THE GANGUE

The Newsletter for
Mineral Deposits Division
Geological Association of Canada

No. 29 *October, 1989*

DUCK POND DEPOSIT, Newfoundland

INTRODUCTION

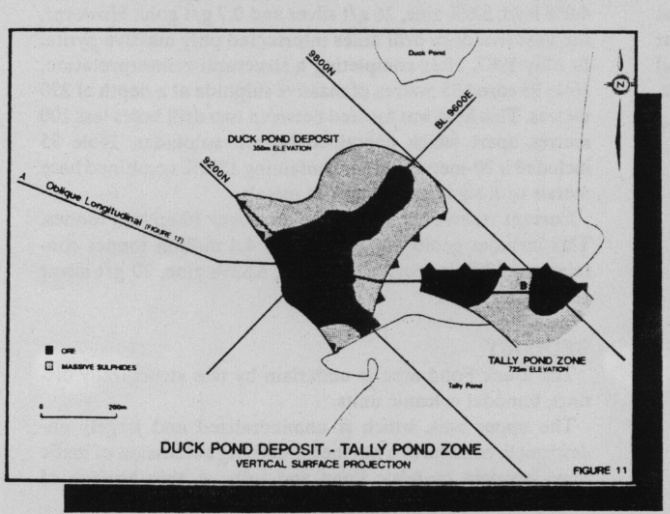
In may of 1987 the Tally Pond Joint Venture, after eight years of mineral exploration in the Central Mobile Belt of Newfoundland, intersected 55 metres of massive sulphides containing economic grades of copper, lead, zinc, gold and silver.

Located in Atlantic Canada, Newfoundland has experienced a long history of mineral development dating from the late 1700s. The Duck Pond base metal deposit, situated almost in the island's geographic centre 35 kilometres southwest of the Buchans mining camp, represents the continuation of this tradition of developing rich mineral resources.

REGIONAL GEOLOGY

Geologically, Newfoundland can be divided into four tectonostratigraphic zones: the Humber and Avalon zones, which represent ancient continental margins; the transitional Gander Zone; and the Dunnage Zone, comprised of thick successions of island arc and ophiolite stratigraphy records the history of the formation and the destruction of the ocean Iapetus. This Central Mobile Belt is the focus of mineral development and exploration activity in Newfoundland.

Central to the Dunnage Zone is the Victoria Lake Group and its components, the Tulk's Hill and Tally Pond volcanic belts. Collectively they represent a thick island arc sequence of volcanics, volcaniclastics and epiclastic rocks ranging from Late Cambrian to Middle Ordovician in age.



DUCK POND DEPOSIT - TALLY POND ZONE
VERTICAL SURFACE PROJECTION
FIGURE 11

DISCOVERY

The discovery of the Duck Pond deposit can be traced to 1971 when the earlier Noranda/Nalco joint venture discovered the 15-million tonne Point Leamington massive pyrite deposit.

The Tally Pond volcanic belt is currently explored under the terms of a 60/40 joint venture between the operator, Noranda Exploration Company, Limited and its partner, BP Resources Canada Limited.

Exploration work carried out over the southern extensions of volcanic stratigraphy defined the Tally Pond volcanic belt; soil and silt geochemistry highlighted its mineral potential. Noranda carried out extensive exploration in the belt and discovered the first base metal sulphide occurrence at Burnt Pond in 1974. During the period 1974 to 1979 prospectors working for Noranda discovered mineralized outcrop and

HAPPY BIRTHDAY GANGUE!

I'm told editors, by nature, know everything, are fantastik spelers, superlative writers, modest (of course!) and are THE Number One choice for inviting to social events!

Alas, this past month I slipped; my files of past issues of The Gangue were somewhat incomplete so I asked around for copies of missing issues. Linda Thorstad, MDD Secretary, kindly supplied them and I managed to skim through to discover that *The Gangue, Number 1* was **issued in July of 1979 - exactly ten years prior to issue Number 28.**

Nothing worse than missing a birthday!

For those interested, **the Mineral Deposits Division is this month celebrating its eleventh birthday, having been officially launched at the G.A.C. Annual Meeting in Toronto, October, 1978.**

One of the more interesting observations in reading the first newsletter is the obvious interest in porphyry copper deposits ten years ago. What goes around, comes around and here we are with issue 28 and 29 delving again into the world of porphyry deposits.

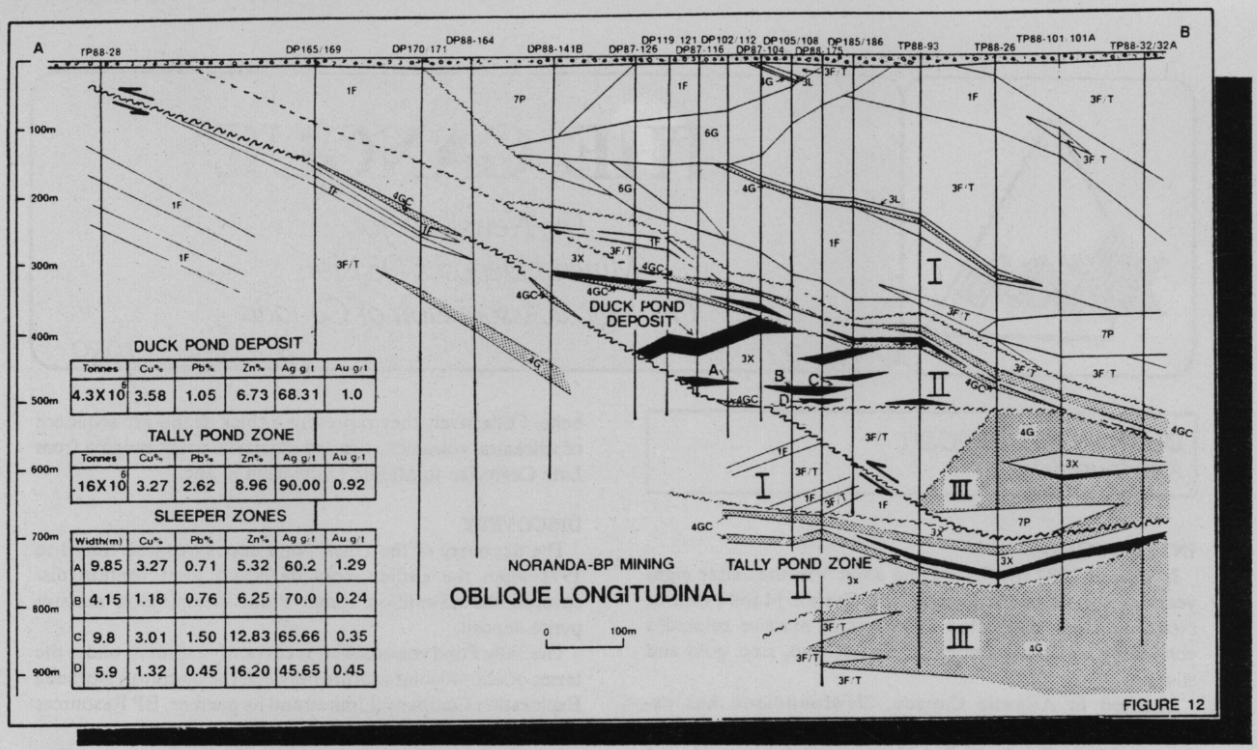


FIGURE 12

numerous massive sulphide boulders which assayed up to 10 per cent copper and 15 per cent zinc. Airborne geophysics and diamond drilling were also completed.

In 1979 the Tally Pond joint venture between Noranda and Abitibi-Price was formed. Abitibi-Price held leased ground covering areas of the Tally Pond belt (BP Canada purchased Abitibi's mineral rights in 1985). Shortly thereafter, in 1981, the Boundary deposit was discovered.

By 1983 drilling outlined three discrete massive sulphide lenses containing almost 500 000 tonnes of 3.5% copper, 4.0% zinc and 1.0 ounce per metric tonne of silver. This discovery led to exploration in the immediate vicinity of the Boundary deposit for further massive sulphide lenses. The exploration was focused by an understanding of local stratigraphy and a comparison with established models for other massive sulphide deposits.

Previous work, including geophysics and geochemistry, was compiled at large scale. Three diamond drill holes(1976) near Duck Pond were relogged. The hydrothermal alteration and lithogeochemical signature of the felsic volcanic package, identified in the core from these drill holes, were recognized to be similar to that of the altered felsic rocks near the Boundary deposit and of those documented in other established base metal camps.

The establishment of a coherent geological model which incorporated observed stratigraphy and hydrothermal alteration, along with anomalous geochemistry and geophysics, prompted a stratigraphic drill program near Duck Pond in late 1985. After an initial miss, the second drill hole intersected one metre of massive sulphides and confirmed the hypothesis of a sulphide mineralized system. The next three drill holes intersected up to 12 metres of massive sulphides which proved to be barren of base metals.

In mid-1986 the sixth drill hole contained the first significant base metal intersection since the discovery of the Boundary deposit. A 12-metre section (Hole 85) assayed 2.6% copper, 4.0% lead, 5.6% zinc, 26 g/t silver and 0.7 g/t gold. However, the next five deep drill holes intersected only massive pyrite. In May 1987, after completing a structural reinterpretation, Hole 95 cored 55 metres of massive sulphide at a depth of 290 metres. This hole was located between two drill holes less 100 metres apart which contained barren sulphides. Hole 95 included a 20-metre section containing 13.6% combined base metals with significant precious metals.

Current reserves at Duck Pond are over 10 million tonnes. This includes geological reserves of 4.4 million tonnes containing 3.58% copper, 1.11% lead, 6.83% zinc, 70 g/t silver and 1.02 g/t gold.

GEOLOGY

The Duck Pond area is underlain by two structurally distinct, bimodal volcanic units.

The upper unit, which is unmineralized and largely undeformed, consists of a northeast-dipping succession of mafic flows overlain by felsic flows and tuffs. A thin horizon of

Erratum

The Gangue, No. 28, page 16, Witwatersrand sediments should range 2750 to 3100 Ma in age, not the 1750 Ma reported. Similarly on page 17 the terminal chapters of basin formation took place from 2750 to 2850 Ma, not the 1750 to 1850 Ma reported.

Alas, your editor inadvertently eradicated 1000 million years from the geological record. This is equivalent to erasing all known life forms on earth since the late Proterozoic. Henceforth the Archean shall remain the oldest rocks on earth.

Our apologies to Dr. Pretorius for the typos.

C.O.G.S.

Profile of the Computer Oriented Geological Society

COGS was organized in 1982 in Denver, Colorado, as a society of working geologists who are interested in using computers for geology. Since that time we have grown to 1500 members worldwide, including about 200 members in Canada. The geological specialties of our members are about 35% petroleum related, 30% groundwater and hazardous waste related, 20% in mining and minerals exploration and the balance in a wide variety of other geological fields, including members in academic and government survey positions. COGS is unique in that we carry information of interest to all geological specialties, not just to one discipline.

Our purpose is to act as a clearing house of information on the use of computers in geology. Our emphasis is on practical problem solving for situations routinely encountered by geologists. Most discussion is on microcomputer applications, with MS-DOS and MacIntosh implementations being most often covered. Members receive a monthly newsletter, COGSletter, and we also publish a technical journal (COGS Computer Contributions). We publish articles on current hardware, general purpose programs used for geological purposes (e.g. drawing programs, spreadsheets), geological databases, and on software specialized for geological problems. The latter include groundwater modeling, petroleum exploration data handling, structural geology, gravity & magnetics, etc., etc.

COGS distributes public domain software for a wide variety of geological purposes, including a mapping and contouring program, decline curves for oil wells, geostatistical programs and many others.

We have a bulletin board, which includes message areas and geological software from a variety of sources. Recently we entered into a cooperative agreement with the Society of Mining Engineers to operate the bulletin board, and this should lead to a big increase in mining-related software and discussions on that board. You are not required to be a member of COGS or SME to use the board but we do encourage you to join. The telephone number is (303) 740-9493.

From time to time, **COGS sponsors short courses in using computers for geological purposes.** In 1989, we have sponsored "Microcomputers in Mining: a Hands-on Course" and "Spreadsheets: The Geologist's All-Purpose Tool". This autumn we plan to hold a course in Denver on the MODFLOW groundwater modeling program.

All of these activities are based on contributions of articles, programs, or time and interest by our members. If you have an experience or a program that you think might be of interest to other geologists but you are not quite sure how to get the word out, please think of COGS! This truly is a "member-supported" professional society.

