

The Gargue

GAC - Mineral Deposits Division Newsletter



Issue 39

May 1992

The Future of Research in Economic Geology MDRU Meeting at UBC, April 14-15, 1992

Submitted by James Macdonald, MDRU

The Mineral Deposit Research Unit (MDRU) at The University of British Columbia organized a research meeting in mid-April on the theme of "The Future of Research in Economic Geology". The purpose of the meeting was to seek new ideas from researchers and the mining industry on the role and direction of research, and its application to exploration. The results will be used to define the focus of MDRU research and the level of interaction with the industry over the next ten years. The meeting was divided into two parts: On the first day over 120 participants from industry, government and universities heard a series of invited presentations addressing the theme of the meeting. Sixty invited delegates returned on the second day for a series of thematic workshops and a plenary session.

The open meeting on the first day began with a review of the development of the MDRU followed by brief descriptions of current MDRU collaborative research projects; 'Ore Reserve Estimation', 'Metallogenesis of the Iskut River Area', and 'Cu-Au Porphyry Systems of B.C.'. Dr. David Strangway, President of UBC, then welcomed all of the participants to the meeting and described his own belief in the importance of collaborative research and the eventual disappearance of boundaries between traditional disciplines. MDRU, the only 'Unit' at UBC, has an important role to play in promoting multi-disciplinary research.

The six invited presentations began with a candid description of Placer Dome's corporate exploration philosophy from Elisco Gonzalez-Urien, VP Exploration for PDI. The need to find large, high-grade deposits in North America was stressed. Success as illustrated by new PDI discoveries, is likely to result from the integration of all data with conceptual ideas (research) rather than the development of new tools. Byron (Barney)

Berger from the USGS in Denver also emphasized the importance of integrating research and exploration in order to increase the probability of discovery. He illustrated successful examples of this approach involving both company and government-university research over the last thirty years.

The scope of the meeting was broadened further by Hugh Wynne-Edwards, president of Terracy, who presented his wide ranging views on the Canadian economy, and the importance of innovation and knowledge intensive industries. He pointed out that Canada spends almost as much on exploration as Japan spends on industrial R&D (approximately \$800 million) and that this expenditure must be productive if the mining industry is to avoid becoming a wealth consumer rather than a wealth generator, its historical role.

Steve Kesler, University of Michigan, took on the difficult task of describing the relevance of advanced research techniques to exploration. In thirty minutes, Steve described oxygen isotope data from Huronian quartz pebbles with suggestions for the provenance of associated mineralization, gas analysis of fluid inclusions in Archean gold, the distribution of gold and sulphur isotopes in pyrite from sedi-

ment-hosted deposits, and age dating of sphalerite by Rb-Sr, fluorite by Nd-Sm, and sericite by Ar-Ar. All of the results had obvious implications for exploration and, in some cases, mineral processing.

Jayanta Guha, University of Quebec-Chicoutimi, returned to a more philosophical theme suggesting that the growing importance of acquisition relative to traditional exploration, evaluation of mature mining districts, and deep exploration all require increasingly advanced knowledge, a team approach, and the innovative application of models. Attracting and keeping the necessary bright people poses a serious problem for the Canadian industry. The presentations were concluded in a similar vein with an antipodean perspective from Dick Henley of Etheridge and Henley Geoscience Consultants, Canberra, Australia. Dick examined the past role of research in exploration and illustrated the difficulty of spotting 'winners'. He suggested that the next ten years will see some advances in exploration tools and significant advances in data handling and imaging, an improved application of genetic pathways for ore deposit systems and their

Field Safety Publication

The American Geological Institute has recently released a book entitled Planning for Field Safety. The book,

- Promotes safety-consciousness
- Describes hazards and pitfalls in the field
- Contains useful tips for many field settings
- Includes guidelines for safe fieldwork
- Helps prepare you for contingencies and emergencies

Topics include: checking out the weather; choosing equipment; medical preparations; food; logistics; evacuation plan; equipment use & safety; drilling rigs & sites; safety in the field; avoiding marijuana & moonshine; contaminated food; contaminated water; safe camping; transportation; hot & cold weather precautions; wildfires; animals; insects & other pests; poisonous plants; high altitude hazards; alpine regions; tundra; tropics; high & low desert and semiarid regions; temperate forested regions; underground mines & caves; fieldwork in other countries; urban environment; day trips; in case of emergency; precautions for the group leader; shipping rock samples.

Cost is US\$14.95 plus shipping & handling. Orders may be placed by phone (301) 953-1744, or prepaid by cheque/credit card: AGI Publications Center, P.O. Box 205, Annapolis Junction, MD 20701, U.S.A.

application to exploration, and continued upgrading of exploration teams. All are dependent on the insight and ability of exploration management.

The format on the second day involved seven working groups, each discussing individual themes of relevance to economic geology and exploration research. These included exploration philosophy, ore deposit models, exploration techniques, exploration and environment, education, collaboration, and company support. The results were pulled together in a plenary session chaired by Jim Franklin of the GSC in Ottawa and were discussed in the context of the MDRU. A number of themes recurred throughout the discussion. These included the critical importance of research, not so much as a generator of competitive advantage in exploration, but more in the development and testing of new ideas. These ideas should be incorporated into exploration by company geologists where their successful application may give those companies an exploration advantage. This is especially important for the big, high-grade deposits that Canada needs. Integration of research techniques, data, and people are all recognized as fundamental for future success. If Canada is to maintain its position at the forefront of exploration at home and abroad, considerable emphasis must be attached to the continued training of professionals. Finally,

although there is clear support from the mining industry for an increased research effort, the meeting also recognized the realities of corporate financial constraints and fiscal problems facing both companies and governments.

