Geologic Setting and Mineralogy of the Cu-Ag-(As) Rosario Vein System, Collahuasi District, Chile

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The purpose of this paper is to describe the geological and structural setting of the Rosario vein system and the mineralogy, paragenesis, and ore geochemistry of the veins, and to comment on the relationship between vein and disseminated mineralization in the Collahuasi district. The Collahuasi district is located 180 km southeast of the port city of Iquique in the First Region of northern Chile (Figure 2, page 5) along a N-S linear belt of major porphyry Cu-(Mo) deposits, which stretches from El Teniente, near Santiago, north into Peru. Mean elevation of the Collahuasi district is 4600 m in a region of rolling to steep topography in the high Andes, adjacent to the Bolivian border.

The Collahuasi District contains at least three, world-class porphyry Cu-(Mo) deposits (Quebrada Blanca, Rosario, and Ujina; Figure 1), associated Cu-Ag-(As-Au) vein systems, exotic copper mineralization, and placer gold (Figure 2). The three porphyry Cu-(Mo) deposits occur in an E-W trending group of separate and distinct hydrothermal systems, closely related spatially, but separated by unaltered and unmineralized rocks. The separate nature of the three systems can be clearly recognized by enhanced satellite imagery, and geophysical (Induced Polarization) methods (Dick et al., 1993).

The Quebrada Blanca deposit, discovered in the 1970s (Hunt, et al., 1983) is entering production, while the Rosario and Ujina supergene-enriched porphyry deposits are in the final feasibility stage of project development. Recent exploration adjacent to Cu-Ag veins led to the discovery of the much larger porphyry deposits. The Rosario porphyry system occurs at a higher elevation and exhibits much shallower erosional levels than the adjacent Quebrada Blanca and Ujina.

FIGURE 1 • Schematic vertical cross-section of the Collahuasi District, Region I, northern Chile. No vertical exaggeration. Quebrada Blanca (Q.B.)
From The Editor

This season finds many SEG members, at least in the northern hemisphere, busy in the field. As a result, several regular contributors have been unable to submit articles. (I hope that this signals a prosperous time for SEG members.) Fear not! We have a lot of interesting and important information for you in this issue. You may notice the emphasis on SEG’s increasingly international character. We also have a number of announcements related to SEG business, in which we would appreciate your participation. The many activities and calls for nominations are part of how this society remains vibrant and reflective of its membership.

Do you ever wonder how you can become involved in SEG, and meet more of your professional colleagues? Consider volunteering for committee work. Think about becoming a regular contributor to the SEG Newsletter. (Having your name appear in a publication that reaches more than 3000 members in more than 50 countries never hurts.) We have regular articles by four officers of SEG or SEGf, several regional editors, and regional vice presidents, as well as the environmental and publications of interest columns. Would you be interested in assisting with production of the SEG Newsletter?

There are other ways to contribute to the profession, by helping to distribute educational materials about mining (e.g. from MII, described in this issue), or by working with the GEM committee of SMF (if you are also a member in that organization). In the U.S., we are facing the threat of major cuts or dismantling of the U.S. Geological Survey’s Office on Mineral Resources and the U.S. Bureau of Mines. (See Letter to the Editor.) Letters to governmental representatives may help to convince the powers-that-be that these groups provide important services to a vital part of our economy.

Wherever you live or work, I urge you to become involved with your profession and local community, to help your colleagues remain informed and to educate your community about how vital mining is to society. Learn about how companies are working to mine with more respect for environmental concerns, and tell others about that, as well. It is never too late to inform the public about the importance of mining to each member of the world community.

NOTE: Deadline for receipt of materials for issue #20 is FRIDAY, DECEMBER 2.

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- Do you need Membership/Fellowship Application Forms?
- Do you have questions regarding SEG committee activities and/or procedures?
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INFORMATION FOR CONTRIBUTORS

The SEG Newsletter is published for the benefit of the worldwide membership of the Society of Economic Geologists. We invite news items and short articles on topics of potential interest to the membership. Exploration news should be directed to the appropriate Regional Editor. The FORUM is for commentary and exchange of ideas on matters of concern to economic geologists; however, please note that discussion of articles in Economic Geology should be directed to that journal, not to this Newsletter. If you have questions on submittal of material, please contact the Editor at 303-988-1124 or FAX details at 303-988-1124.

Format: Manuscripts should be double-spaced, if possible, please submit paper copy and a computer diskette in DOS formats, using WORD or WordPerfect. Pertinent illustrations will be accepted in camera-ready form at publication scale. Authors are asked to obtain peer review of manuscripts to assure clarity and accuracy. All contributions may be edited for clarity or brevity.

Advertising: Paid advertising is solicited to help offset publication and mailing costs; for rates, contact the Executive Secretary. Employment opportunities for economic geologists will be advertised free of charge.

DEADLINE FOR NEWSLETTER #20: Dec. 2, 1994
From the Executive Secretary

This past summer (in the northern hemisphere), SEG added a significant milestone to its history with the merging of the Treasurer's office (formerly located in DeKalb, Illinois) with the Executive Secretary's office to establish an SEG head office in Littleton, Colorado. It goes without saying that the Society lost considerable experience and expertise with the closing of the DeKalb office (GSA's gain). Following a brief transition period and a move in early September across the hall to quarters large enough to accommodate the combined offices, the staff is now functioning as a unit. Tom Loucks, the new Treasurer serving SEG, PUCBO and SEG, has quickly become familiar with his duties. Working with Tom is Ms. Helen Rice Cannon, a bookkeeper-accountant, who already has a remarkable grasp on the operations and interrelationships of the three entities. Tom and Helen expect to have up-to-date financial summaries for 1994 and budget projections for 1995 in time for the SEG, PUCBO and Foundation business meetings at Seattle in October.

In addition to the established functions of the Executive Secretary and the Treasurer, the office is responsible for marketing and sales of SEG publications, including Guidebooks and Special Publications, advertising sales for, and distribution of, the SEG Newsletter, and planning and coordinating arrangements for Exhibit Booths at the GSA and SME annual meetings and for other meetings in which SEG participates. The Exhibit Booths serve as an SEG focal point and a center for SEG's membership recruiting activities which have produced outstanding results over the past few years—thanks to the efforts of the Membership and Admissions Committees and their respective former chairmen, "the Bruces" Bouley and Johnson. Sales of SEG publications, both direct and through Exhibit Booths, and sales of Newsletter advertising are producing significant revenue streams for SEG. Nonetheless, the primary objective of the consolidated office is to provide the best possible service to all SEG members and to do it cost-effectively. To this end, a computerized, comprehensive membership data base has been established. Keeping track of our members is a never-ending task, particularly when exploration geologists are literally working and moving around the world. Additionally, requests for information on Society activities, membership, and Newsletter and Economic Geology subscriptions, as well as orders for publications are a daily occurrence. The SEG office is here to serve you, so please phone, fax or mail in your comments, concerns and suggestions. Although the SEG office has moved, the telephone and fax numbers, and address remain the same.

Society of Economic Geologists Joins Sponsors of Second South Asia Geological Congress

The Society of Economic Geologists has been designated one of the Joint Sponsors of the Second South Asia Geological Congress (GEOSAS-II) to be held in Colombo, Sri Lanka on January 19-24, 1995. The first of the South Asia Congresses, held in Islamabad, Pakistan in February 1992, brought together geologists from throughout the world, with most attendees from India, Pakistan, Bangladesh, Nepal, Bhutan, Sri Lanka, and the Maldives.

The objective of GEOSAS-II is to provide exchanges of geoscientific concepts regarding improved utilization of mineral resources, descriptions of mineral and hydrocarbon exploration activities, and general information regarding mineral commodity supplies in the South Asia region. The Congress program consists of technical sessions, seminars, post displays, and seven geologic field excursions.

Sponsorship of the Congress includes financial support provided by the Society of Economic Geologists Foundation. SEG members are encouraged to attend this unique opportunity to gain background data on the South Asia region. Additional information may be obtained from:

Dr. P. G. Cooray
426, Mahakantha Road
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CONTENTS

Co-Ag-(As) Rosario Vein System, Colleheesi District, Chile.................. 1
Editor.................................. 2
Executive Secretary.................... 3
Presidential Perspective.............. 4
SEG Foundation........................ 4
Economic Geology & The Environment... 5
SEG News................................ 13-27
SEG-MBE, Musch 6-8, Denver......... 13
Letter to the Editor..................... 14
Credit to Ulrich Peterson............... 14
SEG & MBI: A Symbiotic Assoc........ 16
Calls for Nominations............... 16
Calls for Committee Volunteers...... 17
In the Spotlight (photos)........... 18
Thayer Lindsay Lectures.............. 18
In the Spotlight (photos)........... 18
MEMBERSHIP APPLICATION......... 19
PUBLICATIONS ORDER FORM...... 20
Int'l Exchange Lecture Tour........ 21
C. T. Fogarty Professorship........ 27
Exploration Review................... 28
Cotidian's Corner....................... 34
Publications of Interest............ 35
SEG Candidates / Members.......... 35
Personal Notes & News.............. 35
Calendar............................... 36
Presidential Perspective

In the previous issue of the SEG Newsletter (July, 1994), John Thoms, our Executive Secretary, referred to the increasingly international character of the Society. For a North American-based professional organization to become truly international requires much more effort than, say, a European-based organization. As John pointed out, however, we have moved, within the past ten years, from 85-90% North American membership to a position closer to 70%. This is a trend of which SEG officers are, and indeed, all members should be, proud and excited.

But internationalism is much more than simply seeing unfamiliar stamps on postal correspondence—SEG is actively engaged in several, sometimes virtually simultaneous, activities around the globe. For example, SEG is participating, in various ways, in the following events: i) 5th IAGOD Symposium, Beijing (Aug. 1994); ii) Chilean Geological Congress (Oct. 1994); iii) Geological Society of South Africa Centennial (Feb. 1995); iv) International Field Conference on Carbonate-Hosted Lead-Zinc Deposits (Ireland, U.S.A., Australia; May-June 1995); v) SGA Biennial meeting in Prague (Aug. 1995); vi) Tectonics and Metallurgy of Early to Middle Proterozoic Orogenic Belts: An International Conference, Montreal (Aug/Sept 1995). Thus, within a 12-month period, our Society will be actively engaged in activities in all six SEG regions (North America, South America, Europe, Africa, Oceania, and Asia). Additionally, SEG is considering a proposal for a 1997 field conference in Lisbon on the subject of deposits of the Iberian Pyrite Belt of Spain and Portugal. Several of the events described here were not the result of suggestions or recommendations by SEG standing committees of executive officers, but were proposals submitted by individual SEG members. Spontaneous actions such as these are welcomed and encouraged because they are signs of an interested, vigorous membership and a healthy Society. These activities put forward “from the floor” are in addition to our usual participation in North American conferences and annual meetings such as GSA, SME, N.W. Mining Association, etc. All of these are carried out through the auspices of volunteer efforts by SEG members and, to a gratifyingly high level, non-members as well.

Finally, returning to the subject of membership, to further augment the “off-shore” North American component of SEG, a Presidentially-appointed ad hoc committee has been working out the details of a Membership Subsidy Fund (MSF). Purpose of this fund is to elicit membership in those countries where circumstances effectively preclude qualified geologists from joining the Society. Watch future issues of the Newsletter for further details of this imaginative program.

SEG Foundation

The Hickok-Radford Memorial Fund—A Continuing Remembrance

In November 1992, a tragic avalanche accident in the Chugach Mountains near Anchorage took the lives of exploration geologists Bruce Hickok and Geoff Radford. Both long-time Alaska residents, Bruce and Geoff were known in the exploration industry for their ability to conduct quality field work under difficult conditions in remote settings. Their mutual love of the outdoors bonded a personal friendship that included skiing and endurance runs in the mountains near their homes in Anchorage. Because of Bruce and Geoff’s appreciation of life and all that it has to offer, family and friends decided to establish a fund to maintain a living memory of them. The basic purpose of the Fund is “to encourage young scientists to pursue field research and internship to private industry through investigations which will advance the science of economic geology and, in particular, the application of science in the exploration for metallic mineral deposits.”

In the April 1994 issue of the SEG Newsletter, Foundation President Ernie Ohle announced an agreement between the Bruce D. Hickok - Geoffrey W. Radford Memorial Fund and the Society of Economic Geologists Foundation which establishes the Foundation as the Fund manager responsible for the awarding of monies generated by the Fund principal. Administration is under the direction of the Foundation’s Special Grants Committee composed of Society of Economic Geologists members, including two members designated by founders of the Hickok-Radford Fund.

The Fund presently contains approximately $26,500 invested in stocks and bonds to generate an income from which awards will be made. A minimum award of $2,000 will be given from accumulated income monies beginning in 1995. Notices soliciting award applications will be published once this level of interest money is available. A brochure providing details regarding the Fund and award application procedures is available from:

Ernest L. Ohle, Chairman
Foundation Special Grants Committee
8989 E. Escalante, #120
Tucson, AZ 85730 Telephone: (602) 886-3834

Individuals wishing to contribute to the Fund or to apply for future award grants are encouraged to contact the Special Grants Committee.
The Employability of the Economic Geologist as a Mineral-Environmental Geologist

by Geoff Plumlee (SEG 1990)

In a past column (April, 1993), I put forward the premise that, in response to increased global demands for environmentally-friendly mineral resource development, the successful economic geologist of the future will likely also have to be part environmental scientist (a mineral-environmental geologist, if you will). Since that column was written, I have talked with a number of economic geologists who have made or are trying to make the transition into environmentally-oriented careers. This diverse group of geologists includes consultants and current and former exploration or mining geologists. In addition, I have talked to professors who are trying to find environmental employment for their economic geology graduate students. The success of those trying to make the shift from economic geologist to mineral-environmental geologist has been quite variable. In this column, I would like to offer some perceptions about environmental employment issues in general, and how economic geologists might be better able to prepare themselves for a competitive environmental market. I stress that these perceptions are based on a relatively limited sampling of the environmental community. I would love to hear from more readers who have traveled this road, and what your experiences have been on the way.