You may contact COGS at (303) 751-8553 or at the following mailing address:

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...R. Spencer Ramshaw
Hamilton, Ont.

graphitic sediment marks a hiatus between these volcanic units. These lithologies are cut by a shallow dipping gabbro dike which intruded along a minor reverse fault. The base of the upper unit is highly deformed and is characterized by structural intercalations of mafics and felsics, felsic dikes, and a deformation-related carbonatization/silicification overprint.

The stratigraphy of the mineralized lower unit comprises a southeast-dipping, felsic volcanic pile which is encompassed in a northwest directed thrust zone. As a result, little more than the most general stratigraphy is preserved. The massive sulphide horizon underlies, within 50 metres, a cataclastically deformed, upper-graphitic marker sediment which may in part be structurally emplaced. North of the main sulphide occurrence the sediments and sulphides are less deformed and preserve original stratigraphic relationships.

Distal footwall alteration consists of silicification and sericitization replaced by locally intense, sulphide-bearing, chlorite veining closer to the deposit. Unique, late-stage chaotic calcite veins halo the massive sulphides and the host rhyolite contains 5 to 40 per cent stringer pyrite with minor base metals.

Low angle thrusting has, locally, either completely separated the orebody from its underlying feeder zone or overthrust the feeder zone on the massive sulphide horizon.

SULPHIDE DEPOSIT

The orebody averages 20 metres in thickness and extends over an area 500 metres by 400 metres. The massive sulphides consist of barren, medium grained pyrite as a groundmass to numerous zones of highly deformed and interlaminated, fine grained pyrite, chalcopyrite, sphalerite and galena.

The Duck Pond deposit appears to have undeformed western and northern margins containing ore grade massive sulphides which grade laterally into barren, massive pyrite, stringer mineralization and finally into a chaotic, calcite veined zone. To the north, well preserved bedded sulphides and polylithic sulphide conglomerates attest to the exhalative nature of the deposit.

py
cpy
sphal
galena
Exhalative

The ore-grade core is highly deformed and recrystallized on the eastern and southern margins and it is truncated by west and south-directed thrusting respectively. The west-directed thrusting probably brought the detached, eastern portion of the deposit to higher levels where subsequent erosion may explain the high grade boulders found on the property. The detached southern portion of the deposit has apparently been intersected by deep drilling to the northeast, as the Tally Pond Zone. This much smaller deposit has not yet been completely defined by drilling. The stratigraphy of the Tally Pond Zone persists to the south and further drilling of this horizon bodes well for the discovery of more ore lenses.

PROLOGUE

Exploration continues at Duck Pond and although the deposit has been delineated, the favourable volcanic stratigraphy continues to be explored for other ore deposits using deep, stratigraphically controlled drilling.

Re-evaluation of drill core and structural modelling should result in a better understanding of the stratigraphy and the eventual definition of further stratigraphic targets.

The Tally Pond joint venture is proceeding with feasibility studies, including metallurgical and engineering work. Noran-

da and BP Canada are strongly committed to environmental protection and have initiated base line research, to evaluate the environmental impact of mine development, as part of the Project Registration Process in Newfoundland.

The Duck Pond discovery represents a 10-year commitment by Noranda and BP Canada to further exploration and mine development. It illustrates the positive results of dedication and persistence to a favourable geological environment.

... Dan MacInnis
Colin MacKenzie
Gerry Squires

CU-AU PORPHYRY WORKSHOP
April 5, 1989, Vancouver

The following articles are the second installment of articles presented at the Cu-Au Porphyry workshop in Vancouver. Please refer to The Gangue No. 28 for the first three articles.

Iron Mask Batholith & Associated Fe-Cu-Au Deposits

The Lower Jurassic Iron Mask Batholith is a composite alkaline intrusion located at the north end of the Nicola Volcanic Belt immediately west of Kamloops in south-central British Columbia. The batholith consists of two major bodies: the larger Iron Mask pluton to the southeast and the smaller Cherry Creek pluton to the northwest.

Extensive Cu-Au porphyry deposits of the alkalic class are hosted by later phases of the batholith, and include Afton (24.4 Mt @ 0.91% Cu and 0.020 oz/t Au), Ajax (27Mt @ 0.46% Cu and 0.01 oz/t Au), Big Onion (3.6Mt @ 0.71% Cu and 0.012 oz/t Au), Pothook (2.6Mt @ 0.35% Cu and 0.021 oz/t Au), and Crescent (1.3Mt @ 0.46% Cu and 0.006 oz/t Au).

Extensive zones of pervasive or vein controlled sodium silicate (albite), potassium silicate (potassium feldspar), propylitic (chlorite, epidote, carbonate and pyrite) and carbonate alteration (ankerite) are associated with these deposits.

The Iron Mask Pluton consists of four major intrusive phases, the Iron Mask Hybrid, Pothook, Sugarloaf and Cherry Creek units, which range in composition from mafic agmatite and coarse grained gabbro to microsyenite porphyry. Field relationships, and major element geochemistry indicate that all four phases resulted from fractional crystallation of an original gabbroic magma under conditions of high oxidation and continuous crystallization of magnetite. K-Ar age dates of all four phases range from 194 to 2046 Ma, supporting these interpretations.

Emplacement of the Iron Mask and Cherry Creek plutons was controlled by a major northwest trending fault system and the plutons were emplaced at an epizonal to subvolcanic level in an active structural zone. The batholith is essentially coeval with, and is considered to be co-magmatic with, Nicola Group volcanic rocks.

Emplacement of the younger phases of the batholith, particularly the Sugarloaf unit and the more felsic and porphyritic phases of the Cherry Creek unit, was dominated by existing northwesterly trending structures, and these units are confined to the faulted edges of the Iron Mask pluton or along major cross-cutting faults.

Copper-gold mineralization is widespread throughout the batholith and closely associated with the Sugarloaf and Cherry Creek units. Bodies of Cherry Creek micromonzonite and microsyenite explosion breccia are particularly good hosts for mineralization. Field relationships indicate that copper-gold mineralization was deposited by structurally controlled hydrothermal systems that developed during the final stages of crystallization of Iron Mask magma. K-Ar age dates of hydrothermal biotite coincide with ages from primary biotite, supporting this interpretation. Magnetite lodes hosted by the Cherry Creek unit are titaniferous and apatite rich, and are considered to be immiscible segregations from the differentiating alkalic magma.

Note: Material presented in this paper is based on studies by the author, K.E. Northcote and Y.T.J. Kwong, and on contributions by W.R. Bergey of Teck Corporation, L. Bond of Afton Operating Corporation, M. Osatenko of Cominco Ltd. and N. Vollo, Consulting Geologists.

...V.A. Preto

IRON MASK Cu-Au DEPOSITS

Name	Reserve (Production) M short tons	Cu %	Au opt
Afton	Pit 24.4 (1977-87	0.91	0.020
	U.G. 10.5	1.50	0.030
Pothook	2.60 (1987-88	0.35	0.021
Crescent	1.36	0.46	0.006
Big Onion	Vollo - 2.64	0.84	0.012
	Afton - 3.6	0.71	0.012
D.M.	2.96	0.38	0.007
Ajax	27	0.46	0.01
Iron Mask & Erin	0.182 (1904-28	1.4	?

Porphyry Cu-Mo-Au Island Copper Deposit Vancouver Island, B.C.

The Island Copper deposit, operated by BHP-Utah Mines Ltd. on northern Vancouver Island, is an island arc-type porphyry Cu-Mo-Au deposit that resulted from the intrusion of a 180Ma rhyodacite dike-like body into comagmatic basalts, andesites and pyroclastics of the mid-Jurassic Bonanza volcanics. Initial estimated ore reserves were 283 million tons of ore at 0.52% Cu and 0.017% Mo. The geology of the deposit has been substantially clarified in recent years. Research studies (O. Arcancibia, Ph.D. thesis in prep.), as well as pit and surface mapping and core logging by company geologists, form the basis for the advances presented herein.

Current geological knowledge suggests that the porphyry

system evolved from an early, probably juvenile fluid-dominated stage to one strongly influenced by meteoric waters, as the main heat source cooled and further intrusion and brecciation took place. At least three main stages of alteration-mineralization have been differentiated.

1) AN EARLY STAGE, related to the main intrusion of rhyodacite porphyry, involved the development of outwardly progressing zones:

- a) a stockwork core of quartz-magnetite-amphibole-Na plagioclase;
- b) a biotite-magnetite zone with chalcopyrite, pyrite and molybdenite;
- c) a chlorite zone with pyrite and minor chalcopyrite;
- d) an outermost epidote zone. All are developed in Bonanza Volcanic rocks except the quartz-amphibole-magnetite core, which in addition formed along the margins of the rhyodacite porphyry. The biotite alteration, along with the main copper mineralization, partly overprinted the quartz-magnetite-amphibole core.

2) A STRUCTURALLY CONTROLLED INTERMEDIATE STAGE, superimposed upon the earlier assemblages, was related to the emplacement of a quartz stockwork and is characterized by sericite, chlorite and kaolinite assemblages, with local concentrations of pyrite, molybdenite and chalcopyrite. It is mainly developed in the rhyodacite porphyry and immediate wallrocks. Much of the chlorite overprint currently observed in the pit could have been associated with this stage.

3) A LATE STAGE, related to the emplacement of breccias under extreme base-leaching conditions, is characterized by pyrophyllite, kaolinite, sericite and dumortierite. Further low temperature alteration episodes included "yellow dog" ankerite-calcite veining, widespread zeolite development, and the precipitation of remobilized carbon-bearing organic compounds.

The bulk of copper mineralization was introduced during the early stage, to be followed by the main episode of molybdenum. Almost all of the copper occurs in the form of chalcopyrite, predominantly hosted by biotitized Bonanza Volcanics.

Gold output since production started in 1971 is about 880 000 ounces with an annual rate of slightly higher than 50 000 ounces. This renders Island Copper one of the largest gold producers in British Columbia. Average head-grade in the deposit is about 0.22 ppm Au, with large volumes assaying in excess of 0.4 ppm Au. Only 50% of the gold is recovered in the copper concentrate, which averages 25% Cu and 8 ppm Au. Studies on gold occurrence, gold-contoured values from blast-hole samples, and bulk sampling tests indicate that gold was essentially associated with the early and intermediate stages of alteration-mineralization, although it is not clear whether gold of the latter stage was introduced into the system at that time or remobilized from earlier mineralization. Gold has been observed in the native form, as micron-sized inclusions in chalcopyrite, pyrite, molybdenite and silicates.

Certain features, such as the positive correlation between gold and copper, the overall association of gold with the potassic (biotite-rich) alteration zone, and the high content of magnetite in the system (+8% vol.), are characteristic of most known gold-rich porphyry copper deposits.

ORE GENESIS RESEARCH

Chemical controls on metal ore grades - an essential part of exploration models for economic ore deposits - are being investigated by the Australian Bureau of Mineral Resources using a new approach adapted from chemical engineering. The first application is on hydrothermal tin-tungsten deposits, where ore fluid compositions are being analysed semi-quantitatively by a new heavy-ion analytical facility (HIAF) proton-microscope technique. The work is being carried out in collaboration with CSIRO's Division of Exploration Geoscience.

Authors: J. Perello, J. Himes - BHP-Utah International Inc; O. Arancibia, P. Clark - Queen's Univ;P. Burt, C. Clarke, C. Fleming & A. Reeves - BHP-Utah Mines Ltd.; and, C. Leitch - U.B.C.

MT. MILLIGAN
Alkaline Intrusive Au-Cu Deposit

The Mt. Milligan MBX porphyry gold-copper deposit, 90 miles northwest of Prince George, B.C., has a drill inferred inventory of 100 million tons. Grade ranges from 0.01 to 0.15 oz/t gold and 0.2% to 1.0% copper.

The project is a joint venture between Continental Gold Corp.(70%) and BP Resources Canada Limited (30%). The joint venture holds a large contiguous block of claims covering 42 square miles of the mineral belt, accessible by an allweather, heavy-duty gravel logging road from MacKenzie, 40 miles to the east.

In 1983 and 1984 BP acquired the property by staking and acquisition and identified a gold-copper soil geochemical anomaly approximately three square miles in extent. In 1985 after IP and magnetic surveys over the geochemical anomaly, BP exposed gold mineralization in trenches on the Creek and Esker zones.

