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James Doyle Sell Mining Collection

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ASARCO

JDS → (13)

Exploration Department
Frederick T. Graybeal
Chief Geologist

February 16, 1988

John M. Guilbert
Professor of Economic Geology
Department of Geosciences
Building #77
Gould-Simpson Building
The University of Arizona
Tucson, Arizona 85721

Gold '88 Trip

Dear John,

Thanks for your kind letter of January 19, 1988 inviting Asarco to participate in yet another University of Arizona economic geology trip. This one sounds up to the spectacular quality of your previous trips, but the timing is wrong for Asarco.

We will just be getting our field season into high gear arranging for roughly a dozen summer student employees along with a major amount of drilling. Further, having just recovered from the worst financial crisis in Asarco's history, we are keeping our employment at low levels even though our budgets are at levels which used to support substantially larger full-time staffs and as a result we are all doing much more than we ever did before. Finally, we are trying to catch up for a two-year period in which our exploration activity was virtually non-existent and this effort has been the most difficult part of our recovery.

I am sorry that we cannot participate, but we will have a contingent from our Perth Office at the meeting to gather rumors of possible interest for our North American troops. I note you will be making the Norseman-Wiluna run, and I am doubly sorry I will not be on the trip as we recently opened a gold mine at Wiluna which is among our most profitable operations.

It was good to see you at Silver Bell, and I look forward to hearing/reading your story on the Caledonian and associated granites. With best wishes.

Very truly yours,

Fred Graybeal

F. T. Graybeal

FTG:mc

cc: W. L. Kurtz

ASARCO Incorporated 180 Maiden Lane New York, N.Y. 10038 (212) 510-2000
Telex:ITT 420585 RCA 232378 WUI 62522 Cables: MINEDEPART Telegrams: WU1-25991

JDS → file? (B)

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

DEPARTMENT OF GEOSCIENCES
BUILDING #77
GOULD-SIMPSON BUILDING
TEL. (602) 621-6024

RECEIVED
JAN 28 1988
EXPLORATION DEPARTMENT

January 19, 1988

William L. Kurtz
ASARCO
1150 North 7th Avenue
Tucson, AZ 85705

Dear Bill:

Greetings and salutations in the new year! I hope that it will be an excellent one for you and your company . . . and that it will include Melbourne Gold '88! We have had an excellent first semester of '87-'88, with an unusually strong, select group of 'first year grads', a powerful second year bunch working on theses and dissertations, and an amazing several pre-professionals, both MS and Ph.D., finishing up. With SEG and GSA in Phoenix, and lots of visitors and speakers, it has been a great year. With metal prices higher, and with so extraordinary a student group, we're making a run at reviving the famous University of Arizona Economic Geology Field Trips, with Melbourne Gold '88 and the classic ore districts of Australia as the target. We have a superior list of students planning to make the trip, and it is in hopes of a `joint venture' that I write to you.

First of all, Melbourne Gold '88 (May 16-20, 1988) promises to be a stimulating powerhouse of a session, with field trips both before and after. The combination of world class speakers and Australian economic geologic settings calls us, and the economic geology grad students here been have conniving, plotting, and planning to raise money to defray expenses. The students see this trip as the highlight of their graduate education, and they are really going for it. They have formed a student chapter of the Society of Economic Geologists, the second (after CSM). They sold tee-shirts at GSA, they have staged a mineral sale, they will sell tee-shirts at the Tucson Mineral and Gem Show in February, they will raffle gold nuggets there and at AIME-SEG in Phoenix, they will have another mineral sale, they will apply to the UA Graduate Student Development Fund, to GSA, to SEG. They have made a trip to collect suites of Nevada gold mines that will soon be for sale (you'll hear!), and they will sell suites of Jerome specimens to accompany the pilot SEG-financed (JMG produced) economic geology field trip video tape made for worldwide university, company, and government agency distribution. So you can see that they are doing their part to make the trip affordable.

The purpose of this letter is to ask if you can join us in attending Melbourne Gold '88, if you can send someone in your organization, or, failing that, if you can possibly lend a financial hand. What's in it for you? First off, Melbourne Gold '88 will be one of the great meetings of the decade. Speakers are coming from all over. Byron Berger (USA), Sandy Colvin (Canada), and Neil Phillips (South Africa) are just a few, and the Australians - Dave Groves, Ian

Plimer, Mike Solomon - will be going all out. Field trips are planned, but several may already be filled. We have some spaces reserved on the Norseman-Wiluna trip out of Kalgoorlie before the sessions. Our plan is:

May 6-12:	Norseman-Wiluna (for some of us)
May 16-20:	Melbourne Gold '88 Meetings
May 21-25:	Field Trip 7b-Central Victoria gold deposits, Bendigo-Ballarat, etc.
*May 26-29:	Excursion to Broken Hill, New South Wales
May 30:	S-type granites, Laghland Fold Belt, led by Alan White.
May 31-June 6:	Tasmanian ore deposits: Mt. Read, Mt Bischof, Blue Tier Tin, etc. led by Chris Eastoe
After June 6:	New Zealand epithermal? Great Barrier Reef? Your choice.

*From May 26 on = University of Arizona group only.

We would hope that you or your designee could attend all or any part of the trip. We will conduct a seminar on Australian regional and economic geology on campus this Spring to prepare the Tucson group, will send out the seminar reports and bibliographies to you who support the trip, and will offer to stage the oral reports again either during the two days before departure (May 12 and 13 for most folks) in Tucson or as an 'aside' in Melbourne. And of course we would like to have you travel with us, (with our group rate out of Tucson or LA), and to have you participate in the remarkable intellectual-social-academic-professional-scientific chemistry that the mix of heads-up corporate folks and turned-on students has always generated.

What am I really asking for? I don't really know yet, because this cannot be the half-students:half-industry array that we have had before. If you cannot send someone, but could spare a few hundred dollars as a contribution to a non-profit educational institution (made out to "the University of Arizona" and sent to me), that's second best. If you or a designee can go, we will enrich your trip, extend it, save you hundreds of dollars (maybe thousands!), make travel arrangements for you in Australia, pave your way completely on the field trips, and do everything we have done the ten earlier UAEGFT experiences. And I suggest that we negotiate individually how we can maximize our mutual contributions to the success of the trip. Most importantly, please approach this offer-request as positively as you can - we really do need and will appreciate your involvement.

Please write, or call me at 602-621-2509, as soon as possible. We all hope that we will see you either in Tucson in May, or DOWN UNDER!

My best regards,

John

John M. Guilbert
Professor of Economic Geology

F. T. GRANBEAR
NY OFFICE

JDS — for your files 11/15/88
W. L. KURTZ

COST OF ACQUISITION
GOLD PROPERTIES
(1985 — 1988) PARTIAL LIST

		$	OZ/GROUND	COST/OZ
NERCO	CON GOLD MINE in prod; undergrd 1.3 Mt .40	47M	520,000	90.38
WESTERN MNG	GRANDVIEW CARSON HILL, CA in prod, heap leach 16 Mt .046	C$ 95M ≈ US 76M	736,000	US 103.00
WESTERN MNG	HOG RANCH, NV in prod; buy 65% of 7 Mt .065	77M	295,750	260.00
HOMESTAKE	El Hueso, CHILE in prod; 15 Mt .047	50.3M	705,000	71.00
AM. BARRICK	GETTY MERUR, UT purchase Jun 85, in prod (reserves May 87 13M .071 milling 7M .031 leach)	31M cash 9M prod	1,140,000	35.08
ECHO BAY	TENNECO PROPERTIES in prod.			130.00
SONORA GOLD.	BUY BACK PATHFINDER'S $20M 30% INTEREST reserve 1,980,000	32.5	594,000	54.71
CORNUCOPIA (Galactic)	US Steel Ivanhoe, NV inventory 8 Mt .045	5.25 + 5% NSR	360,000	9.02
GLAMIS	SULLIVAN, NV indicated 10.2 Mt .039	1.5M + 5% NSR	397,800	3.77

COST ACQUISITION
W.L.K 11/15/98

FREEPORT	Nev. North Resource's 40% interest in indicated 6.3 Mt .038	3.5 M	90,720	38.58
EASTMAQUE	Newmont's Pedro Mark — Am. Girl; proven reserve heap leach + underground	7.5 M +3% NSR	616,269	12.17
FMC	Euro-Nev Hassbrook, NV indicated 3.2 Mt .038	2.39 M	121,600	19.65
U.S. Gold (Silver State)	Granges Hayden Hill, CA indicated 11 Mt .032 to earn 50%	2.75 M	176,000	15.62
U.S. Gold (Silver State	Buy Granges 50% Hayden Hill, CA	2.00 M	176,000	11.36
AMAX	For 60% JV interest at Hayden Hill, CA	3.00 M	211,200	14.20

This is the data readily available from my incomplete notes. Considerable time would be required to enlarge the list.

JDS

ASARCO

Southwestern Exploration Division

December 6, 1988

W.L. Kurtz

Cost of Finding
1 Million Oz Au

The third quarter report of Freeport-McMoRan Gold Company (attached) gives their cost of exploration in terms of dollars per exploration expenses per ounce.

This expense for the nine months of 1988 was $48.40 per ounce (see page 1).

Thus if you "knew" you were in a million ounce potential area then by these numbers you could invest $48,400,000 in exploration for this million ounces!

I realize that all the other FMI expenses on gold exploration which did not find gold is also in the above figure and thus the 48 million dollars is tongue-in-cheek, but it may indicate what companies may use when thinking about buying reserves.

Also you can note that FMI cost rose six dollars over last year's cost, so they found less ounces for their exploration dollar this year than previously.

James D. Sell

James D. Sell

JDS:mek
Att.

However: !
Newmont reports $4.00 per ounce discovery costs (IGM Newsletter, p.163)
Atlas reports $6.00 per ounce discovery costs (IGM N, p.167).

ON THE COVER

Ore haul road connecting the company's Jerritt Canyon mine and mill in northern Nevada.

Freeport-McMoRan Gold Company, an affiliate of Freeport-McMoRan Inc., mines, mills and processes gold in Nevada, where it continues to enhance its efficient, low-cost operations. The company operates and owns a 70 percent joint-venture interest in the Jerritt Canyon operation, one of the largest and lowest cost gold mines in the United States, and a 60 percent joint-venture interest in the nearby Big Springs project. Exploration activities are conducted throughout the United States and Canada. Freeport-McMoRan Gold Company common shares trade under the symbol "FAU" on the New York Stock Exchange (NYSE).

FREEPORT-MCMORAN GOLD COMPANY FINANCIAL HIGHLIGHTS

	Third Quarter		Nine Months	
	1988	1987	**1988**	1987
Revenues (000s)	**$27,298**	$25,426	**$81,711**	$71,143
Exploration expenses (000s)	**4,441**	3,208	**8,972**	6,950
Net income (000s)	**6,589**	7,317	**24,534**	20,068
Net income/share	**.16**	.18	**.59**	.49
Cost per ounce:				
Production	**$159.06**	$163.15	**$154.08**	$157.17
General and administrative	**36.39**	39.48	**37.49**	39.12
Freight and handling	**.31**	.30	**.34**	.41
Management fees	**(3.80)**	(4.89)	**(4.17)**	(4.69)
Depreciation and amortization	**58.69**	56.14	**58.02**	56.14
Total cost before exploration	**$250.65**	$254.18	**$245.76**	$248.15
Exploration expenses/oz.	**$ 68.88**	$ 56.97	**$ 48.40**	$ 42.46
Average realized price/oz.	**$423.42**	$451.55	**$440.78**	$434.60

OWNERSHIP AT SEPTEMBER 30, 1988:

	Shares	Percent
Freeport-McMoRan Inc.	25,865,501	62.5
Public	15,514,133	37.5
	41,379,634	100.0

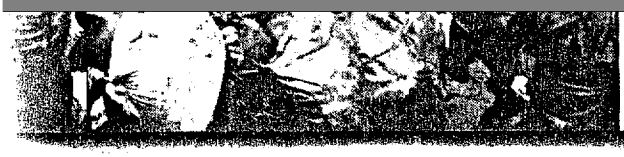
International Mining

October 1987

ASARCO Incorporated
JAN 4 1
Sys Exploration

Gold production and prospects around Kalgoorlie
Practical examples of mine reclamation success
Trends in mine productivity improvement

Serra Pelada



AMERICAN SMELTING AND REFINING CO.

Orange, California

November 13, 1968

FILE MEMORANDUM

Present-day hydrothermal
precious metal deposition
in Northern California

Two examples of present-day precious metal deposition in Northern California were noted this past summer. Though primarily of scientific or academic interest, these examples might just hint that exploration should not fully ignore Quaternary or even now-forming mineral deposits.

At the Trinity Gold prospect about 11 miles south of Weaverville in Trinity County, a scab of tufa has formed on greenstone in a roadcut. The greenstone, probably meta-andesite of Mesozoic age, has been bleached and argillized where ruptured by the tufa-forming agencies. A California Division of Mines geologic map indicates the presence of a major north-trending fault in the immediate locality. The spring that formed this small tufa deposit is apparently no longer active. Sample RE-108 consisted of this tufa, while samples RE-107 and RE-308 were composed of silicified countryrock. The assay results are shown below:

Sample	ppm gold	ppm silver
RE-107	<.01	.25
RE-108	.02	.50
RE-308	<.01	.05

Both silver and gold values in RE-108 are substantially higher than the area background as crudely established by the other two samples. A value of .02 ppm Au seems insignificant, but possibly is not quite so innocuous when it is noted that this tufa formed in a very short period of time (since the road was built) and that Helgeson and Garrels (Econ. Geol., Sept.-Oct. 1968, p. 634) suggest that "less than 0.02 ppm gold in solution is sufficient to account for major gold ore deposits." What might these gold-bearing hydrothermal solutions be producing in the fault zone at depth? Probably nothing important, but then.....

Near Indian Falls some 9 miles south of Greenville in Plumas County, another example of silver deposition in recent times was seen. A travertine deposit of several hundreds of thousands of tons of manganese-bearing calcareous material is even today forming at a bend of Indian Creek. Bright algal colors can be seen at several points near the base of this recently-formed mass. The travertine is being mined on a minor scale by open pit methods, apparently for ornamental usages. The countryrocks are Paleozoic slates and calcareous siltstones which are silicified and intruded by quartz veins in a wide northwest-trending zone that includes the hot springs. Several Late Tertiary volcanic plugs are found within a couple of miles to the west.

Eighteen samples taken from the countryrocks about the travertine deposit showed no gold and, at maximum, .15 ppm of silver. Most of these samples assayed from .10 ppm Ag to undetectable silver. A sample of the quarried travertine contained no gold but assayed .35 ppm Ag. In retrospect, it might have been of academic interest to have sampled the hot spring waters for their silver content. The factor of enrichment of silver-bearing travertine over the formational hydrothermal fluids, if such a factor exists, might be revealing. If less than .02 ppm gold in solution is sufficient to create major gold ore deposits, how much silver in solution does it take to make, say, a Waterloo?

Neither the Trinity Gold nor the Indian Falls hydrothermal activity is worthy of any further Company interest, but they might be good subjects for purely academic study.

Barry N. Watson

Barry N. Watson

cc: JHC
JAB

JHC

FORM SL-1035-A 1 M 4-70

KEEP THIS ON TOP

File No.

From to

Subject: GOLD - GENERAL

J. H. C.

AUG 24 1977

RECEIVED
AUG 23 1977
EXPLORATION DEPT.

August 19, 1977

Mr. S. Von Fay
Denver Office

file "Gold"

South Dakota
Estes Conglomerate

Dear Mr. Von Fay:

F. Allan Hills and M. H. Delevaux have a short note in the recent Geological Survey Circular 753, in which they describe the Estes Conglomerate, a quartz-pebble conglomerate. It is noted in the article that pyrite can form as much as 25% of the matrix of the rock, that the beds are moderately radioactive, and that they contain minor gold. This description could also fit the quartz-pebble conglomerate at Blind River, Ontario, and the authors make this suggestion.

I wonder if you would review Open File Report 77-75 and bring me up-to-date on the exploration activity and possibilities, and let me know what the previous exploration work is. I have never heard of this formation before, which on the basis of the three-page paper, would appear to be of some interest.

Very truly yours,

Original signed by
R. L. Brown

R. L. Brown

Enclosure

cc: JHCourtright w/enclosure
WLKurtz "
RSGray "

and inexpensive and promises to be a useful exploration tool for sedimentary uranium deposits.

Adams, S. S., Curtis, H. S., and Hafen, P. L., 1975, Alteration of detrital magnetite-ilmenite in continental sandstones of the Morrison Formation, New Mexico, in Uranium exploration methods: Internat. Atomic Energy Agency, Vienna, p. 219-253.

Adler, H. H., 1973, Exploration for uranium in sandstones--geochemical, remanant magnetic, and sulfur isotope applications, in Uranium exploration methods: Internat. Atomic Energy Agency, Vienna, p. 155-166.

Ellis, J. R., Austin, S. R., and Droullard, R. F., 1968, Magnetic susceptibility and geochemical relationships as uranium prospecting guides: U.S. Atomic Energy Comm. R.I.D., rept. 4, G.J.O. Grand Junction, Colo., 21 p.

Reynolds, R. L., 1975, Alteration of iron-titanium oxide minerals associated with uranium deposits in sandstones, in Craig, L. C., Brooks, R. A., and Patton, P. C., eds., Abstracts of the 1975 Uranium and Thorium Research and Resources Conference: U.S. Geol. Survey Open-File Rept. 75-595, p. 38-39.

ORIGIN OF URANIUM IN THE MIDDLE PRECAMBRIAN ESTES CONGLOMERATE, EASTERN BLACK HILLS, SOUTH DAKOTA--INFERENCES FROM LEAD ISOTOPES

By F. Allan Hills and Maryse H. Delevaux,
U.S. Geological Survey, Denver, Colo.

The middle Precambrian (or Precambrian X) Estes Conglomerate, which crops out approximately 23 km northwest of Rapid City, South Dakota, in Lawrence, Meade, and Pennington Counties, contains beds of well-sorted quartz- and quartz-pebble conglomerate (oligomictic conglomerate), in which pyrite may form as much as 25 percent of the matrix. Commonly these beds are moderately radioactive (table 1) and locally they contain minor gold (table 2 and fig. 1).

The Estes Conglomerate lies unconformably upon the Benchmark Iron-formation (a banded quartz-taconite rock) and upon the Boxelder Creek Quartzite (Bayley, 1970) both of the Nemo Group. Most pebbles and larger clasts in the Estes apparently were derived from these two formations. In its northernmost exposures, at the head of Little Elk Canyon, the Estes may lie unconformably upon the lower Precambrian (or Precambrian W) Little Elk Granite, although outcrops are poor and the contact relations are not firmly established. Quartz pebbles predominate over quartzite pebbles in oligomictic beds in the Estes at this locality, suggesting that the granite, and quartz veins within the granite, may have been the source rock for these oligomictic beds.

Pyrite, gold, and radioactive minerals in oligomictic

Table 1.--Uranium and thorium concentrations in weathered rocks, calculated fresh-rock uranium concentrations, and $^{207}Pb/^{206}Pb$ ages of Estes Conglomerate

Sample No.	Weathered rock (Delayed neutron analyses)			Fresh-rock (calculated)		$^{207}Pb/^{206}Pb$
	U ppm	Th ppm	Th/U	U ppm	Th/U	Age in m.y.
BH-76-5b	41	164	4.0	66	2.48	1925
BH-76-13a	11	700	6.4	114	6.14	2150
BH-76-14a	36	188	5.2	104	1.81	2075
BH-76-19	21	173	8.2	77	2.25	2000
BH-76-26	11	110	10.0	44	2.30	2810

Table 2.--Gold content of samples of Estes Conglomerate containing ≥0.05 ppm Au[1]

Sample No.	Au (ppm)	Sample No.	Au (ppm)
BH-76-9b	0.16	BH-76-20a	0.08
BH-76-14a	0.06	BH-76-26	0.28
BH-76-14d	0.05	BH-76-28a	1.39
BH-76-14e	0.25	BH-76-28b	0.49
BH-76-19	0.06	BH-76-28c	0.37

.04 oz $6.00 at $150 Au

[1]All samples reported by Hills (1977) were analyzed for Au. For the locations of barren samples, see his figures 2 and 5. Au determined by fire assay and atomic absorption by J. G. Crock, Joseph Haffty, and A. W. Haubert.