Those Who Have Made the Mineral-Environmental Transition Successfully

IN THE MINING INDUSTRY: There is a significant and growing number of economic geologists who started their careers as mining or exploration geologists, but have since been tapped by their employers to handle a wide variety of environmental duties (such as permitting, developing environmental remediation plans, presenting mining and remediation plans to a skeptical public, etc.). These pioneer mineral-environmental geologists in many cases had fairly limited or no training in pertinent environmental disciplines such as hydrology, aqueous geochemistry, and the like, but picked up the necessary training on the fly and under fire. Those who made the transition more easily had at least some training in aqueous geochemistry (via ore genesis research or exploration geochemistry) and/or hydrology. One might expect that the greatest proportion of geologists who are tapped for environmental duties would occur in smaller mining companies lacking the resources to employ a large environmental staff; however, I know of several former mining or exploration geologists who are working on environmental matters for major mining companies.

IN THE ENVIRONMENTAL INDUSTRY: My limited survey of mineral-environmental geologists hired by environmental consulting firms indicates that most of the geologists had fairly extensive prior education or work experience in environmental geochemistry and/or hydrology prior to getting their jobs. There are some currently employed who had no formal environmental geochemistry training but did have extensive backgrounds in hydrothermal geochemistry and/or exploration geochemistry. There are also some currently employed who have strong geostatistical backgrounds (after all, statistics is the name of the game in environmental sampling). In general, it seems that classical economic geologists with limited training in hydrology or geochemistry are having a tough time finding employment with environmental consulting firms. In part, this may reflect that most companies have not been adequately sold on the crucial role of geology in predicting, mitigating, and remediating mineral-environmental problems. It may also reflect that many of the smaller environmental firms lack the resources to have a specialized economic geologist on staff, rather, they can only afford to hire scientists with multi-disciplinary backgrounds. I know of a few economic geology consultants who have been able to get contract work for environmental firms, but full-time environmental work for these consultants seems hard to come by.

Improving Employability of the Economic Geologist as a Mineral-Environmental Geologist

SCHOOLING: The bottom line is that, in order to make the successful transition to mineral-environmental geologist, the economic geologist must most likely have expanded his or her educational background to include one or more disciplines such as environmental geochemistry, hydrology, microbiology, chemical engineering, or geostatistics. In addition, coursework in organic chemistry will likely prove highly useful to many environmental companies that do a bigger business in remediating organic contaminant problems than...
mining-related problems. Lacking the opportunity to go back to school for a degree in one of these disciplines, an economic geologist can get a broader environmental background through individual study, reading, and/or attending short courses presented on mineral-environmental issues. However, formal schoolwork is always easier to sell to a prospective employer than a course of self study.

WORK EXPERIENCE: There is no substitute for actual work experience. For example, sampling waters for metal contaminants is much more complicated that merely dipping a bottle in the water. Careful scientific thought, planning, execution, and interpretation are critical if the data collected are going to be interpretable. Thus, carrying out such a sampling program is always more informative than merely studying about it. A few suggestions on getting work experience: 1) Propose geology-oriented environmental studies that could be done on mine sites in collaboration with the mining companies' environmental engineers (this would be especially useful for mining geologists to try); 2) Propose and/or get involved as a geologic expert in multi-disciplinary studies with industry, universities, government agencies, and national laboratories, some of whom may (or may not!) be able to help obtain support for the studies; 3) Become a volunteer for university- or government-sponsored environmental studies; a lack of money earned now may be a small investment in experience that could yield major returns in future employment opportunities.

SELLING: It is clear that we as economic and mineral-environmental geologists have to do a better job of selling the importance of geology to those who predict, remediate, and regulate the environmental effects of mining. The more studies that are published demonstrating the usefulness of geology, the easier the sell will be. I thus encourage all of the pioneer mineral-environmental geologists out there to disseminate results of their studies as rapidly as possible. For those who are job-hunting, be savvy enough about geology's role in the environment that you can quickly recognize how your knowledge could be used by your prospective employer.

Acknowledgments

I gratefully acknowledge the large number of geologists, consultants, and industry representatives who have talked with me over the past year on this subject. Of these, special thanks go to Lisa Kirk, Steve Atkin, Stan Flagel, Dale Andersen, and Mark Stevens for particularly thought-provoking discussions.
HISTORY OF VEIN MINING AND EXPLORATION IN THE COLLAHUASI DISTRICT

Historical mining was restricted to Cu-rich vein systems peripheral to and within the Rosario porphyry Cu-(Mo) deposit. The Poderosa and La Grande veins were exploited between the late 1800s and the mid-1930s by English and French mining companies. The Montecuzuma Ag vein system is localized along a 7 km structural feature on the western edge of the Rosario hydrothermal system (Figure 3). It has never been mined because of high Mn content and associated refractory metallurgical problems.

The earliest known exploitation of copper at Collahuasi was by the Incas. Ruins of a crude copper smelting facility, and copper jewelry discovered in Inca ruins near Ujina, probably represent the earliest extraction of copper ore from the exposed veins, most likely the Poderosa or La Grande vein systems.

Significant mining of copper veins did not begin until 1896. Underground mines were developed on the La Grande and Poderosa vein systems. The average grades of hand-sorted ore extracted from the 1- to 5-meter wide, steeply-dipping, bornite-rich veins, were reported to have been 23% to 32% Cu. Between 1900 and 1930, the copper-bearing vein mines at Collahuasi represented the third most important copper producer in Chile (after Chuquicamata and El Teniente). Available records indicate that approximately 300,000 tons of ore, with an ore grade of approximately 30% Cu, were extracted from the two principal vein mines. Silver was an important byproduct, averaging approximately 200 grams per tonne. The mines closed in the 1930s and no further vein production has taken place.

Almost no data regarding mineralogy, morphology, or structural features of these historically mined veins were recorded. However, at La Grande, accessible upper levels expose large pods of bornite-rich ores surrounded by oxidized zones containing the copper arsenate chenervixite (Cu2Fe2(AsO4)2(OH)2·12H2O), probably derived from enargite. Recognition of the potential economic importance of both porphyry-type mineralization and vein occurrences caused renewed interest in the Collahuasi area in the 1970s.

Discovery of the Quebrada Blanca deposit and identification of the main components of the adjacent Rosario hydrothermal system resulted from surface mapping and drilling from 1976 to the mid-1980s. The major vein systems at Rosario are contained within an area of hydrothermal alteration over 5 km in diameter. This exploration, led by John Hunt and his colleagues on behalf of The Superior Oil Company, outlined alteration and mineralization indicative of a porphyry copper system along strike and northwest of the Poderosa vein. With subsequent drilling, they discovered additional high-grade vein-hosted mineralization (the Rosario vein system) and confirmed that the Rosario vein system was hosted by a significant porphyry copper deposit, now called the Rosario porphyry deposit. Further exploration during the mid- to late-1980s by the Collahuasi Joint Venture (Falconbridge, Chevron, and Shell) focused on the economic potential of the bornite-rich Rosario vein system as a candidate for a moderate-size, high-grade underground mine. In 1990, the exploration focus changed to quantifying the overall economic potential of the Rosario disseminated copper deposit along with concurrent exploration of the entire Joint Venture land holdings east towards the Bolivian border. Ujina, the most easterly of the porphyry deposits identified thus far, was discovered beneath post-mineralization ignimbrite cover in 1991 (Dick et al., 1993).

During exploration drilling of the Rosario vein system, an exploratory shaft and associated developments at the 4350 m level, provided information on the vein system and the enclosing disseminated copper orebody to a depth of over 600 meters.

Deep drilling in the La Grande vein system, 3 km south of Rosario, reveals enargite-rich veins with well-developed advanced argillic alteration envelopes near surface changing progressively to more bornite-rich enargite-poor ore assemblages with quartz-sericite alteration envelopes at depth. The La Grande vein system is exposed at 5,000 m elevation and is auriferous in its upper part. Disseminated, porphyry-style mineralization occurs adjacent to the deep, bornite-rich, non-auroiferous part of the system. This deep alteration and mineralization includes white phyllosilicate and quartz replacement of intermediate to felsic rocks. It contains disseminated and fracture-controlled pyrite + chalcopyrite (py + cp) mineralization, similar to porphyry-style, dissemination mineralization at Rosario. Exploration ceased at La Grande when high-grade pegmatite enrichment was discovered at Ujina (Dick et al., 1993).

ENVIRONMENTAL GEOCHEMISTRY OF SULFIDE MINE-WASTES

Short Course handbook, Vol. 22, published in 1994 by the Mineralogical Association of Canada: 13 chapters, 436 pp. (1) Physical hydrology of tailings impoundments; (2) Modelling of tailings impoundments; (3) Mineralogy of sulfide-rich tailings and their oxidation products; (4) Mineralogy of ochre deposits formed by sulfide oxidation; (5) The waste-rock environment; (6) Iron-sulfide oxidation mechanisms: laboratory studies; (7) The nature and role of microorganisms in the tailings environment; (8) Sulfide oxidation mechanisms: controls and rates of oxygen transport; (9) Secondary minerals and acid mine-water chemistry; (10) Acid-neutralization mechanisms; (11) Geochemistry of cyanide in tailings; (12) Geochemistry of the Kidd Creek tailings, Timmins, Ont.; (13) Remediation and prevention of low-quality drainage from tailings impoundments.

PRICE: $38 U.S. or CAD, includes postage and handling; GST exempt. Order from MINEROGICAL ASSOC. CANADA, CITYVIEW 78327, NEPEAN, ONTARIO K2G 5W2, CANADA. Please include payment and return address with your order.
The Collahuasi district is structurally complex on both regional and local scales. The stratigraphy in the district is characterized by a variably-dipping assemblage of Permo-Triassic rhyolites, andesites, andesitic sediments, and minor carbonates, highly complicated by faults subparallel to the bounding regional faults. The district lies within an upthrown block of Permo-Triassic rocks faulted against Jurassic deep-water marine sedimentary rocks on the west by the West Fissure fault (Figure 4). This regional structure, which passes through the open pit at Chuquicamata, 180 km to the south, can be followed on satellite imagery north to the Peruvian border. The eastern limit of the Collahuasi District, 20 km east of the West Fissure fault, is defined by another major structural feature, locally referred to as the Loa fault. This structure is traced by the Rio Loa, and is a splay from the West Fissure fault north of Chuquicamata. The Loa fault (Figures 1, 3, and 4) puts Permo-Triassic basement against Tertiary volcanic terrain. A recently discovered mineralized zone, deeply buried beneath young ignimbrite cover east of Ujina is characterized by phyllic alteration of porphyritic intrusive rocks, and appears to have been cut by the Loa structure. This apparently deeply-eroded Cu-Mo system is referred to as the La Profunda mineralized zone.

The major hydrothermal systems at Collahuasi are aligned roughly E-W, orthogonal to the horst-bounding West Fissure and Loa structures. However, major controls on both vein and porphry mineralization are NW- and NE-trending structures conjugate to these major faults (Dick and Ossandón, 1994).

The most significant structural features at Rosario are the NW-trending Jack and Rosario faults. The Rosario fault is the principal control on the Rosario veins. Figures 5 and 6 show the highly-generalized structural geology of the Rosario hydrothermal system (simplified after Munchmeyer, et al., 1984). The Rosario fault transects the Rosario porphyry deposit, and can be shown not only to have been an important control on vein emplacement, but also to have been important throughout the geological history of the Rosario hydrothermal system. The fault appears to have significantly influenced emplacement of the mineralizing porphyritic intrusion, the Rosario porphyry, and provided a channelway for hypogene fluid flow as well. Copper ore grades of disseminated, porphyry-related sulfides decrease systematically away from the Rosario fault. Later, the fault controlled vein emplacement, and later yet, provided access for supergene enrichment to depths of hundreds of meters below surface (Dick and Ossandón, 1992).

A representative NE-SW cross section through Rosario (Figure 6) illustrates the main stratigraphic and structural characteristics of the deposit and highlights the relationship of the Rosario veins to the Rosario porphyry system. Closest to surface, the stratigraphy consists of a NE-dipping assemblage of rhyolites, andesites and volcanic sediments. Intrusive rocks predominate at depth. Three intrusive bodies are recognized: the Ines and Collahuasi dacite porphyries, and the younger (32 Ma) Rosario porphyry, also of dacitic composition. The Rosario porphyry is thought to have been both disseminated and vein mineralization.

The NW-trending Rosario fault system represents the lowestmost of a series of parallel, imbricate, normal and reverse faults. The most significant is the Jack fault, a major, low-angle normal fault with km-scale displacement. The hangingwall consists of propylitically-altered, non-mineralized lithologic units, and the footwall consists of quartz-sericite-altered rocks containing ore-grade copper mineralization (Figure 6). This indicates significant structural displacement after hypogene mineralization at Rosario. The complete lack of veins within the Jack fault and hangingwall rocks also suggests that significant movement on the fault is younger than vein emplacement.

The principal ore structure in the Rosario area, the Rosario I vein, ranges in width from a few meters to locally 15 meters and dips SW at 50 degrees. Many other, smaller veins have similar mineral assemblages and structural orientations. The topographically lower portions of the Rosario I vein are composed of a copper-poor quartz + pyrite assemblage, and are highly-brecciated. The upper portions, approaching the hangingwall, contain economically-important bornite and chalcopyrite. Width and grade are crudely correlated, and the thickest portions are richest in bornite. The pinch-and-swallow nature of the Rosario veins, and the intense faulting on the hangingwall suggest reverse movement during vein emplacement.