United Lincoln Resources Inc., (a Continental Gold Corp. subsidiary) optioned the property from BP in 1986. Lincoln, having undertaken extensive trenching within the soil geochemical anomaly and additional magnetic surveys, commenced diamond drilling on the Creek and Esker zones and discovered the MBX deposit in 1987.

Regionally the property lies within the central volcanic core of the Upper Triassic-Lower Jurassic Takla Group. Takla volcanics are dominated by subaqueous alkalic pyroxene porphyritic andesite and basalt flows and pyroclastics with subordinate intercalated tuffs and argillites. Intruding the volcanic stratigraphy are comagmatic alkaline syenite, monzonite-diorite stocks.

The MBX porphyry gold deposit is situated on the eastern side of a 3,000 foot diameter porphyritic monzonite stock. Mineralization is hosted by easterly dipping pyroxene porphyritic andesite to latite flows, pyroclastics, interbedded

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trachytic tuffs and a 30 to 150 foot thick porphyritic monzonite dike. Mineralization persists into the eastern margin of the monzonite stock but with decreasing grades.

The multi-phase monzonite stock is fine to medium grained with 20% plagioclase laths in an aphanitic potassium feldspar matrix. This is one of three alkaline plutons on the property that form a north-northeast alignment, suggesting a structurally controlled emplacement. The porphyritic character of the intrusive units and the number of dikes is indicative of a hypabyssal subvolcanic environment.

Potassium silicate and propylitic alteration assemblages have formed outwardly from the stock for 1000 and 8000 feet respectively. An early, fine grained felted hydrothermal biotite superimposed on the volcanics is over printed by pervasive grey potassium feldspar. Biotite comprises 10 to 35 per cent of the volcanic units and potassium feldspar up to 50 per cent, while pyroxene is typically replaced by actinolite within the potassic zone. In fine grained laminated tuffs massive potassium feldspar replacement is common. The potassium silicates overprint the enclosing propylitic assemblage which is principally comprised of epidote, carbonate and pyrite. Veinlets of magnetite with minor chalcopyrite post date the main period of sulphide precipitation and are restricted to the potassic zone. Weak but pervasive sericite partially replaces plagioclase phenocrysts in the monzonite stock and in the porphyritic monzonite dike within the zone of potassic alteration. Throughout the MBX deposit, alteration is typically pervasive and veining is infrequent.

Disseminated grains and coalescing grain aggregates of chalcopyrite and pyrite comprise approximately 60% of the total sulphide content. Fracture controlled pyrite-chalcopyrite mixed veinlets are less abundant. Chalcopyrite and pyrite-bearing K-feldspar-carbonate veinlets are relatively rare. Quartz veining is noticeably absent. The distribution of sulphides is zoned but not uniformly. At the north end of the MBX deposit pyrite and chalcopyrite occur in equal concentrations. Bornite, though present, is a minor constituent. Within the west central portion of the deposit the pyrite:chalcopyrite ratio is approximately 3:1. Along the east and southeastern margin of the deposit the pyrite content increases to 5 to 10%, and the pyrite:chalcopyrite ratio is approximately 20:1.

Metal zoning closely parallels that of the sulphides with gold concentrations increasing with the pyrite:chalcopyrite ratio. This relative gold enrichment, coincides with the transition from potassium silicate to the propylitic alteration assemblage.

Both chalcopyrite and pyrite are auriferous and occur as separate grains. Intergrown sulphides are rare, an important positive metallurgical feature. Gold associated with pyrite occurs as small particles on grain margins.

At the West Breccia zone, situated on the western flank of the monzonite stock, an intrusive breccia, comprised mostly of monzonite and a few scattered volcanic clastics, is enclosed by a broad zone of brecciated and fractured monzonite. Within the intrusive breccia pink secondary potassium feldspar is pervasive, however, moving outward from the breccia, the potassium feldspar is fracture controlled. Both chalcopyrite and pyrite occur as fracture fillings and as discrete fine grains partially replacing altered mafic minerals. Chalcopyrite predominates over pyrite and gold concentrations are low.

The Creek, Esker and 79 zones are located within propylitized hornblende-pyroxene porphyritic andesites approximately 1000 feet southwest and 1500 feet west, respectively of the MBX porphyry deposit. These zones are northeast striking, steeply northwest-dipping, tabular bodies of auriferous semimassive to massive sulphides occupying fracture systems radial to the monzonite stock. Each of the deposits comprises three to five subparallel, sulphide-rich bodies, spaced across 200 to 300 feet. Individual structures range from 1 to 10 feet in thickness and grade from 0.10 to 2.89 oz/ton gold and 0.2 to 10% copper. Each zone is open along strike and down dip. The propylitically altered andesites between the individual sulphide bodies carry 30 to 350 ppb gold and 200 to 2500 ppm copper. Silver, arsenic and antimony are present at background concentrations.

Pronounced metal zonation is related to the proximity to the monzonite stock. The MBX porphyry deposit adjacent to the stock, contains less than 10 ppm combined arsenic and antimony. At the Creek, Esker and 79 zones, combined concentrations increase to 300 ppm and to 2000 ppm respectively. Silver shows a similar relationship with concentrations ranging from 1.5 ppm in the MBX zone, to 10 to 40 ppm in the Creek zone, and 60 to 200 ppm in the Esker zone.

Mark Rebagliati, P.Eng., who conceived the original exploration program and Dave Copeland, P.Eng., are Vancouver-based consulting geological engineers who have directed and managed this project to its current stage.

[Ed. Note: Recent news releases from Continental Gold Corp. indicate the Mt. Milligan Cu-Au deposit is a massive, blanket-shaped deposit 4,300 feet long, up to 3,100 feet wide and up to 800 feet thick. Over 150,000 feet of drilling has been completed in 200 holes. Reserves are reported to be in the 150 to 200 million ton range, grading 0.3% copper and 0.02 oz/ton gold].

STEWART - ISKUK BELT
Northwestern B.C.

K-Feldspar Connection: Relationship of K-Feldspar Intrusions to Cu Porphyries and Au Veins, Stewart-Iskut Belt

Hypabysaal copper-gold porphyries and mesothermal to epithermal gold-silver veins in the Stewart-Iskut gold belt are related to Early Jurassic intrusive rocks which are either alkaline or calc-alkaline in composition. In the Premier and Sulphurets areas the intrusive rocks feed and cut a Lower Jurassic volcano-sedimentary sequence of the Hazelton Group. At the Snip, Skyline and Galore Creek deposits the intrusive rocks cut Upper Triassic, Stuhini Group volcanic and sedimentary rocks. Porphyry and vein-type ore deposits are linked by:

1) their spatial and inferred temporal association with intrusive rocks, in particular distinctive two-feldspar porphyry with K-feldspar megacrysts (Premier porphyry is a well documented example)

2) potassic alteration - pervasive sericite, K-feldspar (adularia), and less commonly biotite

3) a structural control, interpreted to be syn-volcanic (ex. Premier and Galore Creek)

At Premier, hornblende-plagioclase-K-feldspar-quartz prophyritic dacite dikes (Premier porphyry), derived from the Texas Creek granodiorite batholith, are emplaced along intersecting northeast and northwest structures. These appear to control volcanic stratigraphy and are interpreted to be synvolcanic faults. The ore consists of quartz-K-feldspar (adularia) veins, stockwork and breccia that follow the same structures as Premier porphyry. Past production at premier is 4.7 Mt at 2.2 g/t Au and 80.3 g/t Ag. Mineralization dies out abruptly near overlying maroon (oxidized) strata, which suggests that ore deposition resulted from mixing of hydrothermal fluid with meteoric water. Silver and gold are most abundant in the upper part of the deposit, abundance of base metals and mineral grain size increase at depth. The sericite alteration zone flares outward toward the top of the deposit. These are classic features of an adularia-sericite epithermal deposit. Gold occurs primarily as electrum that has a close spatial association with tetrahedrite.

Mineralization in the Sulphurets area is controlled by two north-trending structures; the steep Brucejack fault and the Sulphurets fault, whose shallow west dip results in a sinuous map pattern. These, and secondary structures, control Early Jurassic diorite, syenite and granitic intrusions and localize sericite-K-feldspar alteration. An alteration zone of this type hosts the West Zone deposit (0.775 Mt at 12.1 g/t Au and 786 g/t Ag) adjacent to the Brucejack fault. Mineralization is an anastomosing network of vein stockworks and breccia, interpreted to be a silicified shear zone, bounded by intrusive K-feldspar porphyry.

The Kerr deposit (60 Mt at 0.84% Cu, 0.34 g/t Au and 2.05 g/t Ag) occurs within sheared and sericite-altered volcanic rocks that are bounded by splays of the Sulphurets fault. A diorite body, K-feldspar porphyry dikes and high grade Au-Ag-Cu veins are all contained within the north-trending structural zone. The Kerr porphyry deposit contains pyrite, chalcopyrite, tennantite, bornite and chalcocite occurring as disseminations and disrupted quartz veins.

The Snip deposit(Twin zone 1.43 Mt at 21.9 g/t Au) is a mineralized shear zone that trends 120 and dips moderately to the southwest (about 55). Discordant mineralization, that cuts massive feldspathic wackes, comprises pyrite, pyrrhotite, chalcopyrite, sphalerite, galena and arsenopyrite. The ore is both massive and strongly foliated, quartz is commonly brecciated with a crackle texture. Mineralization is restricted to the shear zone and contacts with wallrock are sharp. Potassic alteration is represented by pervasive biotite-flooding and irregular K-feldspar (adularia) replacement of the wallrock.

The Johnny Mountain gold mine, 1 km southeast of Snip, is a structurally disrupted mesothermal gold-bearing quartz vein deposit. Current reserves are 0.622 Mt at 19.5 g/t Au and 0.75% Cu. Silicification and potassic alteration occur along a series of northeast-trending structures in close proximity to an orthoclase porphyry.

The Galore Creek alkalic porphyry Cu-Au deposit (125 Mt at 1.06% Cu, 0.40 g/t Au and 7.7 g/t Ag) comprises 10 tabular to manto-shaped deposits. Mineralization is hosted in volcanics, breccia pipes and K-feldspar megacrystic syenite dikes and plugs. The mineralization and several phases of syenite porphyries are in part controlled by north and northeast

structures, interpreted to be synvolcanic. the deposits are characterized by skarn-type, metasomatic or late magmatic alteration products (epidote, garnet, diopside and magnetite) along with pervasive K-feldspar and biotite alteration, anhydrite and gypsum. Ore minerals consist of pyrite, chalcopyrite, magnetite, bornite and minor sphalerite and galena.

Porphyry and mesothermal mineralization could be incorporated into the Premier ore depositional model. This would suggest synchronous mineralization and depth/temperature dependency in a single stage process. This is probably too simplistic. Intrusive, structural and mineralization histories are known to be multi-stage and the ore fluids probably range from magmatic to mixed juvenile/meteoric. More work needs to be done to answer questions concerning:

1) age, displacement, history of ore controlling fluids
2) relative and absolute ages of mineralization types
3) composition of fluids

The authors acknowledge informative discussions with: R. Britten (Esso Minerals); F. Hewitt (Northair Group); B. Hewton and B. Butterworth (Sulphurets Gold Corporation); R. Nichols, I. Paterson and B. Wolfe (Cominco Ltd.)

...Derek A. Brown
Paul Wojdak

FUTURE MEETINGS, WORKSHOPS & FIELDTRIPS

OCTOBER 1989

14 - 19th **STRATIGRAPHY AND METALLOGENY OF THE SICKER GROUP, VANCOUVER ISLAND.** Workshop and fieldtrips, Nanaimo, B.C. Details: H. Paul Wilton or Nick Massey, c/o B.C. Geological Survey Branch, 220-756 Fort Street, Victoria, B.C., Canada, V8W 3A3. Telephone (604) 356-2818.

NOVEMBER 1989

5 - 8th **WORLD GOLD '89,** Reno, Nevada. Details: Meetings Dept. SME, Box 625002, Littleton, Colorado, USA 80162, Tel. (303) 973-9550.

20 - 21th **MODERN EXPLORATION TECHNIQUES.** Conference sponsored by the Saskatchewan Geological Society. c/o Robert Troyer, SGS Symposium '89, P.O. Box 234, Regina, Saskatchewan, S4P 2Z6. Tel: (306) 787-2562.

DECEMBER 1989

3-5th **ORE MICROSCOPY AND FLUID INCLUSION ANALYSIS SHORT COURSE,** Pullman Washington. Registration Fee $375 U.S. Contact: Dr. Lawrence D. Meinert, Ore Microscopy Short Course, Washington State University, Pullman, WA 99164-2812.