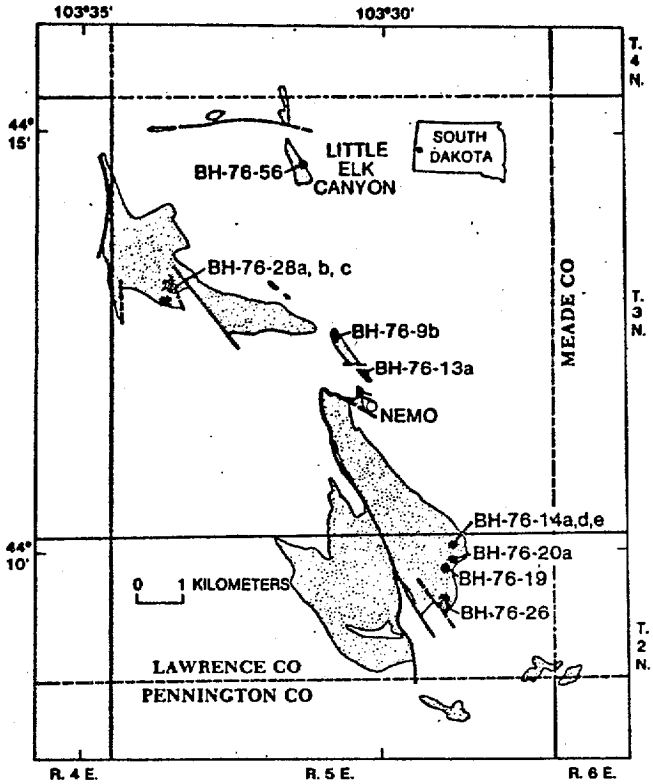


Figure 1.--Area of explosure of the Estes Conglomerate (stippled) with sample localities. (Geology adapted from Bayley, 1972).

beds of the Estes Conglomerate have been interpreted as heavy-mineral concentrates formed in placer deposits of early middle Precambrian age (Hills, 1977). However, the possibility that uranium was introduced into these conglomerates by more recent epigenetic processes cannot be ruled out on the basis of field and geochemical evidence. Intense weathering of outcrops, facilitated by oxidation of pyrite, would have eliminated any easily altered uranium minerals that originally were present, making mineralogical studies of samples from outcrop of little value in distinguishing between a syngenetic and an epigenetic origin for the uranium. The degree of weathering and oxidation of Estes Conglomerate appears to be greatest where the oligomictic beds originally contained the most pyrite (estimated from pyrite molds). Therefore, these same areas probably have the greatest potential for containing commercial-grade uranium.

Oxidation and leaching of the oligomictic conglomerates have obscured the answers to two important questions: (1) What process concentrated uranium in the Estes Conglomerate?; and (2) how much uranium is present below the zone of oxidation and leaching? Lead-isotope ratios from weathered samples provide tentative answers to these questions that may be useful in deciding whether a bore-hole program is warranted. According to the syngenetic or placer hypothesis, the uranium has resided in the oligomictic beds since the early middle Precambrian, whereas according to the epigenetic hypothesis, uranium was introduced at a relatively recent time. The $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios should be higher than those for most ordinary rock lead if the syngenetic hypothesis is correct, and $^{207}Pb/^{206}Pb$ ages should be early or middle Precambrian.

The exact uranium content of the fresh rock cannot be determined from analyses of highly weathered samples because the uranium, as well as the lead and thorium, are depleted or enriched to some unknown extent in weathered samples. Nevertheless, if the age of a U-Th-Pb system is known or can be estimated from other data, the U/Th ratio responsible for producing the lead isotope system can be calculated with the following equation

$$\frac{^{238}U}{^{232}Th} = \left(\frac{^{206}Pb}{^{208}Pb}\right)_r \times \frac{(e^{\lambda' t}-1)}{(e^{t\lambda}-1)} \qquad (1)$$

where $(^{206}Pb/^{208}Pb)_r$ is radiogenic lead, t is the age of U-Th-Pb system, is the decay constant for ^{238}U, and is the decay constant for ^{232}Th. This equation is strictly true only where the U-Th-Pb system has remained closed until geologically recent times.

The $^{238}U/^{232}Th$ ratios determined by equation (1) are not sensitive to errors in the independently determined age (t); errors as great as 500 m.y. produce variations of less than 5 percent in $^{238}U/^{232}Th$, provided the lead is moderately radiogenic. However, the $^{238}U/^{232}Th$ ratio calculated may be in error because the degree of weathering and lead removal from uranium-rich phases may differ from that in thorium-rich phases.

The low solubility and low mobility of thorium in the weathering environment suggests that the fresh-rock uranium tenor can be estimated by using a chemical analysis for thorium in conjunction with the $^{238}U/^{232}Th$ ratio derived from equation (1). The effects of weathering (preferential loss of uranogenic lead, introduction of lead from nearby rocks, and mobility of thorium) and of Precambrian metamorphism (loss of lead) are most apt to cause underestimation of fresh-rock uranium, whereas loss of uranium early in the history of the sample (perhaps during metamorphism) would cause overestimation of fresh-rock uranium.

Five samples of weathered Estes Conglomerate (fig. 1) yield the following ranges of isotope ratios: $^{206}Pb/^{204}Pb$ from 38.65 to 92.02; $^{207}Pb/^{204}Pb$ from 19.57 to 25.18; and $^{208}Pb/^{204}Pb$ from 50.04 to 168.25. These ratios are higher than normal Precambrian rock leads and yield apparent $^{207}Pb/^{206}Pb$ ages that range from 1925 m.y. to 2810 m.y. (table 1).

Based on an assumed age of 2500 m.y. for the U-Th-Pb system and corresponding common lead ratios (Stacey and Kramers, 1975, Table 9), equation (1) yields apparent fresh-rock Th/U ratios that range from 1.8 to 6.1 and

fresh-rock uranium concentrations of as much as 114 ppm.

Geologic age, sedimentary characteristics, and the coherence of uranium, thorium, and gold in oligomictic beds of the Estes Conglomerate support an interpretation of uranium in the Estes as fossil placer deposits, similar in origin to uraniferous conglomerate in the Elliot Lake District of Ontario and the Witwatersrand of South Africa. By their antiquity, the $^{207}Pb/^{206}Pb$ ages support the syngenetic or fossil placer hypothesis and appear to rule out the recent-epigenetic hypothesis.

Although the semiquantitative estimates of fresh-rock uranium tenor, based on lead-isotope analyses of five samples, do not confirm that ore-grade rock is present, they indicate that as much as 90 percent of the uranium originally present has been leached from the conglomerate. This suggests that part of the uranium may be present in soluble minerals, such as uraninite, and that economic concentrations may occur in the Estes where sedimentologic conditions and source rock were favorable. The Estes Conglomerate, especially where it contains a high proportion of detritus from the Little Elk Granite, merits further examination by means of boreholes.

Bayley, R. W., 1970, Iron deposits of the Estes Creek area, Lawrence County, South Dakota, in Geological Survey research 1970: U.S. Geol. Survey Prof. Paper 700-B, p. B93-B101.

_____1972, Preliminary geologic map of the Nemo district, Black Hills, South Dakota: U.S. Geol. Survey Misc. Geol. Inv. Map I-712.

Hills, F. A., 1977, Uranium and thorium in the Middle Precambrian Estes Conglomerate, Nemo District, Lawrence County, South Dakota--A preliminary report: U.S. Geol. Survey Open-File Rept. 77-55, 27 p.

Stacey, J. S., and Kramers, J. D., 1975, Approximation of terrestrial lead isotope evolution by a two-stage model: Earth and Planetary Sci. Letters, v. 26, no. 2, p. 207-221.

THE ROLE OF BOREHOLE ELECTRICAL MEASUREMENTS IN URANIUM EXPLORATION

By Jeffrey Daniels and James Scott
U.S. Geological Survey, Denver, Colo.

The only borehole electrical resistivity-related measurement that is commonly used in uranium exploration is the single-point resistance log. This measurement is used exclusively for stratigraphic correlation and, as such, is a valuable and inexpensive exploration tool. However, single-point measurements do not provide quantitative information concerning the physical or lithologic properties of the rocks.

Resistivity and induced polarization (IP) logs are also useful for stratigraphic correlation, and in addition they can provide information concerning the physical characteristics of rocks. Quantitative characterization of lithologic conditions by use of these logs can be a useful indicator of favorable environments for uranium occurrence.

Figure 1 shows the single-point resistance and resistivity logs in an ore zone and outside of the ore zone for a uranium deposit in the Powder River Basin. The ore deposition is characterized by a high calcite cement content at the bottom of the ore sand, a depletion of calcite cement in the middle of the ore sand, and an increase in calcite cement at the top of the ore sand (off top of fig. 1). This is clearly illustrated by the resistivity logs in figure 1. However, the single-point resistance logs do not clearly show the difference (in spite of the fact that the recording sensitivity is much higher for the resistance logs). Although calcite cement near the bottom of the ore zone is indicated on the single-point resistance log, the log also shows spikes such as the one at a depth of 53 meters that are caused by variations in borehole diameter rather than lithology.

The primary advantage of using quantitative resistivity and IP logs, is the ability to use them for detecting anomalous concentrations of non-radioactive minerals associated with uranium mineralization. Figure 2 shows the correlation that was found between resistivity values and clay content in the ore sand of a south Texas uranium deposit. This figure indicates that, for this deposit, the total clay content of the sand can be estimated directly from the resistivity logs. This can be important in areas where the clay content varies in different parts of the roll front.

IP measurements respond to the presence of certain clay minerals (particularly montmorillonite) and sulfides such as pyrite. Since the amounts of montmorillonite and pyrite vary across a uranium geochemical front, IP measurements can be

ASARCO

Southwestern Exploration Division

September 2, 1976

TO: G. W. Pickard

FROM: F. T. Graybeal

Precious Metal Exploration in New Mexico

The results of exploration for porphyry copper deposits in New Mexico indicate that the potential for their discovery is far less than in Arizona. Accordingly, I would like to change the emphasis of our exploration in New Mexico to precious metal deposits and I am asking you to initiate this program. The objective would be the discovery of a vein or disseminated gold-silver ore deposit of sufficient size to be of interest to Asarco.

A review of the literature shows that most of the known precious metal districts are located in or adjacent to the Mogollon volcanic plateau which lies south of the San Augustine plains, west of the Rio Grande River, and north of Lordsburg-Deming. There are several important districts outside this area, but you should clear with me any work north of Route 66 (EW through Albuquerque), which would normally be handled by the Denver Office.

As a first start you may want to review data on the Mogollon district the largest producer in the area (brief reference attached), and the Chloride district, site of recent discoveries by Goldfield Consolidated Mines Co. (extensive data in our files). Although most of the published literature on the precious metal districts is old it may contain useful references to stratigraphic control and disseminated ore.

The program has no time limit so the investigations of the various districts should be thorough. Your work can involve, as a first step, surface geochemical sampling between productive veins to determine whether dispersion of precious metals has occurred. However, it should also evaluate

1) stratigraphy -- for permeable or reactive units which might serve as ore controls (see attached memo by J. H. Courtright; review discussion of geology and disseminated siver deposits in the Creede formation by Steven and Rattee, U.S.G.S. Prof. Paper 487)

2) possibilities of blind, vein-controlled ore shoots such as those recently discovered in the Chloride district

3) pre-mineral caldera structures (see attached paper by Elston, Rhodes, & Erb).

We will be most interested in any new approaches you might use in this area, particularly as they might apply to similar exploration in Nevada.

Please keep me advised from time to time as to your progress, and keep an eye out for other good-looking prospects as well -- we'd take anything that looked profitable.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Atts.

cc: WLKurtz

ASARCO

Exploration Department

August 5, 1976

Memo for J.H.G. Fuchter

ARCHEAN GOLD -
SOUTHERN AFRICA
(LITERATURE SEARCH)

Enclosed is "The Nature and Distribution of Archean Gold Mineralization in Southern Africa" along with Mr. Fletcher's brief comment. You may have already seen the paper, but am passing it along anyhow.

Aside from the conclusion that most if not all of the gold is volcanogenic in origin with remobilization accomplished by subsequent granitoid intrusions, of significance in respect to prospecting is the observation that it often occurs so finely divided as to be megascopically invisible ---- a characteristic in common with much younger deposits such as Carlin, Cortez etc., which escaped discovery until recent times because of "no colors in the pan."

Production figures are of interest, showing Canada topping the list for Archean gold (173 million oz.) with Africa 2nd. (78 M.) and Western Australia 3rd. (70 M.). But dominating the field, Witwaterstrand (Post Archean) produced over one billion ounces, accounting for 55% of all gold so far mined in the World, according to the author. However, another source (International Monetary Market of the Chicago Merchantile Exchange Inc.) estimates 35% for South Africa; World production for 1974 is estimated at 43 million ounces with South Africa accounting for 28 million, or two-thirds of the total.

J. H. Courtright

J.H. Courtright

JHC:vh
Enclosure
cc: TCOsborne w/o enc.
WLKurtz/FTGraybeal w/enc.
RSGray w/enc.
JCBalla w/enc.
SVonFay w/enc.
DMFletcher w/o enc.

1-30-76

FROM: J. H. [illegible]ORTRIGHT

TO: RB Sprague

After talking by phone yesterday with Dick Brown, it occurred to me that a search for possibly favorable bed in the Au-Ag vein Districts of Spain might be worthwhile ——

Has there been any follow-up on stratiform scheelite — Cecil Von Hahn, Mar. 20, 1974 ?

JHC

cc JJ Merz

Att. — "Gold-Silver Prospecting"

March 20, 1974

J. H. C.

FEB 3 1976

file Gold

PETROGRAPHIC MEMO

Comparison of samples from Larder Lake area, the Dome mine (Porcupine district), and the Giant mine (Yellowknife district)

The samples from the Larder Lake area were either greenish carbonate-fuchsite schists or brownish quartz-carbonate (ankerite schists) with minor brownish mica. Carbonate varies from 50-90 percent of the three rocks collected.

Two of the samples collected from the Dome mine were schistose quartz-carbonate-fuchsite/chlorite schists. Chlorite in the schists was Mg-rich. Chlorite in an altered amygdaloidal andesite was slightly Fe-rich. A quartz eye, lapilli-rich volcanic, thought to be an extrusive equivalent of the Pearl Lake porphyry, showed a moderate resemblance to the dacite at Silver Bell.

The "vein" at the Giant mine is actually a brownish, quartz-sericite-carbonate schist. It is similar in its buff-brownish color to some of the schists at both the Dome mine and near Larder Lake. The Giant sample also showed a tendency for quartz to occur in layers of variable grain size similar to the cherty tuffs in the Noranda district. The similar megascopic and microscopic features of the quartz-carbonate rocks from these three areas suggests a similar origin for the associated gold ores. The possibly syngenetic aspect of these deposits is interesting, particularly since the "vein" at the Giant mine is strongly folded.

The "assay cutoff" nature of the ore at the Giant mine is illustrated by an article in the 3/14/74 Northern Miner (p. 23). The article notes that 600,000 tons, about 2/3 of the present total reserve was added by recontouring existing stope blocks at a lower cutoff. The grade dropped from 0.52 oz. to 0.36 oz. Au.

Metals Sourcebook, V. II, no. 11, June 3, 1974, p. 3

Giant Yellowknife open pit feasibility complete, production in 1975. Open pit reserves are 480,000 tons @ 0.3 oz. Au/ton

ASARCO

Exploration Department

January 23, 1976

Memo for J.C. Balla
M.P. Barnes
R.E. Gale
F.T. Graybeal
L. Montoya
S. Von Fay

GOLD-SILVER PROSPECTING

Although it has been recognized for sometime that important sized deposits of gold and/or silver tend to occur in sedimentary or pyroclastic horizons associated with veins (such as Hardshell, Waterloo and Carlin) our search for new deposits has been largely oriented toward the study and sampling of exposed vein wallrock.

Mr. Kurtz reports that recent work at Rochester indicates that the Weaver formation (tuffs and fragmental volcanics) appears to contain the best silver values and that at Pueblo Viejo in the Dominican Republic open pit gold ore is apparently confined to a sedimentary sequence, ranging from shale to conglomerate. Freeport's recent discovery in the Creede District is another example.

He has proposed, and I agree, that a more effective approach in prospecting should include a search for possibly favorable horizons in precious metal districts, rather than relying entirely on sample results from exposed vein wallrock.

J.H. Courtright

J.H. Courtright

JHC:vh

cc: TCOsborne
WLKurtz

file : Gold

J. H. C.
NOV 4 1975

OPERATING COSTS OF GOLD PLANTS

FREE MILLING ORES

U. S. $ per Short Ton

COMPANY	Benguet Consolidated	Camflo	Cortez	Dome	Homestake
Cost Period	1973	1973	1973	1973	to 6/1/74
Capacity, short tons per 24 hours	3000	1040	2400	2000	5250
Mining Cost per short ton	-	$3.82 (1)	$0.25(1)	$8.30	$7.13
Milling Cost per short ton by Facility					
Crushing	0.08	0.33	0.14	0.42	0.25
Grinding and classification	0.38	0.46	0.23	0.55	0.45
Cyanidation and thickening	0.49	0.27	0.34	0.41	0.53 (6)
Clarification and precipitation	0.10	0.25	0.07	0.39	0.06
Refining	0.04	0.02	0.05	0.03	0.12
Flotation, if used		-	-	-	-
Concentrate handling		-	-	0.02 (2)	-
Tailings storage and water recovery	0.05	0.05	0.11	0.29	0.04
Indirect and overhead	0.42	0.20	0.44	(3)	0.05
Other		0.20	-	-	-
Total Mill Operating Cost	$1.56	$1.78	$1.38	$2.11	$1.50
Total Labor	0.12	0.90	0.32	0.70	0.71
Operating	0.10	0.55	0.27	-	0.52
Maintenance	0.02	0.35	0.05	-	0.19
Other	-	-	-	-	-
Total Supplies	0.95	0.55	0.60	1.41 (4)	0.50
Reagents	0.42	[0.29	0.27	0.16	0.14
Grinding Media	0.31		0.12	0.15	0.25
Maintenance	0.09	-	0.21	-	0.06
Other Supplies	0.13	0.26	-	-	0.05
Power	0.18	0.24	0.17	0.17	0.16
Supervision	0.05	0.09	0.13	0.15 (5)	0.18
Overhead	0.26	-	0.04	0.11 (5)	0.05
Other		-	0.12	-	-
Total Mill Operating Cost	$1.56	$1.78	$1.38	$2.11	$1.50

(1) Direct cost
(2) Jigging and amalgamation
(3) Included in above
(4) Includes maintenance labor
(5) Included in total labor above
(6) Cyanidation of sand, 26¢ per ton, carbon-in-pulp, 27¢ per ton, sand is 60%, slime is 40% of tons milled

OPERATING COSTS OF GOLD PLANTS

USING SULFIDE FLOTATION AND CYANIDATION

U. S. $ per Short Ton

COMPANY	Benguet Exploration	Itogon-Suyoc Itogon	Itogon-Suyoc Palidan	Knob Hill	Pamour
Cost Period	1970	1970	1970	1973	to 7/1/74
Capacity, short tons per 24 hours	130	600	430	250	3200
Mining Cost per short ton	$9.46	$1.82	$3.30	(6)	$5.86
Milling Cost per short ton by Facility					
Crushing	0.30	0.09	0.16	6.77	0.40
Grinding and classification	0.99	0.21	0.50	19.35	0.42
Cyanidation and thickening	2.76 (1)	0.30	0.50	21.60	0.14
Clarification and precipitation	0.62 (2)	0.09	-		0.02
Refining	0.24	0.02	0.04	-	0.02
Flotation, if used	1.89	0.09	0.19	12.25	0.14
Concentrate handling	0.30	-	-	0.07	-
Tailings storage and water recovery	0.10	-	-	5.70	0.05
Indirect and overhead	-	0.21	0.63 (3)	34.26	0.26
Other	-	0.04	0.11 (4)	-	0.22 (5)
Total Mill Operating Cost	$7.20	$1.05	$2.13	100.0	$1.67
Total Labor		0.30	0.25	53.9	-
Operating		Not	Not	41.9	-
Maintenance		Stated	Stated	12.0	-
Other					
Total Supplies	Breakdown Not Available	0.54	1.10	46.1	-
Reagents		0.42	0.52	10.2	0.09
Grinding Media		0.12	0.37	8.7	0.20
Maintenance		-	-	5.8	-
Other Supplies		-	0.21 (5)	-	-
Power		0.17	-	8.2	0.17
Supervision		0.04	0.02	4.0	-
Overhead		-	0.76	9.2	-
Other		-	-	-	-
Total Mill Operating Cost	$7.20	$1.05	$2.13	100.0	$1.67

(1) Leaching only, cyanide usage 16 lb per ton
(2) Includes thickening
(3) Power, assaying and other
(4) General, amalgamation, testing and laboratory supervision
(5) Includes power
(6) All figures in percentages:

Mining cost per ton	59.7%
Milling cost per ton	14.1%
General overhead per ton	26.2%

~~WLK~~, ~~EPG~~, ~~GJS~~

October , 1975

Memorandum to J.J. Collins

Gold Ores
Mining and Milling Costs

You may be interested in the attached.

cc. J.H. Courtright
C.E. Beverly
Summitville file

RECEIVED
OCT 24 1975
EXPLORATION DEPT.

