-mafic complex believed to be a pipe and lopolith complex. Samples collected by government agencies contained values up to 1,600 ppb Pt and 400 ppb Pd, along with anomalous Cr, Ni and Co. Heavy mineral concentrates returned values up to 19.7 ppm Pt and 19.9 ppm Au.

Alaska newcomer Medallion Resources Ltd. has optioned lands adjacent to the Salt Chuck Co-Pd mine on Prince of Wales Island. The 2,000-acre property covers a portion of the old Rush and Brown mine. Previous sampling returned Pd values up to 247 ppm, with a Pd/Pt ratio of 6.1. The company conducted limited sampling during staking. Geophysical, geochemical and geological evidence indicates that the Salt Chuck mafic-ultramafic layered intrusive complex is considerably larger than previously believed.

**Western Canada**


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A 1999-2000 survey of mining companies by the Fraser Institute provides an interesting, albeit rather subjective, ranking of the exploration attractiveness of 35 Canadian provinces, states in the U.S., and miscellaneous countries. The survey was based on a combination of geological potential, infrastructure, and regulatory effects on exploration, such as taxation, environmental regulations, and land claims, and showed a wide variation between the regions of western Canada. Manitoba was fourth overall after Nevada, Quebec, and Chile. Saskatchewan, NWT, Alberta, Yukon and Nunavut were clustered near the middle of the pack. British Columbia, despite its relatively good geological potential, tied with Wisconsin near the bottom, barely escaping last place, thanks to Maine. The poor ranking for BC is reflected in annual exploration spending, which has fallen to C$25 million, the lowest level in 40 years.

**British Columbia**

Wheaton River Minerals purchased the Red Mountain gold project located 18 km east of Stewart. The property was originally drilled by Bond Gold in the 1980s and subsequently by Lac Minerals and Royal Oak; work included 127,900 m of diamond drilling and 2,000 m of underground development. More than 12 million tonnes of material grading 2.5 g/t gold is indicated, although Wheaton River is currently considering the feasibility of mining a 700,000 t ore body which grades 12 g/t Au. Red Mountain is a stockwork/p海绵ite-style deposit within Triassic-Jurassic volcanics and intrusives. Gold-silver mineralization occurs in tabular, pyrite-pyrrhotite-sericite altered zones. The company is looking at Red Mountain to replace production from their Golden Bear mine (Newsletter 47, April 1999). Exploration has not
been successful in locating additional ore at Golden Bear and it will probably be mined out in 2001. **DRC Resources** has been diamond drilling the Afton Mine property 10 km west of Kamloops. Afton, which formerly produced 24 million tonnes grading 1.0% Cu plus 0.7 g/lt Au, is a porphyry deposit where gold is actually higher grade in the sulfide zone beneath the oxide cap. Apparently, an open pitable resource may still exist and an underground resource of as much as 6.5 million tonnes grading 1.5% Cu was never mined. Recent drilling has extended the deeper zone with intersections up to 2.4% Cu and 1.1 g/lt Au over 262 m.

**NORTHWEST TERRITORIES**

Diamonds were first discovered nine years ago in the Lac de Gras area of the barren lands, 300 km northeast of Yellowknife. The NWT could be producing approximately 10% of the world's supply. The Ekati mine (BHP Diamonds, Dia Met Minerals, Fipke & Blissom) produced 2.5 million carats in its first full year of operation, to the end of January 2000, most of which sold at an average price of US$168/carat. This value is 29% higher than that used in the feasibility study and at the high end of the scale for the world's diamond mines. Permits are currently in place at Ekati to mine the Panda, Koala, Misery, Fox and Leslie pipes, although Leslie is not currently considered to be economic. Permits have also been applied for to mine three other pipes: Sable, Pigeon and Beartooth, which will extend mine life to at least 2016. The kimberlites are geologically similar to those in South Africa and Russia. Fossilized and fresh sequoia and metasequoia wood preserved in crater facies rocks at Ekati have been dated at 74–47 Ma.

The Diavik diamond mine (Rio Tinto & Aber Resources), about 35 km east of Ekati, is currently under construction and expected to begin production in 2003. Some 995 truck loads of fuel, supplies, and equipment required for the 2000 season were transported over the winter road from Yellowknife. The total resource of 37 million tonnes in four pipes is unchanged from 1999; however, as a result of a recent independent valuation, 25.7 million tonnes have been upgraded to a reserve with an average grade of 1.2 ct/t. This reserve contains 107 million carats having an average value of C$105/carat, or C$54.58/million carats.

Also in line for production is Snap Lake (Winspear Resources 68%; Aber Resources 32%), 220 km east-northeast of Yellowknife and 125 km south of Ekati. Winspear, as operator, is currently driving a 1,200 m decline plus 600 m of development drift in kimberlite. Approximately 20,000 tonnes of kimberlite will be mined, from which three 2000-tonne samples will be processed on site. Kimberlite occurs as a narrow, 10°-20° east-dipping dike, which has been intersected in drill holes as deep as 700 m; although the dike is generally only a few meters thick, drill holes have intersected as much as 15.6 m of kimberlite. Not including recent drilling, the estimated resource is 21.5 million tonnes grading 2.0 ct/t, a diluted, mineable resource, within the dike with a true thickness >2.0 m to a maximum depth of 350 m, is estimated at 12.6
million tonnes grading 1.8 cwt. Diamond in the mineable resource is valued at US$118/cwt. If the permitting process doesn’t cause too many problems, production could begin in 2003. At the time of writing this summary, De Beers Consolidated Mines had made a C$259 million offer to buy Winspear.