**MINERALOGY OF THE ROSARIO VEINS**

Petrography of Rosario veins provides detail on vein-related alteration, mineral paragenesis, and ore mineral zoning. Although the vein system contains numerous mineralized structures, our study indicates that similar alteration assemblages and ore mineral paragenesis characterize all Rosario veins. This similarity suggests that these structures represent hydrothermal mineralization which followed
disseminated, porphyry-style pyrite +chalcopyrite +/- bornite mineralization. Vein mineralogy is shown in Table 1 for veins of the Collahuasi District, and vein paragenesis for Rosario assemblages is given in Table 2.

The earliest mineralization in the Rosario veins consists of white phyllosilicate, quartz, and rutile adjacent to the vein footwall. Some of the quartz in this assemblage is euhedral, suggesting open-space growth. Vein widths vary from cm-scale to several meters, and phyllic alteration envelopes range up to several meters wide adjacent to vein-wallrock contacts. Pyrite associated with this early phyllic assemblage represents the initial sulfide development in the Rosario veins.

Minor copper sulfides occur as micron-scale inclusions in pyrite. Bornite, digenite, chalcoite, covellite and covellite-like phases, chalcopyrite, enargite, tetramorphite, mawsonite (Cu$_{2+y}$S$_{3+y}$Sn$_{y}$Te$_{y}$, where 0.5<x<1.0), and stannite (Cu$_2$SnS$_4$) occur in early pyrite. This pyrite-associated mineralization constitutes the early copper mineralizing event in Rosario veins and is similar to disseminated and veinlet-controlled pyrite-chalcopyrite mineralization of the Rosario porphyry system.

Breciation followed pyrite deposition, although paragenetic relationships are ambiguous, and it is not clear whether this brecciation took place prior to, or after, development of initial chalcopyrite mineralization. In any case, intense fracturing of pyrite, and possibly chalcopyrite, was associated with minor quartz deposition. This brecciation-mineralization may have been related to boiling in the Rosario hydrothermal system, as suggested by the occurrence of fluid inclusions with variable liquid-vapor ratios.

The first significant phase of copper mineralization is chalcopyrite. Pyrite is crosscut and replaced with chalcopyrite mineralization varying from incipient to essentially complete replacement. In some vein intervals, chalcopyrite comprises more than 50% of total vein sulfides.

The assemblage py + cp + quartz + white phyllosilicate + rutile was followed by high-grade, bornite-chalcoite mineralization. This phyllic assemblage is also early with respect to the historically important enargite-bornite-chalcoite mineralization in the genetically-related, higher-elevation, epithermal veins of the La Grande system (Dick et al., in prep). This early phyllic alteration includes both within-vein replacement of brecciated wallrock fragments and cm- to m-scale envelopes adjacent to vein margins.

Molybdenite is associated with the pyrite + phyllic mineral assemblage, probably as a paragenetically early (pre-chalcopyrite?) mineral. Although no molybdenite + quartz structures are noted from this early, phyllic alteration, observations from phyllic veinlet assemblages in the Rosario
porphyry system suggest molybdenite constitutes a pre-pyrite, deep-seated mineralizing event.

Chalcopyrite deposition was followed by a complex paragenesis of copper-rich mineralization. Bornite replaced pyrite and chalcopyrite, and apparently was deposited along with minor quantities of other sulfides, including mawsonite, tennantite, and enargite. Some vein intervals do not show bornite formation, but instead contain an arsenic-bearing, copper-rich assemblage associated with quartz-phyllosilicate-kalinite alteration (see below). No distinctive wallrock alteration is apparently related to this copper-rich assemblage. Replacement of bornite by chalcocite, digenite, covellite, and/or chalcopyrite appears to have involved continued introduction of copper, along with Ag and Sn. Minor enargite occurs with bornite and is replaced by chalcocite and tennantite.

Iron released as a result of bornite replacement produced chalcopyrite as sub-mm scale blades intergrown with digenite or chalcocite. Hematite associated with bornite replacement, as specular hematite, is scant. Latest hypogene copper mineralization consisted of covellite and covellite-like phases as replacement of other copper sulfides, especially chalcocite and digenite.

High-grade bornite- and chalcocite-rich segments of the Rosario veins occur adjacent to the hangingwall-vein contact, and apparently constitute a distinct post-brecciation, post-phyllitic mineralization event.

Supergene replacement and enrichment of hypogene sulfides shows a similar but spatially distinct paragenesis related to elevation and pre-enrichment vein mineralogy. Weathering-derived digenite, chalcocite, and minor covellite occur within 200 meters of the present surface.

ORE GEOCHEMISTRY

Paragenetic relationships of sulfide and silicate assemblages reveal elements of the ore-forming environment of the Rosario vein system. Early vein-forming phyllic assemblages, developed adjacent to vein footwalls, are mineralogically similar to hydrothermal disseminated and veinlet-controlled sulfide mineralization of the Rosario porphyry system. Pyrite associated with Rosario veins contains a complex suite of Cu, As, and Sn sulfides and sulfosalts. Phosphory-styline, pyrite sulfides in Rosario porphyries contain the same sulfide assemblage, suggesting that early Rosario vein assemblages are genetically related to phyllic alteration and mineralization in porphyritic rocks. Wallrock alteration adjacent to Rosario veins show phyllic (phyllosilicate + rutile + py) development at cm- to m-scales, and are interpreted to represent larger-scale, structurally-controlled H+ metasomatism related to late hydrothermal alteration.

Chalcopyrite followed tectonic brecciation of phyllic alteration and associated mineralization and comprised the initial major copper mineralization in Rosario veins. Chalcopyrite replaced pyrite, indicating that copper activity was sufficient to render pyrite unstable, yet iron activity must have remained great enough to preclude bornite formation. Minor tennantite is the only other sulfide interpreted to be cogenetic with chalcopyrite.

High-grade bornite represents the most significant introduction of copper, arsenic, and tin into Rosario veins. Bornite replaces chalcopyrite in footwall mineralization and is an important mineral in structurally distinct hangingwall mineralization. Because bornite and later digenite + chalcocite + covellite mineralization constitute structurally separate mineral assemblages from paragenetically earlier py + cp, it is concluded that copper was introduced in significant amounts during bornite genesis, with subsequent and apparently gradational copper addition represented by successive digenite and chalcocite development. Minor tennantite and/or enargite accompanied bornite, with traces of mawsonite and stannite. Thus, arsenic activity was apparently low during significant copper introduction into the Rosario veins. However, the La Grande vein system (Figure 3) contains abundant bornite + enargite + chalcocite mineralization, suggesting that arsenic activity relative to that of copper increased upward in the Rosario-La Grande vein system. Minor covellite and chalcopyrite, associated with digenite and chalcocite, are interpreted to be alteration products associated with hypogene replacement of bornite.

Specific silver minerals have not been observed in Rosario veins. Electron microprobe and scanning electron microscope analyses of hypogene digenite, chalcocite, and covellite indicate that silver occurs in solid solution.

Supergene copper addition to py + cp + from porphyry has produced copper grades in excess of 1.5 wt-% Cu in some enrichment zones. Supergene processes include local copper leaching and enrichment and resulted in replacement of pyrite, chalcopyrite, and bornite by digenite, chalcocite, and covellite. Vertical zoning of supergene sulfides is digenite-chalcocite overlying weakly-developed covellite. Digenite is replaced by chalcocite in hypogene assemblages. Oxide mineralization includes cuprite, chrysocolla, and brochantite, as well as native copper, and appears to represent in situ oxidation of sulfide minerals without significant addition of copper. Oxidized veins show replacement of sulfides in the sequence: pyrite—chalco-
cuprite—chrysocolla, suggesting that supergene copper enrichment was followed by oxidation under near-neutral pH conditions.

Copper enrichment of early pyrite-blendrite assemblages by bornite-chalcopyrite-covellite implies significant increases in $a_{\text{Cu}}/a_{\text{Fe}}^+$ and $a_{\text{Cu}}/a_{\text{Fe}}$ with time. This high-grade copper mineralization shows no evidence of having been generated by supergene processes, albeit ore mineral paragenesis mimics that observed from the zone of supergene copper enrichment; the bornite + digenite + chalcocite + covellite assemblage occurs at depths significantly below rock volumes which show evidence of weathering-induced oxidation and leaching. As such, the high-metal-to-sulfur ratio mineral assemblage is interpreted as the result of hypogene enrichment of vein-hosted pyrite-chalcopyrite protore, with only minor supergene copper addition. Rosario veins are minerallogically similar to economically important vein systems at Butte, Montana (Brinshall, 1979), Superior, Arizona (Gustafson, 1981; Hamer and Peterson, 1986), and Coquequirac, Peru (Chavez, 1984), and apparently represent Cu-Ag-As mixture entrapment following development of disseminated and vein-controlled, porphyry-related mineralization.

**ACKNOWLEDGMENTS**

The pioneering geological work during the 1970s and 1980s of John Hunt, Carlos Munchmeyer, Juan Carlos Marquardt, Jack Phillips, and many others in the Collahuasi district provided the foundation for further exploration and discoveries. The dedicated work of the entire present Collahuasi geological and technical staff is gratefully acknowledged. Particular thanks to Louis De Beer, Cebo Carvajal, Erika Segueth, and Gabriela Cabezas.

Editor’s Note: Two SEG members reviewed this paper, in the absence of the editor (who was out of town), John Wilson spent much time on this paper and deserves credit for his contributions to the final form of the manuscript.

**REFERENCES**


The 17th International Geochemical Exploration Symposium is to be held in Townsville, Queensland, Australia, from 15 to 19 May 1995, coinciding with the 25th Anniversary of the AEG. The symposium will cover advances in the latest geochemical exploration, analytical and computer interpretation techniques. Emphasis will be on gold and base metals, with advances in environmental geochemistry being an important aspect of the symposium.

CALL FOR PAPERS
The 17th Symposium Committee invites you to submit papers for presentation in the technical sessions, or for inclusion in the poster sessions. Oral presentations and posters are considered to be of equal merit, and the poster sessions will be major contributors to scientific communication at the symposium. Both the technical and the poster sessions will focus on the main themes of the symposium. We are therefore inviting papers covering topics pertinent to the symposium themes, but papers on any subject relevant to geochemical exploration are welcomed.

Abstracts submitted in any written form will be accepted for oral presentations or posters. All accepted abstracts will be published in the symposium proceedings.

For guidelines for preparing abstracts contact the Publications Co-ordinator, 17th IGES
Department of Earth Sciences,
James Cook University of North Queensland
Townsville, Q 4811, Australia
Tel: +61 77 81-4900 or +61 77 81-4776
Fax: +61 77 81-5522
Email: iges@jcu.edu.au

FIELD EXCURSIONS & SHORT COURSES
A number of pre- and post-symposium excursions have been organised to various parts of Australia, including the Yilgarn Craton, W.A., gold and base metal deposits, Queensland, and the Mt Isa Inlier, Queensland. Excursions to precious metal deposits in PNG & Indonesia have also been organised.

Several pre- & post-symposium short courses have also been planned. These include:
- Lithochemical Exploration using Pearce Element Ratio Diagrams
- Applied Biogeochemistry in Mineral Exploration and Environmental Studies
- Progress and Pitfalls in Analytical Geochemistry
- Regolith Mapping for Mineral Exploration
- Ore Fluids, Alteration and Geochemical Signatures
- Supergene Ore Deposit Geochemistry

REGISTRATION
Symposium registration fee, as before, $250.00.
AEG/IGEM Members $20.00
Non-members $50.00
Student Concession Rate $20.00
Prices include morning and afternoon tea, lunches, and dinner on Monday and social function. Address all registration inquiries to the Conference Secretary, 17th IGES, c/o Economic Geology Research Unit, Department of Earth Sciences, James Cook University of North Queensland, Townsville, Q 4811, Australia
Tel: +61 77 81-4776 or +617 81-4726
Fax: +61 77 81-5522
Email: iges@jcu.edu.au
Short Courses for the 1995 SME Annual Meeting

Gary B. Siddar (SEG 1981), Society Short Course Committee

The SEG Short Course Committee is sponsoring three courses before and after the 1995 SME Annual Meeting in Denver on March 6-9, 1995. These courses will focus on the geology, geochemistry, and geophysics of mineral deposits and on the integration of field methods and technology in mineral exploration. Two of the courses are repeats of popular, successful courses taught at the SEG '93 Conference in Denver. A fourth course, sponsored by SME, *Ore Reserve Estimates in the Real World*, is also a repeat of a course first presented at SEG '93.

- **GEOLOGY I** — 9:00 a.m. (SEG)
  Precambrian Gold Deposits, Geology and Exploration
  Chair: Craig Ford, Lac Minerals

- **GEOLOGY II** — 8:30 a.m. (SME)
  Integration of Geology in Exploration and Operations—Porphyry Deposits
  Chair: Robert North, Phelps Dodge
  Moreno, Inc., Moreno, AZ

- **SEG LUNCHEON, BUSINESS MEETING AND AWARDS PRESENTATIONS**
  11:30 a.m. – 2:00 p.m.

- **GEOLOGY III** — 2:00 p.m. (SME)
  Integration of Geology in Exploration and Operations—Epithermal Deposits
  Chair: Carl Nelson, Boulder, CO

- **GEOLOGY IV** — 9:00 a.m. (SEG)
  Diamond Deposits, Geology in Exploration and Development
  Chair: Hugo Dummett, BHP Minerals

- **GEOLOGY V** — 9:00 a.m. (SEG)
  The Role of Geology in Advanced Evaluations and Acquisitions
  Chair: Max Baker, Newcrest Mining Ltd.