ASARCO

Mineral Beneficiation Department

October 14, 1975

J. H. C.

OCT 15 1975

Memorandum To: Mr. Harold Courtright

file Gold

Subject: Economic Evaluation of Gold Ore Processes - Article by Bhappu and Lewis

I have the following comments regarding the capital and operating costs given for CCD/Merrill-Crowe Zn precipitation plants in the subject article:

Capital Cost

1. The 13.4 million capital cost given (excluding mining capital cost) is far lower than the comparable cost estimated for Waterloo which would be about 29.5 million (Waterloo estimate of May, 1975 less cost of barite plant, tailing dam, cyanide destruction unit and reduced to 5,000 tpd throughput instead of 6,000 tpd). Possibly an additional 2 million could be deducted from the Waterloo cost to compensate for the fine grinding equipment required, but this still gives a comparable cost of 27.5 million.

2. The Waterloo plant construction would require considerable craft labor from the Los Angeles area and this would run up costs somewhat compared to a construction site near a population center such as, say, Tucson or Phoenix. However, mines generally are in remote areas and importing craft labor is a normal expense unless a mine is very fortunately located.

3. I suspect that the Bhappu/Lewis cost estimate is based on non-union labor. This would indeed save considerable money but is by no means possible everywhere.

4. For additional comparison, the feasibility study for Troy (8,500 tpd copper flotation plant) indicated a plant cost of 45.0 million. Equalized for size and more normal location this would still give a comparable cost of at least 25.0 million.

5. It should be noted that the Bhappu/Lewis plant life is calculated for six years. Some money might be saved by constructing a plant for only a six year life, but I doubt that more than a million or two could be saved and this would probably be at the expense of higher operating costs.

Operating Cost

1. The operating cost given (4.358 million per year) calculates out to $2.64 per ton milled. This compares with our estimate

of $2.91 per ton for Waterloo. The Bhappu/Lewis cost includes provision for only .5 lb. per ton cyanide consumption which would require a very clean ore.

2. It is interesting to note that the mining cost used is $0.60 per ton. This is the same as we estimate for Waterloo which is an ideal open pit with very low stripping ratio.

In general it appears that Messrs. Bhappu and Lewis have come up with artifically low capital costs and operating costs attainable only with ores which are very easy to mine and mill. This is not too surprising since these gentlemen are in the business of designing and building metallurgical plants and would undoubtedly like to attract a few customers.

D. E. Crowell
Director

vh

ASARCO Incorporated
Tucson Arizona

J. H. C.
OCT 1 1975

September 30, 1975

Memorandum for J. J. Collins

file

Gold
Cyanide Plants

Reference is made to Mr. Entwistle's letter of September 5, 1975 subject: Open Pit Gold Mines, Getchell Mine, and Mr. Courtright's memo of September 16, 1975 subject: Summitville.

I have listed below heads, recoveries, and tails from selected cyanide plants. The information has been gleaned from the recent publication: Gold and Silver Cyanidation Plant Practice by McQuiston and Shoemaker, published by the AIME 1975.

A. Free milling gold ores

Mine	Heads	% Recovery	Tails
Camflo	0.25	96.4	.009
Cortez*	0.10	85	.015
Dome	0.2235	97.4	.0059
Homestake	0.24	94.6-95.0	.013-.012
Homestake Carbon-in-pulp	0.1-0.08	90-94	.006-.01

B. Other

Itoy-Suyoc Philippines Palidan mill feed from flotation	0.54309		.00851
Rio Tinto Cerro Colorado, Spain*			
	1.225 Ag	40	.735
	0.07 Au	90	.007
Tayoltita, Mexico	16.08 Ag	95	.804
	0.225 Au	96	.01
Rochester silver ore pilot plant studies			
	.0067	86.6	.0009
	.0095	82.1	.0017
Hayden Hill (preliminary test)			
	.05-.07	+90	<.005

*open pit mines

In addition, the publication states that, at least in the first years of mining (when gold was $35.00 per ounce), cutoff at Cortez was .08 with an average head of 0.10; and since the rise in price of gold cutoff at Carlin has been .03 with an average head of 0.20.

Each low grade precious metal deposit must be evaluated on its own merits. As learned at Waterloo, some preliminary metallurgy should be done early in the game; cutoff cannot be arrived at until a sufficient amount of sampling has been done and mine-mill costs and recoveries established.

W. L. Kurtz

W. L. Kurtz

WLK:lb

cc: JHCourtright

File "Gold"

point since the measurement of ores,

tion, and Cyanide Regeneration.

of South Africa.

1975 June World Mining

JHC.

J. H. C.
SEP 15 1975

LAWSON P. ENTWISTLE
CONSULTING MINING GEOLOGIST
10,000 E. BROADWAY
TUCSON, ARIZ. 85710
(602) 296-3090

September 5, 1975

Mr. John J. Collins, Vice President
ASARCO Incorporated
120 Broadway
New York, N.Y. 10005

file "Gold"

OPEN PIT GOLD MINES
GETCHELL MINE

Dear John:

Bill Kurtz showed me your recent letter concerning the Getchell gold mine and we discussed various factors that are, in many ways, peculiar to the low-grade, open pit type gold mine. Bill did not have the exact figures immediately available, but the main facts are about:

1) The reserves are said to be 4 million tons, averaging 0.19 oz. Au pt;
2) The stripping ratio is in the range of 5 to 1;
3) The milling costs (roasting and cyanidation) may be around $6.25 per ton; and
4) The ore contains arsenic and carbonaceous material.

I would guess that the over-all costs, including indirect but not depreciation, depletion, and other book charges, would be about $10.00 per ton.

It has been suggested that by lowering the cut-off from 0.10 oz. to 0.05 oz., the tonnage could be increased to 10 million and perhaps the stripping ratio reduced. The over-all grade would be reduced to about 0.10 oz. pt.

We have talked on the phone various times about some of the problems that can be encountered with low grade gold prospects, and this is a good time to review them.

The first problem is accuracy of samples. It should be recalled that there are 29,167 troy ounces in a short ton, so that for each 0.01 oz. Au pt there are over 2.9 million parts of barren material by weight. By volume, the difference increases over seven-fold due to the disparity in the specific gravity of gold compared to that of usual gangue (barren) material. We are, therefore, dealing in extremely small quantities.

The natural thought is to take large samples in order to insure accuracy, but it should be kept in mind that regardless of size of the original sample less than 30 grams (one assay-ton = 29.167 grams) is actually used for a fire assay; therefore, sample preparation is of utmost importance. Let us assume that a sample weighs 50 lb. If the entire 50 lb. is first crushed to minus 1/8 inch, it can then be quartered. Each quarter (12-1/2 lb.) can then be reduced to minus 10-mesh and quartered again so that you now have four portions 3-1/8 lb. each. If each of the last four portions are pulverized to minus 100-mesh, then an assay-ton from each portion can be assayed.

By handling in this way, you will have four assays for each 50 lb. sample and all should check within very tight limits, say 0.005 oz. per ton. If they don't, you probably have some segregation of values. One place such segregation can occur is in rolling the pulverized material to mix it, as the heavier material will gravitate towards the bottom of the pile. I suggest that rolling be minimized.

Provided the samples have been handled very carefully in the assay office, especially in the preparation, the reagents used should be checked carefully. On one occasion I was asked to check on a laboratory who claimed they had a method of assaying for gold that could not be found by normal fire assay. Briefly, the method was to treat the sample with a tri-acid solution and then extract the gold with a resin and finally assay the resin by the fire method. I discovered that the litharge used was army surplus and actually contained the small amount of gold that was found in each sample.

Now we come to another point -- the actual amount of gold that is lost in the concentrating process. If the cyanide process is used, a tailing of 0.015 oz pt can be expected regardless of the mill head. Thus, if the mill head is 0.07 oz. pt, you will probably have a recovery of about 78%, whereas with 0.20 oz. pt mill head the recovery will be around 92%. This is a substantial difference, with gold at $150 per ounce the tailings contain $2.25 per ton, gross value (comparable to 0.17% Cu tailings at 63¢ per lb.).

To obtain the best recovery one must know something about the size of the gold particles in the ore. For example, if the ore is ground to 7.5 microns and the gold particles are only 0.75 microns, the probability of having any gold exposed (in order for the cyanide to attack it) is only 29%; if the gold is 0.075 microns the probability is reduced to 3%. At Neptune, the gold ore is reduced to 68% minus 200-mesh to obtain a 0.015 oz. pt tailings; but if the grind is only 50% minus 200-mesh, the tailings assay increases greatly.

Next comes milling costs. Cyanide costs about 35¢/lb., and an ore that uses only 3 lb. per ton ($1.05) would be exceptional; probably 5 lb. ($1.75) would be closer to an average "good" cyaniding ore. Frequently the gold occurs in a quartz gangue and grinding costs may be on the high side. Again at Neptune, the milling cost is about $5.50 per ton (gold ore only), and they have very cheap hydro-electric power and low labor costs. Supplies are more expensive than in the States -- cyanide costs 43¢ per lb.

Mill construction for the cyanide circuit is high because of all the large tanks required and the movement of great amounts of pulp from one place to another.

The final point is the amount that will be realized for the gold produced. First, you will be paid for only 98% of the gold contained in the dore at the London final less $3.00 per ounce for refining. The dore varies in fineness but may be only 1/3 gold, the rest being silver, copper, zinc, etc. On a bulk shipment there is an additional charge of $200 per 1,000 oz. gross weight for sampling and assaying. Thus, if the gold quotation is $150 per troy ounce, the shipper will receive about $143.40 per ounce, less shipping and insurance to the refinery. Perhaps the quotation less $10 would be a good ballpark figure.

From all of the above discussion, if we assume that you are confident that the grade is correct to within 0.005 oz. pt, and that the total costs may be $10 per ton, then a cut-off of 0.05 oz. pt is far too low. At 0.05 oz. pt only 0.035 oz. pt is recoverable with a net refinery return of $4.90 pt at $150 gold.

It appears to me that the first estimate, using a cut-off of 0.10 oz. pt, is reasonable as far as the economics are concerned. Whether the estimate itself is correct, I can't say; or what other problems can arise from the arsenic content are another matter. I must stress, however, that this whole discussion really is not pointed directly at the Getchell mine.

The main point of the entire business is that you can't compare gross metal values of an open pit gold mine with those of an open pit copper mine. They're not the same animal.

Very truly yours,

Larson

LPE:lb

cc: JHCourtright
WLKurtz

RECEIVED
AUG 1 1975
EXPLORATION DEPT.

29 July/75

J. H. C.
AUG 19 1975

Dr. L.D. James,
Chief Geochemist,
Exploration Department,
Asarco Incorporated,
3422 South 700 West,
Salt Lake City, Utah 84119.

Gold Geochemistry

Dear Lloyd:

Further to your letter of 21 July/75 concerning gold geochemistry, the attached copy of Canadian Geological Survey Paper #75-24, SOME OBSERVATIONS ON THE SOLUBILITY OF GOLD, may be of interest.

This paper is a new release and may not have reached your desk as yet.

Yours very truly,

S.A. Anzalone.

SAA:sm
Encls

CC: JJCollins, JHCourtright, w/attach.

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

GEOLOGICAL SURVEY
PAPER 75-24

SOME OBSERVATIONS ON THE SOLUBILITY OF GOLD

R.W. BOYLE
W.M. ALEXANDER
G.E.M. ASLIN

1975

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Ottawa
1975

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SOME OBSERVATIONS ON THE SOLUBILITY OF GOLD

ABSTRACT

Solubility experiments confirm that gold can be transported in natural humic waters probably in the form of a metal-organic compound, as a chelate, or adsorbed to humic matter. In gossans and in auriferous sulphide (pyritic) deposits similar experiments indicate that gold can be transported in ferric sulphate solutions. Under hydrothermal conditions gold is readily soluble in alkali carbonate solutions containing H_2S, AsH_3, or SbH_3 or combinations of these constituents.

RESUME

Des expériences de solubilité confirment que l'or peut être transporté dans des eaux humiques naturelles sous la forme d'un composé organo-métallique, soit un chélaté ou soit adsorbé à la matière humique. Dans les chapeaux de fer et les gisements de sulfures aurifères (pyritique) des expériences similaires nous montrent que l'or peut être transporté dans des solutions de sulfate ferrique. Dans des conditions hydrothermales, l'or est facilement soluble dans des solutions de carbonates alcalins contenant H_2S, AsH_3, ou SbH_3, ou un mélange de ces constituents.

INTRODUCTION

For some twenty years the senior author has been investigating the geochemistry of gold in all of its natural settings. Some of the results of this work have been published (Boyle, 1961, 1969; and Boyle and Jonasson, 1973). A forthcoming bulletin will cover the entire research on the element.

One problem in the geochemistry of gold has been of particular interest--namely, the solubility of gold in various natural solutions. Considerable work on this problem has been done in the past, particularly by Liversidge (1893), Stokes (1906), Harrison (1908), Lenher (1909, 1912, 1918), Hatschek and Simon (1912), Freise (1931), Fetzer (1934, 1946), Johnston and Leyland (1938), Ogryzlo (1935), Frondel (1938), Garces (1942), Smith (1943), Kreiter *et al.* (1959), Kelly and Cloke (1961), Shabynin (1966), Goni *et al.* (1967), Listova *et al.* (1966), Machairas (1967), Ong and Swanson (1969), Weissberg (1970), Curtin *et al.* (1970), Lakin *et al.* (1971), Vilor and Sarapulova (1971), Vilor and Skharupa (1971), Henley (1973), Seward (1973), Fisher *et al.* (1974) and Miller and Fisher (1974). The results of these various researches have shown that the principal soluble species of gold are gold hydroxide, $Au(OH)_3$ or $[AuO_2]^-$; halogen complexes of the type $[AuCl_4]^-$; various thio complexes of the type $[Au(S_2O_3)_2]^{3-}$: cyanide and thiocyanate complexes of the type $[Au(CN_2)]^-$ and $[Au(CNS)_4]^-$: and sulphide and polysulphide complexes such as $[AuS]^-$ and $[Au_2(HS)_2S]^{2-}$. Gold can also be transported by humic substances in which the gold appears to be adsorbed to the humic complexes forming some uncharacterized Au-humate. Colloidal gold is also well documented, the "Purple of Cassius" being known for centuries.

Our experiments on the solubility of gold have covered a wide range of natural solutions, some of which such as those containing chlorides, thiosulphates, cyanides, thiocyanates, and alkali sulphides and bisulphides need not be considered here since they are well documented in the papers referred to above. We have been most interested in the solubility of gold in synthetic solutions representative of those that probably deposited auriferous quartz veins and those that have been responsible for the transport of gold in supergene processes. With respect to the first we have experimented with alkali carbonate and bicarbonate solutions saturated with hydrogen sulphide, arsine, stibine, and combinations of these substances. Concerning the supergene solutions, we have experimented with those containing humus or ferric sulphate, the former common in many surficial environments and the latter particularly characteristic of gossans and oxidizing gold deposits containing pyrite, pyrrhotite, and arsenopyrite. All of our experiments are essentially qualitative, the aim being to obtain a general estimation of the solubility of gold in the above mentioned solutions. The concentrations we have used in our experiments are perhaps greater than those encountered in nature; however, we consider that the greater concentrations compensate in part for the time factor in geology.

OCCURRENCE OF GOLD IN NATURE

Gold occurs in a number of ways in its various deposits, the chief modes being as the native metal and combined with tellurium in the various tellurides and with antimony in aurostibite, $AuSb_2$. In addition, gold is a submicroscopic and/or lattice constituent of a number of sulphides, arsenides, and sulphosalts. In minerals like tetrahedrite gold is a lattice constituent probably substituting in the silver sites; in minerals like pyrite and arsenopyrite some gold is present as microscopic blebs, but in some deposits there is also much gold in a submicroscopic form or present in lattice sites in these minerals.

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The various modes of occurrence of gold in its deposits are important in the solubility and migration of gold, particularly in supergene processes. Where the gold occurs in the native form in particles with diameters greater than 50μ the solubility of the metal is much less than when the element is released in a very finely divided form during the oxidation of minerals such as the tellurides, aurostibite, and auriferous pyrite and arsenopyrite which contain the metal as a lattice constituent or as submicroscopic particles. With the latter in mind, and since it seems probable that the source of gold for transport in both hydrothermal and supergene solutions would be largely in an extremely finely divided state, we have used gold as prepared below.

PREPARATION OF GOLD FOR SOLUTION EXPERIMENTS

The gold used in the solution experiments was precipitated in a fine (amorphous) state from sodium gold thiosulphate by reduction with stannous sulphate. The sulphates were thoroughly washed free from the gold ($BaCl_2$ test), and the gold was kept under metal-free water to prevent it from drying out and producing anomalous surface effects[1]. An X-ray of the gold gave an amorphous pattern; X-ray fluorescent analyses showed only traces of tin in the gold sample.

RESULTS OF THE EXPERIMENTS (SUPERGENE PROCESSES)

The solutions tested for dissolution of gold consisted of specially prepared metal-free deionized water, humic solutions, and solutions containing sodium chloride, ferric sulphate, ferric sulphate and H_2SO_4, and ferric sulphate plus H_2SO_4 and NaCl. An excess of amorphous gold was added to each of these solutions, and the solutions were allowed to stand for varying periods being agitated from time to time to ensure thorough reaction. The solutions were then progressively filtered and analyzed directly for gold by atomic absorption, using a Perkin-Elmer 303 spectrophotometer. The 242.8 nm line was used with background correction and dilutions made on any samples indicating a concentration greater than 15 g/ml. The results are shown in Table 1 and discussed briefly below:

Metal-free water

Two samples of deionized metal-free water, to which an excess of amorphous gold was added, were allowed to stand with repeated agitation for nine days, filtered through millipore filters, and tested for soluble gold. Both samples showed undetectable amounts of gold.

Humic-rich solutions

Humic-rich solutions, such as those that occur in streams draining swamps, peat bogs, muskegs, etc., were prepared by reacting metal-free water for some 18 months with peat finely comminuted in a blender. The solutions obtained, containing approximately 0.5 per cent humic matter, were filtered through a No. 1 Whatman paper and tested for gold. None was detected. The humic solutions were then reacted with an excess of amorphous gold for 8 days with frequent agitation. Samples filtered through No. 1 Whatman paper contained 0.15μ g/ml Au, whereas those filtered through the millipore contained no detectable gold. Examination of the two solutions after filtration revealed that the one filtered through the Whatman paper retained much of the brown (colloidal?) material whereas that filtered through the millipore was quite colourless, all or most of the humic matter being removed. These results are entirely in agreement with those obtained by the senior author with humic substances in natural waters over several years, namely that the gold, silver, copper, and other metals are intimately associated with the humic matter being either chelated, organometallically bonded, or adsorbed. When the humic matter is removed the solutions are essentially relatively free of metals.

Sodium chloride solutions

Successive gold-free solutions - saturated, 50 per cent saturated, and 30 per cent saturated with sodium chloride - were prepared and reacted by constant agitation with excess amorphous gold for an hour, filtered through millipore filters, and tested for soluble gold. All three samples showed undetectable amounts of gold.

Ferric sulphate solutions

Successive gold-free solutions - saturated, 50 per cent saturated, and 30 per cent saturated with ferric sulphate - were prepared and reacted by constant agitation with excess amorphous gold for an hour. Similar solutions, but with the addition of 2 ml of concentrated H_2SO_4 and with the addition of 2 ml of concentrated H_2SO_4 and 4 ml of saturated NaCl solution, were reacted with excess amorphous gold. In all cases as shown in Table 1 considerable amounts of gold were taken into solution, the largest amounts being present in the solutions containing H_2SO_4. The presence of

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[1] In various experiments carried out over a number of years the senior author has noted that there are marked differences in the solution properties of gold, some of which are of interest here. Nascent gold in a finely divided amorphous state as prepared above is relatively soluble in a number of solvents. If exposed to the air this gold becomes difficultly soluble; the same is true if the gold is left for any length of time in metal-free water. It appears that gold exposed to air and water becomes armoured against solution in some manner or other by a coating the nature of which is unknown. Furthermore, the state of the gold is important; the finely divided gold prepared as described above is much more soluble than gold filings or gold leaf. While not of particular interest in this study it is also notable that gold containing impurities such as silver is more soluble than gold of very high purity.