A resource estimate has been completed for the Hearne and 5034 kimberlites on the AK-CJ claims (Monopros. Mountain Province Mining & Camphor Ventures). 115 km southeast of the Ekati mine. The twin-looped Hearne pipe contains 6.9 million tonnes grading 1.7 cwt and has a value of US$111/t; 5034 contains 12.5 million tonnes grading 1.6 cwt and has a value of US$103/t. Other diamondiferous pipes are known on the AK-CJ claims and an aggressive exploration program is underway. On Victoria Island, 700 km north of Yellowknife, Major General Resources and Ascot Resources are left as equal partners on an extensive property, which contains five diamondiferous kimberlite pipes. After Monopros left the venture, Dia Met Minerals continues to explore a portion of the Major General/Ascot Victoria Island property.

**SASKATCHEWAN**

In the eastern Athabasca basin, midway between Dry Lake and McMurray River deposits, several companies are getting good results on unconformity uranium targets. Northern Continental Resources is exploring a 5-km-long conductor on the Russell property; the conductor is coincident with a basement graphic zone and a reverse fault that offsets the unconformity. Holes drilled by the original owners encountered narrow intervals up to 3.5% U3O8 and three of four holes completed by Northern Continental intersected mineralization at the unconformity, 320–350 m below surface. About two-thirds of the conductive zone has yet to be tested. Just to the east of the Russell property, at Moore Lake, JNR Resources and Kennecott Canada Exploration reported an intersection of 0.44% U3O8 over 9.2 m, straddling the unconformity at a depth of 269 m. Both exploration groups plan further drilling. Joint venture partners Monopros, Kennecott Resource, and Cameco have continued to explore for diamond in the Fort la Gorce area east of Prince Albert. Large numbers of kimberlite bodies, including many which are diamondiferous, have been identified in the region. The kimberlites, some of which are very extensive, are largely composed of pyroclastic rocks.

The prolific Early Proterozoic Flin Flon greenstone belt of Manitoba extends into Saskatchewan, where Hudson Bay Mining and Smelting put the volcanic-associated massive sulphide Konuto copper-zinc-gold-silver mine into production last year. Also in this area, Foran Mining is exploring the Melville Bay deposit, a resource of 11.5 million tonnes with 6.1% Zn and 0.9% Cu is reported.

**WESTERN UNITED STATES**

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**ARIZONA**

Echo Bay Exploration has completed nine holes totaling 3,140 ft at Nevada Pacific Gold’s Moreau gold property. Only minor alteration and traces of gold were encountered causing Echo Bay to terminate its interest. Guess what? Nevada Pacific believes that the main zone of gold mineralization located to the northwest of the area drilled by Echo Bay still remains the most prospective area on the Moreau Property.” How could Echo Bay have drilled the wrong area? Or maybe the “most prospective area” says something.

**COLORADO**

Leadville Mining and Milling has released a statement that it recognizes open-pit gold and silver mine potential on Breece Hill in the Leadville district (Lake County). Leadville goes on to say that heap leaching is considered the most economical way to extract the gold. Leadville Mining would talk to Canyon Resources about the attitude in Montana, since Colorado is going down the same road, with respect to heap-leach gold operations.

**MONTANA**

And the saga of the McDonald Gold Project continues. Initially, Franco-Nevada sued Canyon Resources, wanting its money back, which was put up to cover legal fees to undertake a “takeovers” lawsuit against Montana. Recent problems at McDonald and Canyon’s Kendall operation (also in Montana) have caused Franco to conclude that McDonald is not permitting. Shortly thereafter they called Canyon to say, “show me the money!” Finally, a settlement agreement was concluded with Franco giving up all rights to the property in exchange for the return of $3 million of the $5 million put forth to fund Canyon’s various legal actions.
NEVADA

Rosios Gold Resources continues to intersect high-grade gold mineralization at the Sossia property (Pershing County). Gold occurs in quartz-carbonate veins, breccia zones, and altered diorite dikes. Significant intervals are about 5 feet wide (true hole length), with grades in the 0.5–2.0 opt Au range, with similar levels of silver.

Newmont Mining Corp. has completed a second round of drilling at Nevada Pacific’s Limousine Butte project in White Pine County. Several >250-ft intervals of 0.05 opt Au (several over 0.05 opt Au) have been reported. Many of these intervals are near surface.

Homestake Mining Co. has purchased Case Pomeroey’s 25% interest in the Round Mountain gold mine (Nye County), which increases its interest in the operation to 50%. The 1999 year-end proven and probable reserves were 420 million tons with an average grade of 0.018 opt Au. An additional 126 million tons of other mineralization grading 0.016 opt Au are also known.

Newmont Mining has agreed to acquire Battle Mountain Gold Co. Apparently, a lot of the attraction is the Phoenix deposit at Battle Mountain (Lander County) and the ability to ship a significant portion of the ore to the nearby Lone Tree autochoke. For those of us who drive I-80, this means more “Green Trucks Hauling Ore” on the highway.