For MDRU, the meeting continued the depth of support for the unit within industry, particularly the Vancouver exploration community. There was unanimous approval for the style of collaborative research adopted by MDRU involving a broad conceptual approach supported by detailed deposit/case studies. Additional integrated studies involving geophysics and environmental problems, such as acid rock drainage, will be pursued. The focus of MDRU, however, will continue to be island arc metallogeny and related exploration problems in a western Canadian context and similar environments in the Circum-Pacific region. A number of ways for MDRU to increase its efforts in training, technology transfer and overseas interaction were recommended, many with the overall theme of promoting the more complete use and integration of existing data as much as the generation of new data. This concept came up repeatedly throughout the two day meeting, and it probably represents the future direction of MDRU in terms of a realistic service component. It also represents a major challenge for the industry as a whole.

Developing Resources in the Cordillera Second Annual Field Conference of the Geological Society of the CIM September 28 - 29, Kamloops, B.C.

In spite of a difficult investment climate there are significant mining projects and exploration programs. The progress of many of these developments will be highlighted during a conference sponsored by the Geological Society of the Canadian Institute of Mining, Metallurgy and Petroleum, on developing resources. It will be held in Kamloops, B.C., September 28 and 29, 1992.

Major Topics

- Precious metal enhanced polymetallic VMS deposits of the northwest Cordillera (BC & Alaska). Planning includes a field trip to Kerr, Eskay, Sulphurets and perhaps HW.
- Shale Hosted Deposits. Includes those of the Gataga Basin and other significant deposits.
- Porphyry Copper-Gold. The Jekyll & Hyde aspects of these targets and their development risks will be investigated by examining several recent, high-profile projects. Field trips will include calcalkalic and alkalic porphyries.
- Copper-Gold Skarns of southern BC and western Washington. Speakers will address lithotectonic framework, genesis and exploration models. Field trips will include Hedley, Grandforks and Greenwood areas.
- Advances in the development of bulk-mineable gold deposits and base metal skarns in Nevada and northern Mexico. Field trips include central Nevada and northern Mexico. Speakers will address metallogeny and tectonics of the southwestern U.S.A. (Arizona, northern Mexico).
- Exploration techniques. Several talks will highlight changing databases in lithochemical, and geophysical exploration techniques.

The Gangue, No. 39 May 1992

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

Publication Schedule:

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

Information for contributors:

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

Manuscripts should be submitted on 5¼" or 3½" IBM-formatted diskettes in any major word processor format. A printed version should be included. Illustrations should be in camera-ready format; photos should be of good quality. Short items dealing with news events or meetings can be submitted by FAX or mail.

Contributions may be edited for clarity or brevity.

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



MEETINGS, WORKSHOPS & FIELDTRIPS

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

MAY 1992

- 17 - 22 **GSA Penrose Conference - Tectonics of the Coast Mountains Orogen, British Columbia, Yukon and Alaska. A Tribute to R.L. Armstrong**, in Whistler, B.C. For details contact: George Gehrels, Dept. of Geosciences, University of Arizona, Tucson, AZ, USA 85721. Tel: (602) 621-6026.
- 25 - 27 **1992 GAC/MAC Annual Meeting**, Wolfville '92, Nova Scotia. For information contact: Aubrey Fricker, Atlantic Geoscience Centre, Bedford Institute of Oceanography, Box 1006, Dartmouth, Nova Scotia, B2Y 4A2. Tel: (902) 426-6759.
- 25 - 29 **15th World Mining Congress and Exhibition**, Madrid, Spain. For details contact: Organizacion de Exposiciones Y Congresos, S.A., Plaza de la Encarnacion, 2 - 2, 28013 Madrid, SPAIN. Tel: (341) 247-7042; FAX: (341) 542-7549.

JUNE 1992

- 1 - 4 **15th Canadian Symposium on Remote Sensing**, Toronto. For details: N. Prout, Ontario Centre for Remote Sensing, 90 Sheppard Avenue East, 4th Floor North York, Ontario, M2N 3A1. Tel: (416) 314-1312 FAX (416) 314-1336.
- 22 - 25 **Mineral Resources of Puerto Rico**, San Juan, Puerto Rico. For Details: Sherman P. Marsh, U.S. Geological Survey, MS 973, Box 25046, Denver, Federal Center, Denver, CO 80225. Tel (303) 236-5521, FAX (303) 236-3200.

JULY 1992

- 19 - 22 **Second International Symposium on Mining in the Arctic**, Fairbanks, Alaska. For details contact: Dr. Sukumar Bandopadhyay, Chairman, 108 Brooks Building, University of Fairbanks, Fairbanks, Alaska, 99775, U.S.A. Tel: (907) 474-6876.
- 23 - 26 **2nd Annual Fort St. James Exploration and Mining Conference**, Fort St. James, British Columbia. For details contact: Filippo Ferri, B.C. Geological Survey Branch, 553 Superior Street, Victoria, B.C. V8V 1X4. Tel: (604) 356-2818; FAX (604) 356-8153.