TABLE 1. SOLUTION OF GOLD BY VARIOUS AGENTS

SUPERGENE PROCESSES

Type of solution	Concentration of salt, etc.	Filtration procedure	Gold present in solution (μg/ml)	Remarks
Metal-free water		50mμ millipore	0.00	Two 100 ml samples taken
Humic	0.5% humic matter	No. 1 Whatman	0.15	100 ml sample
		50mμ millipore	0.00	100 ml sample
Sodium chloride	30% saturated	50mμ millipore	0.00	100 ml sample
	50% saturated	50mμ millipore	0.00	100 ml sample
	Saturated	50mμ millipore	0.00	100 ml sample
Ferric sulphate	30% saturated	50mμ millipore	0.07	100 ml sample
	50% saturated	50mμ millipore	0.14	100 ml sample
	Saturated	50mμ millipore	0.21	100 ml sample
Ferric sulphate +2ml H_2SO_4	30% saturated	50mμ millipore	0.36	100 ml sample
	50% saturated	50mμ millipore	0.14	100 ml sample
	Saturated	50mμ millipore	0.07	100 ml sample
Ferric sulphate +2ml H_2SO_4+ 2ml sat. sol. NaCl	30% saturated	50mμ millipore	0.18	100 ml sample
	50% saturated	50mμ millipore	0.07	100 ml sample
	Saturated	50mμ millipore	0.04	100 ml sample

HYPOGENE (HYDROTHERMAL) PROCESSES

Type of solution	Concentration of salt, etc.	Filtration procedure	Gold present in solution (μg/ml)	Remarks
Metal-free water		50mμ millipore	0.00	Two 100 ml samples taken
Sodium chloride	30% saturated	50mμ millipore	0.00	100 ml sample
	50% saturated	50mμ millipore	0.00	100 ml sample
	Saturated	50mμ millipore	0.00	100 ml sample
Potassium carbonate	30% saturated	50mμ millipore	0.00	100 ml sample
	50% saturated	50mμ millipore	0.00	100 ml sample
	Saturated	50mμ millipore	0.00	100 ml sample
Sodium carbonate	30% saturated	50mμ millipore	0.00	100 ml sample
	50% saturated	50mμ millipore	0.00	100 ml sample
	Saturated	50mμ millipore	0.00	100 ml sample
Sodium bicarbonate	30% saturated	50mμ millipore	0.54	100 ml sample
	50% saturated	50mμ millipore	1.00	100 ml sample
	Saturated	50mμ millipore	1.54	100 ml sample
Potassium carbonate +H_2S	30% saturated	50mμ millipore	30.00	100 ml sample
	50% saturated	50mμ millipore	45.50	100 ml sample
	Saturated	50mμ millipore	32.50	100 ml sample
Sodium carbonate +H_2S	30% saturated	50mμ millipore	21.00	100 ml sample
	50% saturated	50mμ millipore	41.00	100 ml sample
	Saturated	50mμ millipore	45.50	100 ml sample
Sodium bicarbonate +H_2S	30% saturated	50mμ millipore	5.50	100 ml sample
	50% saturated	50mμ millipore	7.50	100 ml sample
	Saturated	50mμ millipore	10.00	100 ml sample

HYPOGENE (HYDROTHERMAL) PROCESSES (cont'd.)

Type of solution	Concentration of salt, etc.	Filtration procedure	Gold present in solution (μg/ml)	Remarks
Sodium carbonate +AsH_3	30% saturated	50mμ millipore	17.50	100 ml sample
	50% saturated	50mμ millipore	20.00	100 ml sample
	Saturated	50mμ millipore	23.70	100 ml sample
Sodium bicarbonate +AsH_3	30% saturated	50mμ millipore	3.10	100 ml sample
	50% saturated	50mμ millipore	6.10	100 ml sample
	Saturated	50mμ millipore	12.50	100 ml sample
Sodium carbonate +H_2S+AsH_3	30% saturated	50mμ millipore	29.00	100 ml sample
	50% saturated	50mμ millipore	50.00	100 ml sample
	Saturated	50mμ millipore	63.00	100 ml sample
Sodium bicarbonate +H_2S+AsH_3	30% saturated	50mμ millipore	1.70	100 ml sample
	50% saturated	50mμ millipore	2.10	100 ml sample
	Saturated	50mμ millipore	2.90	100 ml sample
Sodium carbonate +SbH_3	30% saturated	50mμ millipore	1.80	100 ml sample
	50% saturated	50mμ millipore	7.30	100 ml sample
	Saturated	50mμ millipore	13.30	100 ml sample
Sodium bicarbonate +SbH_3	30% saturated	50mμ millipore	0.00	100 ml sample
	50% saturated	50mμ millipore	0.60	100 ml sample
	Saturated	50mμ millipore	1.20	100 ml sample
Sodium carbonate +H_2S+SbH_3	30% saturated	50mμ millipore	29.00	100 ml sample
	50% saturated	50mμ millipore	40.00	100 ml sample
	Saturated	50mμ millipore	66.00	100 ml sample
Sodium bicarbonate +H_2S+SbH_3	30% saturated	50mμ millipore	26.00	100 ml sample
	50% saturated	50mμ millipore	38.80	100 ml sample
	Saturated	50mμ millipore	46.20	100 ml sample

NaCl appears to depress the solubility of the metal. These data indicate that amorphous gold is soluble in ferric sulphate solutions alone, and more so when free H_2SO_4 is present.

RESULTS OF THE EXPERIMENTS (HYPOGENE PROCESSES)

The synthetic hypogene solutions consisted of various carbonate solutions saturated with H_2S, AsH_3, SbH_3, and combinations of these constituents. These were reacted with amorphous gold at room temperature, and the soluble gold was determined as described above.

Carbonate solutions

Sodium and potassium carbonate solutions were reacted for an hour by constant shaking with excess amorphous gold. Both solutions were found to be essentially free of soluble gold after filtration through millipore filters. Sodium bicarbonate solutions (gold free) on the other hand were found to contain significant amounts of gold after the same treatment as shown in Table 1.

Numerous solutions of sodium and potassium carbonate and bicarbonate were prepared and considerable amounts of amorphous gold were added. These solutions were successively treated with hydrogen sulphide, arsine, stibine, and the various gases combined as shown in Table 1. The gases were bubbled through the carbonate solutions with constant stirring for periods ranging from 15 minutes to an hour or more. In most cases all of the amorphous gold added was dissolved and hence the solubility limits while high are unknown.

The results obtained from the qualitative experiments with alkali carbonate solutions indicate extensive solution of gold when the solutions contain H_2S, AsH_3, or SbH_3, or various combinations of these gases. The state of the dissolved gold in such solutions when H_2S or sulphide ion is present would seem to be as a soluble sulphide of the type $[AuS]^-$ or as thioarsenites, thioarsenates, thioantimonites, or thioantimonates of the type $[Au(AsS_3)]^{2-}$ and $[Au(SbS_3)]^{2-}$. Production of these complexes in the alkali carbonate solutions evidently takes place first with the formation of alkali sulphide or bisulphide, thioarsenate, thioantimonate, etc. followed by the dissolution of the gold as the various soluble complexes. When only AsH_3 or SbH_3 are present the soluble complexes are evidently gold arsenides and stibnides such as $[AuAs]^{2-}$ and $[Ausb]^{2-}$ or more complicated polymerized and hydrolyzed species.

Our interest in determining the approximate solubility of gold in alkali carbonate solutions containing H_2S, AsH_3, SbH_3, or their analogous ions is that these solutions are evidently largely responsible for the transport and deposition of gold in veins and other deposits under endogenic conditions. This is based on the general observation that carbonatization accompanies many types of endogenic gold deposits, and that the element is nearly universally associated with S (sulphides mainly pyrite), As (arsenopyrite), and Sb (stibnite and sulphosalts) in such deposits. There is also much sericitization (introduction of K) or albitization (introduction of Na) in shear zones, faults, etc. containing gold deposits.

CONCLUSIONS

We conclude that under supergene conditions gold may be transported by humic waters, the metal being intimately associated with the humic matter probably forming an adsorbed phase or some uncharacterized type of organometallic compound or chelate. In deposits where sulphides, especially pyrite, pyrrhotite, and arsenopyrite are oxidizing, gold can be transported in ferric sulphate solutions. Under hydrothermal conditions gold is readily transported in solutions containing H_2S, AsH_3, or SbH_3 or combinations of these constituents. Having regard to the chemical similarity of Se and Te to S we can assume that gold may also be transported where H_2Te and H_2Se or their analogous tellurides and selenides are present in solution.

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J. H. G.
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MEMORANDUM TO J. J. COLLINS:

GOLD GEOCHEMISTRY

Although the recently released U. S. G. S. Bulletin 1330 - "Geochemistry of Gold in the Weathering Cycle" by Hubert W. Lakin et. al., is primarily concerned with certain restricted aspects of gold geochemistry, it does provide data of potential value to anyone involved in gold exploration. Of greatest significance in terms of exploration, is the apparent importance of biogeochemical processes in gold dispersion in the secondary environment. The evidence presented suggests deep rooted plants and forest mull might be especially useful geochemical sample media in areas of transported overburden. Of considerable potential interest in the field of gold (and silver) extraction are the data of solubilization of gold by micro-organisms and organic substances. There is an obvious possibility that some non-toxic organic substance possessing the complexing characteristics of cyanide might exist. Research in the field could conceivably prove rewarding.

The U. S. G. S. study was primarily concerned with the stability of gold complexes that might be involved in gold transport in oxidizing systems. Recent research has indicated that gold chloride, traditionally considered the principal form of gold involved in migration of gold into plants and in stream and ground water, might in fact only play a minor role. The studies described in the U. S. G. S. report in fact indicate that gold cyanide and thiocyanate may be the most common stable complexes in soils, plants and natural waters. In this context it is significant that thiocyanate occurs in appreciable concentration in many plants. (Cyanide and thiocyanate ions are products of the hydrolysis of plant glycerides by enzymatic action.) Cyanide and thiocyanate ions have the ability to complex gold in moderately oxidizing environments. They can apparently remain in solution when in contact with common rocks and minerals and are readily taken up by plants. The other ion studies - chloride, bromide, iodide and thiosulfate - may form complexes with gold which remain stable long enough to permit some restricted dispersion of gold under special conditions.

L. D. James.

LDJ:am

L. D. JAMES

cc: J. H. Courtright

He does not own or handle the physical commodity. He buys a contract in the hope that prices will go up or he sells a contract hoping prices will go down.

Both the hedger and the speculator are **essential** to each other and to the successful functioning of a liquid futures market.

If the futures market provided **no economic function** for the hedger, there would be less need for it to exist; and **without the speculator** to assume the hedger's risk, there would be **no market.** Together, they provide the needed liquidity to facilitate entry into and egress from the market.

Factors that Determine Gold Prices

Prices and price fluctuations of gold on the "free" world market are not the result of chance, **but are determined by powerful economic and psychological forces** that continuously change. In order to effectively predict price trends, these forces must be analyzed and evaluated continually. As is true with any other commodity, the **primary factors** influencing gold prices are **supply and demand.** Supplies are obtained from production of new gold or from private or official stockpiles. The aggregate consumption of gold reflects demand.

SUPPLY

Gold Production

Two-thirds to three-quarters of the world's yearly production of gold comes from the **Union of South Africa.** Gold in South Africa tends to be found in thin seams, one to two miles or even more beneath the surface. This has meant that gold mining in South Africa has had to surmount significant technological obstacles and has had to be highly capitalized. To start a new mine **in the 1890s cost about $2-million,** but to start one **in the 1970s costs closer to $200-million.** In a recent year, **nearly 80-million tons of rock** were extracted from the 46 South African mines, ground or "milled" to a fine powder, and passed through a cyanide solution to yield **just under 1,000 tons of gold.** That amount, however, was **74 percent** of the non-Communist world's

production for the year. Indeed, South Africa's share of production has grown so mightily and rapidly that it is now estimated that **more than one-third** of all the gold ever mined has come from South Africa. The production of the leading gold-mining countries is shown in Table 2.

It is predominantly in South Africa that **a basic characteristic** of the world's major gold-mining operation can be observed **—cooperation**. Through the Chamber of Mines of South Africa, established in 1889, the seven large gold-finance houses that have controlled South African gold production since the 1930s coordinate their overall operating policy, gold research, labor recruitment, refining, and marketing. Following the dictates of the Chamber of Mines, South African gold production is sold through the South African Reserve Bank.

The Chamber of Mines is trying to **conserve** South African gold resources. The **impact** of its conservation program on **supply** has been to promote the exploitation of **lower-grade ore,** and this **decreases** total gold production. Accordingly, even with higher prices, South African gold production **has been declining since 1970,** a trend also noticeable in Canada and the United States. Mine production in the non-Communist world is expected to continue this trend in 1974, slipping to about 1,075 **tons.** Despite **falling gold-mine production, gold sales** from South Africa **increased** considerably with 1973 sales of 788 tons because of a lower level of gold retention by the South African Reserve Bank.

Primary Gold Production

(Million troy oz.)

Table 2	1970	1971	1972	1973	1974e
Republic of South Africa	32.2	31.4	29.2	27.3	28.2
U.S.S.R.	6.5	6.7	6.9	7.1	7.4
Canada	2.4	2.2	2.1	1.9	2.2
United States	1.7	1.5	1.5	1.4	1.3
Ghana	.7	.7	.7	.7	.7
Australia	.6	.7	.8	.8	.7
Philippines	.6	.6	.6	.6	.6
Southern Rhodesia	.5	.5	.5	.5	.5
Japan	.3	.3	.2	.2	.2
Colombia	.2	.2	.2	.2	.2
Other	1.8	1.7	1.6	1.5	1.3
World Total	47.5	46.5	44.3	42.2	43.3

e-Estimated

Source: Consolidated Gold Fields Limited

The Soviet Union is the second-largest gold producer, although its exact position is unknown outside the U.S.S.R. A recent publication of Consolidated Gold Fields Limited suggests that Soviet gold production has climbed from approximately 244 metric tons in 1964 to 371 tons in 1973, with the 1973 figure being about 140 tons above other estimates. In addition to satisfying **needs for foreign exchange** arising from such problems as poor harvests, there has developed a tendency for the Russians to **expand** Free-World gold sales **when gold prices are high** and **stop them when prices are low.** It is estimated that 280 tons of Russian gold were sold in 1973 at an average price of $95 an ounce. Output in 1974 is forecast at 387 tons, of which 288 tons could be sold on the free markets if the Russians find the price attractive.

Canada and the United States also have experienced **a production lag.** However, in these countries much of the gold mined is a by-product or co-product of other metals, which are not necessarily responsive to gold-price changes. Canadian production is particularly being hampered by the declining availability of high-grade ores, and it is possible that its long-term yields may fall significantly. U.S. gold production peaked in 1915 and again in 1940 at nearly 5-million ounces a year. Since World War II, production has averaged about **1.7-million ounces** a year.

In summary, the wise gold analyst will watch carefully trends in **the production of gold in South Africa and the**

Gold Flows 1968-1974
(Metric Tons)

Table 3
Mine production in non-Communist world
Supply flow from Communist countries
Official purchases (—) or sales
Total supply to free market
Distribution of total supply
Return to market (−) or absorption
Fabrication
Hoarding
Speculation/Investment

p—Preliminary forecast.

Source: "Gold, 1974," Consolidated Gold Fields Limited

gold-selling policies followed by the **South African Reserve Bank and the Soviet Union.**

Gold Stocks

The near indestructibility of gold means that the vast majority of all the gold ever mined is **still in existence.** Some of it is held in jewelry, some in industrial use and equipment, some is hoarded, some is in government hands.

Official gold stocks are estimated at about **44,000 tons or one billion troy ounces.** Of this, about one-fifth is held by the U.S. government and more than 70 percent of it is held by the world's developed countries. Much of this gold is used as a reserve asset in the International Monetary Fund's (IMF) Special Drawing Rights. As of November 13, 1973, the **principal governments of the IMF can sell but not buy gold** on the free market. Whether or not these governments will in fact sell their gold remains to be seen. Recent agreements allowing official gold reserves to be used as **collateral to obtain loans** for countries with balance-of-payments deficits suggest they **may not be willing sellers.**

Hoarding of gold is common in many countries. These holdings and the reserve assets of governments testify to the centuries-old usage of gold as the final standard of value in periods of turbulence, depression, inflation and unrest. Private hoards of gold are difficult to estimate, but figures commonly

1968	1969	1970	1971	1972	1973	1974p
1,245	1,252	1,273	1,236	1,182	1,120	1,075
−29	−15	−0−	60	220	280	—
620	−90	−236	96	−151	6	—
1,836	1,147	1,037	1,392	1,251	1,407	—
1,227	1,205	1,381	1,391	1,350	853	725
72	60	88	80	−8	46	—
537	−118	−432	−79	−91	508	—

cited are **50,000 tons or 1.2-billion troy ounces** of gold. As the data in Table 3 indicate, the movement of gold into hoarding, and into speculative and investment channels has tended to increase. Poor crop yields with the resultant reduction in income, and an increased demand for foreign exchange to pay for imports, led to some dishoarding in 1972 in some of the developing countries while there was a moderate 1973 profit-taking movement in some of these same countries. However, vastly increased oil revenues of the **Arab states** has resulted in their **increased gold purchases,** and their activity possibly could become a key factor in gold-price movements.

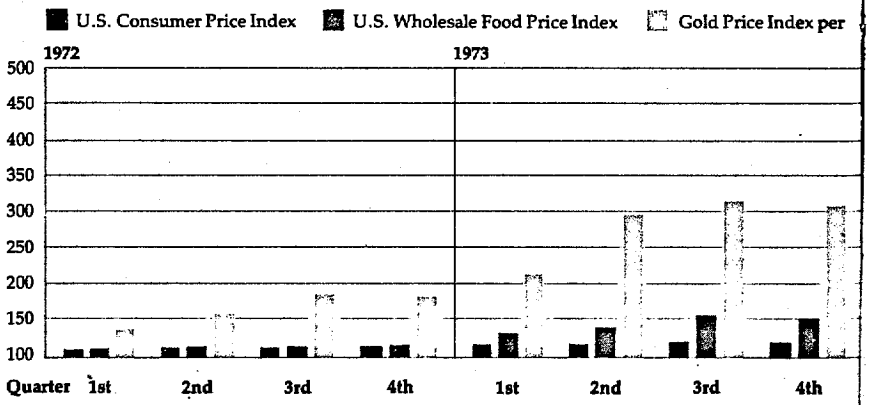
Estimating Gold Supply

The supply coming into the free market was about 12 percent greater in 1973 than in 1972; despite this increase, 1973 saw some of the most rapidly escalating gold prices in the history of mankind. Clearly, **world production of gold responds only slowly to increased prices.** The immediate response is to mine lower-grade ore, which tends to lower total gold production. High capital costs, lead times of seven to 10 years for new mine development, and technological hurdles in gold extraction imply that producers must be assured of **long-term price strength before new mines will be developed.**

Increased supply in the short term will tend to come from **released reserves and dishoarding.** Gold prices continuing in the

Price Indices 1970=100 **Figure 2**

(Average per Quarter)



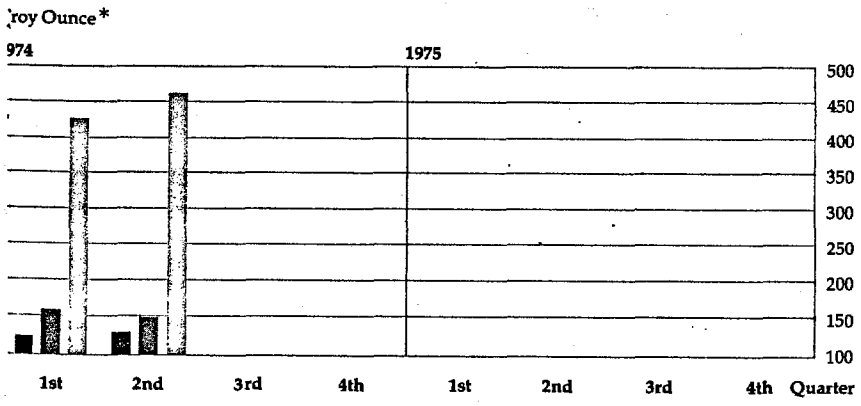
*Based on official Gold Price of $35/Troy oz. in 1970

high 1973 area probably would induce further reserve sales by South Africa and Russia as well as some private dishoarding. Calamities, such as crop failures, probably would stimulate more gold sales from developing countries. At late 1973 price levels, it was estimated that gold-fabricator usage would decline from 853 metric tons in 1973 to 725 tons in 1974. Since 1974 mine production in the non-Communist world is forecast at 1,075 tons, then 350 tons of production would be available for hoarding, speculation, and investment. Table 3 shows comparative figures for previous years. It is, therefore, the level of **demand** that will determine the amount of gold supplied to the **free-world market,** and **that demand** most likely will be **motivated** largely by **monetary and emotional considerations.**

DEMAND

The share of newly produced gold going into **official reserves** has been **declining** since 1965, and **fabricator use** of gold **has slipped** since 1972 while **gold prices have risen to new highs.** The demand pull that gold prices have experienced is caused by gold being increasingly acquired for investment, speculation, and hoarding.