Great Basin Gold continues to extend the size of the Clementine gold-silver vein system at the Ivanhoe project in Elko County. Additionally, recent drilling has discovered other high-grade gold-silver veins in the North Rowena and Velvet areas. Two Clementine extension holes encountered intervals from 2.8 ft of 0.790 opt Au to 7.8 ft of 4.38 opt Au (true hole lengths). The North Rowena area is 600 ft south of the South Gwenivere area and 300 ft north of the Hollister pit. Velvet is 1,100 ft north of Clementine. Great Basin is planning an aggressive drilling program at the property this year.

Golden Phoenix Minerals has released a new measured and indicated resource of 61,513,000 tons with an average grade of 0.77% Cu (0.2% Cu cutoff) for its Contact deposit (Elko County).

Sudbury Contact Mines (a subsidiary of Agincourt Mines) has resumed drilling at Tonkin Springs, Baraga County. Step-out drilling from known gold mineralized areas and drilling to test new targets are planned. Sudbury has reported a gold resource of 1.16 million ounces.

The joint venture of Cypress Development Corp. and Mid-North Resources Ltd. has reported significant zinc-silver drill-hole intercepts at the Gunman project, White Pine County. Mineralization is hosted by limestone and silicate, and is both oxide and sulfide. The three holes reported include 155 ft of 6.98% Zn and 1.29 opt Ag; 120 ft of 2.69% Zn and 1.15 opt Ag; and 225 ft of 0.01% Zn and 0.89 opt Ag.

Vista Gold is conducting exploration at the Hyckof mine, Humboldt County, and has announced the identification of a new geochemical anomaly along a 2,000-foot zone of silicified breccia in a footwall structure of the Brimstone pit. The breccia is from 20 to 120 ft wide. Rock-chip samples contain 0.09 to 0.14 opt Au and 1 to 5 opt Ag. Chalcedonic veins and pyritic silicification, up to 5 feet wide, contain up to 30 opt Ag and occur in the immediate footwall to the breccia.

UTAH

Summo Minerals continues to work at the Lisbon Valley copper project (San Juan County). A total of 62 new holes were drilled to test a southeast extension of the Centennial deposit. Original drilling in the area encountered a zone that averaged 47 ft grading 0.76% Cu. The most recent holes on average cut 30 ft of mineralization averaging 0.55% Cu. The property is fully permitted, but apparently is not proceeding until funding is in place. How many properties fall in that category?

WASHINGTON

Echo Bay has reported positive results from exploration to the northeast of the K-2 deposit (Ferry County). The indicated resource is approximately 400,000 tons with an average grade of 0.2 opt Au. If a mineable plan can be developed, the deposit would add about one year of life to the operation.

MEXICO

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I have just returned from a hastily called meeting between SEMARNAPE (the environmental protection agency here), the Dirección de Minas, various State of Sonora officials, and a number of mining company managers. The topic was the Apop-Huizache-San Pedro Biosphere Reserve that is about to descend on the heart of the pueblito valley in Sonora. This isn't ecological reserve almost slipped in under the radar but not quite. During the Cardenas presidency in...
of the 1930s, a number of natural reserves were decreed in Mexico, including several in the Sierra Madre del Sur. There has been little activity in these areas due to the high cost of mining and the lack of infrastructure. Nevertheless, the potential for discovering new deposits remains high.

The most recent exploration activities in the region are focused on the discovery of new porphyry copper deposits. The most promising areas are those adjacent to known porphyry systems, such as the Chihuahua and Saltillo regions. These areas are believed to be underlain by a significant copper and gold mineralization.

In Chihuahua, the Summo Minerals project is the most advanced. The company has drilled over 150 holes in the area and has discovered a new porphyry system, the Chihuahua porphyry copper project. The deposit is estimated to contain 1 billion pounds of copper and 1 million ounces of gold. The deposit is located in the heart of the porphyry copper belt, which stretches for over 1,000 miles from Chihuahua to the United States.

Another exploration project in Chihuahua is the San Antonio porphyry copper project, which is owned by the BHP Billiton and the Barrick Gold. The project is located in the San Antonio mining district, which is known for its rich copper and gold deposits. The deposit is estimated to contain 3 billion pounds of copper and 1 billion ounces of gold. The deposit is located in the heart of the porphyry copper belt, which stretches for over 1,000 miles from Chihuahua to the United States.

In the state of Durango, the most notable exploration project is the Cerreto porphyry copper project. The deposit is estimated to contain 2 billion pounds of copper and 1 billion ounces of gold. The deposit is located in the heart of the porphyry copper belt, which stretches for over 1,000 miles from Chihuahua to the United States.

In the state of Zacatecas, the most notable exploration project is the Ormoc porphyry copper project. The deposit is estimated to contain 1 billion pounds of copper and 1 billion ounces of gold. The deposit is located in the heart of the porphyry copper belt, which stretches for over 1,000 miles from Chihuahua to the United States.

In conclusion, the exploration activities in the state of Chihuahua are focused on the discovery of new porphyry copper deposits. The most promising areas are those adjacent to known porphyry systems, such as the Chihuahua and Saltillo regions. These areas are believed to be underlain by a significant copper and gold mineralization. The most advanced exploration project is the Summo Minerals project, which is located in the heart of the porphyry copper belt, which stretches for over 1,000 miles from Chihuahua to the United States.
Candidates for SEG Fellowship:

To All Fellows:

Pursuant to Article I, Section 2, of the Society’s Bylaws, names of the following candidates, who have been recommended for Fellowship by the Admissions Committee, are submitted for your consideration. Each applicant’s name and current position are followed by the names of the three SEG sponsors. If you have any comments, favorable or unfavorable, on any candidate, you should send them, in writing before December 15, 2000. If no objections are received by that date, these candidates will be presented to Council for approval.