- **PANEL DISCUSSION: Ore Reserves**
  Chair: Don Ranta, Echo Bay

- **GEOLOGY VI** — 2:00 p.m. (SME)
  New Developments in Economic Geology
  Chair: Art Panaccio, Crusan & Panace, Golden, CO

For registration, call SME at +1-303-973-9550 or write SME, P.O.Box 625002, Littleton, CO 80162-5002.
Notice to SEG Members:

On March 25, 1994 the SEG Student Chapter at the University of Western Ontario held a short course on Current Exploration and Development of Lode Gold Deposits and Andean-Style Porphyries, Central and South America. Written material which accompanied the presentation “Mining Districts of South America, A Summary” by Guillermo Re Kuhl and Robert Horn did not acknowledge that their paper was not their original work but was almost entirely a verbatim copy of portions of three publications by Prof. Ulrich Petersen, Harry C. Dudley Professor of Economic Geology, Harvard University, Cambridge, Massachusetts 02138 USA. The Student Chapter and the Society recognize this lack of acknowledgement as a very serious omission and list below the appropriate references:


Dear Editor:

The Ninth V.E. McKeel Forum on Mineral and Energy Resources organized by the U.S. Geological Survey and held in Tucson, Arizona, February 22-25, 1994 opened with an official welcoming address by Elizabeth Ann Rieke, Assistant Secretary for Water and Science, U.S. Department of the Interior. Much of the speech was a tribute to Vincent E. McKeel as scientist and administrator. It also recognized scientific excellence of the U.S.G.S. and its programs of documenting mineral resources of the U.S. and world.

Ms. Rieke also devoted a significant part of her speech to a critique of the U.S. mining industry. She noted that the mining industry has been economically important in the regions in which it operates, but made no mention of high-paying mining jobs, nor of taxes and grants contributed by companies that provide some of the best schools, health care, cultural, and recreational facilities in the West. She did not acknowledge that industry has spent hundreds of millions of dollars developing and installing new mitigation and remediation technologies to meet environmental regulations. According to Ms. Rieke “the legacy of the U.S. Mining industry is the half million abandoned mine sites that need attention.” She also declared that the Clinton Administration is committed to changing the “archaic” 1872 mining law. Fast forward to June 1994. On TV and in the newspapers, Bruce Babbitt indignantely signs over patented surface rights as required by the courts to protect American Barrick’s billion dollar investment in northern Nevada, saying, “This is the biggest gold heist since the day of Butch Cassidy.”

The Interior Secretary and his deputies must understand that these performances which employ sound bites and misinformation only foster cynicism. Leaders in Washington call for “good science in policy decisions” and urge scientists to become involved in redefining the Nations R & D. Response from the scientific community is less than enthusiastic when these leaders also use intellectually corrupt means to achieve political aims. One aim, of course, is to eliminate mining from public lands in the western U.S. Another aim is to dismantle the U.S. Bureau of Mines and move the U.S. Geological Survey into “politically correct” research. Ms. Rieke’s speech at the McKeel conference was in part prepared by U.S.G.S. management, and its political content is a sign of an increasingly politicized Survey. Further, the Survey’s commitment to politically correct ideas and activities are manifest in the June 1994 “environmental geochemistry” issue of the Survey’s Mineral Resource Newsletter, and in the interview with their new director, Gordon Eaton, published in the July and August 1994 issue of GSA Today.

Most demographic and economic projections indicate that for the next few decades the world’s natural resources will increasingly flow into China and other developing industrial economies. As government policies force the mining industry out of the U.S., this nation will find it difficult to maintain the low cost and reliable sources of raw materials upon which we currently rely. Problems with resource availability are on the horizon. Our vulnerability is illustrated by a recent political incident in Nigeria in which a leading political leader was jailed. Economic analysts suggest that this incident increased U.S. retail gasoline prices by five cents per gallon. A political or military crisis somewhere in the world—in Asia, Africa or mideast—can seriously disrupt supplies of raw materials.

Each of us should take every available opportunity to support those in Congress and the Administration who see wisdom in a balanced program in the Interior Department that, in addition to environmental activities, maintain strong mineral availability programs, mining technology development, and economic geology research. Each of us should make an effort to participate in programs that educate the public about the strong positive impact that mining has made on this country and in the world.

— Richard L. Nielsen, Consulting Geologist
In Toronto in May 1991, the SEG Council adopted a goal to improve earth science and particularly economic geology education. The SEG program to achieve this goal is directed at teachers and students in the K-14 levels (kindergarten through junior college). The objective is to reach as many pupils as possible with the message that mineral resources contribute to our standard of living and that economic geology involves understanding, discovering, producing, conserving, and utilizing mineral resources.

SEG Support for Mineral Information Institute (MII)
The challenge was that SEG had limited resources to achieve this lofty goal. SEG is an international organization of INDIVIDUAL members with interests in the field of economic geology. I've stressed INDIVIDUAL because as individuals it is difficult for any one of us to influence systems as large and as complex as educational systems. Fortunately MII—in existence since 1980—was up and running with its mission focused on educating youth about the importance of mineral and energy resources. In 1991, MII was spending nearly $150,000 per year, had an impressive catalog of products, and an audience in 32 countries. MII was supported then and is supported now by INDIVIDUAL SEG members.

TheSEG Foundation began supporting Global Science in 1988. With the adoption of its educational goals by SEG's Council in 1991, SEG's Foundation increased its interest in, and support of, MII.

Global Science Energy, Resources, Environment
Global Science is a high school science textbook that presents a balanced view of the earth sciences. This project began in the mid-1970s, and has cost $363,000 and more than 4,000 hours of volunteer work. The 3rd edition of Global Science has been used in 49 states in America and in English-speaking schools in Australia, Brazil, Canada, Egypt, Finland, Guatemala, Italy, Japan, Malaysia, Marshall Is., Mexico, Pakistan, and Taiwan.

As a major supporter, SEG Foundation has invested $22,500 in the development of the 4th edition of this book since 1990. The 720-page, 4th edition should be available in early 1995. The publisher is already planning the 5th edition which may serve as the core of a new two-year high school environmental science curriculum, with expansion of the biological sciences sections.

MII's Materials Present the Story of Resources Objectively
MII has published and is working to publish more teaching materials and aids. Most of these materials are intentionally not state/province or country-focused. Most materials are usable anywhere where English is spoken.

Materials, such as these, are essential to the achievement of the goal of the SEG education effort.

MII sends its teacher's packet FREE to teachers who request it (11,000 in the past 4 months). Prices to others vary with size of order. Prices shown are for single copies. This year's teacher's packet contains:
(a) At least 4 of the 8 following posters (others available upon request):
- If It Can't Be Grown, It Has To Be Mined. Everything comes from natural resources. $1.50.
- From the Earth...A Better Life. Illustrates land use in the U.S. & Canada. $1.50.
- Switched on Mining (by the Australian Mining Industry Council). Computer, desk, tennis racket, jewelry, etc. $3.00.
- Mining at Play (by the Australian Mining Industry Council). Skateboard, watch, tape recorder, helmet, etc. $3.00.
- Elements Comprising the Human Body. Shows essential trace elements. $1.50.
- Look Around...Everything Is Made From Something. Cut-away views of house, foundation, plumbing, etc. $3.00.
- And while they last: Minerals of the National Forests and From Mountains to Metals. $3.00.
(b) A 48-page Teacher Guide and Student Pages, which contains reprints of 9 lessons from Instructor and Teaching K-8 magazines; and
(c) A 16-page booklet listing other sources for free or nominally priced educational materials. $1.00.

For information please write or call MII, 475 17th Street, Suite 510, Denver, Colorado, USA 80202. Phone (303) 297-3266, Fax (303) 285-6463. To order, please pre-pay.

With your help, MII can do more!
MII needs your help to literally carry these materials to teachers in your local schools. MII needs your help to introduce Global Science to your school boards. MII sells the teacher packets and posters to individuals, companies, and organizations at a price that enables MII to provide these same materials free to teachers.

The Mineral Information Institute is pleased and proud to be associated with and supported by individual members of SEG and by the SEG Foundation. We at MII thank all of you who have helped us.
SEG Officers

The Nominating Committee of SEG solicits nominations for three positions in the Society (for 1996):

- President
- Vice President
- Councillor (three openings)

We are actively seeking candidates from each of academia, government, and industry. Please send the names of candidates to the Chair of the Nominating Committee:

David Beaty, Chevron, P.O.Box 446, LaJabra, CA 90633 (310-694-7653) or email: dbwee@chevron.com. Deadline for nominations is December 15, 1994.

— David Beaty (Chair), Jill Dill Pastiris, Alan Wallace

The 1995 Prestigious Lindgren Award by the Society of Economic Geologists

The Lindgren Award is offered annually to a young geologist whose published research represents an outstanding contribution to economic geology. The Award is not restricted as to the candidate's nationality, place of employment, or membership in the Society. The work for which the Lindgren Award is given must have been published as a single paper or a series of papers in a recognized journal before the author's 35th birthday, and the awardee must be less than 37 years of age on January 1 of the year in which the award is presented. We are currently seeking nominations for the 1995 Award, for which nominees must have been born after January 1, 1958.

The award can be given for contributions to economic geology from any subdiscipline of geology including, among others, structural geology, mineralogy, environmental geology, hydrology, petrology, geochemistry, stratigraphy, geophysics, and mine geology.

——— How to Nominate ————

A brief biographical summary in the style of American Men and Women of Science or other similar biographical listing should be submitted by the person making the nomination to the Chair of the Lindgren Award Committee by November 15, 1994. In addition, please include:

i) a short summary of contributions and pertinence to economic geology that qualifies the candidate for the award,

ii) a selected bibliography with indication of critical papers, and

iii) additional or related accomplishments.

Supporting letters are helpful and may be attached to the letter of nomination or sent separately to the Chair of the Lindgren Award Committee:

Robert W. Hodder, Chair Lindgren Award Committee
Department of Earth Sciences,
The University of Western Ontario
London, Ontario, Canada N6A 5B7

PACRIM '95
19-22 November 1995
Auckland, New Zealand

First announcement and call for papers

PACRIM '95 will examine the geology and ore deposits of the dynamic environment of the Pacific Rim. It will also examine the political, economic and environmental constraints on mining and exploration in this area of increased investment. The Congress will have eight main themes.
1. Metallogeny at plate boundaries
2. Case histories of recent discoveries
3. Mining and the environment
4. Mining geology: problems and solutions
5. Mining and metallurgy
6. Political and economic constraints
7. Structural geology, tectonics, geophysics and geodynamics
8. Petrology, geochemistry and volcanology

Abstracts (no more than 500 words) due by 31 December 1994. Abstracts and papers will be published in a proceedings volume which will be available at the conference. To express interest, and for more information: Mrs. Charmayne Perera, The Australasian Institute of Mining and Metallurgy, P.O. Box 122, Parkville, Victoria 3052, Australia Phone: +61-3-347-3166, Fax: +61-3-347-8525 or E-mail: J.Mauk@Auckland.ac.nz
SEG needs Committee Volunteers

SEG depends on volunteers from its membership to serve on the committees which are the working arms of the Society. Many programs and policies of SEG are conceived by the committees. As service on most of the committees is for a three-year term, there is a continual need to identify Fellows, Members and Student Members willing to contribute to the Society through committee service.

Listed below are committees and brief descriptions of their responsibilities. Please check one or more of the committees on which you would be interested in serving, complete this form (or a copy) and return it to:

Naomi Orneskes, Chair
SEG Committee on Committees
Dept. of Earth Sciences • Dartmouth College
Hanover, New Hampshire 03755

☐ Admissions—Processes applications for membership
☐ Distinguished Lecturer—Recommends lecturers to Council
☐ Finance—Manages the investment portfolios of SEG
☐ International Exchange Lectureship—Reviews and recommends lecturers to Council
☐ Lindgren Award—Recommends a candidate to Council
☐ Medal—Selects candidates for Penrose, SEG, and Marsden awards
☐ Membership—Concerned with improvement of the state of the membership
☐ Mineral Exploration Statistics—Collects, interprets, and publishes data
☐ Publications—Monitors the SEG publication program, policy and practice
☐ Research—Plans symposia and studies research trends
☐ Short Course—Administers short course program
☐ Student Affairs—Responsible for relations between SEG and students
☐ Thayer Lindsay Visiting Lecturer—Recommends two lecturers per year to Council

Please provide your name, address, current telephone and/or FAX number, and a brief statement indicating your background, interests and special qualifications or expertise.

Name ________________________________
Address ________________________________
City __________________ State ______ Zip __________
Phone __________________ FAX __________________

BACKGROUND, INTERESTS, QUALIFICATIONS:

________________________________________________________________________________________

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Thayer Lindsley Lectures Begin in October


- **BRUCE BOULEY** will begin his lecture tour in November 1994. He will present three lectures during the tour: “Metamorphic Core Complexes, Detachment Faults, Extensional Tectonics, and Gold Mineralization—Progression of a Paradigm,” “Shoshonite Lamprophyres and Gold: The Mt. Estelle Connection,” and “Geology and Exploration at the Pebble Copper Porphyry-Copper-Gold Deposit, Alaska.” The following dates are set: Nov 3-4, Bates College; Nov 7-8, University of Toronto; Nov. 9, University of Western Ontario. Tentative dates for 1995 are: Feb. 1, University of Auburn; Feb. 3, New Mexico Tech.; Feb. 6-7, University of Arizona.