AUGUST 1992

- 10 - 12 **Rare Metal Granites and Their Practical Importance**, Ulan-Bator, Mongolia. For details contact: L. Bayarbileg, Geolo-

gical Institute of the Academy of Sciences of Mongolia, P.O. Box 361210, Ulan-Bator, 36, Mongolia. Telex: ERDEM 305 MH, Tel: 50272.

- 24 - Sept 3 **29th International Geological Congress**, Kyoto, Japan. For details contact: Shunso Ishihara, Secretary General, IGC-92 Office, P.O. Box 65, Tsukuba, Ibaraki 305, Japan.
- 31 - Sept 2 **Sudbury 92 - International Conference on Large Meteorite Impacts and Planetary Evolution**, Sudbury, Ontario. For details contact: Dr. B.O. Dressler, Ontario Geological Survey, 77 Grenville St., 9th Floor, Toronto, Ontario, Canada, M7A 1W4. Tel: (416) 965-1321; FAX: (416) 324-4933.

SEPTEMBER 1992

- 2 - 4 **Second International Conference on Environmental Issues and Management of Waste in Energy and Mineral Production**, Calgary, Alberta. For details contact: Dr. R.K. Singhal, Conference Chairman, P.O.Box 68002, Ranchlands RPO 7750, Ranchview Drive NW, Calgary, Alberta, Canada, T3G 3N8. Tel: (403) 239-3849; FAX: (403) 241-9460.
- 10 - 12 **Industrial Mineral Resources - Today and Tomorrow: The Raw Materials to Build the Upper Midwest**, Minneapolis, Minnesota. Cosponsored by USGS, U.S. Bureau of Mines, Minnesota Geological Survey. Details: Gary B. Sidder, U.S. Geological Survey, MS 905, Box 25046, Federal Center, Denver, CO 80225, U.S.A.
- 12 - 15 **26th Annual Meeting of the Association of Earth Science Editors**, Glacier National Park, Montana. For details contact: H.L. James, Conference Chairman, Montana Bureau of Mines and Geology, Butte, Montana, 59701, U.S.A. Tel: (406) 496-1175.
- 20 - 26 **Volcanic Geology and Mineral Deposits Short Course**, University of Nevada, Reno. Details: Hal F. Bonham, Jr., Tel: (702) 784-6691, or Donald C. Noble Tel: (702) 784-6928.
- 28 - 30 **Developing Resources in the Cordillera**, CIMM Geological Society, 2nd Annual Field Conference, Kamloops, B.C. For details contact: Fred Daley, Teck Corporation, #350-272 Victoria Street, Kamloops, B.C. V2C 2A2. Tel: (604) 372-0032; FAX (604) 372-1285.

OCTOBER 1992

- 1 - 4 **CIMM District 6 Annual Meeting**, Campbell River, B.C. For details contact: Ray Kissack, 1364 Spruce Street, Campbell River, B.C., V9W 3L7. Tel: (604) 287-9271 FAX (604) 287-3022.
- 2 - 6 **Sudbury - Noril'sk Symposium**, Sudbury, Ontario. For details contact: A.J. Naldrett, Department of Geology, University of Toronto, Ontario, Canada, M5S 3B1. Tel: (416) 978-3022 FAX (416) 978-3983.
- 18 - 22 **MINExpo International '92**, Las Vegas, Nevada. For details contact: American Mining Congress, 1920 N Street NW, Suite 300, Washington, D.C., 20036-1662, U.S.A. Tel: (202) 861-2834; FAX: (202) 861-2821.

- 25 - 29 **SEG Fall Meeting and Geological Society of America Annual Meeting**, Cincinnati, Ohio. For details contact: GSA Headquarters, Box 9140, 3300 Penrose Place, Boulder, Colorado, USA 80301. Tel: (303) 447-2020.

DECEMBER 1992

- 7 - 9 **15th Annual Ontario Geological Survey Geoscience Research Seminar**, Toronto, Ontario. For details contact: Symposium Co-ordinator, Ontario Geological Survey, 11th Floor, 77 Grenville Street, Toronto, Ontario, M7A 1W4. Tel: (416) 965-1546.

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APRIL 1993

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

MAY 1993

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

SEPTEMBER 1993

- Mid-September Alaska Mineral Deposits**. Sponsored by the Society of Economic Geologists. Eight-day excursion will commence in Fairbanks and end in Juneau. Further details contact: Will White, U.S. Geological Survey, 4200 University Drive, Anchorage, Alaska, 99508-4667.
- 25 - Oct. 1 **Ancient Volcanism and Modern Analogues**, Canberra, Australia. IAVCEI General Assembly 1993. For details contact: IAVCEI ACTS, GPO Box 2200, Canberra, ACT 2601 Australia. Tel: (616) 257-3299; FAX: (616) 257-3256.

OCTOBER 1993

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

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OCTOBER 1994

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

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CAD: A STANDARD TOOL

One is often stuck with the high level of automation of the tasks performed by the draftsman, geologist and mining engineer while visiting mining operations and mineral exploration offices in North America. Not so long ago massive teams of drafting technicians under the supervision of numerous geological and mining professionals were necessary for manually handling large amounts of information and performing the fundamental tasks of geological interpretation, reserve estimation and mine design.