6 - 8th **NORTHWEST MINING ASSOCIATION 1989 ANNUAL MEETING,** Spokane Washington. **One of the highpoints of the mining year!** Details:NWMA, 414 Peyton Bldg., Spokane WA 99201, Tel. (509) 624-1158.

FEBRUARY 1990

6 - 9th **CORDILLERAN ROUNDUP. This is the premier exploration and mining show in western Canada.** Vancouver Hotel, Vancouver, B.C. Details: Jack Patterson, Manager, B.C. & Yukon Chamber of Mines, 840 W. Hastings St., Vancouver. Tel: (604) 681-5328.

MARCH 1990

1 to 11th. **MEXICAN SILVER DEPOSITS EXCURSION, 1990.** Sponsored by Society of Economic Geologists (SEG) in conjunction with SME/AIME Annual Meeting in Salt Lake City, Utah, Feb. 26 - Mar. 1, 1990. Est. cost US$850. Limit 35 participants. Reservations & Information contact: Kenneth F. Clark, Economic Geology Publishing Co., P.O. Box 637, University of Texas, El Paso, El Paso, Texas, 79968-0637, USA. Tel: (915) 533-1966, FAX: (915) 544-7416.

9 - 10th **CAME SYMPOSIUM - Computer treatment of Exploration and Mining Data - Do's and Don'ts.** Fee CdnS125. Details: P&D Assoc. of Canada, Suite 1002, 74 Victoria Street, Toronto, Ont., M5C 2A5. Tel: (416) 362-1969 FAX (416) 362-0101.

9 - 11th **EXPLORATION GEOCHEMISTRY: Design and Interpretation of Soil Surveys.** Fee CdnS400. Metro Toronto Convention Centre. Sponsored by the Association of Exploration Geochemists and the Prospectors and Developers Association of Canada. Contact PDAC: Tel:(416) 362-1969 or FAX: (416) 362-0101

11 - 14th **PROSPECTORS & DEVELOPERS ASSOCIATION Annual Convention.** Theme: Exploration & Development - New Realities. Royal York Hotel, Toronto, Ont., Canada. Contact PDAC: Tel:(416) 362-1969 or FAX: (416) 362-0101.

APRIL 1990

1 - 5th **GEOLOGY AND ORE DEPOSITS OF THE GREAT BASIN,** symposium and field trips, Sparks, Nevada. Details: Geol. Soc. Nevada, Box 12021, Reno, NV., USA 89510, Tel. (702) 786-0870.

MAY 1990

May 14 -15 **FLUIDS IS TECTONICALLY ACTIVE REGIMES OF THE CONTINENTAL CRUST.** Hotel Vancouver, Vancouver, B.C., Preceding 1990 Annual GAC/MAC Convention. Tentative fees $250 ($150 for students). Contact: Dr. B.E. Nesbitt, Dept. of Geology, Univ. of Alberta, Edmonton, T6G 2E3. Tel: (403) 492-5071, FAX (403) 492-2030.ts

May 28 - June 1 CIMM Symposium on the **POLYMETALLIC BELT OF NORTHWESTERN QUEBEC,** Rouyn-Noranda. Details: Maurice Rive, Ministre de l'-Energie et des Resources, 19 rue Perreault Ouest,

Rouyn-Noranda, Quebec, J9X 6N5, Tel. (819) 762-1748.

JUNE 1990

10 - 13th, **BASE METALS IN NEW BRUNSWICK**. Bathurst - Newcastle camp; field trips in northern NB; technical sessions Fredericton. Contact: Diane Blair, N.B. Dept. of Natural Resources and Energy, Geological Surveys Branch, P.O. Box 6000, Fredericton, N.B., E3B 5H1. Telephone (506) 453-2206; FAX (506) 453-3671.

24 - 29th **GEOINFO IV** 4th International conference on Geoscience Information. Details: c/o David Reade, GeoInfo IV Secretariat, 601 Booth Street, Ottawa, K1A 0E8. Telephone (613) 992-9550; FAX (613) 996-9990.

JULY 1990

29 - Aug 3 **CIRCUM-PACIFIC ENERGY & MINERAL RESOURCES CONFERENCE**, Honolulu. Details: M. Stewart, Circum-Pacific Council on Energy & Mineral Resources, 5100 Westhermer Road, Houston, Texas, USA 77056.

AUGUST 1990

12 - 18th 8th International Association on the **GENESIS OF ORE DEPOSITS** (IAGOD) SYMPOSIUM will hold a conference on Mineral Deposit Modelling. Carleton University, Ottawa. c/o L.M. Cumming, Geological Survey of Canada, 601 Booth Street, Ottawa, Ont. Canada, K1A 0E8.

TURBIDITE-HOSTED GOLD

Potential in the Late Proterozoic of the northern Cariboos

The northern Cariboo Mountains of eastern B.C. are underlain by a thick succession of Later Proterozoic metasedimentary rocks that include over 7 km of siliciclastic turbidites. Many of the features of this region (deformation, metamorphism, lithology, etc.) compare favourably with features associated with deposits of bedding-concordant gold-quartz veins hosted in Paleozoic turbidites of Nova Scotia, which have produced nearly 1 million ounces of gold since 1861. This report briefly compares the geology of auriferous Nova Scotia turbidites with the relatively unexplored homologous strata of the northern Cariboos and identifies potential regions for gold exploration.

Nova Scotia Examples

The Meguma Terrane of Nova Scotia consists of Cambro-Ordovician deep-water clastics of the sandstone-rich Goldenville Formation and overlying slate-rich Halifax Formation. The Meguma Terrane was accreted to North America during the Late Paleozoic Acadian Orogeny. The collision had a strong component of right-lateral obliquity that imparted the doubly-plunging en echelon fold style and slaty cleavage that typifies this terrane. Metamorphic grade ranges up to upper greenschist and the relationship between isograds and the regional structure suggests that metamorphism was late syn to post-kinematic. The entire terrane has been intruded by peraluminous granitoid bodies that are largely post-metamorphic (and thus post-kinematic) although pre and syn-kinematic intrusions are present.

Auiferous quartz veins occur as bedding concordant arrays limited exclusively to the hinge zones of anticlines. Quartz is the predominant mineral in the veins along with trace amounts of carbonate (generally ankerite), white mica, chlorite, arsenopyrite, pyrite, sphalerite, galena, chalcopyrite, pyrrhotite and spectacular hematite. The spatial distribution of the auriferous veins reflects the important influence of several regional features on vein emplacement in addition to obvious structural control. These are the proximity to the Goldenville-Halifax Formation boundary, the chlorite-biotite "isograd" and, contacts with granitoids. These features reflect the strong control of mechanical anisotropy (layering) in the sediments on the localization of veins in addition to metamorphic and hydrothermal(?) fluid fluxes.

The Northern Cariboos

In the northern Cariboo Mountains, Late Proterozoic strata consist of a thick (3 km+) sequence of turbiditic grits of the Kaza Group overlain by 4 km of the slate-rich Isaac Formation of the Cariboo Group. These rocks form the low-grade carapace to the Omineca Belt and record the structural and metamorphic effects of Mesozoic collision. At the latitude of McBride (53N), B.C., plate collision deformed these strata into upright east-verging folds (D1) and a superposed set of west-verging structures (D2).

The Kaza Group consists of feldspathic grits with minor interbedded pelite. The overlying Isaac Formation is a slate-rich unit with subordinate grit and limestone. Pyritic black shale is common, especially in the Isaac Formation, and one black shale unit in the Kaza Group is associated with a Cu anomaly. Two distinct phases of metamorphic mineral growth are present: an early phase that was contemporaneous with D1 deformation and a younger post-tectonic (post D2) phase. Metamorphic grade ranges from subgreenschist to upper greenschist.

Quartz veins are common throughout the region and are dominated by simple mineralogy that includes quartz, ankerite-siderite, white mica, chlorite and rare sulphides. Relationships between regional structural elements and veins indicates a range in the timing of vein emplacement. The systems comprise bedding concordant veins, up to 1 metre thick, that are folded by D2 structures, yet also contain breccia fragments of foliated wall rock, apparently indicating a syntectonic origin to the veins. In several major anticlinal closures close to the Kaza/Isaac boundary, vein systems are associated with pervasive carbonate (siderite) alteration of wall rock. Assayed grab samples indicate low gold values (up to 84 ppb) in the wall rock but significantly this is an order of magnitude above background. In addition, streams that drain these closures (Goat and Milk River) are known to carry placer gold. Younger veins are generally transverse to regional structures and are not associated with wallrock alteration.

Prognosis

Syntectonic veins in both Nova Scotia and the northern Cariboos are inferred to have been emplaced during dilation

of well-layered sediments during deformation. The strong mechanical anisotropy across the Kaza-Isaac boundary and the analogous Goldenville-Halifax boundary, apparently acted to concentrate stress and aided vein formation. In Nova Scotia fluids may have been derived from metamorphic dehydration reactions, as suggested by the spatial relationship between gold veins and the chlorite-biotite "isograd", although hydrothermal fluids derived from the peraluminous granites may have been important. In the northern Cariboos, fluids are inferred to have been derived largely from metamorphic dehydration reactions and modified by pressure solution during cleavage formation. Abrupt changes in the slope of the solubility curves for both silica and gold as a function of temperature suggest that precipitation of these species probably occurred during the cooling of fluids below ca. 400C, the approximate temperature for the first appearance of biotite. The potential for gold mineralization in the northern Cariboos, and low grade Late Proterozoic turbidites on either side of the Southern Rocky Mountain Trench, is considered good. Exploration should be concentrated on structural-stratigraphic targets (anticlines developed close to grit-slate contacts) in regions close to (or below) the first appearance of biotite.

... Gerry Ross
Geol. Survey of Canada, Calgary

BICENTENNIAL GOLD '88

Conference in Melbourne, Australia; May 1988

"Geology is legitimized tourism ... the three key things in this science are travel, travel and travel.".(John McPhee, 1983.)

Toronto, December 12, 1986

I have registered for BICENTENNIAL GOLD '88. For me, the main attraction is a pre-Conference field trip to the southwestern Pacific. In particular, I want to see the Ok Tedi copper-gold mine. Of all the world's mining projects brought on stream in the 1980's, Ok Tedi is the most ambitious. It is huge: in fact, at one point, Ok Tedi was producing more gold than all of Canada. It is located in a remote area of high rainfall, with a stone-age culture and no infrastructure.

Tropical Diseases Unit, Toronto General Hospital, March 22, 1988

Mercifully, only one of my shots needed updating.

Toronto, March 25

During a recent visit to Hawaii, I had purchased several key-rings at the request of a client. The key-rings were in the form of figurines which purported to represent the Hawaiian gods of, variously, happiness, romance, money, dieting, etc. My client reported that the green-eyed "money god" was the most successful, and could I buy three more, please, on my way to Australia?

Honolulu, 1 a.m., April 29

Because I arrived in Honolulu on a flight which continued on to Australia, we could not enjoy Customs pre-clearance in Vancouver. As a result, arrival in Honolulu was tedious: waiting to get off the plane, waiting to board the Wiki-Wiki bus, waiting for the Wiki-Wiki bus to move, waiting to go through immigration, waiting for our bags, waiting to go through Customs, waiting for the hotel minibus and finally waiting at the hotel's check-in desk. But now, finally! I'm in my room and can get some sleep. It was a long flight: it's 1 a.m. in Hawaii but 7 a.m. in Toronto. It will be good to sleep in ...

Observe that the hotel room's windows have no curtains. Back to the front desk ...

The hotel's souvenir store has no money gods.

Hilo, Hawaii, April 29

The Aloha Airlines stewardess was remarkably conscientious about checking that our seat belts were fastened. It was only when I arrived in Hilo that I learned that the top had blown off an Aloha Airlines 737 while it was flying from Hilo to Honolulu yesterday.

Located 3 green-eyed "money gods" in the airport's souvenir store. There was a "happiness god", but no sign of an "airplane safety" god.

The 48th eruptive phase of the current East Rift eruption of Kilauea volcano began in July 1986. Since that time, I had been lucky enough to see this eruptive phase twice. Third time lucky?