Address Comments To:

Chair, SEG Admissions Committee
SOCIETY OF ECONOMIC GEOLOGISTS

7811 Shaffer Parkway • Littleton, CO 80127 • USA

Bogdanov, Kamen B., Geological Survey of Bulgaria, Sofia, Bulgaria: Jeffrey W. Hedlenquist, Christoph A. Heinrich, Antonio Arribus.

Crowe, Douglas E., University of Georgia, Athens, GA: Giles O. Allard, James A. Whitney, Bruce A. Bouley.


Schlather, Denis M., Creo Development Corporation, Hoekv, Norway: Henrik Seland, John L. Pederson, John S. Petersen.


Strathmiron, Strasiltin B., University of Mining and Geology, Sofia, Bulgaria: Jeffrey W. Hedlenquist, Christoph A. Heinrich, Antonio Arribus.

Trejo de la Cruz, Pantaleon, Industrias Peñoles SA de CV, Torreon, Mexico: Tawn Albinson, David A. Gies, Victor De la Garza Negredo.

Wilson, Allan J., University of Tasmania, Hobart, TAS, Australia: Richard H. Sillitoe, Richard A. Jenkins, William X. Chavez, Jr.

The Society also welcomes the above candidates as new members.

The Society Welcomes the Following NEW SEG Fellows:

Biswajit Mishra, Indian Institute of Technology Kharagpur, West Bengal, India

The Society Welcomes the Following NEW SEG Members:

Mireya Y. Anaya, Geological Consultant, Ica, Peru: Carlos A. Angeles, Geological Consultant, Lima, Peru; Kevin M. Ansdel, University of Saskatchewan, Saskatoon, SK, Canada; Luis A. Aurazo, Minera Aurora, Rancas SA, Lima, Peru; Jorge A. Barreda, Minera Yanacocha SRL, Lima, Peru; Hector Barrionuevo-Tolentino, Gia. de Minas Buenaventura SAA, Lima, Peru; Cecilio C. Bautista, Placer Dome Exploration, Laguna, Philippines; Julio A. Bedoya, Empresa Minera Yanacocha SRL, Lima, Peru; Robert C. Bell, Inco Technical Services Limited, Mississauga, ON, Canada; Enrique R. Bernuy-Navarro, Panacon Exploration del Peru, Lima, Peru; Frank P. Bierlein, Monash University, Melbourne, VIC, Australia; Hugh A. Bresser, Billiton Exploration Australia Pty Ltd, Melbourne, VIC, Australia; Juan V. Calzada-Yafra, Minera Shika SAC, Arequipa, Peru; Lucio E. Canchis, Corporacion Minera El Boral SAC, Lima, Peru; Humberto Candelero, Universidad Nacional de La Pampa, Santa Rosa, Argentina; Jose L. Cardone, Minera Yanacocha SRL, Lima, Peru; Miguel Cordova, North Limited, Lima, Peru; Victor S. Carotto, Universidad San Antonio Abad, Cusco, Peru; Graham R. Carr, CSIRO, North Ryde, NSW, Australia; Raoul Carreno, Escuela Politecnica Federal de Lausanne-Switser, Casns, Peru; Emilio Castilho, Gia. Minera Comestable SAC, Lima, Peru; Juan I. Chacon, Geological Consultant, Punta, Peru; Shaun C. Chanter, Namyst Mining, Ltd., East Fremantle, WA, Australia; Cristiana L. Ciobanu, Geological Survey of Norway, Trondheim, Norway; Secondo P. Colque, UNSA, Arequipa, Peru; Carlos R. Conde, Empresa Administradora Chuquicamata SAC, Lima, Peru; Jaime F. Condor, P. L. Guatemalan Estado, Lima, Peru; Andres E. Condor, Gia. de Minas Buenaventura SAC, Lima, Peru; Tierry Jernest C. Corbina, Baguac Corporation, Bagac City, Philippines; Susan J. Daly, Office of Minerals and Energy Resources, Adelaide, Australia; Anibal Davanzo, Geo-Informacion, Santiago, Chile; Jorge T. David-Alvarez, Minera La Aurora Retamas SAC, Lima, Peru; Pablo P. De La Cruz, Empresa Minera Yanacocha SAC, Lima, Peru; Joel Diaz, SGS del Peru SAC, Callao, Peru; E. Jose Diaz-Torres, Ministerio de Mineria SAC, Lima, Peru; Ademir R. Durand, Geological Consultant, Lima, Peru; Baltazar R. Elipane, Delton Pacific Resources Inc, Manila, Philippines; Herbert Escobar, Minera AIA Exploration SAC, Lima, Peru; Lazaro Estacio, Gia. Minera Caraveli, Lima, Peru; Maximo S. Estay, Anglo American Exploration (Philippines) Inc, Baguio City, Philippines; Timothy A. Fletcher, Business News Americas, Santiago, Chile; Martin A. Flores-Zuniga, Gia. Minera de Cusco, Lima, Peru; Malcolm D. Forbes, Minera Geologicas de Asia, Bangkok, Thailand; Pedro M. Galgutti Espinoza, Geoexplor Ingenieros SAC, Lima, Peru; Fereydoun Ghaeban, Tehran University, Tehran, Iran; Sally Goodman, McGill University, Montreal, QC, Canada; Geoffrey K. Green, Mineral Resources Tasmania, Rosny Park, TAS, Australia; Raul Guerra, Minera AIA Exploration SAC, Lima, Peru; Teresa Guerra, DIB, Timber, Callao, Peru; Juan L. Gutierrez-Villalobos, Outokumpu Minera Escondida SAC, Bujama, Peru; Pedro A. Hernandez-Ibaga, Volcan Gia. Minera SAC, Lima, Peru; Albert H. Hofstra, U.S. Geological Survey, Denver, CO; Jorge Iniguez-Espinosa, Gia. de Minas Buenaventura SAC, Lima, Peru; Brando L. Ito Espinoza, Geomin SAC, Lima, Peru; Miguel A. Jimenez, Minera San Facundo SAC, Lima, Peru; Dougall A. Johnston, JEO, Townsvill, QLD, Australia; Paul J. Johnstone, Tekn Ausra Minerals, Perth, WA, Australia; Clark Jorgensen, Big Sky Geophysics, Bozeman, MT; Kevin W. Kunkel, Newmont Mining Corporation, Winnemucca, NV; Nestor R. Landco, Geological Consultant, Lima, Peru; Rolando Lizardo, Pasminco Exploration, Lima, Peru; Ian F. Mackenzie, Trifox Resources Limited, Condobolin, NSW, Australia; Samuel A. Madrid, Gia. Minera Milpo SAC, Lima, Peru; Everett F. Makela, Inco Technical Services Limited, Copper Cliff, ON, Canada; Mirmam I. Mamani, Cusco, Peru; Maria Del Carmen Manrique, Buenaventura Ingenieros SAC, Lima, Peru; Esteban Manrique, North Company Minera SAC, Lima, Peru; Ever J. Martinez, Newmont Peru SAC, Lima, Peru; Julio C. Martinez, Pan American Silver Peru SAC, Lima, Peru; William E. Matthews, M. Hochschild Y G. Ares, Lima, Peru; Julio C. Men, Southern Peru Copper Corp, Lima, Peru; Brian H. Meyer, Geological Consultant, Burnaby, BC, Canada; Paola M. Meza Mendez, Cusco, Peru; Ivan Monteagudo, Sociedad Minera El Boral SAC, Lima, Peru; Juan M. Mora, Doe Run Peru SAC, Lima, Peru; Wolfgang E. Morich, North Company Minera SAC, Lima, Peru; Reginald R. Muskett, Geological Institute, VAF, Fairbanks, AK; Leon Z.
Hungary: Thomas Monecke, Technische Universität Bergakademie Freiberg, Freiberg, Germany; Keri H. Moore, Colorado School of Mines, Golden, CO; Jorg Neff, TU Bergakademie Freiberg, Freiberg, Germany; Michael R. Priestley, University of Tasmania, Hobart, Tasmania, Australia; Stephan G. Redak, Colorado School of Mines, Boulder, CO; Baniulal Sadanandan, Shizuoka University, Shizuoka, Japan; Ahmet K. Sener, University of Western Australia, Nedlands, WA, Australia; Zambang T. Sediwili, Australian National University, Canberra, ACT, Australia; Elizabeth V. Stratton, Queen's University, Kingston, ON, Canada; Koushang G. Sunner, TU Bergakademie Freiberg, Schleussisch-Dreieichen, Germany; Jason W. Sutter, Arizona State University, Tempe, AZ; Monica Turk, Queen's University, Kingston, ON, Canada; Peter J. van der Burgh, University of Western Australia, Nedlands, WA, Australia; E. Wayan Warmada, Technische Universität Clausthal, Clausthal-Zellerfeld, Germany; Camille A. Warren, Colorado State University, Fort Collins, CO; Kelly K. Webb, Southern Illinois University, Carbondale, IL.
ANNOUNCEMENTS