At the heart of this automation trend is the emergence of a powerful graphic driven tool; computer assisted design or CAD. Success stories on the implementation of CAD are told at many mine sites and exploration offices and are supplemented by an increasing number of positive case histories either published, or presented at technical meetings.

From 2D to 3D

Among CAD software packages available in the marketplace, AutoCAD™ is favoured by many exploration and mining organizations. Early versions of AutoCAD were limited to the creation and management of drawings, *i.e.* two-dimensional representations of data. Subsequent releases of AutoCAD incorporated three-dimensional capabilities, in particular the ability to program and tailor the process of three-dimensional modelling as it pertains to specific orebodies or unique needs of an organization. These three-dimensional features allowed a rapid expansion of AutoCAD's use for reserve modelling and mine planning and as a result many mining organizations recognize that AutoCAD is the fulcrum for automating their geological and mining departments. The recent release of AutoCAD (Version 11) introduces a development system that allows high-level programming. Advanced third party applications available to industry are, therefore, expected to increase.

Training Needs

The accelerated pace at which CAD technology is introduced in our industry requires ongoing development and skill training for many technicians and professionals. While some organizations still believe that the mere purchase of CAD software will automate manual tasks overnight, other organizations realize the need for a gradual and well thought out CAD training and implementation program. However, many organizations do not have experienced CAD users on board, or are unable to obtain assistance from vendors or other external CAD experts. Capabilities and price of CAD technology have become non-issues. The real issue for a mining organization is the human resources and time investment required to train adequately and improve skills of its CAD users.

Data Standards and Users Groups

Several recent initiatives have been undertaken by industry members to provide a more effective means of communication among users of CAD technology. These initiatives include the publication of a comprehensive series of standard symbols by the Northeastern AutoCAD User's Group and endorsed by the Canadian Institute of Mining, Metallurgy and Petroleum. Last December a meeting, sponsored by Autodesk Inc., was held in Toronto to discuss the formation of a mining, AutoCAD user group. The proposed group would be an ideal forum for sharing ideas, experiences and resources and provide collective direction to vendors.

A paramount consideration related to the use of CAD throughout industry is a standardized format for CAD file exchange. Most CAD users would agree that DXF

or similar formats are not standardized. In Australia, mining companies have funded, through the Australian Mineral Industry Research Association (AMIRA), a research project to develop and promulgate data interchange standards. Initially, this standards project will not embrace CAD-type data but may do so in the future. In Canada, authors of this article are involved in launching a similar standards project. The industry's quest for standards could benefit from efforts in other industries, for example, the U.S. petroleum industry plans to produce CAD standards for information transfer, data structure and symbols.

The integration of CAD technologies with Geographic Information Systems (GIS) is also important. GIS enables management and complex manipulations of a wide range of information types and is being adopted by mines ministries in most of the leading mineral-producing provinces. Compatibility of CAD and GIS technologies within industry and government will be essential for improving access to Canada's wealth of mineral resource data.

CAME'92

Under the theme *CAD: From Mapping to Mining*, and sponsored by six geoscientific and mining societies, Computer Applications in Mineral Exploration (CAME), together with the Prospectors and Developers Association of Canada (PDAC), is holding a two-day meeting on March 28 and 29, 1992, as a pre-convention activity to the 60th Annual PDAC Convention in Toronto. The first day of CAME'92 is devoted to technical presentations including overviews of CAD technology in exploration, mining and other industries, as well as case histories on its application presented by Inco, Noranda and Placer Dome. The use of CAD/GIS within provincial mines ministries will also be discussed. The second day focuses on training needs and features a hands-on training session. A meeting of all interested parties on the issue of data interchange standards is scheduled during the PDAC Convention.

This article was prepared by Normand Champigny, Senior Consultant with Coopers & Lybrand's National Mining Practice, and Dr. William N. Pearson, President of the consulting firm Pearson & Hofman Associates Ltd. Both authors are members of the CAME'92 Organizing Committee.

VMS Short Course - April 7-10, 1992 Mineral Deposit Research Unit - UBC

Volcanogenic Massive Sulphide Deposits: Environments of Deposition and Preservation

Dani Aldrick, B.C. Geological Survey

The Vancouver-based MDRU has just hosted the ninth in a series of successful short courses. This most recent course consisted of an in-depth review of volcanogenic massive sulphide deposit settings and characteristic features, augmented by background information, several camp-scale examples provided by the primary researchers of each district, an up-to-the-minute review of recent seafloor sulphide discoveries in felsic volcanic environments, and a field trip to the most rapidly developing VMS camp in North America.

The marathon 15-hour lecture program was presented over two and a half days. Course instructors included Dr. J.M. Franklin and Dr. A.G. Galley (Geological Survey of Canada), Dr. R.L. Morton (University of Minnesota, Duluth) and Dr. H.L. Gibson (Laurentian University, Sudbury). The program was adapted to include a concurrent UBC lecture by Dr. S.D. Scott (University of Toronto).

Jim Franklin provided an introductory overview of the course content and objectives. The program focussed on each of the main physical elements of a VMS-producing hydrothermal system. The main topics were:

- Subvolcanic intrusions (heat sources)
- High temperature reaction zones
- Insulating caps
- Conduits
- Near-floor interaction zones (alteration pipes)
- Vent sites and sulphide deposits (high and low-temperature)
- Distal fallout and the hydrogenous zone

Processes of metal transport and ore deposition discussed within this framework included: metal sources and source regions; fluid transport and transport paths; depositional mechanisms; post-depositional preservation; and post-depositional changes.