During the 48th phase, the elders of Kalapana had been urging the U.S. Geological Survey to change the name of the site of the eruption, a low lava shield, from "C-Vent" to "Pu'u Kupai'anaha". "'C-Vent' is no name for a lady", they said, referring to the volcano goddess, Mme. Pele; "she won't stop until she has a name". However, the U.S.G.S. resisted the suggestion, perhaps believing that a shield should be called a "mauna", not a "pu'u". As I heard the story today, after months of lobbying by the elders of Kalapana, the USGS finally endorsed "Pu'u Kupai'anaha" on April 25th. That day, the lava stopped. So, when I drove to the point where Highway 131 was cut by lava of the 48th phase, I was greeted by the sight of dozens of colourful leis, left in gratitude to Pele. (Note added later: The eruption resumed on May 1. My visit coincided with Mme. Pele's only spell of inactivity in 1988.)

Began taking the Toronto General Hospital's malaria pills, in preparation for the visit to the Solomon Islands and Papua New Guinea.

Honolulu, April 30

Should have bought the "happiness god". Just bumped into Mike Downes, of Teck in Toronto. Turns out he's registered for the same field trip as I. Just before he left, he received a telex saying that the Ok Tedi portion of our tour had been cancelled. No reason given. A major disappointment.

Nadi, Fiji, May 3

Downes and I met up with the rest of the tour. There are 11 of us: Aussies, Canadians, Americans, a Swiss, a Japanese and a Malian. Trip leader is Sandy Moyle of Kennecott Explorations (Australia) Ltd. (For some reason, the standard Aussie nickname for a red-head, like Sandy, is "blue".) The role of mining man emeritus is played by Sydney Greenstreet; the role of lady geologist is played by Kathleen Turner.

(Note added later: a card from Ken Dawson, allegedly of the Geological Survey of Canada, suggests that I extend my

cinematic metaphor. Dawson's postcard proposes casting myself as Chevy Chase and himself (Dawson) as Paul Newman.

"O wad some Pow'r the giftie gie us.
To see oursels as others see us,
It wad frae mony a blunder free us
And foolish notion" (Burns).)

One of the rumoured reasons for the cancellation of the Ok Tedi visit is "tribal fighting". The Swiss gentleman grumbles.

Sandy is trying to compensate for our disappointment about Ok Tedi by arranging for a helicopter tour of some of the gold prospects which have blessed so many of the specks of land in the seas north of Papua New Guinea. Sandy is trying especially hard to let us see the Lihir Island's fabulous Ladolam gold deposit (Kennecott-Niugini Mining; 167 million tonnes). Meanwhile, the tour organizers in Sydney have rerouted us through Brisbane and tossed in passes to Expo. The Swiss gentleman doesn't want to see Expo.

My room-mate for the tour is Izawa-san, a professor of mining from Fukuoka, Japan.

Emperor mine, Vatukoula, Fiji, May 4

The Vatukoula joint venture (80% Emperor Mines, 20% Western Mining Corp.) is currently producing a little over 100,000 ounces of gold per year from the Emperor mine. The joint venture's chief geologist, Peter Eaton, is a burly Australian with a black beard. It is easy to imagine him in the role of old-time prospector. Although he and his staff had prepared a first-class tour, they gently discouraged return visits. Apparently, Emperor is a popular target of Australian mining analysts in winter. (I reflect that, if a Canadian company were to have a gold mine in Bermuda, it would be the most intensely analyzed mining operation on the Toronto Stock Exchange.)

The Vatukoula, or Emperor mine has several unusual features. Firstly, because the ore occurs in very narrow veins, "open cuts" (we'd call them "open pits") are a more expensive source of ore than their underground operations. Secondly, the mine is in a hot spring area, and mine water temperatures range up to 40° C. (Understandably, the miners sometimes find it difficult to complete a shift!) However, we didn't encounter these conditions first-hand: we had expected an underground tour, but it was not to be.

(Note added later: apparently women are not permitted underground in Fiji. Would we have gone underground if Kathleen Turner had not been with us?)

Tom Setterfield, a Canadian geologist, introduced us to the geology of the area and guided our tour. Surprise! Out here in the middle of the Pacific they had an orogeny. Between 12 and 7.5 million years ago, the Colo Plutonic Suite was emplaced, deforming the existing arc rocks. Between 5.5 and 4 million years ago, six or more emergent, shoshonitic (i.e. potassic but calc-alkaline) shield volcanoes were built on a basement of Colo and pre-Colo rocks. The largest of these volcanoes was the Tavua volcano, host to the Vatukoula gold deposit. Tavua volcano was 40 km wide, over 2 km high, and has been tilted about 10° to the northwest. (Volcanologists in search of an attractive field project will be interested to know that most of Tavua has been mapped in only sketchy detail.) The origins of neither the Tavua volcano nor of the Vatukoula deposit can be clearly related to the plate tectonic history of Fiji.

The centre of the Tavua volcano is occupied by 3 nested calderas. Tom suggested that it may be better to think of the structures as a series of concentric, discontinuous, steeply inward-dipping ring fractures, rather than as discrete "calderas". In any event, the formation of these structures appears to have been quiet, with no catastrophic ash flow eruptions.

The Vatukoula deposit occurs at the intersection of a northwest-trending shear system with the second-innermost of the nested calderas. Within the mine, most mineralization occurs in steep, north to northwest-striking shear zones; and in low-angle planar structures called "flatmakes". The intersections of shear zones - "shatter zones" - are particularly favourable for mineralization.

1990 MAC SHORT COURSE

FLUIDS IN TECTONICALLY ACTIVE REGIMES OF THE CONTINENTAL CRUST.

The objective of this short course, which will precede the 1990 GAC/MAC Annual meeting in Vancouver, is to bring together experts in a variety of different aspects of crustal fluid flow and fluid chemistry. The course should provide a comprehensive overview of the state of knowledge on fluid flow, fluid chemical evolution and the interactions between fluids and rock units. Topics will cover fluid dynamics in deep crustal settings, geophysical indications of the presence of fluids, effects of fluids on geophysical properties, chemistry of fluid-rock interactions and the implications of flow and chemical evolution of fluids to metamorphism, deformation and the genesis of hydrothermal ore deposits. The course targets individuals with a general background in geology who desire to be brought up to date on current concepts and discoveries concerning fluids in tectonically active regimes of the continental crust.

SPEAKERS & TOPICS:

C. Foster & J.L. Smith: Fluid flow in Tectonic Regimes
T.Lewis: Fluids and Heat Flow
D.I. Gough: Geophysical Evidence of Fluids in the Crust
R.H. Sibson: Fluids in relation to deformation
T.K Kyser & R Kerrich: Chemical Aspects of Fluid-Rock Interaction
E.D. Ghent & T. Gordon: Fluids in Intermediate and Low Grade Metamorphism
B.E. Nesbitt: Fluids and Mineralization
W.S. Fyfe: Plate Tectonics, Fluid Transport and the Hydrosphere

The Short course will be held **May 14 & 15, in the Hotel Vancouver, Vancouver, B.C.** Tentative fees $250 ($150 for Students). Contact: Dr. B.E. Nesbitt, Dept. of Geology, University of Alberta, Edmonton, Alberta, T6G 2E3. **Tel: (403) 492-5071 FAX (403) 492-2030.**

Although most of the mine area is composed of volcanic rocks, monzonite intrusions are common, especially in shear zones. (Tom suggested that a major monzonite body may underlie the mine.)

Peter Eaton described the gold mineralization. Mineralized fractures display evidence of several episodes of filling. The mineralization was deposited close to the surface - vugs and crustiform textures are abundant - but sinters within the caldera are barren. In decreasing order of importance, the gold occurs in tellurides, in pyrite and arsenopyrite, and as free gold. Aduluria (an indicator of boiling?) and the green vanadian mica, roscoelite, are common indicators of high-grade ore.

Wall-rocks adjacent to ore generally consist of basalts which have been altered to silica, pyrite, carbonate, sericite/illite and adularia. Mineralization involved the introduction of silica, CO_2, potash, sulphur, silver, gold and tellurium. The source of the mineralizing fluids may have been a potassic porphyry system which is inferred to underly the centre of the caldera.

A few months ago, a couple of Aussies dug up some World War II grenades and bombs and took them home. They weren't caught until Brisbane...

Nadi, Fiji to Guadalcanal, Solomon Islands, May 5

Up at 4:45 a.m. The Swiss gentleman grumbled, echoing everyone's feelings. Our Air Pacific 737 climbed over a sea of budgie blue. Rings of coral glowed bone-white in the dawn.

The 3-hour flight took us to Henderson Field on Guadalcanal. Solomon Islands Customs officials are remarkably diligent. They subjected us to a very thorough search, with particular emphasis on Sydney Greenstreet's dirty laundry.

The road to Cyprus Minerals' Gold Ridge prospect ran through farms littered with rusting ruins of World War II landing craft and battalions of precisely arranged oil palm trees. The local teenagers, who whizzed by on the backs of trucks, had a startling appearance. The height of fashion on Guadalcanal is to wash one's hair in chlorine bleach. (Sometimes however, appearances can be misleading: people from Lau Island, although black-skinned, have naturally blond hair.)

The road left the coastal plain and climbed a ridge of astonishing grade. We reached the prospect, 2000 feet above sea level, in mist and heavy rain. Cyprus had constructed its camp in the fashion of a Solomon Island village: huts on stilts, with woven walls and thatched roofs with high peaks. The Gold Ridge deposit lies like a blanket on the surface of a steep hill side. Local "alluvial miners" or "high-graders" had been panning gold from sweet spots. The areas which have suffered from such high-grading were ugly red sores. During the rainy season just past, these sores wept mud into the jungle below.

Rob Hartley, of Cyprus Minerals, outlined the geology of the prospect. The host rocks are the Gold Ridge Volcanics, of Pliocene age. Rob pointed out that, in the Pliocene, Guadalcanal was being tilted towards the northeast (a process which continues today). He viewed the Gold Ridge Volcanics as a talus deposit laid down on the northern flank of a stratovolcano. Although our group appeared to accept this view, there was certainly some skepticism that this talus deposit was as extensive and continuous as Cyprus believed. "Sure, the roadcut down the hill is of a similar looking rock, but is it really part of the same unit? Doesn't the fact that it is difficult to correlate even between closely-spaced drill-holes suggest that these deposits are discontinuous?" Good questions - but difficult to answer! All the rocks have suffered intense alteration and/or weathering. (Even the locals find it difficult to distinguish the products of these two processes.) Furthermore, the forest cover is dense (having been made even denser by a fast-growing vine with admirable properties of camouflage and allegedly introduced by the American military), so good exposures are rare.

In the vicinity of the prospect, the Gold Ridge Volcanics generally have a lower zone rich in chlorite and carbonate and an upper zone of silicification and argillic alteration. Highest gold values tend to occur in the transition between the upper and lower zones. Most of the gold appears to occur in pyrite, and as the free gold which has proved so attractive to the alluvial miners. Fluid inclusion work implies that the mineralization occurred at a depth of 2 km. On a small scale, mineralization may follow favourable beds (especially of carbonaceous rocks). On a deposit scale, however, the major structural controls are broad shear zones within which are localized veinlets of mineralization.

At Gold Ridge, just as at the Emperor mine, any connection between the mineralization and plate tectonics remains enigmatic.

To bring Gold Ridge into production, Cyprus would need to prove up reserves of around 5 million tonnes. A likely grade would be 2-3 g/t. Although the ore would be clayey and difficult to handle, it is not metallurgically refractory. Preliminary indications are that treatment via carbon-in-pulp would give a recovery of about 93%.

The Mendara Hotel in downtown Honiara (with 30,000 people, the capital and largest city of the Solomons) has an neat method of energy conservation: the air conditioning works only when you insert your room key in the switch. The Mendara also has a delightful coral sand beach. I waded bravely into the surf for a nocturnal snorkel. Once under water, I switched my flashlight on. To my horror, I saw that the seafloor was covered with a pincushion of sea urchins. My return from the sea was more delicate than my entry.

Guadalcanal, Solomon Islands to Kieta, Bougainville Island, Papua New Guinea ("PNG"), May 6

A few months ago, a couple of Aussies dug up some World War II grenades and bombs and took them home. They weren't caught until Brisbane. This is undoubtedly the reason why the Customs officials searched outgoing bags as rigorously as the incoming ones.

Our Solomon Islands Airways Twin Otter skirted Guadalcanal's mountainous coast and skimmed over sinuous blue ribbons of coral to Kieta, PNG, home of Bougainville Copper's immense Panguna mine. Bougainville's Annual Report says that they mined 83 million tonnes of ore and waste last year. The mind boggles.