1st Announcement

Structural Controls on Ore Genesis

A joint SEG-PDAC short course to be held on Saturday, March 10 through Tuesday, March 13, 2001 in Toronto, Canada. The course will be given prior to the PDAC convention, March 11-14, 2001. Organizers: Richard Tosdal and Jeremy Richards

Topics and Speakers

- Principles of structural control on permeability and fluid flow in hydrothermal systems—Cox, Knackstedt and Braun (Australian National University)
- The role of rock rheological heterogeneity in fluid flow and ore genesis, with examples and numerical models from the Mt Isa District—Oliver, Ord, and Upton (James Cook University (CSIRO))
- Seismogeomorphic framework for hydrothermal transport and ore deposition—Sibson (University of Otago)
- Structural controls on veining in gold deposits in greenstone belts—Robert (Barrick) and Paulsen (Geological Survey of Canada)
- Magmatic and structural controls on the development of porphyry Cu-Mo-Au deposits—Tosdal (MDRI, University of British Columbia) and Richards (University of Alberta)
- Utility of magnetic and gravity data in evaluating regional controls on mineralization: Examples from the western USA—Hildrethbrand, Berger, Jachens, and Ludington (U.S. Geological Survey)

Registration Information

EARLY registration (prior to February 1, 2001): CDN$375—Members of SEG or PDAC; CDN$500—Nonmembers. LATE registration (subsequent to February 1, 2001): CDN$575—Members of SEG or PDAC; CDN$675—Nonmembers. For STUDENTS, a discounted registration rate is currently under review. Registration includes copies of Reviews Volume 14, lunch on Saturday, and coffee breaks. Details on how to register will be published in the January issue of the SEG Newsletter and posted on both www.segweb.org and www.pdac.ca.