Transactions of the Institution of Mining and Metallurgy Section B: Applied earth science

Vol. 103, January–April, 1994

Issue on platinum-group element mineralization

comprising an introduction and ten technical contributions, nine of which were presented at the IAGOD International symposium on mineralization related to mafic and ultramafic rocks held in Orléans, France, 1–3 September, 1993

Scientific editor: D. L. Buchanan

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▲ Mary Davidson (right) and John Wilson (left) look on as Ernie Ohle, Past President, SEG Foundation, standing, presents a gift to Don Davidson for his many years of service as SEG Foundation Treasurer. The gift was an elegant Chinese fluorite bowl. The Davidsons also received a Groenich waterjet aerator from SEGF Secretary, Tom Melrose. The gifts were presented at an SEG Foundation luncheon for Don and Mary Davidson. (Photo by Art Barber, SEGF President.)

▲ Marco Einsaudti (left), SEG International Exchange Lecturer, shakes hands with Shunso Ishihara after Einsaudti’s keynote address at the annual meeting of the Society of Resource Geology, Tokyo, on June 8. See Einsaudti’s article for the full details.
SOCIETY OF ECONOMIC GEOLOGISTS
MEMBERSHIP APPLICATION FORM

Membership in the Society is open to all geoscience graduates holding the bachelor's degree. Student Members must be full-time students. Annual dues for 1995 are US$85 for Members and US$42.50 for Student Members. A one-time application processing fee of US$25 (US$5 for students) is required upon joining. 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 Virginia S. Gillerman, Admissions Secretary, Idaho Geological Survey, MG 229, Boise State University, Boise, ID 83725, USA.

SECTION I (To be completed by the applicant. Please use black ink.)

Surname (Type or Print) First Middle Date of Birth
Company/Institution Address – Street
City State/Province Postal Code Country

EDUCATION: University and Location Years (from - to) Major Degree Year Granted
Undergraduate:
Graduate:

PROFESSIONAL EXPERIENCE: (List in order from most recent at the top.)
From (month/year) To (month/year) Position Employer
PRESENT

Signature Date

NOTE: Please do not include any payment with this application.

SECTION II (To be completed by the sponsor.)

I sponsor the above-named individual for □ Membership, or for □ Student Membership.

Sponsor's Name (Type or Print)

□ Fellow, Society of Economic Geologists, or
□ Head, Earth Science Department

To the best of my knowledge the information provided by the applicant is correct.

Signature of Sponsor

Date Phone Number

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<tr>
<td>Vol. 2</td>
<td>GEOLOGY AND MINERALIZATION OF THE GILMAN-LEAVENWORTH DISTRICT, COLORADO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 3</td>
<td>EPITHERMAL BASE-METAL AND PRECIOUS-METAL SYSTEMS, SOUTHWEST COLORADO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 4</td>
<td>&quot;OLYMPIC DAM-TYPE&quot; DEPOSITS AND GEOLOGY OF MIDDLE PROTEROZOIC AND THE ST. FRANCOIS MOUNTAINS, MISSOURI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 5</td>
<td>MISSISSIPPI VALLEY-TYPE MINERALIZATION OF THE VIBURNUM TRENDS, MISSOURI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 6</td>
<td>MEXICAN SILVER DEPOSITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 7</td>
<td>METALLOGENY OF GOLD IN THE BLACK HILLS, SOUTH DAKOTA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 8</td>
<td>INDUSTRIAL MINERAL RESOURCES OF THE DELTA-WARE BASIN, TEXAS AND NEW MEXICO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 9</td>
<td>GEOLOGY AND GOLD, RARE ELEMENT, AND BASE METAL MINERALIZATION OF THE VAL D'OR AREA, QUEBEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 10</td>
<td>CONTROL ON BASE METAL AND GOLD MINERALIZATIONS, BOUSQUET-ROUYN-NORANDA AREA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 11</td>
<td>ARCHEAN GOLD DEPOSITS OF THE MATAUCHEN-KIRKLAND LAKE-LARDER LAKE AREA, ONTARIO, CANADA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 12</td>
<td>THE DIVERSITY OF MINERAL &amp; ENERGY RESOURCES OF SOUTHERN CALIFORNIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 13</td>
<td>KEWEENAWAN COPPER DEPOSITS OF WESTERN UPPER MICHIGAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 14</td>
<td>ZINC DEPOSITS IN EAST TENNESSEE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 15</td>
<td>ACTIVE AND EXTINCT HYDROTHERMAL SYSTEMS OF THE NORTH ISLAND, NEW ZEALAND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 16</td>
<td>ACTIVE GEOTHERMAL SYSTEMS AND GOLD-MERCURY DEPOSITS IN THE SONOMA-CLEAR LAKE VOLCANIC FIELDS, CALIFORNIA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 17</td>
<td>SELECTED MINERAL DEPOSITS OF VERMONT AND THE ADIRONDACK MOUNTAINS, NEW YORK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vol. 18</td>
<td>GOLD DEPOSITS OF THE CARLIN TREND, NEVADA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Report on
SEG International
Exchange Lecturer Tour:

Japan•Korea•Philippines

June 1994

Marco T. Einaudi (SEG 1976), Stanford University

It didn’t take much arm-twisting by Wally Pratt, John Guiltibert and Jeff Hedenquist to convince me that Asia would be an excellent place to visit on the SEG International Exchange Lecturer tour. We decided to start in southern Japan, hoping to cut-run the rains as we headed north to Hokkaido. It worked. We had sunny weather throughout Japan and into Korea, but I failed to bring the California sun with me to the Philippines.

If I cut-out the rainy season in Japan, I didn’t cut-out Jeff Hedenquist. He was one step ahead the whole way. Between 14 November 1993 and our departure date on 1 June 1994, he organized a trip that would take me to see 7 volcanoes, 3 hot springs, 9 mining districts, 4 universities, and 3 national geological/mines survey offices in three countries in 25 days. Oh, and 11 lectures. In this report on my trip, I record not only the people and places, but also some of the aspects of geology and ore deposits that I found most interesting. I’ve included recent references for those who want to pursue certain topics.

JAPAN

First stop was Kagoshima on the island of Kyushu, Japan. There, I joined a tour of hot springs and epithermal gold deposits led by Professors Eiji Iwada and Koichiro Watanabe of Kyushu University. Kyushu is a dream world of bright green rice paddies and tea farms, pristine calderas, symmetrical cinder cones, isolated country inns nestled around hot springs, and epithermal gold deposits. Still-steaming gold deposits are exposed west of active volcanoes (Iwada, 1992). The Hishikari gold-quartz-achlorite district (Iwada et al., 1990) has 63°C water coursing through its veins. High-temperature hydrothermal activity began at about 1.25 Ma and lasted to 0.66 Ma, synchronous with volcanism (Iwada et al., 1993a). The underground mine has produced 58 metric tons of gold during 1985-1994 and contains a reserve of 4.2 million metric tons (Mmt) of 50 g/t Au (4 g/t Au cut-off). The paleosurface is preserved in lacustrine mudstones containing laminated pyrite-cinnabar-quartz beds with 2 to 4 ppm Au (Iwada et al., 1993b).

Our host at Hishikari was Takashi Kuruiyama of Sumitomo Metal Mining Co. After a presentation on the geology by Kuruiyama, followed by an underground tour, a bath in Hishikari thermal waters, and an excellent lunch, I was beginning to feel pretty good about my lecture tour! Then I gave my first SEG lecture to the Sumitomo mine staff and our field group on Ag:Au ratios in time and space at Bingham.

On June 4, the group visited the Iwato and Akeshi mines in the Nansatsu district (dare I say Goldfield-type quartz-afinite gold deposits?). Our host was Kyoshi Nakamura of Mitsui Kushikino Mining Co. In contrast with Hishikari, which is known for its high gold grade, Nansatsu is best known for its high silica grade (if there were no Cu-smelter demand for silica flux, there would be no Iwato gold mine). The Iwato quartz body, forming a ridge 2 km long, 200-300 m wide, and 100-150 m thick, contains 0.2 to 2 g/t Au throughout. Six km northeast, the Akeshi mine occurs at the north end of a 3 km-long string of silicic hills that stand above a plain of Pleistocene pyroclastics. The Iwato and Akeshi gold deposits are small “plums” within these silicified zones; individual orebodies range from 150 to 40 m in diameter and up to 100 m in vertical extent. At Iwato, the underground operation is finished (6.6 metric tons Au produced 1938-1986; Iwada et al., 1992) and the present open pit yields average grades of 3.5 g/t Au and 5 g/t Ag at a 2 g/t Au cut-off (K. Nakamura, pers. comm., 1994). Cu:Au ratios are about 3:1 to 4:1. At Akeshi, production plus reserves from open pit and underground totals about 1 Mmt at about 10 g/t Au and about 6 g/t Ag (K. Yamanaka, pers. comm., 1994). Cu:Ag weight ratios are approximately 80:1, which probably is more representative than Iwato of primary Cu:Au ratios at Nansatsu, given the greater degree of post-ore sulfide leaching at Iwato (Hedenquist et al., 1994a). At Akeshi, a late steam-heated event and/or surface weathering produced cm-scale oxidative zoning on fractures in vuggy siliceous pyrite rock from (goethite + hematite or totally leached) (covellite) (Native sulfur + original pyrite). I was struck by how massive the Nansatsu silica bodies are (suggesting that abundant new silica was added after the leaching event that produced vuggy quartz) and by the strong evidence for control of gold grades by fractures in massive quartz. See Hedenquist et al. (1994a) for a review of past work, new data, and a summary genetic model.

We spent the night of June 4 at the base of Sakurajima volcano which was erupting ash (according to the Iwada-Hedenquist plan). The next morning, the eruption had ceased, and we drove around the base of Sakurajima, past concrete bunkers (used for bus stops) and elaborate aqueducts (equipped with TV monitors) built to channelize mudflows. A stop
at Kirishima volcano with its summit fumaroles and sulfur deposits presented us with a potential analogue for the paleosurface at Nanatsu 4 m.y. ago (Hedenquist and Aoki, 1991). Then north to Aso caldera for the night. Naka-dake, the youngest of Aso’s volcanoes, gives off mild strombolian eruptions every few years. From its summit the next day (more concrete bunkers), we had a good view of Unzen volcano 60 km to the west, the site of the tragic pyroclastic flow of June 6, 1991. The volcanic hazards of Kyushu are pretty intense, for volcanologists and the public alike.

Next, I traveled to Fukuoka, where I presented a lecture in the Department of Mining at Kyushu University. Professor Iwata translated as I went along, and he appeared to be giving a much more complete lecture than II. After a day in Kyoto, we rode the famous bullet train to Tokyo, where I attended the Annual Meeting of the Society of Resource Geology on June 8 and 9. My keynote lecture on the 8-km vertical cross section through porphyry copper deposits at Yerington, Nevada, was well-received by a standing-room-only crowd. It was good to see some old friends at the meeting, including Hiroshi Ohmoto, Daizo Ishiyama, Shunso Ishihara, and Hideo Shimazaki. On the afternoon of June 9, I was hosted by Professor Sutkine Takenouchi at the offices of the Mining Agency of Japan (MMAJ), where I gave a lecture on high-grade and low-sulfidation ores in porphyry systems to an audience of MMAJ and mining industry geologists. Makoto Ishida and Tomomasa Nakajima presented an overview of MMAJ exploration activities in Japan and abroad, followed by a superb documentary film of the history of discovery (by MMAJ) of the Hishikari mine.

On June 10, we met Shunso Ishihara from the Geological Survey of Japan (GSJ). Shunso had offered to drive us north to Hokkaido, and we jumped at the idea. The GSJ is one of five research institutes of the Agency of Industrial Science and Technology. Twenty-four percent of the GSJ budget in 1993 was directed at research on active geothermal systems (exploration techniques, resource assessment, and basic research). The transfer of knowledge from these areas to ore deposits has been very fruitful (e.g., Hedenquist and Aoki, 1991; Aoki, 1992; Hedenquist et al., 1993; Hedenquist et al., 1994). After a meeting with Hirokazu Hase, Deputy Director General of GSJ, and a brief tour of the extraordinary Geological Museum, we headed for northern Honshu with Ishihara.

We had two stops before arriving at the University of Sapporo: the Osozozan geothermal field of northernmost Honshu and the Toyoa mine on Hokkaido. Osozozan, on the edge of caldera Lake Usori, is a place of extraordinary beauty and sharp contrasts: yellow sulfur, gray and white silica and steam, blood-colored bacteria, orange arsenic sulfide, distant blue lake and green forests. It is sacred ground, a place of the departed souls of children, where grieving families place multi-colored pin-wheels that spin in the wind...

A visit to Osozozan is a visit to an active hydrothermal laboratory (Aoki, 1992) and a marvelous example of superposition through time, and coexistence in space, of contrasting hydrothermal environments (sinter forming on top of earlier advanced argillie alteration; neutral chloride springs flowing within meters of acid sulfate springs).

The next day (June 13) we visited the Toyoa mine, a polymetallic vein deposit hosted by Miocene Green Tuff in southernmost Hokkaido. Total production in the period 1915 to 1990 has been 15 Mmt of ore containing 141 g/t Ag, 2.6% Pb, 7.4% Zn, 0.2 g/t Au, and 150-250 g/t indium (Toyoa Mines, 1990; Yajima et al., 1993). Similar tonnage remains in reserves. Ore is known over a vertical range of 600 m in a complex vein system of 4 km strike length. Zoning is well-developed, from deep central pyrite-chalcopryite-(pyrrhotite, cassetiterite, wolframite, Bi- & In-minerals) to intermediate galena-sphalerite-pyrite-(pyrrhotite, stannite) to peripheral pyrite-calcite-rhodochrosite-(stibnite, jamesonite, argentite) (It. Takeyama, pers. comm., 1994). We visited the recently discovered Shinano vein with Teruo Takeyama, Chief Geologist. Rock temperatures there are 160°C (air T = 47°C) at 450 m below the surface. Drill holes 1.5 km farther southeast have encountered rock temperatures of 305°C.