In keeping with the "short course" concept, a thorough grounding in the principles of sub-aqueous (passive) volcanology, sub-aerial (explosive) volcanology, specialized mapping techniques in volcanic terranes, and the application of mass balance calculations to altered rocks were provided. Detailed 'case histories' from the Noranda, Sturgeon Lake, and Snow

Lake camps were presented by Harold Gibson, Ron Morton and Alan Galley. Steve Scott provided a first look at new seafloor sulphide discoveries in the felsic-volcanic-dominated Manus and Woodlark basins in the southwest Pacific.

Among several points in his course summary, Jim Franklin highlighted some important Archean mineral deposits that resist classification as VMS-type deposits despite decades of effort by researchers. He proposes the provocative (heretical?) concept of Archean epithermal systems to account for the Favourable Lake and Selbaie ore deposits and the broad mineral belt of the Onaman district.

The field trip began with a sunny ferry ride to northern Vancouver Island (appreciated most by the course instructors who were still waiting for spring to reach the far east). The entire geological team at the Myra Falls minesite of Westmin Resources Limited was mustered to ensure a thorough introduction to the property geology, mineral deposits and mineral potential. Steve Juras, Jim MacMillan and Mike Becherer led the underground tours of the new HW and historic Lynx orebodies. Rick Walker capably fielded an avalanche of questions from the contingent of enthusiastic new VMS 'experts' during examination of diamond-drill intersections on the recently discovered Battle and Gap deposits.

Lured by the reputation of the deservedly famous bars of Nanaimo, short-course participants compared notes at a seaside pub before embarking on the moonlit cruise back to Vancouver.

[*Ed. note: When the MDRU was established at UBC two-and-a-half years ago, their mandate included, as a principal function, organization of short courses and workshops to provide opportunities for professional up-grading among exploration geoscientists. Already exceeding their goal of three short courses per year, topics have included geostatistics, sampling, metallogeny of the Canadian Cordillera, hydrothermal alteration, fluid inclusions, structure of ore deposits, lithogeochemistry and VMS deposits. Upcoming courses are:*

- MDRU SC #10 - *Australian Volcanic-hosted Massive Sulphide Deposits September 28-29, 1992*
- MDRU SC #11 - *Geophysics, Remote Sensing and Data Integration for Geologists November, 1992*
- MDRU SC - *Volcanoes and Ore Deposits April, 1993*
- MDRU SC - *Structural Geology in Mineral Exploration November, 1993*

Call Sonya Tietjen at MDRU for further details - (604) 822-6136]

COURSE HIGHLIGHTS

from notes by D.J. Aldrick and T. Höy

A wealth of important data and ideas on VMS deposits has accumulated while awaiting the slow process of writing, drafting, editing and publication. A primary value of any short course, in addition to the extensive personal experience and insights of the researchers, is the opportunity to get an up-to-date review of all this information that is "in the pipeline" and flowing towards formal publication. From the perspective of a geologist who last walked on the Canadian Shield in 1974, there have been two major revolutions in our understanding of the genesis and setting of VMS deposits. First is the discovery of active, sulphide-depositing hydrothermal vent zones on the seafloor. These are now well documented in the literature, although additional information is rapidly accumulating. Second is the progressively broader picture of the scale and features of ancient VMS-producing hydrothermal systems. An overview of this latter category follows.

Camp-scale features in several greenstone belts have now been recognized as important components of the VMS genetic model, and are therefore important exploration guides within a prospective volcanic belt. Historic proximal exploration guides for VMS deposits such as 'mill rock', local paleotopographic and structural controls, favourable horizons (exhalites), footwall stringer zones or feeder pipes, and alteration envelopes have been supplanted by the recognition of subvolcanic (synvolcanic) plutons, cauldron/caldera settings, recharge zones, regionally extensive silica alteration blankets and long-lived structural conduits (growth faults).

Subvolcanic (synvolcanic) intrusions were once included in VMS models as a distant, hypothetical 'point source' for heat. These important intrusive rocks are now frequently identified with the assistance of geochronology, sophisticated petrochemistry and careful textural studies. Plutons underlie ore horizons at an average depth of only two kilometres and may have a lateral extent of up to several kilometres. There is a marked correlation between the horizontal extent of these plutons and the lateral limits of the distribution mineral deposits in the overlying mining camp (Noranda, Sturgeon Lake). Therefore, identification and delineation of subvolcanic intrusions can help define the lateral limits of prospective stratigraphy within a much more extensive volcanic belt. Subvolcanic intrusions typically have a composition similar to the most felsic end member of the volcanic cycle; they may underlie and correlate with the extent of a large caldera or 'cauldron' structure preserved in the overlying strata. These laterally

extensive intrusions provided a regional heat source that elevated the thermal gradient in the overlying strata. Experience suggests that all VMS lenses in a camp will be developed within the overlying 2 to 3 kilometres of stratigraphy. Subvolcanic (synvolcanic) intrusions are recognized by: having similar metamorphic and tectonic histories as the host volcanics; minimal contact metamorphic aureoles (due to rapid convective dispersal of heat); local zones of intense hydrothermal alteration associated with syndepositional faults; very complex intrusive history recorded as multiple intrusions of varying chemistry (tronjdhemites to gabbros); similar immobile element chemistry as all the overlying volcanic lithologies; local obscure 'gradational' or 'diffuse' boundaries with adjacent volcanic rocks.