SEG-SME Annual Meeting in Denver, Colorado

"2001—A Mining Odyssey"

February 26–28, 2000

Technical Sessions

- Applied Mineralogy in Mining and Exploration
- Applied Structural Geology in Mining and Exploration
- Geology of Recent Major Copper and Zinc Discoveries
- Geology of Recent Major Precious Metal Discoveries
- Professional Survival in the Exploration and Mining Business

For information

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Several interactive forms are now on the SEG web page; they are: "Change of Address" and "SEG Publications Order Form." These forms can be filled out right on the screen and will generate an e-mail report to the intended recipient. As always, your comments and suggestions are welcomed.

Member Website Information Update

Current contact information for all members is now listed in the Directory section on our website at www.segweb.org. Frequently members will update their mailing address but not phone, fax and e-mail information. We would encourage all members to check their current listing on the web and contact us with updated information at <membership@segweb.org>. 
2000 Northwest Mining Association Convention
December 4–8, 2000

SEG will sponsor a session on "New International Ore Deposits" at the 2000 NWMAA convention in Spokane, Washington, December 4–8, 2000. The session will be chaired by Greg Hahn (SEG 1986), in the absence of Murray Hitzman (SEG 1978), the original session chair, who will be traveling in Australia on a research grant. Five papers will be presented at the session: The Ken Snyder (Midias) High-Grade Gold Mine, Nevada (Franco-Nevada); The Batu Hijau Copper-Gold Porphyry, Indonesia (Newmont); The Nayan Zinc-Lead-Silver Deposit, Ireland (Outokumpu); A Copper Porphyry System in Mongolia (Dennis Cox and BHP); and (tentative) The Veladero Gold Deposit, Argentina (Homestake). Greg Hahn, who is the president and CEO of Sumco Minerals Corp., is the overall chairman for the convention.

A number of other sessions will be of interest to SEG members:

- Zn-Pb-Ag deposits of the Northwest, including the new discovery (Kanarrav) at Red Dog, Alaska and the Methow deposit, Washington (Jeff Clark, Chair)
- Pb-Zn deposits; Paul Ruhn, Chair
- New developments in Mexico; Peter Megaw, Chair
- New international developments; Greg Fernet, Chair
- Case histories in Geophysics; Dutch Van Haricom, Chair

Sessions on underground and open pit mining, mine closure and successful reclamation case histories, and metallurgy will also be presented.

Short Courses include: Metallurgy for Geologists, Engineers, and Bankers; Cash Flow Models, What They Mean and What To Do With Them; and a field course: Geology and Gold Deposits of the Republic Trough, which will be lead by Eric Cheney (SEG 1973) and Mike Rasmussen.

Editor's note: As the last of the operating mines in the district will be closing, this may be a final opportunity to visit and review the geological details of these mines and the region.

For more details on the NWMA program, visit <NWMA.org>, or contact Greg Hahn at Tel. +363.365.8925, or e-mail <ghahn@sumco.md.com>.

WEB Stable Isotope Fractionation Calendar

Georges Beaudoin and Pierre Therrien of the Département de Géologie et de Génie Géologique, Université Laval, Quebec have developed a website compilation of more than 150 fractionation equations between isotopic species of hydrogen, carbon, oxygen and sulfur. The compilation is regularly updated to account for new data or to correct errors. For further information, contact Georges Beaudoin or Pierre Therrien at the address above or e-mail <beaudoin@jgd.ulaval.ca>.
**Career-Related Changes**

- **Hugo Dummett** (SEG 1974) has been appointed Chief Executive Officer and Co-Chairman of African Minerals, a privately held affiliate of Ivanhoe Capital. He was formerly Group General Manager/Sr. Vice President—Minerals Discovery for BHP Minerals and will initially oversee the launch of exploration work at African Minerals' Platreef project in South Africa.
- **Thomas C. Patton** (SEG 1982) has been appointed to the Board of Directors of Calais Resources. He previously served as President and Chief Operating Officer of Western Copper Holdings, and prior to that was Managing Director—South American Exploration for Rio Tinto Mining and Exploration.
- **Jonathan G. Standing** (SEG 1996) is now working as a structural geology consultant. He was formerly employed by Resolute Limited, which eliminated its entire exploration department earlier this year. He can be contacted at Fluid Focus, 23 Milson Street, South Perth, WA 6151, Australia; Tel/Fax +61 8 9474 5855; e-mail <jstanding@ozemail.com.au> or <fluidfocus@hotmail.com>.
- **Dana C. Willis** (SEG 1985) has been promoted to Senior Geologist with Exponent Failure Analysis Associates, and has recently transferred to Exponent's Bellevue, WA office, where he consults on mining, geology, and construction-related issues. He can be contacted at Exponent, 15375 SE 30th Pl., Suite 250, Bellevue, WA 98007, Tel. +1 425.519.8781, Fax +1 425.654.9827, e-mail <dwillis@exponent.com>.