Panguna mine, Bougainville Island, PNG, May 6

We drove into the misty hills behind the delightful coastal town of Kieta. Our tour guide, Gerald Clark, met us at the Panguna mine office, briefed us, and showed us around. Gerald had carefully selected a series of stops within the pit, showing a surprising variety of different features. In the pit, unlike an underground tour, it was possible to appreciate the 3-dimensional context of each part of the ore-body.

The Panguna deposit was discovered in 1964 as a result of soil and stream sediment sampling. Geologists did not initially recognize the magnitude of the discovery because its geochemical response was subdued by up to 60 m of cover: stream-laid boulder terraces, and what was eventually recognized to be volcanic ash. (In the clear light of retrospection, the presence of a "mask" of volcanic ash seems obvious, because Bougainville is home to three dormant or active volcanoes.) Even during the drilling phase, geologists continued to underestimate the deposit. Apparently, drill core assays gave results which, as shown by subsequent production, were consistently low. The reasons for this problem are obscure (loss of fine mineralization into fractures?).

Bougainville is part of a pile of calc-alkaline volcanic and related rocks, of Oligocene to Recent age. The Panguna orebody occurs on the southern edge of a complex pluton composed of sub-vertical pipe-like intrusions of dioritic composition. In plan, the ore forms a roughly triangular body 2130m x 1200m, 80% of which occurs in the intrusions and related rocks (mostly breccias) and 20% in the adjacent Tertiary andesites.

Biotite associated with primary mineralization is 3.4 million years old, similar to the age of the host intrusions. Chalcopyrite is the most important economic mineral.

The ore-body is associated with a zone of potassic alteration, expressed principally as the occurrence of biotite. A propylite halo surrounds the ore, and argillic alteration occurs within one of the intrusions. The Panguna system was surprisingly poor in sulphur: for example, the average pyrite content is only 0.7%. This may, in part, explain why secondary enrichment is of only minor importance.

My two overwhelming impressions of mining operations at Panguna were SIZE and, funnily enough, simplicity.

Size. It's one thing to read that the size of the pit is 2.6 km by 2.2 km. It's quite another to stand on the pit wall and peer down at 154 tonne trucks which look like ants on spilled sugar.

Simplicity. The ore-body is large, uniform and easily blasted; mining methods are standardized and conventional; the mill circuit is straightforward (grinding and flotation); the concentrating plant can be (and has been) expanded merely by adding more units; the operation produces a single product (a copper-gold-silver concentrate).

At the time Panguna began shipping copper concentrates in 1972, cumulative expenditures on the project were 400 million kina (the "kina" is the PNG dollar). This remains one of the highest capital costs for any copper mine-mill complex anywhere. Nevertheless, Bougainville recouped its capital cost within 3 years.

At the end of 1987, Panguna's proven reserves were 530 million tonnes grading 0.40% copper and 0.46 grams of gold per ton. (Silver runs at about 1.3 grams per tonne.) Although these reserves are sufficient for only 11 years' production at the current rate of 53 million tonnes per year, ore not yet classified as "proven" will undoubtedly extend Panguna's life well into the 21st century. In fact, management is planning to expand the current production rate by 40%.

Bougainville's experience proves that a large, low-grade mine can be successfully constructed and profitably operated in Papua New Guinea. In contrast, the Ok Tedi mine (which, unlike Bougainville, is located in a mountainous region far from the sea) has not enjoyed the same success. Perhaps, as is the case in Canada's High Arctic, proximity to tidewater is an important element in the success of a large mining venture in Papua New Guinea.

Kieta to Rabaul, PNG, May 7

At dawn, Downes, Izawa and I rented a helicopter to fly over Mt. Bagana. We were almost guaranteed a view of an eruption here: Bagana appears to have been emitting lava continuously since 1972. However, it's difficult to tell for sure: the lava is a viscous dacite whose incandescent portion is usually shielded by a thick carapace of congealed, fragmented lava.

Bagana is a classic cone-shaped volcano. There is no summit crater: wrinkled and crevassed grey lava is oozing out of the summit and down the side of the volcano, forming masses of giant entrails when it encounters the flatter ground at the bottom. All this was happening too slowly for us to perceive: the only action we could see was a white plume of gas streaming from the summit.

Every now and then the build-up of lava on one side of the volcano redirects the flow elsewhere. The last such shift happened in September, 1987. Prior to September, the lava flowed to the south, between a pair of spectacular levées. Since September, it has flowed to the east.

(Note added later: The August 1988 "Geotimes" says that this flow is about 50m thick, and is advancing at about a metre per day.)

The communities serving Panguna are on the northwest side of Bougainville Island. Our helicopter returned via the sparsely populated southwest coast and up the Jaba River, into which Bougainville is currently discharging its mine tailings. As we kept a look-out for pukpuks (crocodiles), we could see why Bougainville is spending $60-odd million on a pipeline to flush the tailings directly into the sea. In its lower reaches, the Jaba has become choked and threatens to spill out onto the surrounding plain. In its upper reaches, the valley floor looks like a recently-drained beaver pond.

Rabaul, PNG, May 7

Our group is seated under brilliant sun and bougainvilleas around the pool at the Rabaul Travelodge. The barman shows us faded pictures of the hotel awash in water after the Great Tidal Wave of 1971. The water in the pool seems to date from that event.

An engineer joins us. He tells us that the cancellation of our visit to Ok Tedi may owe as much to a recent flood, which washed out a bridge, as to the tribal fighting.

Simberi Island, PNG, May 8

Sandy Moyle certainly pulled out all the stops! He arranged a tour of gold prospects on Lihir and on the Tabar group of islands. I understand that we were one of the first outside groups to visit these projects.

Kennecott Explorations (Australia) arranged for two helicopters to pick up our group at Rabaul airport. After a

quick circuit of the volcanoes which ominously ring Rabaul's harbour, we flew north over the Bismarck Sea, crossed the island of New Ireland at its wasp-thin waist and headed across 50 km of open ocean to Lihir Island, home of Kennecott - Niugini Mining's Ladolam deposit.

Lihir Island is covered in dense jungle. From the southwest, it appears to be a low-lying, gently wrinkled island dominated by a steep, flat-topped mountain to the northeast. As the helicopter passes over this mountain, you realize that it is, in fact, a horseshoe-shaped ridge, the topographic expression of a breached caldera, with the prongs pointing northeast. Each of the prongs juts into the sea. Between the prongs is a sheltered bay, Luise Harbour. And behind Luise Harbour, between it and the inner curve of the horseshoe, is a small, hilly coastal plain. The coastal plain is marked by scars: reddish-brown scars where men have scratched out roads and poked drill holes into the four mineral zones which constitute the known extent of the Ladolam deposit; and grey scars which mark hot springs, the dying breaths of the Lihir volcano.

Ladolam Camp is located on the sandy shore of Luise Harbour. Just to the west of the camp is the discovery outcrop: rust-stained cliffs which rise impressively from the beach. Niugini's geologists landed here on a reconnaissance program in 1982. They took a few chip samples which returned grades of several grams of gold per ton.

We flew out over the sea again, and landed on Simberi, northernmost of the Tabar Islands. Kennecott and Niugini have been exploring these islands since 1982. Sandy, and John Burgess, a lanky Kiwi in gumboots, briefed us on the joint venture's activities.

The Tabar group was formed by volcanoes of largely Miocene to Pliocene age and of largely trachybasaltic composition. Stream sediment samples taken by Kennecott and Niugini in 1982 showed Simberi's stream sediments to be anomalously rich in gold (i.e. with concentrations of greater than 0.1 ppm). In a follow-up survey in 1983, Sandy discovered a major area of pyritic and argillic alteration. He returned the following year to begin a program of drilling and trenching which continues to this day. The joint venture has now located several gold prospects of which Sorowar, on Simberi, is the most advanced. Near the surface at Sorowar is an inventory of five million tonnes of oxide material, grading 1.7 grams of gold per tonne. Just this year, drilling below this zone has encountered a possible bonanza zone: an 8m intersection ran 102 grams per tonne.

Most of the mineralization occurs in bedded, subaerial tuffs, lahars and other volcanic breccias which have undergone argillic-phyllic alteration. Alunite age dates suggest that the mineralization is 2-3 million years old. Just as at Vatukoula and Gold Ridge, the link between plate tectonics, volcanism and mineralization is vague.

The helicopter took us up to the Pigiput prospect. We were immediately reminded of Gold Ridge: crumbly, clayey, oxidized fragmental rocks. (The locals use machetes to make fresh exposures.) Unlike Gold Ridge, however, the Tabar Islands prospects appear to lack free, coarse gold. Furthermore, fluid inclusion studies suggest that these rocks were never more than a few hundred metres below the surface, unlike the 2 km inferred (though not universally acknowledged) at Gold Ridge.

We strolled down the drill road and along a short jungle trail to the helicopter pad. When we clambered into the helicopter each of us was dripping with sweat.

At dusk, our helicopter swooped over Rabaul Harbour. We noted a new arrival: Cousteau's "Calypso". (We later heard that he was here to make a documentary about the proposed Ladolam mine.)

Izawa-san was delighted to find his laundry, beautifully wrapped, waiting on his bed. He was less delighted when he found that the package included several items of delicate feminine attire. His disappointment and confusion were widely shared, and we were obliged to hold an impromptu "swap meet" to resolve all the mix-ups. (I was glad I'd done my laundry in Crocodile Dundee style.)

Rabaul, PNG to Port Moresby, PNG, May 9

I wonder if Air Niugini has the world's only stewardesses with tattooed faces?

In the Klondike they were 'sourdoughs' in Papua New Guinea... Fossickers.

Port Moresby, PNG, May 10

The Brazilians have a word for them: "garimpeiros". In Mexico, they're "gambusinos". In the Klondike, they were called "sourdoughs". In the Solomons, where we saw the results of their activities at Gold Ridge, and here in PNG, there seems to be no such term to distinguish individual miners of alluvial gold from corporations engaged in the same endeavour. Red-bearded Mike McCulla, an American geologist working for the PNG government, has a suggestion taken from the Australian gold fields: "fossickers". Today's "PNG Post-Courier" carried a front page story: "Gold fever brings on a booze binge". At Mount Kare, 18 km southwest of Placer Dome's Porgera deposit, Papua New Guineans are creating a scene reminiscent of Brazil's Serra Pelada gold rush in the mid-1980's. Thousands of "fossickers" are panning in the muck and mire. As the "PostCourier" reports, "People from the gold-rich areas of Porgera and Mount Kare have gone beer-crazy ... they are drinking with money from the sale of gold ... One 18-year-old youth is walking tall with K 96,000 (about $150,000 Cdn) in his pockets ... people are using helicopters as if they were taxis."

We visited the National Museum of Papua New Guinea. Not much on mining. The central courtyard of the museum was filled with tame(?) animals and birds native to PNG. I was wearing shorts. Izawa-san wasn't. He was vastly amused when a tree kangaroo hopped over to me, wrapped his sharp-clawed "hands" around my ankle and enthusiastically began to lick me. (Salt deficiency?) A quandary: should I push him away? His teeth and claws looked vicious. By now he was up to my knee. Grab his jaw? Up to my thigh. Had to do something ...

The cancellation of the Ok Tedi visit meant that we had to visit Qantas to have our tickets reconstructed. The Qantas lady who performed this tedious task told us that there had been tribal fighting at Ok Tedi, but that the crisis was over for the time being, and that the two airports there (at Tabubil and Kiunga) were once again open.

While waiting for the flight to Brisbane, I bought a Pidgin English dictionary and a bottle of "Nambawan Bia" (Pidgin

for "top-rated beer"). Reading and sipping, I learned that a geologist, in Pidgin, is a "masta bilong lukim ston." And that Prince Charles is "nambawan pikinini bilong misis kwin".

Brisbane, Australia, May 10

Although I grew up in New Zealand, this is the first time I have set foot in Australia. Before I was allowed to do so, however, Australian Customs officials took away my boots and fumigated them.

Brisbane, May 12

Tonight, Izawa-san has been invited to dinner by his friend Malcolm Forbes (no, not that one, the other Malcolm Forbes). Mal graciously extended the invitation to me. Great! Malcolm is with Queensland Metals Corp. N.L., an Australian company with an interesting magnesite prospect and interests in gold exploration.