Gold thus seems to be fulfilling its role as the barometer of international economic disturbances. The **increased demand** for gold is closely linked to the **high levels of inflation** that much of the world is experiencing.



Gold, Currencies, and the Inflationary Spiral

The worldwide acceleration of inflation in 1973 and 1974 resulted in **vastly increased gold investment.** With 1974 levels of inflation expected to be between 7 percent and 24 percent in the leading developed countries of the free world, inflation is a primary incentive for investors to move into gold.

Gold is the logical refuge from depreciating paper currencies and currency unrest. It does not depreciate as paper money does because it is based on scarce resources and not on the world's confidence in the political economy of any country. Unlike paper money, which has been rapidly increased in recent years, **gold is acceptable in exchange for goods and services** in bad times as well as good. **Gold is portable,** with a lifetime's saving generally moveable by an individual; and it is tangible, giving a feeling of monetary stability in times when the major currencies of the world seem to be buying less and less. Because of this attachment to gold, **inflation,** or the threat of inflation, **directly affects its demand.**

It is not surprising then that a people such as the Germans, who have seen their currency wiped out twice in the twentieth century, now are increasing their gold purchases. Yet the German rate of inflation, at a minimum of seven percent for 1974, is the lowest of all the major countries! Germany is not alone.

Gold Fabrication by End Use

Table 4 — **1968**

	Metric Tons	%
Jewelry in advanced nations	472.6	38.5
Jewelry in developing nations (a)	440.7	35.9
Total jewelry	913.3	74.4
Electronics	84.2	6.9
Dentistry (a)	64.5	5.3
Other industrial and decorative	57.6	4.7
Official coins	67.8	
Fake coins, medals and medallions	40.0	
Total	1,227.4	100.0

(a) About 10 tons of the gold attributed to jewelry usage in developing countries probably is used in dental applications.
Source: "Gold, 1974", Consolidated Gold Fields Limited

Gold buying for investment, nonfabrication uses, speculation, and hoarding **is increasing rapidly in developed countries** such as France, Italy, Japan and Switzerland.

The **legalization** on December 31, 1974 of private gold ownership will make it possible for U.S. citizens and companies to use gold as an **inflationary hedge.** How good a hedge it will be remains to be seen. At one time, securities and real estate were generally regarded as inflation hedges, but these have been shown to be vulnerable in the face of tight money and restraints on prices, profits, and dividends. Corporate taxes being levied on inflated rather than real corporate incomes reinforce this trend. A broad economic program to fight inflation would not only use a restrictive monetary policy and high interest rates but also higher taxes on income. Without such a broad program, **gold may be a realistic hedge against inflation.**

Fabricator Demand

The **pattern of gold demand** has changed dramatically since 1973. Higher gold prices have meant higher costs for fabricators and, as Table 3 indicates, a smaller share of the total gold market. Total fabricator demand nevertheless remains strong. Net absorption of gold by jewelry manufacturers fell by 488 tons during 1973 whereas all other fabricator usage for gold was little affected. Total fabricator demand is shown in Table 4.

1969		1970		1971		1972		1973	
Metric Tons	%	Metric Tons	%	Metric Tons	%	Metric Tons	%	Metric Tons	%
502.3	41.7	500.1	36.2	551.7	39.6	700.1	51.9	419.0	49.1
403.9	33.5	562.5	40.7	507.0	36.4	292.6	21.7	86.2	10.1
906.2	75.2	1,062.6	76.9	1,058.7	76.1	992.7	73.5	505.2	59.2
102.4	8.5	93.6	6.8	90.6	6.5	110.2	8.2	129.5	15.1
64.6	5.4	63.9	4.6	70.0	5.0	72.5	5.4	72.7	8.5
63.1	5.2	61.9	4.5	68.2	4.9	71.2	5.3	71.0	8.3
24.6		45.9		52.3		62.0		53.2	
44.0		53.6		51.7		41.2		21.8	
1,204.9	100.0	1,381.5	100.0	1,391.5	100.0	1,349.8	100.0	853.4	100.0

GOLD

J. H. C.

APR 11 1975

clear Dynamics may sell the properties to American Selco or retain up to a 15 percent undivided working interest.

LOUISIANA

Production has begun at AMAX Nickel Refining Company Inc.'s $53,000,000 nickel refinery at Port Nickel. Some nickel and copper were shipped in December, 1974. Expansion and rehabilitation of the refinery is essentially complete. When operating at capacity, the plant will be capable of producing 40,000 tons of nickel, 23,500 tons of copper, 600 tons of cobalt, and 50,000,000 tons of ammonium sulphate annually.

CHIEF CHEMIST

An attractive position is available for a graduate chemist at our 8,000 TPD gold-silver mine in the Dominican Republic. The location offers a healthful climate and good housing.

Applicants should have a minimum of five years experience in gold and silver assays; in ores, solutions and metallic analysis. It is essential that the individual be fluent in Spanish and English and should have the ability and leadership to manage the laboratory. Salary will be based on qualifications with liberal benefits.

The position is for the Pueblo Viejo mine of Rosario Dominicana S.A. an affiliate of ours.

We are an international company, active in many countries in minerals, oil, and gas. Please send a complete resume in confidence to our Corporate Headquarters:

Michael J. Tighe,
Assistant Treasurer
ROSARIO RESOURCES CORPORATION
20 Exchange Place,
New York, N.Y. 10005

Byproduct Metal Contents at Certain Porphyry Copper Mines

Company and Mine	*1971*	*1972*	*1973*	*1974*
Kennecott Copper Corporation[1]				
Utah Mines Division				
Ounces Au per ton Cu[2]	1.37	1.57	1.48	
Ounces Ag per ton Cu[2]	10.70	13.47	12.91	
Ounce Au per ton ore	0.008	0.009	0.008	
Ounce Ag per ton ore	0.06	0.08	0.07	
Pounds Mo per ton Cu[2]	58.08	64.39	61.17	
Pounds Mo per ton ore	0.35	0.38	0.33	
Chino Mines Division				
Pounds Mo per ton Cu[2]	9.7	8.3	13.5	
Pound Mo per ton ore	0.06	0.06	0.07	
Ray Mines Division[1]				
Ounce Au per ton Cu[2]	0.00016	0.00018	0.00014	
Ounce Ag per ton Cu[2]	0.031	0.034	0.027	
Pounds Mo per ton Cu[3]	7.7	....	8.2	
Pound Mo per ton ore	0.07	....	0.07	
Nevada Mines Division[1]				
Ounces Au per ton Cu[2]	1.23	0.52	0.63	
Ounces Ag per ton Cu[2]	3.41	2.69	4.21	
Ounce Au per ton ore	0.007	0.003	0.004	
Ounce Ag per ton ore	0.019	0.014	0.025	
Pounds Mo per ton Cu[2]	0.87	1.61	5.38	
Pound Mo per ton ore	0.005	0.009	0.030	
Granisle Copper Company				
Granisle[4]				
Ounce Au per ton Cu	N.A.	N.A.	0.99	0.95
Ounces Ag per ton Cu	N.A.	N.A.	9.95	9.92
Ounce Au per ton ore	N.A.	N.A.	0.004	0.004
Ounce Ag per ton ore	N.A.	N.A.	0.04	0.04
Utah International, Inc.				
Port Hardy[5]				
Ounces Au per ton Cu	1.15	1.01	0.99	
Ounce Ag per ton ore	0.005	0.004	0.004	

1. Does not include copper from leaching. 2. Only copper produced by flotation. 3. Low price for molybdenum did not warrant all year recovery. 4. Year ending 30 September. 5. Fiscal year. N.A. Not Available.

WITH later and more complete data now available on copper, gold, silver, and molybdenum production in Utah, United States, from porphyry copper mines the data appearing on page 73 of the May 1974 issue of WORLD MINING can, in part, be updated. When additional data for 1974 production become available they will be reported in WORLD MINING.

Caribbean

PUERTO RICO

UOP discusses new nickel recovery process with Puerto Rico

Universal Oil Products Co. is negotiating with the Puerto Rican government on possible use of its patented hydrometallurgical process to recover nickel from a low-grade lateritic deposit near Guanajibo. The company's new process may allow for over 90 percent nickel recovery from a low nickel content deposit like the one at Guanajibo, compared with only 40 percent with conventional methods.

The Guanajibo nickel deposit could yield 15,000 tons of nickel, and revenues of $57,000,000 annually for 25 years, according to the company.

UOP has offered to pay an estimated $1,300,000 for a two-year technical and economic study including field testing and processing of samples at a pilot plant. If the commercial project is justified, a joint venture between the company and the Puerto Rican government could result in a capital investment of $75,000,000 to recover about 15,000 annual tons Ni.

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This job is headquartered in Eastern U.S. but requires 50% international travel. To apply, please send resume and salary history to: Box #10154, c/o WORLD MINING, 123a Chaussee de Charleroi, B-1060 Brussels, Belgium.

AMERICAN SMELTING AND REFINING COMPANY
Tucson, Arizona

June 10, 1974

J. H. C.

JUN 10 1974

file: (separately)

MEMORANDUM

GOLD & SILVER PRICES

The attached tabulation and three graphs illustrate some of the fluctuations in the prices of gold and silver, and their adjusted price based on 1939 dollars as reflected in the Consumer's Index.

During the period 1939 to 1967, inclusive, when the price of gold was fixed at $35.00 per troy ounce, the "real" price eroded steadily and continued through 1971. At least for some years between 1939 and 1967, gold could be sold at a free market price outside of the United States and the premium reached about $10 per ounce.

Silver, on the other hand, worked on a free market and its "real" value more or less followed the free market, and between 1939 and 1961 its "real" value averaged 42¢ per ounce.

The Price Ratio between the two metals is interesting. Except for the period of the Depression and immediately following World War II, the ratio kept largely between 26 and 42 and averaged about 36 to 1. This includes the period when the price of gold was fixed at $20.67 per ounce, $35.00 per ounce, and the current free market. In fact, the current free market ratio, which has ranged between 32 to 1 and 35 to 1 over the past 2 1/2 years is very close to the average.

L. P. Entwistle

LPE:ym

Enclosures

cc: JJCollins w/encl
JHCourtright w/encl
All Tucson Office Geologists w/encl

GOLD & SILVER QUOTED PRICES
ADJUSTED FOR
CONSUMER'S INDEX
1939 BASE

	Quoted Price		Adjusted Price		Ratio		Quoted Price		Adjusted Price		Ratio
Year	Au	Ag	Au	Ag	Au:Ag	Year	Au	Ag	Au	Ag	Au:Ag
1939	$35.00	39.08¢	$35.00	39.08¢	89.6	1957	$35.00	90.82¢	$17.36	45.05¢	38.5
1940	$35.00	34.77¢	$34.72	34.49¢	100.7	1958	$35.00	89.04¢	$16.87	42.92¢	39.3
1941	$35.00	34.78¢	$33.36	33.15¢	100.6	1959	$35.00	91.20¢	$16.76	43.68¢	38.4
1942	$35.00	38.33¢	$30.00	32.85¢	91.3	1960	$35.00	91.38¢	$16.48	43.04¢	38.3
1943	$35.00	44.75¢	$29.73	35.71¢	83.3	1961	$35.00	92.45¢	$16.34	43.17¢	37.9
1944	$35.00	44.75¢	$29.79	35.53¢	83.8	1962	$35.00	108.52¢	$16.17	50.14¢	32
1945	$35.00	51.93¢	$26.99	40.04¢	67.4	1963	$35.00	127.91¢	$15.96	58.33¢	27.4
1946	$35.00	80.15¢	$26.18	59.95¢	43.7	1964	$35.00	129.30¢	$15.75	58.19¢	27.1
1947	$35.00	71.82¢	$22.16	45.46¢	48.7	1965	$35.00	129.30¢	$15.44	57.02¢	27.1
1948	$35.00	74.36¢	$20.26	43.05¢	47.1	1966	$35.00	129.30¢	$15.05	55.60¢	27.1
1949	$35.00	71.93¢	$20.48	42.08¢	48.2	1967	$35.00	154.97¢	$14.66	64.93¢	22.6
1950	$35.00	74.17¢	$20.51	43.46¢	47.2	1968	$38.62	214.46¢	$15.53	86.21¢	18.0
1951	$35.00	89.37¢	$18.83	48.08¢	39.2	1969	$41.08	179.07¢	$15.65	68.23¢	22.9
1952	$35.00	84.94¢	$18.41	44.68¢	41.2	1970	$39.11	177.08¢	$14.16	64.10¢	22.1
1953	$35.00	85.19¢	$18.24	44.38¢	41.1	1971	$40.80	154.56¢	$14.24	53.94¢	26.4
1954	$35.00	85.25¢	$18.13	44.16¢	41.1	1972	$58.16	168.46¢	$17.99	55.92¢	32.3
1955	$35.00	89.10¢	$18.24	46.42¢	39.3	1973	$90.33	255.76¢	$26.98	76.47¢	35.3
1956	$35.00	90.83¢	$17.96	46.60¢	38.5(4mo)	1974	$155.54	483.93¢	$41.72	129.69¢	33.2

Notes: QUOTED PRICE GOLD up to 1968 fixed U.S. Treasury price, since 1968 London final. SILVER - Handy and Harmon

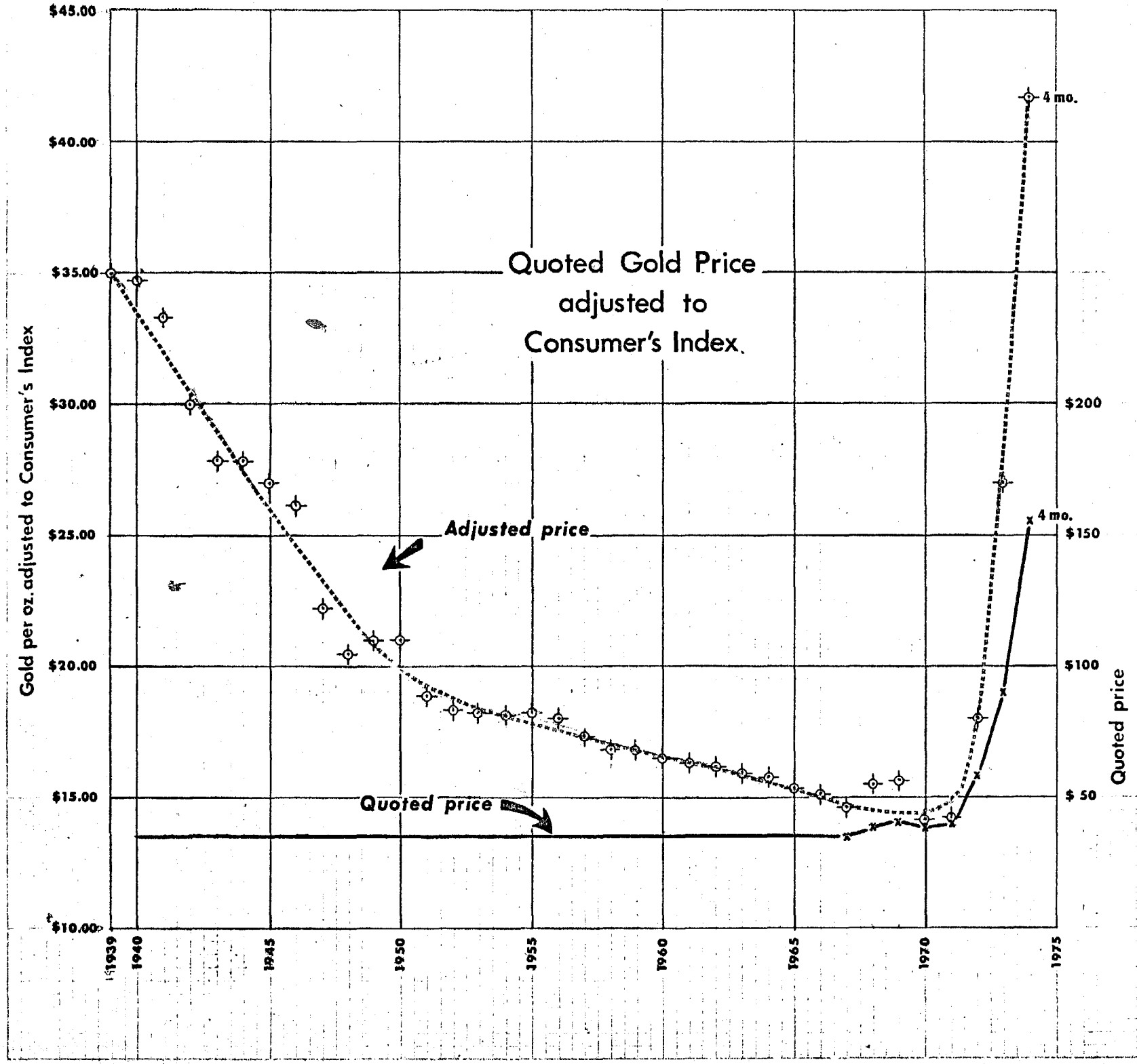
ADJUSTED PRICE All quoted prices adjusted for Consumer's Index, 1939 dollar base. Consumer's Index for 1970-1974 estimated.
For 1974, 4 months (January-April) with estimated inflation for 1974 at 8%