Cauldron or caldera settings in both modern and ancient VMS districts are now considered one of the prime structural controls to the localization and lateral limits of entire mining camps (see subvolcanic intrusions and growth faults).

Recharge zones or reaction zones are preserved as camp-scale and as even broader regional-scale semi-conformable alteration zones that can characterize the entire camp. Semi-conformable alteration zones (SCAZ) may have a lateral extent of tens to hundreds of kilometres, and are commonly on the same order of magnitude as the lateral extent of the mining camp. Alteration is generally less intense than the disconformable alteration pipes that underlie seafloor discharge zones. SCAZ are thought to develop from downwelling or 'recharge' seawater that, in addition to stripping/leaching certain elements and metals from the country rocks, dumps out its characteristic SMOW-type background levels of dissolved elements as it reacts with wallrocks at progressively increasing temperatures. SCAZ typically display large-scale vertical zoning (layering) preserved as (1) Mg-K (smectite-illite) alteration at upper (shallower) levels that corresponded to the seawater-paleosurface interface; (2) Na metasomatism (albite or 'spilitization') where $T > 300\text{C}$; and (3) Ca-Si alteration (epidote-quartz) where $T > 350\text{C}$, developed at depths approaching the subvolcanic intrusion. The silica-dumping is triggered by the reverse solubility of silica at $T > 380\text{C}$ and $P < 700$ bars. Metal-transporting hydrothermal fluids that result from this series of reactions are consequently thought to have a mixed marine and magmatic origin. Recognition of SCAZ zones may be complicated by an overprinting of the silica alteration blanket (see below), and by regional metamorphic alteration assemblages.

Regionally extensive silica alteration blankets are preserved as irregular but crudely horizontal, patchy infillings of original porous stratigraphy. These silica blankets form an impervious hydrologic 'cap' and thermal insu-

lating blanket at shallow to intermediate depths within the volcanic pile. Consequently the convecting hydrothermal fluids trapped beneath this impermeable zone can only vent to the paleosurface along growth-fault conduits that penetrate this barrier.

Long-lived structural conduits or growth faults allow return of metal-enriched hydrothermal fluids to the seafloor along focussed channelways. Growth faults may exist anywhere within the caldera/cauldron structure but are most strongly developed along main ring fracture that marks the bounding edge of the cauldron/caldera complex. The extensive fractures may be preserved through stratigraphic piles greater than 4 kilometres in thickness. They are sometimes the locus for synvolcanic dikes of varying composition (reflecting the varying composition of subvolcanic plutons) and are frequently characterized by localized intense alteration including Mg, Fe and Si enrichment and Na depletion. There are numerous examples of growth faults or conduits associated with "stacked" massive sulphide lenses at several different stratigraphic levels within a complex volcanic pile, indicating that the conduit was able to re-establish or rejuvenate itself after blanketing by a series of volcanic flow and tuff units.

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Thunder-Jug Reading!

A quick sampling of current books & articles which may be of interest to MDD members

ENVIRONMENT

U.N. (1992): **Environmental Aspects of Selected Non-Ferrous Metals (Cu, Ni, Pb, Zn, Au) Ore Mining**, United Nations Environmental Programme, Technical Report Series, No. 5, UNEP IE/PAC, 39-43 Quai Andre Citroen, 75739 Paris, Cedex 15, France. 116p. FF250.

NORTH AMERICA

Davis, M.W. and Randall, K.S. (1991): **Gold Occurrences in Colorado**, The Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, Colorado, 80203, USA. \$12.00.

M.E.G. (1992): **Late-Stage Gold Projects**, Metals Economics Group, Halifax, Nova Scotia, Canada.

LATIN AMERICA

N.M. (1992): **Mining in Latin America**, The Northern Miner, Special Edition, April 20, 1992.

SOUTH AMERICA

Bruce, C. and Gustavson, J. (1992): **Economic Geology of Bolivia**, Gustavson Associates, 5757 Central Avenue, Suite D, Boulder, Colorado, 80301, USA. Free.

M.J. (1992): **Gold in South America**, The Mining Journal, London, April 17, 1992, V.318, N.8169, p.285-287.

EUROPE

G.G.U. (1991): **GEODATA - Geological Information on Greenland**, Part 2 of Trade and Industry in Greenland, Gronlands Baseselskab A/5, Kristianiagade 1, P.O. Box 2669, DK-2100 Copenhagen 0. 20p. Free

G.G.U. (1992): **List of Publications Geological Survey of Greenland**, Publication Sales, Geological Survey of Greenland, Oster Volgade 10, DK-1350 Copenhagen K, Denmark. 28p. Free.

M.J. (1991): **Greenland A Handbook for Investors in the Mining and Petroleum Industries**, Mining Journal reserch Services, The Mining Journal Limited, 60 Worship Street, London, EC2A 2HD, U.K. 190p.

ASIA

A.P. (1992): **Geomark Geological Database of the U.S.S.R.**, Aurora Pacific, 212-470 Granville St., Vancouver, B.C., V6C 1V5, Canada.

SOUTHEAST ASIA

M.J. (1992): **Mineral Potential of the Philippines**, Mining Journal, Attn. Dr. W.G. Prast, 60 Worship Street, London, EC2A 2HD, U.K. 200p.