Brisbane and the Gold Coast, May 13

After a fine dinner with the Forbes family, Malcolm proposed that he, Izawa-san and I visit a mine today. The mine is run by a private company, owned by the Neumanns, a family of Malcolm's acquaintance. Although it sounded most unlikely, the mine is a beach-sand mine at the southern end of Queensland's famed Gold Coast. (The Gold Coast, whose focal point is Surfers' Paradise, is Australia's answer to Miami Beach.) Izawa-san and I jumped at Malcolm's kind offer: Australia is the giant in the world of beach-sand mining. Besides, I'd already spent two days at Expo '88 and found it difficult to think of how to fill a third day.

The end products of Australia's beach-sand industry include garnet, zircon, ilmenite, rutile and monazite.

Mal picked us up at 8 a.m. in front of the Hilton, and took the freeway south towards the New South Wales border. We zipped past real estate signs: 1 acre serviced lot; $29,000; 3-bedroom house with pool and garage, $55,000.

The headquarters of the Neumann family's group of companies is in Currumbin, Queensland. The companies are run by four brothers, two of whom we met: Bruce and Peter. On meeting Peter, I was reminded of a line from the book "How to Survive in Australia": "the richer one is in Australia ... the poorer he must dress, in order to keep the nation democratic." Actually, Peter's practical mode of dress was entirely appropriate: he clambered over, under and inside mineral processing equipment, giving us a very enthusiastic, detailed tour of their plant. The plant is operated by Currumbin Minerals, one of the Neumann's companies. Currumbin's major products are rutile and zircon. My biggest surprise was to learn that each of these minerals constitutes only about 1/2% of the original beach-sand. (I'd always imagined that Australian beach sands were virtually pure aggregates of the end-product minerals.) The processing plant is fascinating: after initial concentration at the mine site, via magnets and spirals, the ore is trucked to the processing plant for further concentration via shaking tables, more magnets and more spirals; then it is dried and run through electrostatic separators. Peter took great pains to show us the internal workings of these machines, which separate the rutile from the zircon. I'm not aware of any electrostatic technology in use in Canada's mining industry. There must be some situations where it could be used. Another surprise: beach-sand mining got the Neumanns into the dredge construction business. And, since gold tailings reclamation projects are very fashionable around the world, this business is booming. Oddly, however, their only Canadian sale so far has been to Saskatchewan Minerals' sodium sulphate mine at Ingebright Lake, Saskatchewan.

masta bilong lukim ston

We drove to Currumbin Minerals' mine, just across the border from Queensland, in New South Wales. Mining is by a dredge, and by trucks and loaders. Activities are currently just landward of the beach. Perhaps on a warm day it would be covered with sunbathers: today the beach was empty. On the horizon, a magnificent procession of tall ships sped north on a brisk cool breeze. The ships were on their way from Sydney to Expo '88.

Ansett Flight 17, Brisbane to Sydney, May 14

I realize that one of the reasons we have trouble understanding Aussies is that they tend to drop syllables which seem unnecessary to them. This would explain why the purser referred to the stewardesses as "fly tendons."

Melbourne, May 15

Eighty of the participants in the BICENTENNIAL GOLD '88 conference took a trip to Ballarat today. At Sovereign Hill, the local community has re-created the Ballarat of 130 years ago: a booming gold town. Superb, one of the highlights of the trip.

For Professor so-and-so from England, the underground tour was marred by the presence of a sobbing child. He bawled "shut up, you little sod!" Much to the astonishment of her mother, the child immediately stopped crying.

On board the "Abel Tasman", Devonport, Tasmania to Melbourne, May 17

Last night I flew to Devonport, rented a car, and spent the night at Wynyard, Tasmania. Past experience had taught me to borrow one of my daughter's crayons for the trip: I used it to write "LEFT" on the car's windshield to remind me not to start out on the wrong side of the road.

This morning I drove through the postcard-pretty countryside of northwestern Tasmania. Although the green rolling farmlands were reminiscent of eastern Ontario after spring rains, the steep-sided, flat-topped mountains to the south (Jurassic Gondwanide dolerite sills) looked more like the country north of Thunder Bay, and the red soils reminded me of Kauai, Hawaii. (As well they might: both are developed on Tertiary basalts.)

The road wound south into dense rain forest. Scattered along the road were the carcasses of plump, furry animals: Tasmanian devils!

I was in Tasmania to see the Hellyer mine of Aberfoyle Limited. Although not as large as Red Dog, Hellyer has the potential to be a major player in the world's lead and zinc markets in the 1990s. Proven reserves are at the end of 1987 were 15.2 million tonnes grading 13.1% zinc, 6.7% lead, 0.3% copper, 160 g/t silver and 2.3 g/t gold.

I parked in front of the Hellyer mine office at Que River. While waiting to meet Gary MacArthur, Chief Geologist, I

OBITUARY

A tragic helicopter accident in Northern Saskatchewan on Monday, Sept. 18th, 1989, claimed the life of **Mr. Wolfgang Stoeterau of Saskatoon.** Wolfgang, a familiar figure in the mining industry, graduated in geology from Memorial University of Newfoundland in 1972 and subsequently worked for the Falconbridge organization in the Ungava and Northern Manitoba until 1975. He then attended the University of Manitoba after which he joined the Saskatchewan Mining and Development Corporation in Saskatoon. He more recently completed an MBA degree from the University of Saskatoon and had been working as a consultant to the mining industry. Wolfgang is remembered by all for his keen love of geology, a professional approach to all projects and a fine sense of humour, even under the most arduous bush conditions. Wolfgang is survived by his wife, Judy and their two sons Steven and David.

enjoyed a learned zoological treatise pinned to the staff notice board. It explained why, as a result of the animal's unusual sphincter, wombat droppings are square.

Gary, a remarkably patient man given that he has been invaded by visitors on their way to and from BICENTENNIAL GOLD '88, emphasized that one of the keys to understanding the Hellyer project is an appreciation of the complicated history and geography of its infrastructure.

In February of 1981, Aberfoyle brought into production the Que (pronounced like the letter "Q") River zinc-lead mine. In an unusual arrangement, Que River trucks all of its ore, 300,000 tonnes per annum, to Rosebery, where it is sold to a company called EZ.

In 1983, Aberfoyle discovered the Hellyer zinc-lead deposit 3 km north of Que River. The discovery can be largely attributed to a UTEM survey. (If Aberfoyle were to have delayed that survey a few years, it might never had found Hellyer, because a power line now runs down the middle of the orebody!) Gary was brought in during the exploration phase and, as a result, knows the ore-body inside out. Even today, he maintains this knowledge by means of an interesting discipline: he logs every third drill-hole himself.

In 1987, Aberfoyle brought Hellyer into production at a rate of 250,000 tonnes per year and on a shoestring budget. The ore is trucked to Aberfoyle's Cleveland mill (which used to serve the old Luina tin mine). The Cleveland mill has been converted, and now produces a bulk zinc-lead-silver concentrate.

Aberfoyle's experience with Hellyer has been a happy one. The Company is expanding ore production to a million tonnes per annum and building a new mill right at the Hellyer site. The Hellyer mill will probably never treat Que River's ore. Aberfoyle's contract, whereby EZ mills Que River's ore, ends in 1991. So, it seems, will the Que River ore-body: recent exploration has not given much hope for the possibility of extensions to the reserves.

Hellyer and Que River occur in the Mt. Read Volcanics, a Cambrian island arc which runs through northwestern Tasmania like the mirror image of a sans serif letter "J". The Que-Hellyer volcanics, which host the ore-bodies, are among the youngest rocks of the Mt Read arc, and occur where Tertiary flood basalts truncate the northern tip of the "J".

The Hellyer ore-body is stratabound. The mineralized strata are overlain by, in turn, 5m of volcaniclastites (fine tuffs and "mill rock") and 250m of basalts. Footwall rocks are feldspar-phyric andesites.

The ore-body occurs in the core of a broad, northeast-trending anticline. Also in the core of the anticline, and parallel to it, is a fault, the Jack Fault. Although the Que River deposit has undergone tight, isoclinal folding, folding at Hellyer is gentler and broader. The Hellyer orebody is approximately horizontal in an east-west direction. It dips to the north for the most part gently, but the northward dip steepens rapidly at the north end of the orebody.

The ore-body occurs as a single lens (though faulted) and is composed 85% of sulphides (pyrite, sphalerite, galena, arsenopyrite and chalcopyrite) and 15% of gangue (quartz, barite, calcite, sericite and siderite). The ore tends to be enriched in Zn, Pb, As, Ag and Au towards the hanging wall, and the footwall portion is enriched in Fe and Cu. Beneath the ore-body is a vertical zone of pyritic, generally barren alteration. The core of the altered zone is enriched in silica and barite whereas the outer parts are enriched in magnesia and depleted in soda. Contacts with unaltered rocks are sharp (in contrast with the diffuse alteration boundaries at Que River). The basalts above the Hellyer deposit are widely carbonated and locally contain fuchsite.

Gary's reconstruction of the paleogeography at Hellyer suggests that the Jack Fault was probably active before any of the rocks of the Hellyer sequence were deposited. The surface trace of the Jack Fault was a west-facing escarpment on the sea floor. It ran along a major north-south ridge which adjoined basins to the east and west. Hydrothermal solutions passed up through the Jack Fault and were ponded in the basin to the west.

Before taking me underground, Gary took me to meet Bill Lannen, the Mine Superintendent. Bill assured me that, by December of this year, Hellyer will be able to produce at its planned rate of a million tonnes per annum. "Soon", he said "this will be Australia's most boring mine!" He outlined some of the keys to what may be Australia's most productive underground mine, if not the most boring:

(a) The orebody is inside a mountain, so trucks can drive straight into and straight out of the mine - no expensive hoisting required (at least, not in the early stages of mining).

(b) The orebody is massive, with little internal waste, permitting the use of large-scale mining techniques. (The mine openings, 18 feet square, dwarfed the pick-up in which Gary and I toured the mine.) "An open-pit mine with a cap on it", beamed Bill.

(c) The workers have accepted flexible job assignments and scheduling.

The metallurgical aspects of Hellyer are less favourable than the mining side. Although the ore grades are high, the ore is fine-grained (which will lead to lower recoveries than at, for example, Cominco's Sullivan mine); the ore has a relatively high arsenic content (which can be overcome by careful production scheduling); and the gold is difficult to recover.

The latter problem leads to an amusing situation. Hellyer

MINERAL DEPOSITS RESEARCH UNIT (MDRU)

The Mineral Deposits Research Unit (MDRU), a new initiative between the University of British Columbia and the Vancouver mining/mineral exploration community, has several objectives, which are:

- **To undertake research programs of interest to its members.** Towards this end, members are funding a full-time research associate who will promote use of MDRU facilities as well as carry out sponsored and in-house research projects which will be designed to address significant mineral deposit problems using modern exploration technology. Members and other interested parties are currently establishing research directions.
- **To initiate and promote short courses and workshops** designed to up-date members as well as the exploration-mining community at large with on-going developments in industry as well as those that have been initiated in-house. Members will have preferred fees and admission to short courses.
- **To promote liaison between mining industry representatives and the University** through provision of space made available to MDRU by U.B.C. within the Department of Geological Sciences. This space will house a reading corner, a computer capability that will permit access to various library, mineral deposit, and other data banks, provide binocular, transmitted and incident light microscope facilities, together with a significant collection of maps and reports focussed on the Canadian Cordillera.

Dr. Peter Bradshaw of Pan Orvana Resources initially conceived of the MDRU and, together with **Professor Alistair Sinclair, Head of the Department of Geological Sciences,** determined there was a significant level of interest in the exploration/mining community for the unit which is based on a similar unit established at Sir James Cook University, Townsville.

At this stage, the MDRU Board has met twice since mid-August. **John McDonald, formerly regional exploration manger for Esso Minerals Canada, has undertaken to serve as Director for a one-year period.** Although MDRU is actively seeking new members, those presently in MDRU include Cominco-Teck (joint Foundation Member), and Cominco, Teck, Pan Orvana, Echo Bay, Homestake, Falconbridge, Gulf International Minerals as Members; in addition, Ralph Westervelt has joined as an individual member. Both the Geological Survey of Canada and the British Columbia Ministry of Energy, Mines and Petroleum Resources are board members and support the unit.

Immediate plans include the hiring of a suitable post-doctoral fellow or research associate. In addition, two short courses to be aimed at member's needs are planned for the first year's operations. The first of these, which will address sampling problems of precious metal deposits, is planned for late November - details will be announced when arrangements are completed.