ORIGINAL SIGNED BY
L. P. ENTWISTLE

L. P. Entwistle

June 7, 1974

cc: JJCollins
JHCourtright
All Tucson Office Geologists


Quoted Gold Price
adjusted to
Consumer's Index.
Adjusted price
Quoted price
4 mo.
4 mo.
Gold per oz. adjusted to Consumer's Index
Quoted price
$45.00
$40.00
$35.00
$30.00
$25.00
$20.00
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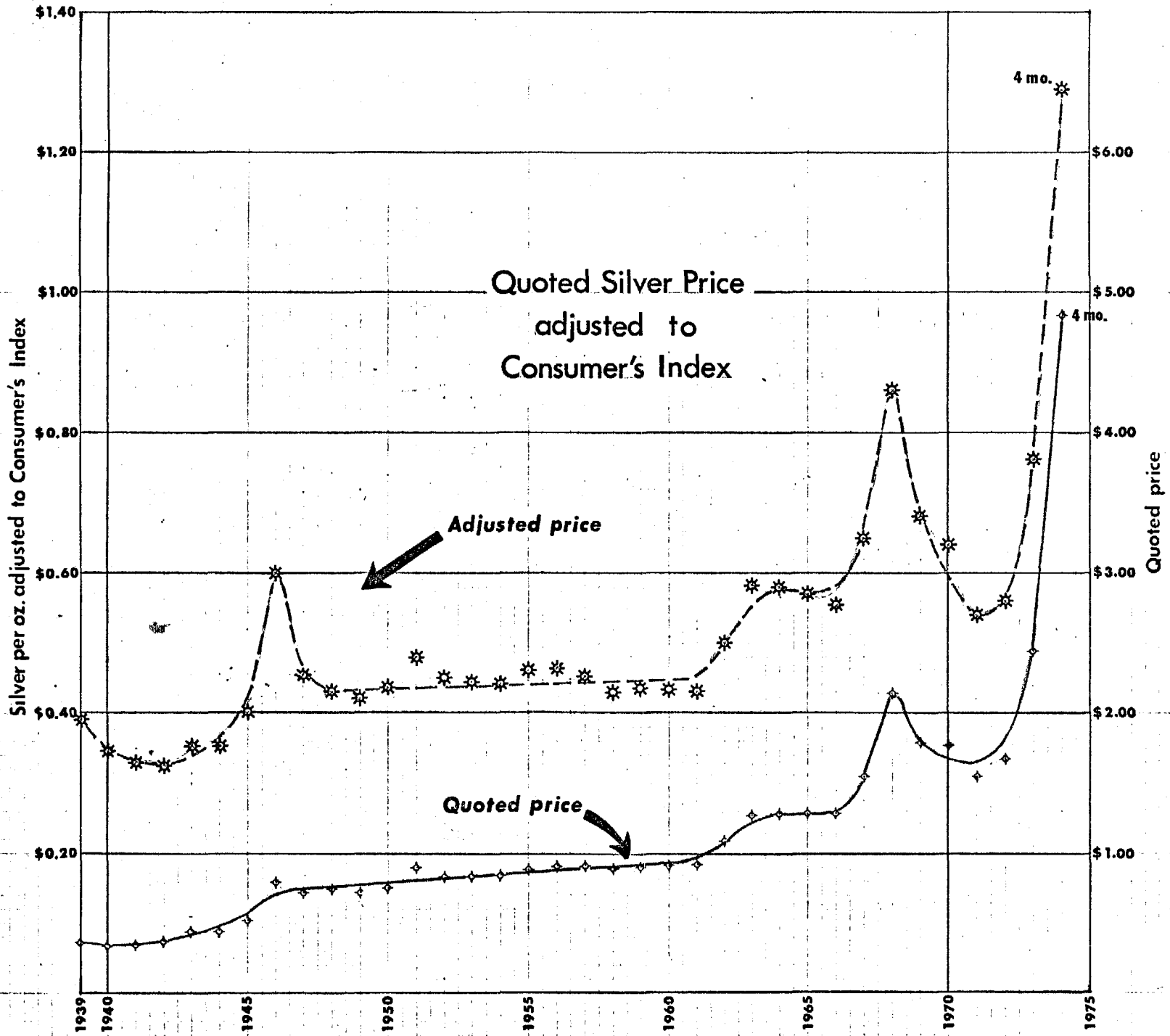
Quoted Silver Price
adjusted to
Consumer's Index
Adjusted price
Quoted price
4 mo.
4 mo.
Silver per oz. adjusted to Consumer's Index
Quoted price
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$6.00
$5.00
$4.00
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1939
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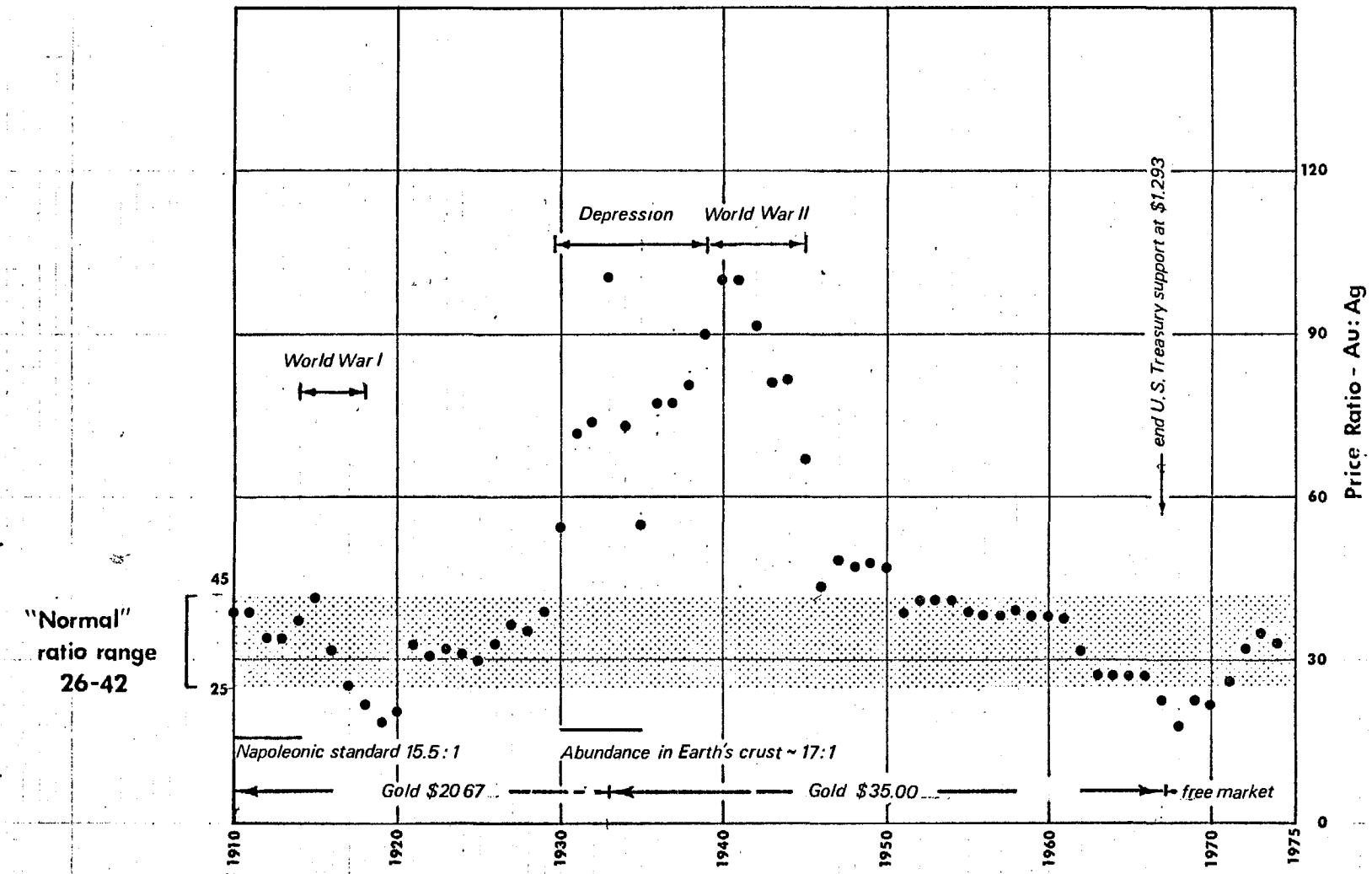

Price Ratio ~ Au : Ag

~~ETG~~ - ~~WLR~~ - ~~GJS~~ - ~~JRK~~

Abstract is a highly generalized review — nothing new here. GJS.

RECEIVED MAY 31 1974 EXPLORATION DEPT.

ASARCO

509-489-7870

AMERICAN SMELTING AND REFINING COMPANY
NORTHWESTERN UNITED STATES
EXPLORATION DIVISION

KEITH WHITING
MANAGER

EAST 920 WOLVERTON COURT
(HAMILTON AT NEVADA)
SPOKANE, WASHINGTON 99207

May 28, 1974

J. H. C.
MAY 31 1974

file

Mr. J. H. Courtright
ASARCO - Tucson

Precambrian Gold Deposits

Dear Sir:

Several recent memos by various company geologists have been on the above subject. A rather comprehensive abstract on "The Geochemistry of Gold and Its Deposits" by R. W. Boyle of the Geological Survey of Canada has recently been published, and may be of interest to those who haven't seen it yet (copy attached). Boyle has previously published an impressive volume on silver (The Geochemistry of Silver and Its Deposits, Canada Geological Survey Bulletin 160); presumably the attached abstract is a precursor of a similar volume on gold.

Sincerely,

John C Balla

John C. Balla

JCB/ir
cc: J.J.Collins - w/enc.
W. L.Kurtz - "
S. VonFay - "
F.T.Graybeal- "
Enc.

RECEIVED
MAY 17 1974
EXPLORATION DEPT.

J. H. C.
MAY 17 1974

Air Mail

May 15, 1974

Mr. M. P. Barnes
Salt Lake Division
Salt Lake City

Dear Sir:

Herewith is a copy of Chuck Beverly's mineralization thesis "Gold-Silver Potential in Advanced Argillic (Summitville-Type) Alteration Systems" dated January 23, 1974 which I see as an excellent example of inductive thinking applied to the discovery of ore, sooner.

After your staff has studied this paper, please invite Chuck to Salt Lake City to discuss the application in your territory by your staff. It may modify your pediment drilling program.

Very truly yours,

Originally Signed By
John J. Collins
John J. Collins

Attachment

cc: JHCourtright

ASARCO

509-489-7870

AMERICAN SMELTING AND REFINING COMPANY
NORTHWESTERN UNITED STATES
EXPLORATION DIVISION

KEITH WHITING
MANAGER

EAST 920 WOLVERTON COURT
(HAMILTON AT NEVADA)
SPOKANE, WASHINGTON 99207

RECEIVED
APR 8 1974
EXPLORATION DEPT.

April 2, 1974

J. H. C.
APR 8 1974

Mr. J. H. Courtright
ASARCO - Tucson

filed.

Silver and Gold Mineralization
Idaho

Dear Sir:

Attached is Mr. Smith's two memos on the above subject. It seems to me that there is considerable potential in the Northwest for the discovery of bulk, low grade, precious metal deposits. Large areas of Tertiary volcanism with associated gold and silver deposits occur in Idaho and Montana. The Thunder Mountain District in Idaho is one such example.

Placer-Amex has been looking for these types of deposits for some time and, according to Bob Garwood of Placer, they have an economically viable one just north of Whitehall, Montana. Its geologic occurrence, and size and grade are unknown.

Yours very truly,

John C. Balla

John C. Balla

JCB/ir
Enc.

J. H. C.

MAR 21 1974

RECEIVED

MAR 21 1974

EXPLORATION DEPT.

AIR MAIL

March 18, 1974

Mr. John C. Balla
Spokane Office

Gold ← file

Dear Sir:

We will be glad to have you find a gold deposit as described in your memorandum of March 14. Good Luck!

Very truly yours,

Original Signed By
John J. Collins

John C. Collins

cc: JHCourtright

RECEIVED
MAR 18 1974
EXPLORATION DEPT.

Spokane, Washington
March 14, 1974

J. H. C.
MAR 18 1974

TO: John J. Collins
FROM: John C. Balla

file

Precambrian Syngenetic
Gold Deposits

Recent memos by Messrs. Osborne and Graybeal have been of interest to us in the Northwest. Due largely to literature research, it has become apparent that there exists in the Northwest a potential for stratiform, stratabound gold deposits in both younger Precambrian and older Precambrian age sediments.

Younger Precambrian

Love (1973), in attempting to explain the source of the gold and quartz pebbles in the gold-bearing Cretaceous Harebell and Pinyon formations of western Wyoming, tentatively concluded that one of the quartzitic units of the Belt Supergroup (Purcell equivalents) may have been the source. As an alternative, he thought that the post-Belt, Cambrian sediments (in part Windermere equivalents) could also have been the source. The source area itself is believed to be underneath the Snake River basalts. (Various aspects of the gold-bearing rocks themselves are described by Antweiler and Love, 1967).

Mr. F. C. Lincoln described the gold deposits of the Gibbonsville District in east central Idaho in 1912. In this article, he states, in discussing a quartzite unit of the Belt Supergroup:

> "This quartzite is interesting because it contains gold. I obtained an assay of 40¢ per ton in gold and was credibly informed that assays of $1, $2, and in one instance even as high as $8, had been obtained by disinterested parties. As there are no marked signs of secondary mineralization, the quartzite may represent an ancient placer." (Dollar values based upon a gold value of $20.67/ounce. At $20.67/ounce, an assay of $1.0 represents 0.05 ounces/ton and $8 represents 0.39 ounces/ton.)

Thus, there appears to be some reason to believe that low grade stratiform gold may exist in Proterozoic quartzitic units of the Northwest.

If true, what is the grade that might be needed to be of economic interest? Acquisition of the Spar Lake deposit (Troy Project) from Kennecott has provided some "order of magnitude" figures that can be extrapolated to a potential deposit with similar characteristics (flat lying, quartzite host rock, favorably situated geographically). Initial estimates on the Troy Project were based upon 60,000,000 tons of ore that had a gross dollar value of between $11.34 and $13.78/ton. At $100/ounce for gold, the deposit need only average 0.11 to 0.14 ounces/ton to be of interest. As a comparison, the average ore grade at Homestake in 1972 averaged 0.278 ounces/ton with ore reserves figured at 0.299 ounces/ton.

Older Precambrian

Older Precambrian rocks are largely confined to the area of southern Montana and consist of highly metamorphosed marine sediments (Pony and Cherry Creek groups), and the Stillwater Complex. In the Jardine-Crevice Mountain district and at the Hellroaring Ranger Station area (both just north of Yellowstone National Park), Wedow and Gaskill (1973) of the U.S.G.S. report gold occurring in highly folded cummingtonite and garnet-cummingtonite schists of older Precambrian age. Sampling of the schists at old prospects by the U.S.G.S. has produced values ranging from 0.34 ounces/ton to trace amounts, with several assays around 0.1 ounces/ton. Arsenopyrite is the dominant sulfide mineral.

Total gold production from the Jardine district exceeded 220,000 ounces, and the principal mine closed in 1948. The U.S.G.S. feels that there still exists a potential for discovery of commercial gold deposits.

John C. Balla

John C. Balla

cc: T.C.Osborne
J.H.Courtright
S.A. Anzalone
M.P.Barnes
W.L.Kurtz
S.Von Fay
F.T.Graybeal

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Wedow, H., and Gaskill, D., Mineral Resources of the Absaroka Primitive Area and Vicinity, Park and Sweetgrass Counties, Montana. U.S. Geological Survey Open File report, 1973, 207 pp.

EXPLORATION SERVICES DIVISION
3422 SOUTH 700 WEST
SALT LAKE CITY, UTAH 84119

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FEB 1974
J. H. C. EXPLORATION DEPT.
MAR 15 1974

February 4, 1974

Mr. W. L. Kurtz
Tucson Office

file

GEOCHEMICAL METHODS OF
TRACE GOLD ANALYSIS.

Dear Bill,

I read with interest George Stathis' recent memorandum on disseminated gold exploration which you circulated to certain exploration offices.

The Geochemical Laboratory in fact did some research in the field of low level trace gold analysis some five years ago. We developed a method combining fire assay and A. A. procedures capable of determining gold concentrations as low as 5 ppb (i.e. 0.005 ppm) in 30 gram samples. We preferred the initial fire assay approach as it enabled us to take a large sample to give good representativity and sensitivity while at the same time ensuring complete extraction of all the gold present without time consuming ultra fine sample grinding. We should have no problem in achieving as good or better reproducibility than that reported by Rocky Mountain Geochemical Corporation's Reno Laboratory.

Any request for low level trace gold analysis by the Geochemical Laboratory should be explicit otherwise our standard less sensitive gold technique would probably be applied.

Yours very truly,

L. D. James.

L. D. JAMES

LDJ:db
cc:T.C.Osborne
J.H.Courtright
S.A.Anzalone
M.P.Barnes
S.VonFay
G.J.Stathis

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

J. H. C.
JAN 24 1974

January 24, 1974

file Gold

Memorandum

TO: W. L. Kurtz

FROM: G. J. Stathis

Peter E. Galli, Jr. on
Disseminated Gold Exploration

During the course of my review last month of Cordilleran Exploration's drill project area in the Winnemucca Mining District, Nevada, Pete Galli (Cordilleran partner and former Reno office manager for Union Carbide Corp.) made the following comments concerning his approach to exploring for "no see 'em"-type gold mineralization.

Galli prefers the atomic absorption over the fire assay method, because of the greater sensitivity of the former analysis method. This assumes, of course, that the lab doing the A.A. work is reliable and the results are reproducible. Galli checks on the lab by submitting one or two sample standards with every sample shipment. His past experience has been that Skyline Lab of Denver is erratic and Geochem Systems (now defunct) of Orange, California is very erratic. Galli's gold assaying, for the past few years, is done by Gary M. Fechko of Rocky Mountain Geochemical Corp.'s Reno, Nevada lab. Fechko reports gold down to 0.003 troy oz./ton (approx. 0.1 ppm). According to Galli, Fechko's gold assays are reproducible down to the 0.003 to 0.006 troy oz./ton range.

Galli considers 0.003 oz. gold as being anomalous (Rocky Mtn.'s gold detection limit!) and any surface area of 0.006 oz. gold is a definite drill target. Cordilleran has discovered two, 1 to 1-1/2 million ton, shallow gold ore bodies, averaging 0.12 ounces, near the Getchell mine and a similar size and grade deposit near Golconda. Plans call to heap leach these deposits in the near future. One of the two deposits near Getchell had surface values running 0.006 ounces or less, yet drilling showed gold values up to 0.4 oz./ton, 60 to 100 feet below the surface. The host rock at Getchell was described as occurring in siliceous, sedimentary rocks. Cordilleran does some fire assay checks on the A.A. results in the project stage of exploration.

As I mentioned in the Nevada competitor activity section of my 1973 4th period quarterly report, there is an increase in precious metal, mostly gold, exploration activity in Nevada. Recently the "Mining Record" reported a discovery by a group in the Cornucopia district of Elko County. A potential of 3 million tons of $12 gold-silver rock is claimed. Mineralization is said to occur in silicified andesites east of the Leopard Shaft. It is beginning

to appear that perhaps more of these small tonnage, plus 0.1 oz. gold deposits will be found in Nevada and possibly in other western states as well. According to Galli and Don Jennings (Cordilleran geologist), in detail, lithology and structure exercise an important control in the location of these disseminated gold deposits.

In conclusion, I feel that Galli's remarks on lab performance (i.e., use of standards as checks) and recognition that 0.1 to 0.2 ppm gold as being anomalous are well taken. Skyline Lab of Denver currently offers geochemical gold assays with a detection limit of 0.02 ppm. The average crustal abundance of gold is 0.004 ppm (S.R. Taylor, 1964). This can be broken down further as follows (after Vinogradov, 1962):

ULTRAMAFIC ROCKS (dunites, etc)	= 0.005 ppm
MAFIC ROCKS (basalts, gabbros, etc.)	= 0.004 ppm
INTERMEDIATE ROCKS (diorites, andesites, etc.)	= ?
FELSIC ROCKS (granites, granodiorites)	= 0.0045 ppm
SEDIMENTARY ROCKS (clays and shales)	= 0.001 ppm

Thus, labs offering low detection limits should be checked. Recognition and use of low range, possibly 0.01 to 0.02 ppm, gold assay values as anomalies may outline potential areas of better gold mineralization at depth.

George

George J. Stathis

GJS:lb

cc: JHCourtright

J.H.C.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

J.H.C.
NOV 8 1973

October 25, 1973

Memorandum to: W. L. Kurtz

From: F. T. Graybeal

file

Syngenetic gold deposits

In my resume of the Quebec-Ontario field trip of May 1973, I mentioned the stratabound occurrences of gold in the Larder Lake-Kirkland Lake region. Recent work in this area, done mostly by R. H. Ridler (1970), indicated that the gold was deposited syngenetically in a carbonate-facies of an Algoman-type iron formation. Although subsequent metamorphism had resulted in some mobilization of gold into crosscutting quartz veins, the majority of the lower grade ore in the Kerr-Addison and other mines is rather uniformly distributed within the so-called quartz-ankerite schists and has assay boundaries. Ridler noted during the field trip that, because the gold is syngenetic, persistence of the host rocks over 20 miles of strike length and repetition of them by folding may provide additional near-surface targets for exploration.

A more recent paper by Fleischer and Routhier (1973) discusses mineralization at the Passagem mine in Brazil. Here, gold is associated with a tourmalinite in the Batatal fm. which consists of graphitic phyllite, ferruginous dolomite, and chert. They note the stratigraphic confinement of the gold mineralization over 10 miles of strike length and suggest a syngenetic origin in a boron-rich sediment. They also note the similarity of this area to the Morro Velho deposit which occurs in similar rocks about 40 miles to the northwest.

The host rock stratigraphy and the nature of gold distribution in the Larder Lake and Passagem areas appear similar to descriptions of gold deposits in the Homestake area in South Dakota and the Mother Lode belt in California. I have not reviewed the literature on this subject and there may be other similar occurrences in North America.

Should gold come into favor in ASARCO's exploration program, it might be worthwhile to review previous work in the aforementioned areas with respect to additional exploration for large, low-grade, stratabound gold deposits.

F. T. Graybeal

FTG:lb F. T. Graybeal

1) Fleischer, Ronald and Routhier, Pierre, 1973, The "Consanguineous" origin of a tourmaline-bearing gold deposit: Passagem de Mariana (Brazil): Econ. Geol., v. 68, p. 11-22.
2) Ridler, R.H., 1970, Relationship of mineralization to volcanic stratigraphy in the Kirkland-Larder Lakes area, Ontario: Geol. Assoc. Canada Proc., v. 21, p. 33-42.

5-19-74

Fred say Giant Yellowknife "vein" conforms to bedding in Pre C and is a qtz-ser-ank schist — also fuchite or mariposite. 5 yrs g. gold remobilized and concentrated in qtz veinlets — JHC

GOLD REGULATIONS

The following is a summary of U.S. Treasury gold regulations pertaining to the mining, processing, and marketing of gold. (Courtesy of the Arizona Department of Mineral Resources.)

1. Gold may be bought and sold at any price agreed upon between the buyer and seller (usually the free market value for refined gold) provided the buyer and seller meet certain legal requirements, outlined below.