Is the Toyoa deposit still forming or is a younger and unrelated geothermal system superimposed on it? Twenty-seven K-Ar ages of sericite from the deposit range from 2.9 to 0.5 Ma with no age gaps (Toyoa Mines, 1990), but ages younger than 1.5 Ma are limited to samples taken from areas with highest present-day temperatures (>110°C). Because rock temperatures decline as mining progresses, these samples may have been above 300°C in the recent past, above the Ar-closure temperature of fine-grained sericite. The age of the deposit is important from many perspectives. Continuous high-temperature (300°C) hydrothermal activity since 2.9 Ma is implied by the K-Ar data, but this period is longer than expected for a shallow crustal magma chamber. The deposit, if as young as 0.5 Ma, formed essentially within a few hundred meters of the surface, which may
be difficult to reconcile with what is known of similar deposits in Peru and Bolivia.

After a lunch hosted by Nippon Mining, we headed to Sapporo and the University of Hokkaido, where Dr. Shunso Ishihara is now teaching at Hokkaido, where he is surrounded by a very active group of undergraduate and graduate students. I found that geological discussions and Sapporo beer go very well together. Our trip through northern Honshu to Hokkaido was a highlight of the lecture tour, thanks to the graciousness and hospitality of Ishihara.

KOREA

We flew from Sapporo to Seoul on June 15, where we were met by Professor Chil-Sup So, Director of the Center for Mineral Resources Research (CMR) at Korea University. Through the efforts of Prof. So, CMR has become an important source of funding for geological research conducted in universities throughout Korea. My lectures coincided with the Annual Meeting of CMR and were sponsored by CMR, the Korea Science and Engineering Foundation, and the Society of Economic and Environmental Geology. Although my visit to Korea was brief, and I was unable to visit any mines due to closures, I appreciated the chance to see Korea University, to visit with two Stanford geology graduates (Dr. Moonsoo Cho now at Seoul National University, and Dr. Chang Won Oh now at Chonbuk National University), and to see some sights of historical interest. From Seoul, I flew to the Philippines.

PHILIPPINES

Sunday, June 19, was a free day in Manila, highlighted by a visit with Harvard classmate Ben Austria, Professor at the National Institute of Geological Sciences, University of the Philippines, whom I hadn't seen for 27 years. On Monday, I presented a lecture at the Mines and Geosciences Bureau (MGB) of the Department of Environment and Natural Resources (DENR). My hosts were Joel Muyco, Director of MGB, and Edwin Domingo, Chief of the Land Resources Division of MGB. Muyco and Domingo kindly arranged my visits and lectures at Dizon (Benguet), Santo Tomas II (Phillex), Baguio, and Legaspi-PSE. My guides and hosts on various portions of this trip were Elveta Comst and Florindo Lazo of MGB, Thomas Malihan of Benguet Corp., Reynaldo Estacio of DENR-Cordillera Region, Atina Imai of the University of Tokyo, and our DENR driver, Jimmy Obar. Whether driving through the notorious Manila traffic or on the Mountain Trail in monsoon rains, Obar was expertly at home. I am greatly indebted to these new friends, and especially to Comst and Lazo, for making the Philippine leg of my trip a great success.

The drive from Manila to Dizon gave us a close look at the devastation wrought by the eruption of Pinatubo in 1991. We drove past houses buried to their roof lines in ash, over mud flows and lahars that filled the valley of San Antonio-San Marcelino, and past the new Mapahuepe lake (ex-river) that backed up to Dizon, submerging a new chapel, school buildings and part of a new housing project. One can still see flashes of light at night following heavy rains, as head-wall erosion cuts into hot rock.

The Dizon porphyry Cu-Au deposit, the Philippines' third-largest copper producer and second-largest gold producer, contains 140 Mnt of 0.43% Cu, 0.93 g/t Au, and 2.5 g/t Ag at a 0.2% Cu cut-off (Malihan, 1987). Highest gold grades are displaced toward the center relative to the copper zone (i.e., Cu-Au decreases inward, as at Bingham and Grasberg). The best copper grades are in chloritized-biotitized andesite and quartz diorite containing disseminated chalcopyrite > bornite or chalocite > pyrite and quartz-sulfide veins (chalcopyrite-magnetite or chalcopyrite-pyrite-pyrrhotite). Some higher grade areas in biotitized andesite contain disseminated chalcopyrite-bornite-magnetite. Most of the rocks have a weak chlorite-clay overprint (CSSC alteration of Sillitoe and Gappe, 1984) that doesn't appear to be related to ore. A low-grade "core" is the result of dilution of earlier mineralization by a sheeted set of NW-striking quartz-hematite-pyrite veins, 0.5 to 2 cm thick, that constitute 30 to 50% of the rock and locally up to 85% (shades of the "barren quartz core" at Panguana and elsewhere). These late quartz-pyrite-hematite veins, without visible alteration halos, are cut by sparse pyrite veins with narrow sericitic halos.

On the southern margin of the pit, the post-ore Pua diatreme is cut by faults that guided advanced argillic alteration accompanied by abundant fine-grained pyrite and 0.1 to 0.2 g/t Au. Carbonized wood occurs in the upper portion of the diatreme (T. Malihan, pers. comm., 1994). That significant erosion occurred between the time of porphyry emplacement and the diatreme-forming volcanic event is supported by paleodent estimates and K-Ar dates (>1 km depth for the porphyry event at 3 to 2.5 Ma; 100-300 m depth for advanced argillic alteration at 1.8 to 1.1 Ma). On this basis, Aquino (in prep.) concludes that advanced argillic alteration exposed at higher elevations around the pit is unrelated to evolution of the Dizon porphyry Cu-Au deposit. The search for documented transitions from porphyry ores to acid-sulfate ores continues...
At Santo Thomas II, another very young (1.5 Ma) and gold-rich porphyry, we were hosted by Alexander Madera of Philex Mines Corp. Initial open-pit ore reserves blocked out in 1956 were 18 Mmt of 0.90% Cu and 0.98 g/t Au (Imai et al., 1992). Mining has gone underground and grades have declined. Total production plus reserves amounts to 370 Mmt of 0.31% Cu and 0.63 g/t Au (Imai et al., 1992) and in 1993 the average grade was 0.27% Cu and 0.50 g/t Au (500 m below the initial ore reserves). Highest grades of Cu and Au are in bornite-dominant ores; areas of bornite = 1:3 typically contain 0.6-1.0% Cu and 1.5 g/t Au; Ag: Au in Cu concentrates averages 1:1, and magnetite concentrates are low in gold. Approach to the orebody on the 908 mining level is marked by pyrite-magnetite veinlets with chlorite-albite-pyrite selvages in magnetite-rich, biotized andesite. The ore zone within porphyry is characterized by magnetite and anhydrite (gypsum)-quartz-chalcopyrite-magnetite or chalcopyrite-bornite) veins, the latter with biotite halos. It was striking to see the weak degree of biotization of mafic minerals even within ore; hornblendes millimeters away from biotite selvages are dark and fresh-looking or replaced by actinolite. We observed the same variable degree of biotization of hornblende at the Southeast (Black Mountain) porphyry Cu-Au deposit at Camp 6 on the Kennon road, where fresh hornblende occurs within cm's of biotized hornblende associated with disseminated bornite-magnetite-biotite and quartz-borneite-chalcopyrite veinlets. We left Santo Thomas II still not knowing where Santo Thomas I is located.

On June 23 we were off to the Mankayan mining district (Lepanto-FSE) by way of the "Mountain Trail," past bright green vegetable terraces built on steep ridge lines surrounded by forested gullies, and over the highest point (7,400 ft) on the Philippine highway system at "Ice Peak." That evening, our dinner host was Gus Villaherna, Resident Manager at Lepanto, who has solved the dilemma, "Is Lepanto a copper mine, or is it a gold mine, or is it both?" He has proclaimed it to be a copper mine, thereby simplifying the mining and milling operations. Grades of ore at Lepanto have declined over the years from 3.52% Cu and 4.68 g/t Au in the early 1950s (Gonzalez, 1956) to 2.34% Cu and 3.37 g/t Au in the early 1980s (Philippine Bur. Mines, 1986). Total contained metal is 900,000 tons of copper and 122 tons of gold (Hedenquist and Garcia, 1990) in about 40 Mmt of ore. Silver-gold ratios average around 4:1, based on metal produced (Philippine Bur. Mines, 1986), and these increase toward the NW (as expected), away from the subjacent FSE porphyry Cu-Au deposit (P. Lillian, pers. comm., 1994). Joel Diaz, Resident Geologist, and his staff summarized the geology, and the next morning Diaz and Peter Lillian escorted us underground to look at the enargite ores. On-going studies of Lepanto-FSE by geologists from the Philippines, Japan, Australia, and the United States were summarized during the 1994 Tokyo meeting of the Society of Resource Geology. The genetic link between porphyry Cu-Au ores and enargite-gold veins is tightened, based in part on overlapping K-Ar ages from the two deposits (Arribas et al., in press) and on thermal patterns from infrared studies of fluid inclusions in enargite (Mancano and Campbell, in press). These new data remain to be integrated with the time-space relations based on geological mapping. This district will be a classic case-study of the transition from low-sulfidation porphyry copper ores to high-sulfidation (acid-sulfate) enargite Au ores.

The FSE (Far Southeast) porphyry Cu-Au deposit is the highest grade porphyry discovered to date in the Philippines, with a resource of 356 Mmt of 0.73% Cu and 1.24 g/t Au at a 1.0% Cu-equivalent cut-off (Conception and Cinco, 1989). The top of +1.0% Cu-equivalent is located at 650 m below the surface, and the feasibility of mining remains to be demonstrated. As at Dizon and Philex, gold shows a positive correlation with copper grade, abundant magnetite and the presence of bornite (Conception and Cinco, 1989; Garcia, 1991). High-grade portions of drill core (approx. 1% Cu, 2 g/t Au, 3 g/t Ag) contain abundant veins of quartz-anhydrite-chalcopyrite-bornite, fine-grained veinlets of quartz-chalcopyrite-magnetite, and disseminated magnetite in biotized quartz-diorite porphyry. The FSE hydrothermal breccia contains clasts of similarly mineralized porphyry (and other rock types); the breccia is partly cemented and veined by anhydrite-speleiorite-chalcopyrite.

I have come to the end of my tour. The trip has been a highlight of my career and I am indebted to SEG for giving me this opportunity. The sponsorship of international exchange by SEG fosters the essence of geology and mineral exploration; the companionship and common goals of economic geologists, and the bond that transcends national boundaries. SEG's progress in this area is reflected in the increasing non-American membership and in the goal to integrate these new members into mainstream SEG activities. Out of such trips also comes the personal excitement of discovery of common themes that reinforce past observations. There is a system to it all, if only we could figure it out.
What are the geological and geochemical themes that emerged for me? One relates to the distribution patterns of copper and gold in magmas-hydrothermal systems. Figure 1 summarizes metal data on deposits visited on this trip and similar deposits from around the world, all hosted by intermediate to felsic igneous rocks. The tip of the porphyry Cu-Au field, represented by the high-gold deposits (e.g., Grassberg, PSE, Dixon, Santo Thomas II), curves upward toward higher Au and Cu at constant Cu:Au and merges with the field of enargite-(gold) deposits. The latter field displays a slight increase in Cu as Au increases several orders of magnitude (Nena, Lepanto, El Indio). In contrast, the epithermal gold-(enargite) field has a different slope: Cu declines as Au increases, and the overall Cu:Au ratios and Cu grades are lower than for the enargite deposits. Those deposits that are oxidized-leached (in which most of the original sulfides have been leached by whatever process, but likely at temperatures below 100°C; e.g., Nena Au cap, Iwato) approach the field of leached caps of porphyry Cu-Au deposits (e.g., Ok Tedi, El Hueso, Refugio?) in which low Cu:Au ratios are achieved by weathering.

The data in Figure 1 represent the bulk Cu and Au contents of deposits, thereby not taking into account the different metal ratios for different paragenetic stages (e.g., late gold introduction at El Indio and Lepanto). Assuming that bulk metal contents are representative of some dominant ore-forming process, then are the separate areas of Figure 1 artifacts of too few deposits? (Data are the worms that eat away at great ideas.) Or, are we seeing here some real gaps, an absence of a continuum between enargite-(Au) deposits and high-sulfidation epithermal Au-(Cu) deposits? Are the former linked to higher chloride waters that are more likely to occur near mineralized porphyry systems? Are the latter linked to lower chloride waters that are more distal (or unrelated) to mineralized porphyries? To what extent are the low Cu:Au ratios of deposits like Iwato the result of copper leaching during low-temperature oxidation in steam-heated or weathering environments? To answer these questions, more attention needs to be paid to the metal contents of different paragenetic stages and to copper grades of sulfide-bearing portions of high-sulfidation epithermal deposits. Also, we need to devise better means to recognize secondary dispersion of metals in the near-surface by late, low-temperature (<100°C) groundwaters of various origins that are unrelated to the introduction of metals.

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**REFERENCES**


geochronological environment of high-sulfdation Cu and Au ore deposits: Geology, v. 21, p. 731-734.


Toyoha Mines Co. Ltd., 1990, Geology and ore deposit of the Toyoha Mine, unpub. rept., 9p (in English).