AFRICA

I.M.R. (1991): **Angola Mineral Resources Database**, International Mineral Research, Suite 16, 5 St. Neots Avenue, Sydney, New South Wales, 2011, Australia. 350 pages. US\$2,100.00.

M.J. (1992): **Angola's Mineral Resources**, Mining Journal, London, January 24, 1992, V.318, N.8157, pp.63-65.

Ore Deposits, Tectonics and Metallogeny in the Canadian Cordillera

British Columbia Geological Survey Branch,
Paper 1991-4; Price \$60.00

by: W.J. McMillan, T. Hoy, D.G. MacIntyre, J.L. Nelson, G.T. Nixon, J.L. Hammack, A. Panteleyev, G.E. Ray and I.C.L. Webster

This 276-page, multi-authored publication comprises nine chapters: an introduction, an excellent summary of the tectonic evolution of the Canadian Cordillera and the tectonic setting of mineral deposits within it, followed by overviews of sedimentary exhalative, carbonate-hosted lead-zinc, volcanic massive sulphide, ultramafic-mafic, epithermal and mesothermal gold, skarn, and porphyry deposits. Those active in the study of mineral deposits, i.e. professors, students, consultants, resource analysts, and explorationists, should make a concerted effort to make certain this timely and extremely useful publication is on their shelf. Furthermore, other provincial geological surveys contemplating similar mineral deposits overviews, should study it carefully to avoid its shortcomings but, at the same time, capitalize on its many strengths.

At the outset it is made clear that the title of this paper refers primarily to plate tectonics. Following an excellent five-page summary of Cordilleran tectonics, a short discussion focusses on mineral deposit settings in plate tectonic terms: deposits are set in either island-arc or oceanic settings. This results in the sedimentary-exhalative and carbonate-hosted deposits being left somewhat orphaned relative to plate tectonics (although, curiously, they are briefly mentioned in the summary of this chapter). Mineral deposits are then presented, not in groups according to their tectonic setting as might have been anticipated, but according to a smorgasbord of other criteria. These range from lithology of host rocks (carbonate, ultramafic-mafic, porphyry, volcanic), to element (gold), and genesis (volcanogenic, skarn). This results in the inevitable overlap replete with caveats (the reader is warned that skarn Pb-Zn is omitted from carbonate-hosted Pb-Zn; skarn Au is omitted from mesothermal Au) and mild confusion (deposits referred to as sedimentary exhalative (SEDEX) in one chapter are carefully described as Kootenay Arc and Shuswap type in another). By grouping deposits in this manner, this reviewer felt the authors missed a golden opportunity to discuss the metallogenic relationships, or lack thereof, between different deposit-types in the same tectonic setting or belt. In defiance of the title, the discussions of four of the seven deposit-types cover only those in British Columbia rather than the entire Canadian Cordillera, leaving the reader to wonder whether the authors were trying to avoid potential wrangles over federal-provincial jurisdiction!

Editorially, the volume is excellent with only a few irritating exceptions: this reviewer counted eleven location maps, one panoramic photo, and five photos of polished ore slabs, all without scale, a cardinal sin in geological publications; and one index map, clearly labelled SEDEX deposits of the Canadian Cordillera, has been rendered unnecessarily busy and confusing by the inclusion of Mississippi Valley-type and volcanogenic massive sulphide deposits.

The strengths of the paper, fortunately, far outweigh its shortcomings. With one exception (carbonate-hosted lead-zinc), the mineral deposit chapters are essentially mini short courses on the deposit-type in question, placing B.C.-Cordilleran deposits in the context of world examples, presenting genetic models, extensive discussions of source rocks, chemical and physical parameters relating to mode of transport

and deposition, *etc.* This in-depth coverage is reflected in the length of the papers which ranges from 23 to 50 pages. The chapter by Panteleyev on gold, in particular, is an excellent example of the short course approach with the author obviously having combined his wide knowledge of B.C. deposits with information derived from the seemingly endless gold symposia held around the world during the past ten years. Those in the teaching profession will exult in the many, many clear, large location maps, geological cross-sections and plans, and schematic genetic diagrams included in all chapters. Many of these could easily have been reduced without loss of detail but, to the predictable delight of many readers, the editor(s) chose to print them large, rendering them easily usable for overhead projection, report/thesis preparation, *etc.* Most mineral deposit chapters include information of grade, tonnage, reserves, production, geological characteristics, tectonic setting, host rock lithologies and ages, *etc.* in tabular format. Also included in many tables are the computer-based B.C. MINFILE or Yukon CANMINDEX mineral deposit file numbers; this, combined with the several pages of references, permits and facilitates follow-up research and documentation.

In summary, one could only wish other provincial and territorial surveys would recognize the benefits which would accrue from the time, effort, and funds required to publish an analysis such as this one and be inspired to do likewise. The B.C. Geological Survey Branch is to be commended for leading the way in presenting their mineral heritage in a modern metallogenic context. Well done!