**Awards & Accomplishments**

- **Damien Gaboury** (SEG 2000) has been awarded the Canadian Institute of Mining and Metallurgy’s first prize for his Ph.D. thesis and has been appointed Research Geologist for CONSOREM, a newly formed Québec-based consortium dealing with applied research for mineral exploration.
- **John S. Livermore** (SEG 1993), has been elected to National Mining Hall of Fame and will receive the honor at the 13th Annual Induction Banquet, October 8, 2000, in Las Vegas, Nevada. He was an exploration geologist for Newman, and provided the drive that led to the 1961 discovery of the Carlin mine, and subsequently played an "energizing role" in exploration that established northern Nevada as one of the world’s premier gold districts. Shortly after the Carlin discovery, he became head of Newman’s exploration in Canada and remained there until his retirement in 1970. He then returned to Nevada and, with Peter Gallo, formed Cordex Exploration. Prospecting work carried out under Livermore’s direction led to the discovery of the Pinson, Preble, Sterling and Dee mines, and to the development of the Getchell Trend, second only to the Carlin Trend in Nevada gold production.
- **Douglas B. Silver** (SEG 1983) has been named a 2000–2001 Henry Krumb lecturer for the Society of Mining Engineers. He holds an MS degree in economic geology from the University of Arizona and has worked as an exploration geologist for The Anaconda Company, Normandy, and Bond International Gold, where he also...
served as Director of Investor Relations. For over 15 years, his private company, Ballour Holdings, has advised major international mining companies, banks, investors and small private and public companies on appraisals, acquisitions, divestures and corporate strategy. His lecture, We Would Sell Our Company for $100 per Ounce, We Think — will examine valuation issues and factors that influence the fair-market value of gold deposits.

Thomas A. Steven (SEG 1955, SF), U.S. Geological Survey (retired), has been awarded the 7th Annual Dibblee Medal for excellence in field geology and geologic mapping. The medal is named for Tom Dibblee, a renowned California field geologist, now 88, and is awarded by the Dibblee Geological Foundation. During a 42-year career with the Survey, Steven authored over 170 scientific and technical publications, and achieved recognition as a leading authority on geologic mapping, complex volcano structures, genesis of ore deposits, and landscape evolution. With other specialists, he established the first detailed history of the evolution of the rocks of the San Juan (Colorado) volcanic field and their role in the formation of associated mineral deposits. He was an active partner in the team that developed a modern understanding of calderas. His contributions to that effort were based on careful field observations and interpretation of the rocks.

DEATHS

Victor Popov, a recognized expert in Russian metallurgy, died on February 13, 2000, in St. Petersburg, Russia. He was a leading research fellow at the All-Russian Research Institute of Geology, and a full member of the Russian Academy of Natural Sciences and of the International Academy of Mineral Resources. He was one of the leading experts in the study of ore deposits of the Altai-Kyrgyz and Karcha-Kolo regions of Russia, and also actively participated in the work of the International Association for the Genesis of Ore Deposits (IAGOD). He held the position of Chairman of the Committee for Tectonic-Sedimentary Ore Formation of the Ore Genesis Council at the Russian Academy of Sciences, and is the author or co-author of over 500 scientific and technical articles, including geological and mineralogical maps of several regions of Russia and the former USSR.

Hal T. Morris (SEG 1962, SF) died on October 17, 1999 in Mentor Park, California, of cancer. A geologist with the U.S. Geological Survey, his career spanned nearly 42 years from 1947 to 1986. Early in his career, he initiated — with Tom Loring — some pioneering applications of geochemistry, structural geology and hydrothermal alteration to focus the attention of private industry on hidden base- and precious-mineralized rock in the East Tninc mining district in Utah. Those studies resulted in the discovery and development, in 1963, of the Bingham copper mine, with total resources of lead, zinc, silver, and molybdenum estimated at more than one billion dollars. He served a number of administrative tours in Washington, D.C., and from 1968 to 1999, was Chief of the Branch of Base and Ferronous Metals. In 1976, he received the Meritorious Service Award of the Department of the Interior.

George F. Warnock (SEG 1972), a resident of Creede, Colorado, died on April 7, 1999, of natural causes. He earned BS and MSE degrees from the University of Arizona in 1958 and 1963, respectively, and spent much of his early career working as a consulting geologist at international locations for the W.R. Grace Company of New York and for other mining companies. In the 1970s, he relocated to New Mexico to start his own business, became involved in uranium exploration and mining, and eventually formed Todd-Exploration and Development Corporation, which operated profitable open pit and underground mines near Grants, New Mexico. His retirement years were spent at his home in Creede.

Publications of Interest

Patricia Sheahan \ Konsult International, Inc. 44 Gemini Road, Willowdale, Ontario, Canada M2K 2G6 Tel: +1.416.223.7750 \ Fax: +1.416.223.4229

World distribution of nickel deposits. G. R. Eckstrand and D.J. Good. Geological Survey Canada Open File 3791a, b, report & 3 disks $C53.82; map 1:35,000,000 C$19.50 plus P & H; email: gsc_bookstore@gsc.NRCan.gc.ca. Accept VISA.

Broken rocks breccia 1. R. Taylor, Ore Textues vol. 4, EGRU James Cook University, email: lucy.Chapman@jcu.edu.au. A$38.50 plus P & H. Accept VISA.