2. The United States Mint no longer buys gold.

3. Gold may be mined without a Treasury Department license.

4. "Gold in its natural state" is defined in the Treasury Gold Regulations as being gold recovered from natural sources, which has not been melted, smelted or refined, or otherwise treated by heating or by a chemical or electrical process. Gold in its natural state may be held, purchased, sold and transported without a Treasury license regardless of the amount.

5. Gold amalgam results from the addition of mercury to gold in its natural state for the purpose of recovering the gold. Gold amalgam produced from domestic sources may be dealt with in the same manner as gold in its natural state. In addition, gold amalgam may be heated to a temperature sufficient to separate the mercury from the gold (but not to the melting temperature of the gold) producing a material known as retort sponge, without a license by the person *who recovered the gold* from natural deposits in the United States.

6. Gold in its natural state and gold amalgam may *not* be melted, smelted, leached or refined or otherwise treated by heating or by a chemical or electrical process except for the heating of amalgam as explained above, without a Treasury Department license regardless of the quantity.

7. Up to 200 fine troy ounces of retort sponge (amalgam cake) resulting from the heating of amalgam may be held and transported by the person who mined or panned the gold, without a license. Retort sponge produced by a miner or panner may be sold to a person holding a Treasury Department license authorizing the purchase of such gold or to an unlicensed person provided such unlicensed person does not hold at any one time over 200 fine troy ounces of gold.

8. Persons other than the miner or panner, who acquire retort sponge, may sell the gold only to the holder of a Treasury Department license. An unlicensed person may not retort gold purchased by him from miners or other persons.

9. Gold in a melted or treated form (except gold amalgam and retort sponge) may be sold or disposed of *only* by persons and concerns operating under a Treasury gold license authorizing the disposition of gold in such form.

10. Any person regularly engaged in an industry, profession, or art, who requires gold for legitimate, customary and ordinary use may, without a Treasury license, acquire gold in any form from any person authorized to hold and dispose of gold, hold, transport, melt and treat such gold and furnish melted and/or unmelted scrap to licensed scrap handlers. The maximum quantity of gold that can be so held or processed is limited to 50 fine troy ounces at any one time and 350 fine troy ounces in any one month. The Treasury gold regulations exclude the miner and panner from those persons who are regularly engaged in an industry, profession, art, etc., unless that person is the same person who produces the final industrial, professional, or art object. Example: a gold jeweler can mine and refine gold and construct gold jewelry without a license subject to the above mentioned quantities.

Additional federal regulations cover gold coins, gold certificates, speculative gold markets, gold securities, and gold art objects. The State of California no longer issues gold buyers licenses. ⚒

RICHTER APPOINTED TO STATE BOARD OF REGISTRATION

Governor Ronald Reagan recently announced the appointment of California Institute of Technology professor Charles F. Richter, Ph. D., as the geophysicist on the State Board of Registration for Geologists and Geophysicists.

Richter, 73, is professor emeritus, seismology, at the Pasadena institution. He is the founder of the Richter Magnitude Scale used worldwide to measure the size of earthquakes.

He is a graduate of Stanford University, earned his doctoral degree at California Institute of Technology, and was a Fulbright Research Scholar at Tokyo (Japan) University. He is a fellow in the Geological Society of America, the American Geophysical Union, the Royal Astronomical Society (London), and the Royal Society of New Zealand. The appointment is to a four-year term. ⚒

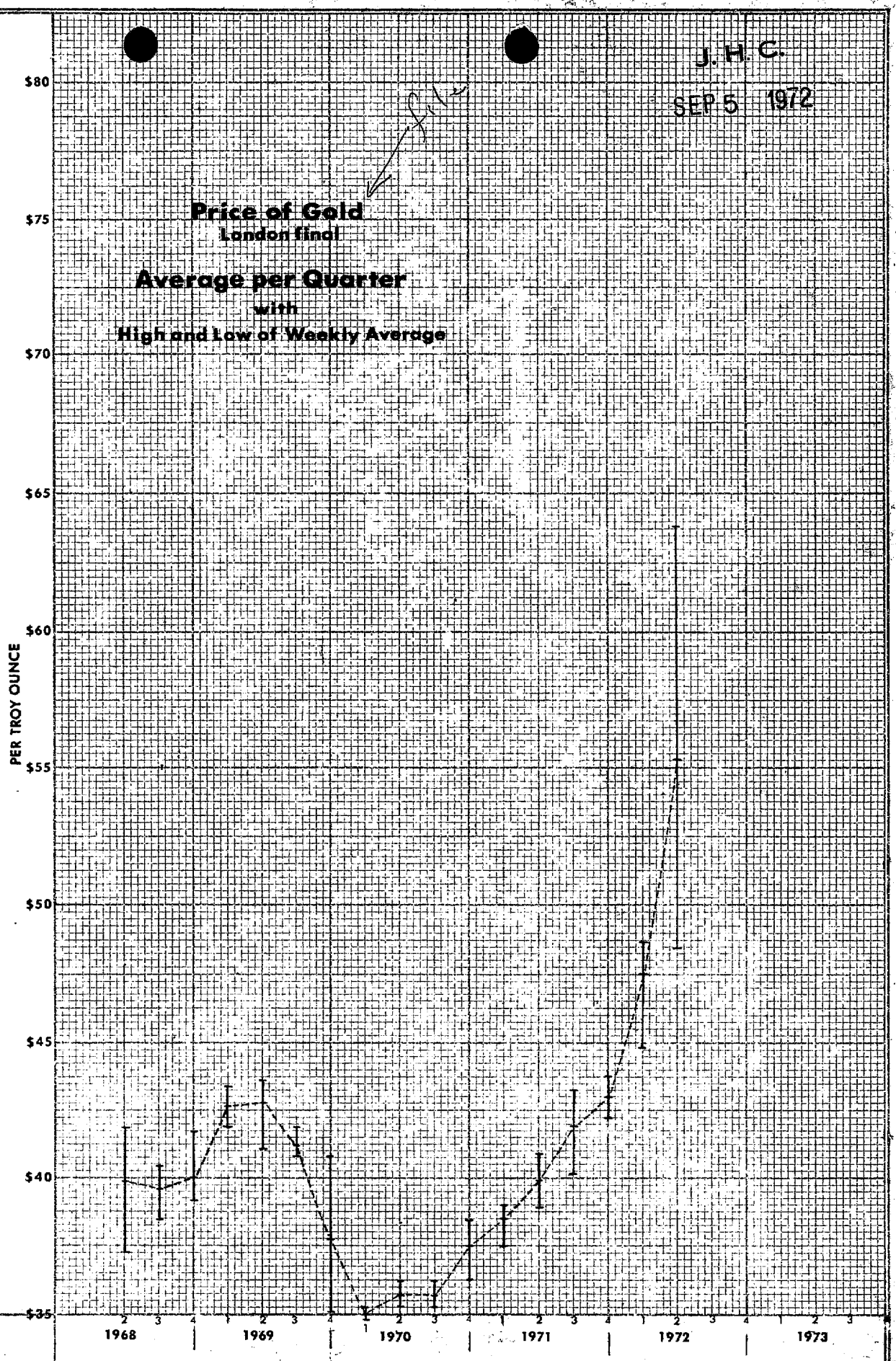
FIFTEENTH SYMPOSIUM ON ROCK MECHANICS

September 17-19, 1973

The Fifteenth Symposium will be held this year at the famous State Game Lodge in Custer State Park, South Dakota, about 40 miles south of Rapid City. The topic of the symposium is "Applications of Rock Mechanics". For further information, write to Dr. Earl R. Hoskins (technical content), Professor Edwin H. Oshier (registration and housing), or Mr. Peter Oslund (student registration and housing) at the Department of Mining Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701. ⚒

J. H. C.

SEP 5 1972



AMERICAN SMELTING AND REFINING COMPANY
ROCKY MOUNTAIN EXPLORATION DIVISION
1805 SOUTH BELLAIRE STREET. DENVER. COLORADO 80222
TELEPHONE 303-757-5107

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June 2, 1972

J. H. C.

JUN 5 1972

Mr. J.J. Collins
Director of Exploration
ASARCO
120 Broadway
New York, New York 10005

Au - Other Metals

Dear Sir:

It appears that there is dissatisfaction with regard to further extensive work on stratiform oxide or sulphide coppers.

Attention is invited to the last memorandum received on gold exploration dated December 1, 1969, and signed by C.P. Pollock, attached for ready reference.

This memorandum states that we should not "pass up any possible Carlins" (reserves at end of 1970, 4.3 million tons at .293 oz Au; stripping ratio 1970, 6.3/1, initial reserves 1963 Annual Report, 5.5 million tons; 1800 TPD mill, capital investiment $7,000,000).

The memorandum also states that we should continue interest in potentially large low grade reserves, if these could be held at low cost. At that time it appeared that there would be no significant increase in the gold price for the foresseable future. "In the meantime, we will not give special priority to gold property investigations..."

In light of the fact that the "free" price of gold is close to $60.00/oz and generally rising, it appears that there has been a significant increase in the price of gold since Mr. Pollock's memorandum. Gold, gold-copper, and gold-other metals may now warrant consideration, at least to the extent of careful office and field investigation.

Colorado, Wyoming, and western South Dakota comprise a significant gold province, with gold mineralization ranging in age from Precambrian to Tertiary, and these areas deserve careful study if gold is now of any interest.

Mr. J.J. Collins

June 2, 1972

I would appreciate your opinion as to whether or not we should consider gold as worthy of any special interest on our part.

Very truly yours,

Stephen Von Fay

Stephen Von Fay

SVF/pln
enclosure
cc: JHCourtright

AMERICAN SMELTING AND REFINING COMPANY
EXPLORATION DEPARTMENT
120 BROADWAY, NEW YORK, N.Y. 10005

R. K. K.
DEC 3 1969

C. P. POLLOCK
VICE PRESIDENT

December 1, 1969

MEMORANDUM FOR: Regional Supervisors

Gold Exploration

In view of the recent decline in the free world gold price, some of you have asked about Asarco's exploration policy in regard to gold deposits.

As in the past, you should always be on the lookout for gold properties that could be operated profitably at the current world price, in short, do not pass up any possible Carlins. Likewise, we continue our past interest in potentially large low-grade reserves, if these could be held at a nominal annual cost for possible future production based on a price of $70.00 per ounce. Extraordinarily large deposits requiring a gold price in excess of $70.00 for profitable operations should be referred to us here for decision as to whether to investigate. Each occurrence of this category will have to be considered on its individual merits.

The substitution of special drawing rights for international monetary gold appears to be working satisfactorily, at least for the present. It seems doubtful, therefore, that there will be any significant increase in the gold price for the foreseeable future. In case the price falls much below $35.00, however, a considerable proportion of the South African gold production will probably be eliminated. Thereafter, property owners might become discouraged and the time would be appropriate to negotiate favorable agreements on potentially large deposits. Today with the price near $35.00, we know that favorable deals on promising deposits are generally not available but you should remain alert for major occurrences that might become available in the future. In the meantime, we will not give special priority to gold property investigations especially those that require a considerable part of your time or substantial expenditures as authorized exploration projects.

C. P. Pollock

CC-LPEntwistle
JHCourtright
WLKurtz
JFLord
JVDesvaux
RKKirkpatrick
SAAnzalone
TCOsborne
KWhiting
RJLacy
RBSprague
DMFletcher

File Gold

Report from South Africa

Deep gold mine hit by rising costs

[redacted]

File: Gold

GOLD 5/8/ WES

DEPARTMENT of the INTERIOR

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GEOLOGICAL SURVEY

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Forrester (202) 343-4646

J. H.
MAY - 8 1970
MAY - 1 1970

For release Wednesday, April 15, 1970

GOLD CONTENT OF WATER, PLANTS, AND ANIMALS

Gold is not only contained in the earth's crust, but is found in varying amounts in ocean water, streams, ground water, plants, insects, animals, and in humans, a new U. S. Geological Survey, Department of the Interior, report points out.

The 15-page circular is the latest in a series of four USGS reports that summarize available data on the normal occurrence of gold. Previous reports are on gold in the earth's crust, in rocks, and in minerals.

The reports have been prepared as background material for the Interior Department's Heavy Metals Program--an intensified program of research on new sources of heavy metals, including gold, being carried out by the U.S. Geological Survey and the U.S. Bureau of Mines.

The new report reveals that sea water contains from 0.001 to 44 parts per billion (ppb) gold, and averages about 0.05 ppb as calculated from neutron activation analysis. The seas and oceans contain varying amounts of gold; for instance, at least 10 times more gold for a given volume of water has been found in the North Atlantic Ocean than in the South Atlantic. The total amount of gold in sea water, world-wide, is estimated to be nearly 27.5 million tons.

The amount of gold commonly found in ground waters and river waters appears to lie within the range of the amount found in sea water. A few analyses of hot spring waters show that the gold ranges from 0.01 to 2.2 ppb, averaging about 0.5 ppb. Other ground waters contained from 0.001 to 0.9 ppb gold. River waters contained from 0.003 to 4.7 ppb gold. It has been estimated that the average amount of gold in the hydrosphere is not likely to exceed 0.01 ppb.

Varying amounts of gold are contained in the ash of algae, fungi, lichens, mosses, herbs, shrubs, and trees, according to the report. The maximum amount of gold detected in plant ash by neutron activation methods is 36 ppm (parts per million), and the average is about 7 ppm.

(more)

Gold has been looked for in only a few animals. Known analyses have been made on four types of insects, seven types of marine organisms, and seven types of warm-blooded animals, and the amount of gold occurring in them varies greatly. Values range from as little as 0.0012 ppb gold in the dry matter of fish muscle, and as much as 430 ppb in human hair. Human teeth show 10 to 30 ppb gold. Marine animals, by far, contain the least amount of gold, and terrestrial animals the most. Naturally occurring calcium phosphate compounds, such as teeth and antlers, appear to be similar in their gold content, irrespective of their origin, and probably reflect the gold level of their environment. The known content of gold in animals apparently supports the contention that the amount of gold found in animal organs is entirely casual, and that there are no "auriferous" (gold-containing) animals anywhere in the world.

The report, "Gold Content of Water, Plants and Animals," by Robert S. Jones, is published as USGS Circular 625, and may be obtained free upon request from the U.S. Geological Survey, Washington, D.C. 20242.

# # #

23957-70

WES, SHB, RDK, ~~SRD~~, ~~EDS~~ ~~BLK~~ ~~RHK~~

S. I. B.
DEC 4 1969
NPW 12-8-69
J. H. C.
DEC 2 1969

AMERICAN SMELTING AND REFINING COMPANY
EXPLORATION DEPARTMENT
120 BROADWAY, NEW YORK, N.Y. 10005

C. P. POLLOCK
VICE PRESIDENT

W.E.S.
DEC 2 1969

December 1, 1969

MEMORANDUM FOR: Regional Supervisors

Gold Exploration

In view of the recent decline in the free world gold price, some of you have asked about Asarco's exploration policy in regard to gold deposits.

As in the past, you should always be on the lookout for gold properties that could be operated profitably at the current world price, in short, do not pass up any possible Carlins. Likewise, we continue our past interest in potentially large low-grade reserves, if these could be held at a nominal annual cost for possible future production based on a price of $70.00 per ounce. Extraordinarily large deposits requiring a gold price in excess of $70.00 for profitable operations should be referred to us here for decision as to whether to investigate. Each occurrence of this category will have to be considered on its individual merits.

The substitution of special drawing rights for international monetary gold appears to be working satisfactorily, at least for the present. It seems doubtful, therefore, that there will be any significant increase in the gold price for the foreseeable future. In case the price falls much below $35.00, however, a considerable proportion of the South African gold production will probably be eliminated. Thereafter, property owners might become discouraged and the time would be appropriate to negotiate favorable agreements on potentially large deposits. Today with the price near $35.00, we know that favorable deals on promising deposits are generally not available but you should remain alert for major occurrences that might become available in the future. In the meantime, we will not give special priority to gold property investigations especially those that require a considerable part of your time or substantial expenditures as authorized exploration projects.

C. P. Pollock

CC-LPEntwistle
JHCourtright
WLKurtz
JFLord
JVDesvaux
RKKirkpatrick
SAAnzalone
TCOsborne
KWhiting
RJLacy
RBSprague
DMFletcher

NEWS LETTER

NEVADA MINING ASSOCIATION
RENO, NEVADA 89505

ROOM 602
ONE EAST FIRST STREET

NOVEMBER 15, 1969

PAUL GEMMILL, Executive Secretary

NUMBER 200

POST OFFICE BOX 2498
TELEPHONE 323-8575

L.P.F.
NOV 24 1969

S. I. B. J. H. C.

NOV 25 1969 NOV 24 1969

File: Gold

TECHNICAL DEVELOPMENTS

CARBONACEOUS GOLD ORE RESEARCH LEADS TO MERCURY LEACHING PROCESS:- The U.S. Bureau of Mines, Reno Metallurgy Research Center, made significant progress in developing an oxidation step in preparing carbonaceous gold ores for cyanide leaching. In cooperation with the Carlin Gold Mine, subsidiary of Newmont Mining Corporation, Eureka County, Nevada, pilot tests have been conducted at the Carlin mine. (See 4/15/68 News Letter, Page 8, and 5/15/69 News Letter, Page 3). Dr. Thomas A. Henrie, director of the Reno Center; Dr. R. E. Lindstrom, project coordinator, and Dr. Bernard Scheiner, project leader, have conducted the research project.

Weak salt (NaCl) brine in agitated ore pulp is electrolyzed with rectified current, thus providing chlorine in pulp. Both shipping and handling chlorine is avoided with this method and tests show noxious fumes are avoided since the chlorine stays in pulp at a level of concentration sufficient to completely convert the black carbonaceous ore pulp to buff color, indicative of oxidized ore ready for trouble-free recovery of gold by cyanidation.

The researchers have done bench work on low-grade mercury ores that are plagued with typically poor recoveries due to mercury vapor losses. Bench tests, using the generation of chlorine in pulp followed by weak acid leach and precipitation of mercury on iron filings has been demonstrated. Solution for pulp make-up can be recycled. This method makes high recovery from low-grade ore possible and at the same time, provides a recovery process free from the health hazard of salivation. Processing entails use of some 45 kilowatt-hours of electricity per ton of ore for electrolysis which is a modest cost for recovering an extra pound of mercury at the present price of $6.57 per pound ($500 per 76-pound flask).

The research team believes low-cost power for remote sections of Nevada will be very important to future development of "clean" processing methods such as the proposed mercury process.

NEVADA MINES, COMPANY REPORTS, ETC.

KENNECOTT COPPER CORPORATION:- reports for the quarter and 9-months ending September 30, as follows:

Quarter:	1969	a1968
Share earnings.	$1.41	$1.26
Sales	261,783,066	222,210,381
Net income.	46,544,519	41,745,434

VHC · File

MR. ~~WES~~, ~~BEK~~, ~~FDS~~
READ AND RETURN
PREPARE ANSWERS ____ HANDLE ____
FILE ✓ INITIALS ____

EXPERIMENTAL LEACHING OF GOLD FROM MINE WASTE

J. H. C.
SEP 26 1969

By H. J. Heinen and Bernard Porter

W.E.S.
OCT 7 1969

* * * * * * * * * * * report of investigations 7250

UNITED STATES DEPARTMENT OF THE INTERIOR
Walter J. Hickel, Secretary

BUREAU OF MINES
John F. O'Leary, Director

This publication has been cataloged as follows:

Heinen, Harold J

Experimental leaching of gold from mine waste, by H. J. Heinen and Bernard Porter. [Washington] U. S. Dept. of the Interior, Bureau of Mines [1969]

5 p. tables. (U. S. Bureau of Mines. Report of investigations 7250)

Includes bibliography.

1. Gold mines and mining—Nevada. 2. Gold ores—Nevada. 3. Leaching. I. Porter, Bernard, jt. auth. II. Title. (Series)

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2. Gold distribution in the cyanide tailings 4

EXPERIMENTAL LEACHING OF GOLD FROM MINE WASTE

by

H. J. Heinen[1] and Bernard Porter[2]

ABSTRACT

Excellent gold recovery was demonstrated in a laboratory-scale leaching test on waste material from an open-pit mine in northeastern Nevada. An injection system of leaching was applied in which the sodium cyanide solution was introduced into the interior of the dump at selected points. Dissolution of gold from the waste material, which assayed 0.06 ounce gold per ton, was readily achieved because the gold occurred as submicroscopic particles in a porous host rock. Gold recovery of 80 percent was obtained in 11 days from material crushed to 1 inch in size, and recovery was 90 percent after 21 days.