The MDRU plans initially to focus its research efforts in the following directions:

- **Area-specific metallogeny that will build on the geological work of the BCMEMPR and GSC to provide a more detailed understanding of mineralization controls.**
- **Exploration-potential maps that will provide industry with a focus for ore search as well as a basis for addressing future multi-use land issues.**

If you have questions, ideas or initiatives you would like to discuss, please contact Al Sinclair (228-3763), Peter Bradshaw (682-4929), or John McDonald (228-4563).

will be a reverse gold mine! From ore grades of 2.3 grams of gold per ton, the Hellyer mill will produce tailings grading 2.5 grams gold per ton. (The silver content of the tailings will also be appreciable: about 75 g/t.) The tailings, therefore, will represent an important potential reserve of precious metals. I understood that Aberfoyle will tackle the problem of extracting those metals once the current capital program is completed.

In the middle of the afternoon, Gary reminded me that it was a long drive to the ferry terminal at Devonport, and that the 6:00 o'clock ferry waited for no man. The poor fellow thought he'd got rid of me ... no such luck! My car wouldn't start ... in my muddle over finding all the controls on the car back-to-front, I'd left the parking lights on. Fortunately Gary knew where to find jumper cables, fortunately I was parked next to a truck, and fortunately everyone leaves his keys in the ignition at Que River. So, fortunately, I caught the ferry ...

Sydney, May 19

Followed up our tour of Niugini Mining's properties in PNG with a visit to Gavin Thomas, Niugini Mining's General Manager. Today, most of Niugini's mining interests are properties held in joint venture with Kennecott. Niugini has a 12% carried interest and an 8% working interest in the Ladolam deposit. Kennecott owns the other 80%: however, the Government of PNG has an option to buy into a 20% interest, which would dilute Niugini to 16%. The mineral inventory at Ladolam is 167 million tonnes of ore grading 3.43 grams of gold per ton, equivalent to 18.4 million ounces of gold; work in the areas currently being drilled will probably increase the inventory reserves to 30 million ounces.

The caldera which hosts the Ladolam deposit, Luise Caldera, is of Quaternary age and has dimensions of 6 km x

4 km. Potassium-argon dates suggest that the mineralization at Ladolam occurred between 0.35 and 0.10 Ma ago. Like the Tavua volcano of Fiji, it is composed of shoshonite and, like Tavua, Gold Ridge and the Tabar Islands, any obscure relationship to plate tectonics is an obscure one.

The reserves quoted above relate only to two mineralized zones, Lienetz-Coastal and Minifie, in the well-explored central portion of the caldera. Two adjacent zones, Kapit and Camp, will probably be added to these reserves. Yet more zones could yet be discovered closer to the inner rim of the caldera, where a thick annular wedge of talus has discouraged drilling.

Ladolam is hosted by altered volcanic flows, tuffs and breccias. A monzonite stock occurs within 200 m of the surface below the Lienetz zone, and minor intrusions of monzonite and syenite occur in both the Lienetz and Minifie zones.

The deepest alteration zone at Ladolam is the potassic zone. This zone (which is generally barren) grades upwards and outwards to propylitic rocks. The potassic and propylitic rocks are generally capped by a "boiling zone" composed of a breccia with no matrix. (The boiling zone and propylitic rocks are commonly mineralized). Above the boiling zone is a weakly mineralized, discontinuous zone of argillic alteration, and above the argillic zone are discontinuous zones, some mineralized, of advanced argillic alteration, silicification and oxidation. (Oxidized rocks account for about 8 million tonnes of the mineral inventory at Ladolam.) The joint venture will probably have completed a feasibility study by mid-1989. The biggest decision concerns the treatment of ore other than oxide ores. Because of their refractory nature, these ores must undergo either flotation followed by roasting (as at Emperor in Fiji), or pressure oxidation. In either case, mining would begin in the easily-treated oxide ores about a year after a production decision, and the mining of the refractory ores would begin a year to 18 months later.

One of the lessons of Ladolam is that this part of the world has been only lightly explored. The Ladolam deposit is exposed in bold, rusty sea cliffs, yet it was not discovered until 1982. Kennecott and Niugini have made several discoveries elsewhere on their extensive properties in PNG for example, at Simberi Island - suggesting that Ladolam is not an isolated occurrence.

Los Angeles, Tuesday, May 24

The U.S. Immigration Services computer flagged me as an "undesirable alien." (Our Institutional Sales department has known this for some time.) I cooled my heels for half an hour while they decided that the drug smuggler with a name similar to mine was born on a different date.

...Ray Goldie
Richardson Greenshields of Canada Ltd.

EDITORIAL COMMENT

On August 24th and 25th, 1989, Voyager II broadcast spectacular images and data of the planet Neptune and its satellites. At a distance of 2 billion miles this represents an impressive technological success and a milestone in man's exploration of the solar system. We, as earthlings, have now viewed indirectly all the major satellites in our solar system (except Pluto) using sophisticated computer and aerospace technology. The geological and geophysical data, which this and other spacecraft have gathered over the years, has in a large way changed and contributed to our basic understanding of the universe and our place in it. What is most interesting in this solar system exploration is that the primary data collection is focussed predominantly on geology and geophysics. Geoscience, in all its aspects, is a leader in implementing new technologies. Voyager I & II, launched in 1977, carried computer equipment which, although obsolete by todays standards, functioned perfectly and not only did the job it was designed for but managed to amaze all who viewed the images recovered after this long and hazardous space flight.

At this point you are probably wondering what this may have to do with mineral exploration. Well, the successors to the Voyager technology have been available to geoscientists for the same twelve year period that took Voyager to Neptune. Geophysicists have embraced the technology with open arms and have added an impressive array of methods to the exploration toolbox; geochemists have vastly improved analytical techniques and now produce reliable data in parts per billion or trillion; geologists have, however, only dabbled with the technology and other than a rare application to mineral exploration or an impressive full-color image of a project area, we are still in the boot-and-hammer mode.

Think about it! How involved are YOU in using remote sensing data and image analysis techniques in your current exploration programs? Do the geologists in your organization have sufficient experience or training in remote sensing technology?

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I would like to acknowledge Pat Sheahan and her Scanning Service as a great source of ideas for articles.

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GANGUE newsletters:

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

Articles on ore deposits, deposit models, news events, gossip, field trips, conferences etc. are welcomed. For lengthy articles **please submit a 5 1/4" floppy disk in IBM format with the printed version - this will save me endless hours of typing!** Submissions may be addressed to:

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THE GANGUE
c/o B.C. Ministry of Energy, Mines
and Petroleum Resources
Geological Survey Branch
Victoria, B.C. V8V 1X4
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REVIEW OF THE BRITISH COLUMBIA Geological Survey Branch

In response to a request from the B.C. Geological Survey Branch, the Canadian Geoscience Council has formed a committee of six whose general terms of reference are:

1) To review the current mandate of the Geological Survey Branch and to recommend changes, if any, that are deemed warranted in order to enable the Branch to better meet the Province's needs for geological information to the year 2000. Specifically, to review whether the Branch's mandate should be broadened to include geophysics and/or offshore geology.

2) To review the organization of the Branch in the context of responsibility, reporting relationships, workload and effectiveness, and recommend any changes.

3) To review and report on adequacy of staff and budget resources of the Branch and its various sections to effectively meet its mandate and serve the mining industry and its other major clients in the next decade, having regard to the longer term prospects for public expenditure.

If you have comments that you think should be considered by this committee, please write or phone one of the members listed below. Any comments must be received by December 31, 1989. Submissions will be kept confidential and will not be attributed to the author if quoted in the final report.

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Economic Guidelines Seminar December 10th to 16th, 1989 Queen's University

Economic guidelines for mineral exploration will be discussed in a seminar on Dec. 10-16, 1989, at Queen's University. The organizers, led by Dr. Brian Mackenzie, will emphasize case study analysis and small-group workshops. For further information, contact:

Shirley Treadgold
DONALD GORDON CENTRE
QUEEN'S UNIVERSITY
KINGSTON, ONT. K7L 3N6
Tel: (613) 545-2221 FAX: (613) 545-6624

Short Course - P&D 1990

Exploration Geochemistry: Design and Interpretation of Soil Surveys

MARCH 9, 10 & 11, 1990
METRO TORONTO CONVENTION CENTRE
FEE $400

This **two and a half day course** will be presented by members of the Association of Exploration Geochemists. It is intended for those professionals already familiar with soil geochemistry however, it will also be of interest to those seeking an overview of geochemical techniques. Course fee will include a course manual, two lunches and admission to the trade show. All aspects of exploration geochemistry will be examined, including:

sampling techniques
types of analyses
interpretation of results

There will be a special section devoted to reverse circulation drilling, deep overburden surveys which will be of particular interest to those working in the Canadian Shield.

SPONSORED BY:
Prospectors and Developers Association of Canada
and
The Association of Exploration Geochemists (AEG)

PUBLICATIONS
MINERAL DEPOSITS DIVISION

THE FOLLOWING PUBLICATIONS OF THE MDD ARE AVAILABLE FROM:
GAC PUBLICATIONS
Department of Earth Sciences
Memorial University of Newfoundland
St. John's, Newfoundland
Canada, A1B 3X5
Tel: (709) 737-7660 FAX: (709) 737-4569

Geology and Ore Deposits of the Highland Valley Camp
by: W.J. McMillan, 1985, 121 p., $16

Gold and Copper-Zinc Metallogeny within Metamorphosed Greenstone Terrain, Hemlo-Manitouwadge-Winston Lake, Ontario, Canada
by: R.H. McMillan and D.J. Robinson(Eds.), 1985, 91p., $22

Yellowknife Guide Book - Guide to the Geology of the Yellowknife Volcanic Belt and its Bordering Rocks
by: W.A. Padgham (Ed.) 1987, 209 p., $30

Volcanogenic Sulphide Districts of Central Newfoundland
A Guide Book and Reference Manual for Volcanogenic Sulphide Deposits in the early Paleozoic Oceanic Volcanic Terraine of Central Newfoundland
by: S. Swinden & B.F. Kean (Eds.) 1988, 260 p., $40

ALSO AVAILABLE:

SHORT COURSE NOTES NO. 5
MICROCOMPUTER GRAPHICS FOR GEOSCIENTISTS
by: Malcolm Reeves, 149 p., 9 diskettes,
members GAC $65, non-members $80

Ontario's OMEP Grants

A total of $6.27 million in 101 grants has been approved by Ontario's Ministry of Northern Development and Mines. These grants were for programs completed under the Ontario Mineral Exploration Program between April and June, 1989.

The OMEP program provides grants and tax credits to companies that had not been mining in Ontario and has to date assisted more than 1800 exploration programs.

CAME Workshop
Computer Treatment of Exploration and Mining Data
Do's and Don'ts

Toronto Convention Centre
March 9th and 10th, 1990.

THEME: Many case histories have been published on the successful implementation and use of computer technology for managing exploration and mining data; there are also a number of disaster stories concerning the improper use of computers. This has produced a degree of skepticism about computer usage among some exploration and mining professionals. There is a real opportunity to learn from past mistakes but many organizations are hesitant to speak of them.

This CAME workshop will provide an opportunity to present examples of problems encountered and solutions adopted in computerized data management. More important, the workshop will provide a forum for an exchange of views on why computer treatment did not work, or was simple not applicable, and what action should be taken to prevent such problems.

Papers will be invited, by members of the CAME Technical Committee, covering diverse topics such as: geochemistry, remote sensing, geophysics, geographic information systems(GIS), geological modelling, drilling data, ore reserve estimation and mine planning. These papers will emphasize practical experience, gained by computer users, and will provide suggestions for future applications. A presentation on future trends in computer applications in the mineral industry is tentatively planned for the final panel discussion.

FORMAT: The workshop and technical exhibit will run for two full days. Presentations will be lecture style and will take place in one of the large meeting rooms at the Toronto Convention Centre.

The daily schedule will comprise 11 papers, each 25 minutes in length, including a 5 minute question period. Panel discussions of 15 to 20 minutes will be held at the end of each day, or after each session if the number of papers on a single topic warrants it.

PUBLICATION OF PROCEEDINGS: Speakers will be required to submit a short manuscript of approximately 3,000 words before January 15, 1990. It should include figures or tables in the equivalent text space. Papers will be reviewed by the CAME Technical Committee and published in a paper-bound, workshop proceedings volume.

REGISTRATION:
Workshop delegates - $125 Exhibitors - $600

SPONSORING SOCIETIES:
Mineral Deposits Division, GAC
CIM, Toronto Branch
Association of Exploration Geochemists
Canadian Exploration Geophysicist Society
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Toronto Geological Discussio