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EXPLORATION REVIEW

ALASKA

Regional Editor: Bruce A. Bouley (SEG 1985)
Cominco Alaska Exploration, 5650 "B" Street
Anchorage, Alaska 99518
(907) 563-7111 • FAX (907) 563-4244

USMX into ILLVILLE: mild-mannered entrepreneur Dennis Lance and compatriots see an opportunity for an aggressive company to make a go at North Pacific Mining's Illinois Creek Project. The announcement described more than 6 million tons of material at over 0.07 ounces per ton. The USMX boys have made silk purses out of stuff way smaller and lower grade than that, although the reality of heap leaching in Alaska has yet to be demonstrated.

Exploration is going along big time on the Seward Peninsula: Teck, Barrick, Cominco, Kennecott, Asarco, Canadian Juniors, et al. The drilling contractor at Kennecott's Rock Creek project near Nome apparently thought one could march right onto the tundra with the same gear and personnel that work just fine in Nevada. It took a while to learn how to float on the muskoged, but after several breakdowns and vehicle accidents, it all came together and the chips are flying. Sort of a quick ending, though, to the Anügi Kennecott drilling project on NANA lands near Candle. Results weren't quite up to expectations? Palmer property near Haines—drilled, but no ore. More exploration is planned. At the Forty Mile district around Chicken, locals report KCC spent a month there staking claims with a helicopter, mostly through Bob Pankhauser. All this KCC activity demands asking the question of the month: What is the reason for Kennecott not opening a regional exploration office in Alaska? Ask Russ Babcock.

Good outcrops are so scarce in the Interior (all that loess and tundra stuff), that it's not too surprising to run into other explorationists on the few recent exposures. Like the great meeting between John Galey and his AMAX hordes (whoops, I mean Cyprus-Amax) running into professor/consultant Bob Hodder and company at the Darth Vader Property (name disguised to protect the innocent) in eastern Alaska. John must be pushing those guys pretty hard—Dr. Zoom required stitches to close a nasty head wound caused by rushing around too fast (hope you're OK, Dave).

Good ol' sneaky Teck Corp, out on the Aleutians, with ever-present geon Don Stevens. Those with the highest levels of surreptitiousness get shipped off to Singapore.

Alaska geology expert/semi-deity Lorne Young reported that he has finished "sailing" one of his project areas. Did the Dr. make a verb from a noun, or was he following established usage? That's a tough call. Second quarter report from Cominco Ltd and scuttlebutt say that the much publicized grade control and metallurgical problems at the Dog (Red Dog) are subdue, and the project is starting to perform nicely. If only zinc and lead prices would perform. With Cominco's announcement of a new VMS occurrence in Yukon, there's been a lot of palpitations working on untransforming Tintina motions for look-alikes in Alaska.

Correction: Don Ranta (Echo Bay) does like Alaska, especially Pikes Landing in Fairbanks during the summer. Dealing with the mining-oriented and friendly folks there must be a real treat for Echo Bay-ers used to chlorophyll-infused types around Juneau and the AJ project. Now the FBI is involved in investigating the fish kill of last spring. Can Inspector Clouseau be far behind?

First Peter Thurston leaves mother INCO, then John Lukens jumps ship to work for Bondar Clegg in Reno. What is it about motherhood? Will there be new offspring in Anchorage? And Bigfoot finally has a ticket out. Roy McMichael will be moving to Reno, too—will be working with Chemex in a marketing capacity. Roy is an institution around these parts, and we wish him well.

Prediction: Steve Masterman will leave mineral exploration and work for Princess Cruise Lines after this field season. He'll be well-trained because that's all he's been doing at Ryan Lode mines this summer—giving tours. Same for Rich Hughes. Now they have more than doubled the size of their property (True North) with the acquisition of Freegold's adjacent Golden Summit property. The state actually repaved the road over Cleary Summit because of all the exploration traffic, or at least that's one reason given.

Frampton (George, not Peter) was in town and spoke to a Commonwealth North breakfast re Interior Department's views on land management issues in Alaska and elsewhere. It was refreshing to hear a bureaucrat talk about his agency's views and plans without a veil of political camouflage and double-speak. The message came through loud and clear all right: adios to state's rights
and sovereignty of private property. However, when asked if mining and exploration have any place within the ideology and philosophy of the Clinton/Gore/Babbitt—Interior Department, the Assistant Secretary remarked that mining was very important for the country, which is why they are going to such great lengths to revamp the archaic mining law of 1872. At that point, Paul Glavovich choked on a sausage. According to the Assistant Secretary, the guidelines for managing lands open to mineral entry will be "to conserve and protect and...build a quality environment." There's nothing more to add.

SEALASKA, the Native Corporation of Southeast Alaska, has started doing its own mineral exploration, and is drilling at Dolomi on Prince of Wales Island. This is a significant change from the way Native Corps typically have gone about exploring on their lands, and may well set the stage for others to do the same. CIRI tried this a few years ago when it formed North Pacific Mining, but became disenchanted when they realized that in exploration there's only one side to a P & L statement.

At the Nixon Fork project, Nevada Goldfields has advanced twin declines to the mineralization and is well along in a crosstrench. Continued exploration at Greens Creek has outlined a significant new ore zone, which serves to add more fuel to the rumor fire about resuming production. Although only about 2.8 M tons, the 34 ounce silver and 0.27 ounce gold plus 19% combined lead/zinc make a very attractive start for a renaissance.

Cominco geophysicist Dutch Van Blaricom was glimpsed around the region. Despite being known for his electromagnetic mystique and fun-loving ways, people were still wondering why he purchased $160 worth of pantyhose at the local supermarket. It's okay, Dutch—you can tell us.

Cyprus-AMAX has been drilling on the Gil property next to Fort Knox. Westmin is acting rather salmon-like (specifically, post-spawn) after finding for Johnson River dried up, although there is some work going on in Southeast Alaska. Addwest (love that Jā vu) is reborn and shows up in the Last Frontier with front man Chuck Hawley (yes). Chuck has a tough act to follow, what with the track record that Bob Schaefer held with the first incarnation of coal-into-metals.

It's been a very active summer for exploration in the Last Frontier, and the next installment should have all the details unknown or glossed over for this issue.

GREAT BASIN
Regional Editor: Bob Cuffe
Newmont Exploration (7), Carlin, Nevada (2)
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EXPLORATION NEWS

Not unexpectedly, the level of exploration activity in the Great Basin this summer is down a bit from last year. Those companies who own mining properties are very active in and around the mines, but only a handful of companies are conducting true grassroots exploration elsewhere. Meanwhile, the rest of the herd keeps picking over the dead carcasses of the same properties that were passed around last year, and the year before, and...

MINING EVALUATION PROFILES
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INTERNATIONAL ARCHIVES OF ECONOMIC GEOLOGY
The IAEG has a large number of collections with documents related to exploration in South American countries.

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Kencott continues to be one of the most aggressive explorers in the Great Basin and is rumored to have made as many as half a dozen “discoveries” in the past couple of years. The absence of shovels and huckpaks at any of the sites suggests that the term “discovery” is rather liberally interpreted. Semantics aside, the company is doing something right (like drilling a lot of holes) and is at least into some mineralization (which is something those who don’t drill will never encounter). The immediate payoff is a big increase in budget dollars, which will no doubt equate to more drilling and more “discoveries,” and eventually a mine. Simple principle, but somehow lost on most senior managers these days.

Also very aggressive is Santa Fe, who in addition to outright owning most of the Great Basin, now have a ton of money to spend as a result of the company’s initial stock offering. Reserves plus production now total 11.0 million oz gold at Twin Creeks and 4.4 million oz gold at Lone Tree. The Trenton/Valmy resource (20.8 million tons @ 0.03 oz gold/ton), south of Marigold, adds another 624,000 oz gold to the company’s coffers. Mineralization is in the Vinini, which translates to strong structural control and continuity problems, but this one may yet break the magical 1 million ounce barrier. Three drill rigs have been pushing the deposit limits northward.

First Miss Gold’s aggressive exploration program at Getchell ($5.7 million worth) has paid off handsomely with a 21% increase in reserves (for a total of 1.59 million oz gold). Most of the increase comes from down-dip extensions of the Getchell deposit (400,000 oz gold). The Turquoise Ridge deposit, northeast of Getchell, added 344,000 oz in sulfide ore at a grade of 0.32 oz gold/ton, which should be more than rich enough to support underground mining of the deposit, lying at depths of 700 ft to 2500 ft. The Company is looking at a possible JV with Santa Fe on the Section 13 deposit which straddles the property line with Twin Creeks.

Alta Gold consummated the $6.9 million deal with Phelps Dodge for the Olinghouse deposit, about 20 miles east of Reno. Alta drilled 30 in-fill holes during the due diligence period to confirm P.D.'s reserve estimate (some majors could learn a lesson here). The "No. 2 Vein" is estimated to contain 250,000 oz gold in a 1200-ft-long x 75-ft-wide vein/stockwork zone developed in intermediate volcanics. Alta sees potential to expand the reserve to at least 500,000 oz gold. A $2 million in-fill drilling program is planned for 1995. At Kinsley, Alta has started construction and should be in production by press time.

Has Cattleguard moved southwest to Hawthorne? Rumors abound that Newmont either has made a discovery in the area or has acquired the Paradise Peak mine from FMC and plans to reopen the mine. Not! Best I can figure, this one got started when locals saw FMC fencing off some land for reclamation purposes and figured there must be some awesome new discovery to protect.

Another rumor has Homestake making a discovery in the greater Hog Ranch or Mountain View area. I haven’t been able to confirm this yet, but do have a call into Pinkerton Security to see if they’ve sent any guards up that way. Meanwhile at Ruby Hill, the rig count is reported to be down to 2 drills from a peak of 8 earlier in the summer. Ore continuity is rumored to be less than originally thought (by HMC, that is). Drilling this summer has focused on the southern extent of the trend, rather than the pediment area to the north.

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WHEELIN' AND DEALIN'

Over in Utah, Akiko Resources obtained an option on the Burgin property in the Tintic district. Akiko gets the “pull-the-wool-over-the-stockholders’ eyes” award of the year for promoting the lead-zinc-silver prospect as carrying an “equivalent gold” grade of 0.3 oz gold/ton, when there is no gold in the deposit. Why not report its “equivalent rhodium” grade instead? Also in the Tintic area, Centurion Mines purchased 980 acres of patented ground containing 7 old mines and plans to explore from underground for high-grade gold-silver-copper veins and breccia pipes. They will have their hands full, since Kencott withdrew from the Tintic Joint Venture at about the same time and returned a huge land package to Centurion. In the past 8 months, Atlas Minerals has been taken over by Phoenix Holdings, has purchased a stake in Granges, has talked of merging with Dakota, and now has optioned out the north part of the Roberts Mountains holdings to Rayrock. Rayrock will spend $1.5 million over 3 years to earn a 60% interest in the property. Cyprus Minerals leased the Slaven Canyon property (ca 50,000 oz gold refractory resource) from Alta Gold. Northwind Resources has acquired a 44-claim position adjacent to Kencott’s Gemfield property.
OFFICE CLOSURES

Following the Tallapooza debacle, Pegasus closed the Reno office doors in August. The few remaining geologists transferred to overseas assignments or the Spokane office.

In a move to ostensibly save money through consolidation, Newmont Exploration, announced the closure of the Reno exploration office in mid-August. Holy cow, did I report that correctly? Yes indeed, the letterhead on the memo does say "Newmont Mining Corporation." Four support staff were let go in the move; 8 geologists and a geophysicist have been offered transfers to Carlin. More on this new item later—I will be following this one closely!

GOVERNMENT NEWS

— No news is good news. —

SOUTH AMERICA

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GENERAL

Several recent events surprised the exploration community, of which the purchase play for LAC Minerals, concluded by American Barrick in late August, may directly affect the El Indio district in Chile and existing programs in Argentina and Peru as well. American Barrick also exercised its option for the Cerro Corona Cu-Au porphyry in northern Peru and is aggressively present in Chile, Argentina, and elsewhere. The combined assets of the companies place Barrick in an enviable position.

A high level of competitor activity persists in South America, reflecting receptive attitudes by governments and national mining legislation, paired with new investment based on technological expertise and available foreign capital. It is a form of synergy that apparently works to the benefit of both. In several cases, new peaks in generative exploration activity have temporarily slowed the facilities for mineral property applications. During July, Peru announced a moratorium on new applications until January 1, 1995, although this has not impacted the pace or interest level for South American exploration.

CHILE

Exploration focus in Chile continues to be on copper and gold. In the far north (Regions 1 and 10), large tracts of concessions have been filed in a staking spree by two major companies notably outside the two traditional "porphyry belts." Targets may be the more enigmatic, magmatic sources of copper mineralization in the Mesozoic coastal belt. Examples of such include Anglo's Mantos Blancos mine near Antofagasta and Sociedad Minera Pudahuel's Lo Aguirre mine near Santiago. Where was the magmatic arc in Late Cretaceous time—or can these be of Tertiary age?

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A short list has been finalized of companies invited to bid for Shell's one third interest in the world class Collahuasi porphyry deposit near Quebrada Blanca. Anglo could exercise its first right to purchase the interest, but the price set by competitive bidding may be quite high. Meanwhile, Quebrada Blanca is "en marcha," producing its first shipment of cathode copper in mid-winter. QB marks the first high altitude (4000-meter) test case of copper leach/SX-EW technology, using Pudahuel's patented process, an important test for several exploration and development-stage projects which could benefit (El Abra, Quellaveco, etc.).