*Review by D.F. Sangster,
Geological Survey of Canada, Ottawa*

International Mining Industry Highlights

*Information courtesy of
Ontario Ministry of Development & Mines
& U.S. Bureau of Mines*

- The Australian mining industry hopes amendments to the Aboriginal Land Right's Act will boost mining and exploration activity in Australia's Northern Territory. Exploration declined sharply as a result of concerns regarding obtaining the rights to mine a deposit once it has been delineated. Problems have arisen because the act does not define the basis for payment, compensation or royalty, to Aboriginal groups.
- The South African government will form a working group to study enhanced incentives for mineral prospecting and to consider other aspects of mining taxation. The need to find and develop new ore bodies, and open new mines in order to replace those approaching reserve depletion, has been exacerbated by recent economic conditions. Mine lives have been shortened by the need to mine higher grade ore in order to maintain profitability. South Africa now has the highest operating costs of major gold producing nations. Cost-cutting measures have resulted in the loss of 80 000 jobs in the last two years in South Africa.
- The Metal Mining Agency of Japan (MMAJ) and the Japan International Cooperation Agency (JICA) have reached an agreement with the Mongolian State Geological Center to assist in exploration and development of non-ferrous metal resources in Mongolia, MMAJ announced.

Under the agreement, MMAJ is to cooperate with the Mongolian government to carry out a 3-year geological survey on a 500,000 square-kilometre area known as Uudam Tal (flat plain) in southeast Mongolia. JICA is to provide funding of the 3-year geological survey project, estimated at \$2.2 million.

- A potentially rich source of rare earth's (lanthanide group elements) has been discovered in the Pea Ridge iron mine near Sullivan, Montana. Rare-earth oxide concentrations of up to 12% are reported. The ratio of heavy to light rare earth elements is 1:4. This compares to 1:100 at Molycorp's Mountain Pass mine in California. The United States accounts for nearly half of world rare-earth production but only two US companies are involved; Molycorp is the only primary REE producer.
- World cobalt demand is expected to exceed supply in 1992 for the fifth consecutive year, according to a report issued by Roskill Information Services Ltd. The year-end average price of cobalt increased to over US\$30 per pound in 1991 from \$15 in 1990, the result of a 4% decline in production. The shortage of supply is attributed to reduced production from the politically troubled Gecamines Mine in Zaire and supply problems at state-run ZCCM in Zambia, which together account for 70% of the world supply. Roskill predicts a return to historical price levels and a more stable supply situation because of improvements in recovery technology, and new production from operations in Australia, the Philippines and Uganda between 1993 and 1995.
- According to Metals Economics Group, in 1991 Canada had eight gold mine startups, compared to four in the U.S.A. In the preproduction stage Canada had six gold projects, the U.S. 15, Latin America 20, and Australia/Western Pacific 16. **Canada is the only region with more gold projects at all four stages (new producer, preproduction, feasibility and reserve**

development) on hold than are currently active. Ratios of Active to On-Hold are: 0.7:1 for Canada, 1.4:1 for the U.S., 1.9:1 for Latin America and for Australia, 3.6:1 for Africa/Middle East, and 5.2:1 for the Western Pacific.

- A report of a proposed ban on scrap metal export from Russia has caused little concern in the West. As one U.S. shipper put it, With the confusion over there, now nothing is happening. So, if they want to make it official, they can have a ban on exports. Although the former USSR has a technical surplus of scrap, there are serious transport & organizational problems.
- Due to environmental approval problems, Mitsubishi withdrew from the Texas City, Texas, copper smelter project, thus killing it. US\$11 million had already been spent. Mitsubishi's new smelter at Naoshima, Japan, identical to the one planned for Texas City, started up in May 1991, after a 42-day permitting process and 18 months construction. The Houston law firm representing intervenors only stated that they weren't trying to block the project.
- Large new copper reserves were recently announced for the Collahuasi Project in northern Chile, located 4500 metres above sea level. It comprises several deposits and reserves at the Rosario deposit are estimated at more than 1 billion tonnes of primary copper mineralization grading 0.92% copper to a depth of 600 metres. These reserves are overlain by 50 million tonnes of secondary copper mineralization grading 1.5% copper. At Ujina, six kilometres east of Rosario, a preliminary reserve estimate is more than 100 million tonnes of secondary mineralization grading about 2% copper and located 160 metres below surface. At La Grande, 2.5 kilometres south of Rosario, recent exploration drilling intersected significant copper mineralization. The Collahuasi Project is jointly owned by Falconbridge (Chile), Chevron Minera Corporation of Chile and Shell Chile. Falconbridge anticipates completion of a feasibility study in 2 to 3 years and large-scale production could commence by 1997.
- The value of Canadian mineral production fell by 14.6% from 1990. 1991 Canadian mineral production is estimated at \$34.8 billion compared to \$40.8 billion in 1990.
- Venezuelan air force planes attacked a Brazilian gold miners' camp inside Venezuelan borders. Mineral-rich Yanomani Indian land, which overlaps the border, was put off limits to mining by Brazil last November, causing the miners to cross the border into Venezuela. There have been a number of other incidents. [Ed. note: *perhaps black flies, bears and politicians aren't so bad after all!*]
- As a result of changes to economic and trade policies, the inflow of private capital to Latin America is estimated to have tripled last year, reaching US\$40 billion.
- The Parliament of the Russian Federation is drafting new mining and petroleum resource legislation, as well as laws regarding privatization of the mining and petroleum industries. A London-based law firm has won a contract from the European Commission to advise the Russian parliament on how to draft the legislation to best attract foreign investment in the two industries, to assist with the drafting of the laws, and to advise on their administration.