Fe oxide Cu Au deposits: A discussion of critical issues and current developments. M.D. Roberts and M.C. Fairclough. EGRU # 58 Extended Symposium Abstracts, March 2000; EGRU James Cook University; email: lucy.chapman@jcu.edu.au. A$55.00 plus P & H. Accept VISA.
MEMBERSHIP APPLICATION

Membership in the Society is open to all geoscience graduates holding the bachelor's degree. Student Members must be full-time students. Annual dues are US$55 for Members and US$10.00 for Student Members. Subscriptions to Economic Geology, the quarterly SEG Newsletter, and SEG Membership Directory are included in the membership. Application may be made by completing this form and submitting it with the appropriate sponsor signature to Society of Economic Geologists, Inc., 7811 Shaffer Parkway, Littleton, CO 80127, USA, phone: 720-981-7882; fax 720-981-7874; e-mail: seg@segweb.org

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UNIVERSITY AND LOCATION  YEARS (FROM TO)  MAJOR  DEGREE  YEAR GRANTED

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## Special Publications

| SPEC. PUB. 7: | Geology and Ore Deposits of the Central Andes: Brian J. Skirrow, Editor. 1999, 303p. | | $US38 |

## PUBCO Monograph Series


**ECONOMIC GEOLOGY MONOGRAPH 10:** The Giant Kild Creek Volcanogenic Massive Sulfide Deposit, Western Abitibi Subprovince, Canada: Marc D. Hamilton & C. Tucker Barrie, Editors. 1998, 675p. 32 colored figures, hard bound, $US60. Shipping outside the US please include $US7 per copy all countries except Canada. For Canada, $US15 per copy.

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Mar. 11–14, 2001 International Prospectors & Developers Association of Canada (PDAC) Convention, Toronto, Ontario, Canada. Contact: PDAC, 34 King Street East, Suite 903, Toronto, Ontario, Canada M5C 2W8. Tel.: +1-416-382-1600. e-mail: info@pdac.ca.


May 2–4, XIV European Current Research on Fluid Inclusions (ECORF) Meeting, Porto, Portugal. For information contact ECORF website: www.fc.up.pt/gcg/ECORF

May 9–12, 47th Annual Institute on Lake Superior Geology, Madison, Wisconsin. Contact: 47th Annual Institute on Lake Superior Geology c/o Wisconsin Geological and Natural History Survey, 3177 Mineral Point Road, Madison, Wisconsin 53705, USA. Preliminary information, including invitation to submit abstracts for consideration, proposed field excursions including images of some locations to be visited, and outline of special symposia may be found at http://www.lgri.org/2001lgi.html

May 17–19, New Developments in Metasomatized Hydrothermal Systems, Townsville, Queensland, Australia. Organized by EQM and the X3I SEG Student Chapter. Contact Lucy Chapman, Economic Geology Research Unit, School of Earth Sciences, James Cook University, Townsville, QLD 4811, Australia. Tel.: +61-7-4781-4726. Fax: +61-7-4725-1500. e-mail: lucy.chapman@csu.uq.edu.au

May 23–27, 37th Forum on the Geology of Industrial Minerals 2001, Victoria, B.C., Canada. Information on the technical program, contact: George Smirniotis, B.C. Geological Survey, Tel.: 250-652-0413. Fax: 250-652-0381. e-mail: george.smirniotis@gov.bc.ca. For information on registration: contact: Susan Currie, ECOG, University of Victoria, Tel.: 250-472-4347. Fax: 250-472-4190. e-mail: carl@ubc.cc


Aug. 19–24, Garden Conference on “Inorganic Geochemistry,” Proctor Academy, New Hartford, New York. The theme will be the formation, modification, and preservation of ore deposits, with a focus on prechondritic processes related to tectonic, climatic, and sulfuric factors. For more information contact: Jeff Hodenquist, e-mail: jhodenquist@proctor.org

Aug. 26–29, 6th Biennial Meeting of the Society for the Application of Geology to Ore Deposits (SAGA), Krakow, Poland. First circular available at website: http://geology.uci.edu/saga

Aug. 31–Sept. 12, Fluid Escursion to the St. Lawrence Seaway, East Greenland. Sponsored by the Cambrian College of Mines, SEG Project 472, and SAGA. Contact: Dr. Jens C. Andersen, Cambrian College of Mines, University of Exeter, Redruth, Cornwall, United Kingdom. Tel.: +44-1209-714666 Fax: +44-1209-714977. e-mail: andersen@ex.ac.uk. website: www.epx.ac.uk/SEG4 confess.htm

OTHER EVENTS

Jan. 21–22, 2001, Volcanic Processes and Products Important to Ore Formations, Vancouver, British Columbia, Canada. Short course sponsored by the Mineral Deposit Research Unit held in conjunction with the Cordilleran Roundup. Contact: Dick Torday, MINEQUEST, University of British Columbia, 633 Stares, Vancouver, B.C. V6T 124. Tel.: +604-822-5149 Fax: 604-822-5088. e-mail: mdr@web.ubc.ca.

Jan. 23–28, 18th Annual Cordilleran Exploration Roundup, Vancouver, B.C., Canada. Contact: B.C. and Yukon Chamber of Mines, 840 West Hastings Street, Vancouver, B.C. V6C 1B9. Tel.: +604-681-3522. e-mail: chamber@chamberofmines.bc.ca website: www.chamberofmines.bc.ca

Feb. 16–18, Geostatistical Mineral Exploration Workshop, Windham, Maine. Also included a Copper Hydrometallurgy (sockets) workshop. Sponsored by the Geological Society of Harford County. Contact: Nick Stevens, Rockwater Consulting, 10 Evergreen Lane, Glen Allen, Virginia, 23060, Cape Town, South Africa. Tel.: +27-21-794-4483 Fax: +27-21-794-7841. e-mail: nstein10@web.co.za

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