Near Calama, activity in the Sierra Gorda district is booming, as several majors test copper targets near Outokumpu's Santa Catalina Cu-Mo-Au breccia deposits. Mineralization at Sierra Gorda, an historic copper district, is apparently related to the early (Paleocene-Eocene) porphyry belt; however the unusually high Mo and Au content at Sta. Catalina adds interest for more unconventional targets. Drill rig availability is reportedly at a premium.

As of this writing, the intentions of American Barrick are unknown concerning newly purchased LAC Minerals' assets. El Indio is Chile's largest gold producer, the Tambo expansion is underway, and LAC's Nevada project is Chile's largest funded gold exploration program this year. Further news is awaited.

If possible, exploration and investment is even hotter in Peru, where a new generation of players is emerging. Filings for exploration concessions reached an all-time high this year, prompting an emergency moratorium by the government on new applications from July to year's end, 1994. This temporary, but extreme, measure will likely increase competition in 1995 and give these companies with active exploration programs a real head start.

In July, American Barrick exercised its option to earn-in at Cerro Corona, a stockwork Au-Cu porphyry located on trend north of Yanacocha. A preliminary drilling program of 178 diamond and RC drill holes to 70 meters outlined a resource of 3 million ounces Au and 450,000 tons of Cu, at grades of 1.2 g/t Au and 0.6% Cu, respectively. Geologists and mining analysts alike anticipate that the resource could double. This deposit will make money.

Other activity north of Cajamarca includes Southern Peru Copper Corp. and Buenaventura drilling Tanta Huaytay north of Co. Corona, a large scale program by Newmont/Buenaventura in northern Peru close to the Ecuador border, and initiation of exploration by Crown Resources (Solitario) at their property immediately north of Yanacocha. Place Dome's initial results are reported very encouraging from Chiuamarka, the Au-rich sector adjacent to the Canaricao Cu porphyry, a Minero Peru property privatized to Place Dome earlier this year.

While gold exploration dominates the north, copper exploration expands in southern Peru with large generative programs (and land positions) by majors in the porphyry belt, and specific property acquisitions. Twenty-two companies have qualified for Minero Peru's licitation of the Tintaya skarn district, set for early October. Tintaya is a "classic" contact skarn developed in limestones where past production and exploration point to significant potential for additional ore, particularly under shallow cover. Within the same sedimentary belt, Southwestern Gold's projects, notably the Santa Rosa venture with Cambior and others nearby, show potential for multi-million ounce (Au), poly metallic mineralization in a large-tonnage, bulk mineable setting. This may be one of the most exciting gold plays in Peru, but more information should be known following Cambior's first-stage drilling program.

Acuarios Minera y Exploradora continues to explore their attractive portfolio of Cu and Au projects with recent encouraging drill results from the Parron Au project, the San Jose porphyry Cu project, and the Los Pinos Cu project (optioned to Asarco). All show excellent potential for small to medium-size deposits. Drilling is planned in the near future at several of the company's porphyry copper prospects to the southeast of Arequipa.

Exploration in Argentina continued through the South American winter at lower elevation projects such as Argentina Gold's El Carrizal, generative exploration in northwestern provinces Jujuy and Salta (Canyon Resources, Crowne Resources, others) and within the Pre-Cordillera of Mendoza-San Juan-La Rioja (American Resources, Argentina Mineral Development, Argentina Gold, RTZ, etc.). The approximately fifteen foreign exploration companies now established in Argentina have the benefit of two (or more) exploration seasons since passage of new mining legislation. Exploration programs are reaching a level of maturity; new,
conceptually-driven exploration programs mark this turning point. Remote sensing (thematic mapping imagery) and geophysical surveys, applied over large areas augment this effort. State-sponsored programs exist in 1994 to complete country-wide topographic map coverage at 1:100,000 scale and to fly airborne magnetic surveys in three key areas, with results to be publicly available. A recent session convened by the Secretary of Mines to solicit comments from exploration companies underlined Argentina's commitment to foreign investment in mining, although some obstacles remain.

As summer begins, second-season exploration of high-altitude alteration anomalies is underway over large property positions held by Eldorado Corporation, Solitario (Crown), and the San Juan provincial mineral reserve, among others; all of which project east of Chile's Miocene, volcanic-hosted El Indio and Maricunga gold belts.

In the vicinity of the Farallon Negro volcanic field, which hosts multiple Cu-Au porphyry targets, notably Bajo de la Alumbrera, BHP plans drilling at Mi Vida. Placer Dome, who recently dropped their option at El Durazno, will continue exploring Cerro Atajo. A drilling program is planned for this season at CRA's Famatina (La Mejicana) polymetallic vein district in La Rioja Province (+4500 meters), but for a bulk-tonnage target.

Southern Argentina is opening from Neuquen to Santa Cruz. Placer Dome has identified drill targets in their exploration of Neuquen reserve areas; Newcrest, LAC, and others are actively exploring for epithermal precious metal targets in Santa Cruz, and a mix of explorationists is active in Chubut Province.

**ECUADOR**

Exploration activity in Ecuador is focused primarily on gold and continues at the elevated levels seen for the past 2 to 3 years. Newmont is concentrating efforts on their Cerro Pelado prospect near Machala, where gold mineralization is associated with sheeted to stockwork quartz veining within and surrounding a breccia developed at the contact between metamorphic basement and overlying Tertiary volcanic rocks. Newmont recently concluded a major evaluation effort at the Fierro Urec Cu-Au prospect but returned the property to Armeno Resources. TVX Gold is reportedly drilling at their Cordillera del Condor joint venture with DINE (Ecuadorian military) and they are also active at the Gima project near Cuenca. Newmont previously held Gima but was unable to complete drill evaluation due to complex local social issues.

Ecuadorian Mineral Company (EMC) continues a major drilling program at Gaby, an intrusion-related Au-Cu project near Ponce Enrque, designed to define a sulfide resource through deeper drilling. EMC has also recently completed a first phase drilling program at their Tres Chorreros Au-Cu-Mo project. Zappa Resources appears ready to drill the Ponce Enrquez project directly south of Gaby. Targets include intrusion-related Au-Cu mineralization similar to Gaby as well as higher grade veins and silicified zones.

Odin Resources is actively pursuing placer and lode Au opportunities in the Western Cordillera, and rumors indicate that Teck may be dropping their Rio Agravico placer project in the northern Oriente. Advertisements for up to six exploration geologists have been spotted recently in Quito newspapers.
The busy schedules of our regional editors, early deadlines for this issue, and summer field seasons have all conspired to provide a little space for me to pass along some information and request your input. But first, I want to say THANK YOU to all of the Regional Editors. Keeping us informed of the various activities in their region is a major task that takes time from things that they should or would rather be doing (especially when they’re facing deadlines). When you run across them in airports, the field, meetings, or wherever, please take the time to give them a “thumbs-up” for a job well done. I also want to thank Alan Wallace who stood in for me to help get the last issue out to you on time.

NEEDED: REGIONAL EDITORS

As you may have noticed, we have not had recent reviews of activities in the Southwest, Northwest, or eastern Canada. Regional editors for those areas are needed! Volunteers, please contact me! If you don’t want to volunteer, but know someone who will do a good job and may be willing to put in long, thankless hours for no pay, send me their names and I’ll try to sign them up. Remember, this is a volunteer effort and if we as the consumers of the information don’t do our share of the work, we all suffer.

A REJUVENATED JOURNAL

During my efforts to get up to speed on Russia and central Asia, I learned that International Geology Reviews is now edited by Kevin Burke and Brian Skinner and “is published in association with Economic Geology and the International Union of Geological Sciences.” Did I miss an earlier announcement by the Economic Geology folks? In any case, it was a pleasant surprise to find a journal that once specialized in publishing translations of Russian articles has been significantly rejuvenated and is publishing, original, English language articles. There seems to be an emphasis on areas of the world other than North America and Europe; so, for central and southeastern Asia, Russia, and a few other regions this is the place for information. Turn-around time for good papers is short and the level of basic geologic data is refreshingly high. Good reading! (That’s supposed to be an expression similar to Bon Appetit!, but somehow it lacks the punch.)

ABBREVIATIONS

OzAu/t, Mmoy/mt, Mg/t Au, gmAg/t, etc. Are you as confused as I am? Starting in the next issue, I will try to apply a consistent set of abbreviations to this section of the Newsletter. However, I’d like your input before imposing my opinion. Do you have a favorite set of abbreviations? If so let me know. Below are the suggestions of our editor. Any comments?

- t = tonne
- st = short ton
- M = million
- g/t = grams per tonne
- oz/st = ounces per short ton
- M/a = million tonnes per annum
- Ms/ty = million short tons per year (what about Ms/ty?)
- What do you think about 3.3 g Au/t as opposed to 3.3 g/t Au?

[Editor’s note: With the next deadline for the SEG Newsletter being December 2, please send your ideas to Dick soon. If you will be at the GSA meeting in Seattle, you can hand me your comments, and I will pass them on. —HH]
CANDIDATES FOR SEG FELLOWSHIP:

To All Fellows:

Pursuant to Article V, Section 2, of the Society’s Constitution, names of the following 5 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, to the Admissions Secretary before December 15, 1994. If no objections are received by that date, these candidates will be presented to Council for approval.

ADDRESS COMMENTS TO:
Virginia S. Gillerman, Admissions Secretary, SEG
IDAHO GEOLOGICAL SURVEY, MG-229
Boise State University • Boise, ID 83725 USA

Andrew, Ross L., CRA Exploration, Box Hill, Victoria, Australia: Ross R. Large, Donald P. Sangster, David I. Groves

Bal, Michel L., Hansa Geomin Consult (FRG), Dusseldorf, Germany: Josef G. Schmitz, Guenter Friedrich, E. F. Stumpfl

Enderlin, Dean A., Homestake Mining Company, Calistoga, CA: Jeffrey W. Hedenquist, Richard W. Henley, Stuart P. Simmons

Hattori, Keiko, University of Ottawa, Ottawa, Ontario, Canada: Jeffrey W. Hedenquist, Shunso Ishihara, Eiji Izawa

Mau, Jeffrey L., University of Auckland, Auckland, New Zealand: William C. Kelly, S. E. Kesler, Greg B. Archard

THE SOCIETY WELCOMES THE FOLLOWING NEW SEG MEMBERS:

Ross L. Andrew, CRA Exploration, Box Hill, Victoria, Australia; Michel L. Bal, Hansa Geomin Consult (FRG), Dusseldorf, Germany; Richard Côté, Rio Algom Exploration Inc., Val d’Or, Quebec, Canada; Stephen R. Dinkowitz, Flamboro Mining Company, Ladysmith, WI; Dean A. Enderlin, Homestake Mining Company, Calistoga, CA; Keiko Hattori, University of Ottawa, Ottawa, Ontario, Canada; Robert Mason, Queens University, Kingston, Ontario, Canada; Daniel Müller, Placer International Exploration, Santiago, Chile; Piotr M. Paleczek, lac Minerals, La Serene, Chile; Brion D. Theriault, Newmont Exploration Ltd., Elko, NV.

THE SOCIETY WELCOMES THE FOLLOWING STUDENT SEG MEMBERS:

Randy L. Levasseur, University of Windsor, Canada; Victor B. Maglambayan, Akiwa University, Japan; Geordie Mark, James Cook University, Australia; Michael J. Nugus, James Cook University, Australia; Susannah E. Price, James Cook University, Australia; Virginia M. Ragan, Univ. of Missouri—Kansas City, USA.

THE SOCIETY WELCOMES THE FOLLOWING RECENT SEG REINSTATEMENTS:

C. Graham Miller, fellow, Cyprus Gold Australia Corp, Perth, Australia; Kent E. Ausburn, member, Tri-Valley Corp., Tacoma, Washington, U.S.A.
SOCIETY OF ECONOMIC GEOLOGISTS

1994


1995

March 6-9, with Society for Mining, Metallurgy and Exploration (SME), Denver, Colorado. Robert W. Binkley, 6030 Vivian St., Arvada, Colorado 80004 USA. Tel. +1-303-422-3198, fax +1-303-424-5983.

May 13-17, IAMG/SEG 7-day Field Conference on Carbonate-Hosted Lead-Zinc Deposits, Irish Zinc district, plus 2-day course on stratigraphy and basin analysis of the Irish Midlands. Garth Earls, c/o Crowe, Schaltalascke and Assoc., Ltd, Block 2A, Beech Hill, Clonskeagh, Dublin 4, Ireland. Tel. +353-1-269-4077, fax +353-1-269-4424. (See ad, p. 14)


June 15-23, Univ. of Western Australia/SEG Field Conference on Carbonate-Hosted Lead-Zinc Deposits, to Loddon Shelf, Canning Basin. J. R. Vearncombe, Department of Geology, University of Western Australia, Nedlands, Western Australia 6009, Tel. +61-9-380-2637, fax +61-9-380-1179, E-mail jearv@geo.uwa.edu.au. (See ad, p. 14)

Nov. 5-9, with Geological Society of America, New Orleans, Louisiana. Robert B. Cook or James C. Snider, Dept. of Geology, 210 Petrie Hall, Auburn University, Auburn, Alabama, 36849 USA. Tel. +1-205-844-4828, fax +1-205-844-4866.

1994

Oct. 17-21, 7th Chilean Geological Congress, Concepcion, Chile. Organizing Committee, Universidad de Concepcion, Departamento de Ciencias de la Tierra, Casilla 3-C, Concepcion, Chile. Tel. 56-41-23-4093, fax 56-41-24-0280. SEG co-sponsored symposium and pre-congress field trip, with English-Spanish translations.

OTHER EVENTS

SEG Newsletter 588 S. Rapp St., Ste. 209 • Littleton, CO 80120 • USA

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