INTRODUCTION

In recent years, the domestic consumption of gold for industrial purposes, such as the manufacture of electronic equipment, has increased markedly. This growing demand for gold has encouraged efforts to develop low-grade ores and submarginal materials. One phase of the Bureau of Mines Heavy Metals Program is directed toward the investigation of processes for recovering gold from such sources. This paper is concerned with a preliminary effort to evaluate dump leaching as a potential method for recovering gold from low-grade sources.

Several significant gold deposits occur over an extended area in northeastern Nevada (3).[3] Most of these ore bodies could be or are being mined by normal open-pit methods. In practice, material sent to the dump contains less than 0.05 to 0.08 ounce gold per ton, depending on the mine cutoff figure. Mining engineers estimate that about 10 million tons of low-grade ore and mine waste from past and present operations contain 0.05 to 0.13 ounce gold per ton. In addition, other deposits of relatively high-grade oxide ore are too small for commercial exploitation using the conventional countercurrent decantation cyanide process. However, it may be economically feasible to treat both types of material by dump-leaching techniques to recover the gold.

---

[1]Metallurgist.

[2]Research chemist.

Both authors are with the Reno Metallurgy Research Center, Bureau of Mines, Reno, Nev.

[3]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

Dump leaching of low-grade ores or mine wastes is widely used in the copper industry (2, 4-6) and more recently has been applied to uranium ores. Advantages are the low capital cost and the relatively low operating cost. In dump leaching mine waste material piled in dumps on prepared pads is treated with a leach solution introduced either on top of or inside the dump to extract values. For a successful operation the rock must be fractured or of high porosity to insure thorough contact between the mine waste and the leach solution. In addition, intermittent partial drying of the dump is necessary.

Mine waste material from northeastern Nevada was used in this study. The gold occurs as submicroscopic particles in a porous sedimentary rock, which is chiefly siltstone and limey shale and contains large amounts of clay.

APPARATUS AND PROCEDURE

Small-scale percolation leaching tests on 1-inch-size rock gave encouraging results. Essentially all the gold was recovered from the rock, which assayed approximately 0.06 ounce gold per ton. The resultant tails from these tests contained ~0.005 ounce gold per ton.

Consequently, a test was conducted on an expanded scale in a 27-inch-high plastic barrel with a 13.5-inch ID. Centrally located in this barrel was a 27-inch-long, 1.5-inch-diameter plastic pipe, which was closed at the lower end. The pipe was perforated with holes (0.25 inch in diameter) spaced 90° apart around its periphery and at 4-inch intervals along its length. Provision was made at the bottom of the barrel for draining and collecting the leach solutions. The barrel held approximately 200 pounds of mine waste crushed to 1-inch size. The leachant for extraction contained 2 pounds of sodium cyanide per ton of solution. Lime for protective alkalinity was not added since the water and rock formed a pulp with a pH of 8. The quantity of solution was 400 pounds per ton of waste rock.

The injection system (1) of leaching was selected because it minimized the mechanical difficulties often encountered in leaching clay-bearing materials. The solution was fed into the inner perforated pipe at a controlled rate to first wet the lower portions of the charge. Gradual permeation of the leach solution into the upper portion of the charge occurred through capillary action. Leaching took place as the solution percolated down to the bottom of the barrel where it was collected and then fed back into the top of the plastic pipe. The solution was recycled several times throughout an 8-hour test period. The system was allowed to drain overnight, and during this time the charge was partially dried and aerated. The gold was stripped from the leach solution each morning by use of activated carbon. The gold-laden carbon was collected by filtration, and the barren solution was then recycled for another 8 hours. The carbon was ashed and fire assayed for gold content.

Each day, prior to beginning the extraction, the inner pipe was filled with sufficient mine waste to raise the level 2 inches. This blocked the lowest set of holes every second day and forced the leach solution into the bed at the next higher set of holes. After 12 days the material in the pipe approached the top set of holes. The leaching test was continued with the top

set of holes uncovered. At no time was the leachant poured directly onto the top of the bed.

The total leaching period was 21 days. To compensate for liquid lost by evaporation, tapwater was periodically added to the barren solution. At the end of the test, the residue was removed from the barrel, dried, and sampled for analysis by fire assay and atomic absorption methods.

RESULTS

Gold recoveries are shown in table 1. At the end of 5 days, 64 percent of the total gold had been recovered; after 10 days, the recovery was 80 percent. In the remaining 11 days, an additional 10 percent of the gold was extracted for a total recovery of 90 percent. The resulting tails assayed 0.006 ounce gold per ton.

TABLE 1. - Metallurgical balance for leaching test

Description of product	Gold, milligrams	Gold distribution	
		Percent	Cumulative, percent
Strip No.:			
1	38.92	20.69	20.69
2	30.25	16.08	36.77
3	23.45	12.47	49.24
4	16.91	8.99	58.23
5	10.58	5.62	63.85
6	7.13	3.79	67.64
7	7.62	4.05	71.69
8	6.56	3.49	75.18
9	5.28	2.81	77.99
10	4.26	2.26	80.25
11	3.50	1.86	82.11
12	2.28	1.21	83.32
13	2.07	1.10	84.42
14	2.20	1.17	85.59
15	1.45	.77	86.36
16	1.20	.64	87.00
17	1.07	.57	87.57
18	1.08	.57	88.14
19	2.76	1.47	89.61
20	.83	.44	90.05
21	.68	.36	90.41
Total recovery	170.08	90.41	90.41
Cyanide tails	18.04	9.59	100.0
Composite	[1]188.12	100.0	100.0

[1]Equivalent to 0.06 oz gold/ton.

Table 2 shows the distribution of gold in the cyanide tailings as obtained by wet screen analyses. As expected, the coarser fraction (plus 1/2-inch) retained the largest portion of the undissolved gold. About 19

percent of the gold lost in the tailings was soluble gold not washed out of the waste material.

TABLE 2. - Gold distribution in the cyanide tailings

Screen size	Size distribution		Gold assay, oz/ton	Gold distribution, percent
	Weight-percent	Cumulative, weight-percent		
Plus 1/2 inch.....	19.4	19.4	0.007	24.2
Minus 1/2 inch plus 1/4 inch	20.0	39.4	.006	20.7
Minus 1/4 inch plus 10 mesh.	17.5	56.9	.005	15.5
Minus 10 plus 100 mesh.....	15.4	72.3	.004	10.3
Minus 100 mesh.....	27.7	100.0	.002	10.3
Composite.....	100.0	100.0	.0047	81.0
H_2O-soluble gold.....	-	-	.0011	19.0
Total tails.....	100.0	100.0	.0058	100.0

The reagent consumption was 0.4 pound NaCN per ton of mine waste. Part of this consumption was due to adsorption of NaCN by the activated carbon. The final strip solution had <0.002 pound NaCN per ton of solution.

CONCLUSIONS

The results of the test show that the injection system of leaching is potentially feasible for large-scale use in the extraction of gold from mine wastes and submarginal oxide ores. The efficiency of the method was demonstrated by the 80-percent gold recovery in 10 days and a total gold recovery of 90 percent in the 21-day test period. Reagent consumption was 0.4 pound of NaCN per ton of mine waste treated. The results suggest larger scale tests and tests on other low-grade materials.

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INT.-BU.OF MINES,PGH.,PA. 13466

GOLD
JHC Sec'y file

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 28, 1969

Mr. D. M. Fletcher, Managing Director
ASARCO (Australia) Pty, Ltd.,
190 Hay Street East
Perth, Western Australia 6000

Dear Dave:

I just wondered if you knew anything about the enclosed article.

Sincerely,

J. R. Wojcik

JRW/kvs
Enc: "Amad N.L. and Vam Ltd. plan
Joint Gold Prospecting Venture"

cc: JLord w/enc.

Queensland . . . .

Amad N. L. and Vam Ltd. plan Joint Gold Prospecting Venture

Of considerable interest is a joint venture by Amad N.L., a prospecting company, and Vam Ltd., in the Burdekin River area, south of Townsville. Hydro Mineral Development, Vam's subsidiary company, has obtained an authority to prospect covering 426 square miles from Cape Upstart to Cape Bowling Green, also covering foreshores and extending for several miles out to sea.

A scout drilling program along lines normal to the coastline, and extending for up to 6,000 feet from the sea has indicated eight grams of gold per cubic yard for more than 200,000,000 cubic yards.

A pilot plant of 60 cubic yards per hour will be installed, and a more detailed drilling program is planned. Further areas have been applied for by Hydro Mineral Development. The Burdekin drains many former goldfields, and although its delta is highly developed for agriculture, the zones of interest are claimed to be underdeveloped sand dunes and swamp. There is already talk of a 1,000 cubic yard per hour dredge. Eventually they expect six dredges to be in operation.

Copied from
WORLD MINING September 1969

J. H. C.

W.E.S.
AUG 27 1969

GEOPHYSICAL DIVISION

3422 South 700 West
SALT LAKE CITY, UTAH 84119

AUG 22 1969

RECEIVED
AUG 13 1969
JOHN J. COLLINS

August 5, 1969

MR. W.E.S.
READ AND RETURN
PREPARE ANSWERS ___ HANDLE ___
FILE ✓ INITIALS ___

MEMORANDUM to R. J. LACY:

GEOCHEMICAL SYSTEMS COMPANY
GEOCHEMICAL GOLD ANALYSIS

(Ref. Mr. J. J. Collins' letter to Mr. R. J. Lacy - July 29,1969)

It is probably true that the Geochemical Systems Company of Orange, California, can generally analyze geochemical samples for gold with a reasonable degree of accuracy and precision at the 40 ppb level. Their initial problems in the analysis of Cortez (very fine grained gold) type material were apparently overcome as a result of some investigations they carried out for Asarco in late 1967 (see attached correspondence). The gold analytical technique they use is apparently based on a well tested method developed originally by the U.S.G.S.

However, I am of the opinion that the geochemical gold analytical technique developed in the Asarco Geochemical Laboratory is generally superior to that used by Geochemical Systems. Our use of a fire assay procedure in the preliminary stage of the method ensures that fine grained gold will invariably be extracted without special sample preparation (i.e. very fine pulverizing). In addition the fire assay stage enables far larger samples to be readily dealt with than is normally possible with the acid leach method employed by Geochemical Systems. Large samples have the advantage of enabling erratically distributed gold to be more satisfactorily determined as well as allowing greater sensitivity to be achieved.

I would recommend that in general Asarco geochemical analysis for gold be carried out here in the Geochemical Laboratory.

Original Signed By
L. D. JAMES

L. D. JAMES

LDJ:db
Encl.

cc:J.J.Collins w/encl.

Gold General

MR. ~~SIB~~ ~~JDS~~ ~~HCU~~ ~~NPW~~ - ~~ADV~~ ~~WGF~~

READ AND RETURN JHC Desk

PREPARE ANSWERS ____ HANDLE ____

FILE ____ INITIALS ____

W.E.S.
JUL 18 1969

New York, July 15, 1969

J. H. C.
AUG 12 1969

S. I. B
JUL 18 1969

Memorandum to: Regional Supervisors, Exploration Department

Please report values of precious metals in ounces or grams, milligrams, etc., not dollars unless you specify the price of gold or silver on which your monetary figure is based. It has been quite some time since industrial gold was sold at $35 per ounce and the future market price is uncertain. To make our reports readily understandable in the future, we should take pains to utilize weight measurements whenever appropriate.

John J. Collins

John J. Collins

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 16, 1969

FILE MEMORANDUM

In the recent USGS circular 610, titled "Gold in Igneous, Sedimentary and Metamorphic Rocks," there are several analysis listed showing substantial amounts of gold, for instance:

Rock	Location	Gold content (ppm)	Silver (ppm)
Granite	Australia: Timbarra, New South Wales	3.406	829
Granite	Candelaria, Nevada	1.130	
Syenite	Candelaria, Nevada	0.72	
Diabase	Washoe District, Nevada	0.75	7.2
Prophylite	New Zealand: Thames, North Island	2.42	
Basaltic Tuff.	New Zealand: Richmond River	15.180	
Serpentinite	New Caldonia: Northern Part	7.5	

The foregoing analyses are from tables regarding analyses prior to 1955 and are mainly fire assays. In the tables of analyses made since 1954, mainly by neutron activation, results are generally lower.

J.H. Courtright

JHC:lzb J.H.Courtright

cc: JJCollins
WESaegart
WLKurtz
DMFletcher
RBSprague

2-3-69 LZB

Copy for ~~[illegible]~~

READ AND RETURN

PREPARE ANSWERS ..... HANDLE

FILE ✓ INITIALS

J. H. C.

FEB 3 1969

New York, January 31, 1969

MEMORANDUM FOR: Messrs. J. H. Courtright
J. V. Desvaux
R. K. Kirkpatrick
Keith Whiting
R. J. Lacy
L. P. Entwistle
T. C. Osborne
R. S. Gray
R. L. Brown
D. M. Fletcher
R. B. Sprague

file

Possible Increase in Gold Price

For your information and guidance, I am enclosing copy of Mr. S. D. Strauss' memorandum of January 27, 1969, to Mr. Tittmann, concerning a possible increase in the price of gold.

In this connection, please note Mr. Tittmann's pencil notation addressed to me in which he indicates a price of $70.00 looks favorable but he does not wish to overlook deposits which would require a price of $100.00.

The U. S. Geological Survey has published a report which describes the geology, mining history, and production of more than 500 gold-producing districts in 21 states. As it may be of some assistance to you in your pursuit of gold-bearing properties, I would suggest that you order a copy of this 283 page report, "Principal Gold-Producing Districts of the United States," by A. H. Koschmann and M. H. Bergendahl. It is published as Geological Survey Professional Paper 610 and may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 for $4.75 per copy.

C. P. Pollock

Enc.

CC-EMcLTittmann

E. McL. Tittmann
JAN 27 1969

SALES DEPARTMENT

January 27, 1969

MEMORANDUM

Mr. E. McL. Tittmann
B U I L D I N G

The January issue of the MONTHLY ECONOMIC LETTER of the First National City Bank contains its annual gold review starting on Page Eight. A copy of the letter is attached for you and for those receiving copies of this memo.

At the recent panel discussion staged by the American Mining Congress, one of the economists present repeated the threat being voiced by American economists that gold would be demonetized. The article by the First National City Bank seems to me to put this matter in proper perspective. I quote in part four sentences.

> "The fact that the opportunity to add to monetary gold reserves has been seized by a strikingly large number of governments and central banks once again illustrates the deeply anchored desire to build up gold stocks."

> "For the governments of most of the large nations are not ready to demonetize gold -- substituting for gold U. S. dollars or claims on an international institution."

> "While demands by governments for gold can be restrained, they cannot be suppressed."

> "The most essential task today is to face the matters related to gold in an emotion-free atmosphere so as to avoid misunderstanding, mistrust and mishandling."

In my opinion the Bank is exactly correct in each of the four statements quoted. Gold will retain its position in the monetary

system and the pressure of growing world trade will force an increase in the price of gold, not only in the open market but also in terms of monetary values.

I bring this to your attention because it seems to me that just as in the case of silver, better opportunities exist if we pursue potential sources of new gold production before an advance in the price rather than after.

S.D.S.
SIMON D. STRAUSS

cc: Messrs. R. D. Bradford
C. F. Barber
R. L. Hennebach
F. G. Hamrick
C. E. Nelson
C. P. Pollock
H. L. Goodenough
R. J. Plumb, Jr.
Sir George Fisher
J. Foots
J. Morgan
W. R. B. Foster
Walter Nock
Marion Boone

file Gold-General

TO Mr. J. H. Courtright

FROM Tucson Office

Phone (702) 786-1919
American Smelting and Refining Company
Southwestern Exploration Department - Reno Office
P. O. BOX 7637
RENO, NEVADA 89502

SUBJECT: USBM Reports

DATE: Sep 6, 1968

FOLD ↑

Enclosed are two reports of the USBureau of Mines, one concerning Gold Resources in Tertiary Gravels of California and the other concerning Oxidation Systems for improving gold recovery from Carbonaceous Mate ials.

Perhaps John Lord would be interested in the Gravel paper--I am not qualified to evaluate it.

Would you please Xerox a copy of both reports for return to the Reno Office.

RETURN TO ⟶ SIGNED

Bill Thanks for the reports. Zerox copies enclosed

Zeroxed - 9-12-68 LJB

DATE SIGNED JHC

GRAYARC CO., INC., BROOKLYN, N. Y. 11232

PERSON ADDRESSED RETURN THIS COPY TO SENDER

mail addn'l copy to Watson. 8-16-68 Jim

Barry: Perhaps Jim Briscoe could look in on this while he is in S. Calif reviewing Randsburg Dist. Suggest you contact Jim if you agree

W.E.S.
AUG 15 1968

WES

J.H.C
AUG 19 1968

cc:
CPPollock
HCourtright
BWatson

USGS CIRCULAR 561.

AN ATOMIC-ABSORPTION METHOD FOR THE DETERMINATION OF GOLD IN LARGE SAMPLES OF GEOLOGIC MATERIALS

W.E.S.
AUG 8 1968
J.H.C.
AUG 19 1968
J.H.C
AUG 19 1968

By GORDON H. VANSICKLE and HUBERT W. LAKIN

Abstract

A laboratory method for the determination of gold in large (100-gram) samples has been developed for use in the study of the gold content of placer deposits and of trace amounts of gold in other geologic materials. In this method the sample is digested with bromine and ethyl ether, the gold is extracted into methyl isobutyl ketone, and the determination is made by atomic-absorption spectrophotometry. The lower limit of detection is 0.005 part per million in the sample. The few data obtained so far by this method agree favorably with those obtained by assay and by other atomic-absorption methods. About 25 determinations can be made per man-day.

INTRODUCTION

The Heavy Metals program of the U.S. Geological Survey requires large numbers of gold analyses and an analytical capability to determine gold in very small amounts. Several rapid methods for gold determination that have been developed recently (Lakin and Nakagawa, 1965; Huffman and others, 1967; Thompson and others, 1968) have proved to be very useful for reconnaissance-type sampling of most areas (Erickson and others, 1966; Gott and McCarthy, 1966). However, these methods, which use samples weighing only 2–15 grams, are inadequate for the determination of the gold content of potential placer deposits because of the erratic distribution of particulate gold in these materials (Antweiler and Love, 1967; Clifton and others, 1967). Analysis of a larger sample (100 g) permits a more accurate determination of the gold content of such material. The 100-g sample also gives a detection limit for gold of 0.005 ppm (part per million), lower than that of the earlier methods, which have a detection limit of 0.02 ppm or more.

With the recent development of atomic-absorption spectrophotometry the measurement of gold has become simple and routine. Methods of sample dissolution vary. In a method described by Thompson, Nakagawa, and VanSickle (1968) a mixture of hydrobromic acid and bromine is used to solubilize the gold. The gold is then extracted into methyl isobutyl ketone (MIBK), and the gold concentration is determined by atomic-absorption spectrophotometry.

Shima (1953) described a method of leaching gold from large samples (100–500 g) with a mixture of bromine and ethyl ether and estimating the gold colorimetrically with dithizone.

The method which is proposed here, and which is a combination and modification of these two methods, results in a simple, reliable, sensitive, and low-cost analysis for gold in a large sample. The gold is dissolved by a mixture of bromine and ethyl ether and is extracted into MIBK; the gold concentration is then determined by atomic absorption.

We wish to acknowledge the help and advice of C. E. Thompson of Skyline Laboratories, Inc., and formerly of the U.S. Geological Survey. Arthur Kinkel, Paul Theobald, and Garland Gott of the U.S. Geological Survey provided the samples for our experimental work.

REAGENTS AND APPARATUS

Bromine, reagent grade.

Ethyl ether, reagent grade. (Note: Because of the toxicity of bromine and the explosive nature of ethyl ether these reagents should be used only in a well-ventilated laboratory hood. They should be stored in a refrigerator.)

Hydrobromic acid, concentrated, reagent grade, distilled.

- 1.5 *N* HBr: Dilute 172 milliliters of concentrated HBr to 1 liter with water.
- 0.1 *N* HBr: Dilute 25 milliliters of concentrated HBr to 2 liters with water.

Methyl isobutyl ketone (MIBK), (2 methyl 4 pentanone), reagent grade.

Standard gold solution, 0.1 percent: Dissolve

low-grade ore and two samples of sulfide ore from North Carolina has been determined by the atomic-absorption method in combination with four methods of sample solution (table 2): (1) Fire assay and aqua regia, (2) cyanide, (3) hydrobromic acid-bromine, and (4) bromine-ether as described here. The fire-assay method gives slightly higher gold content in materials containing less than 1 ppm than the bromine-ether procedure. Otherwise the agreement between the various methods is acceptable.

TABLE 1.—*Repeatability of the method*

Sample	Description and locality	Number of determinations	Gold (ppm)			Standard deviation	Relative standard deviation (percent)
			Maximum	Minimum	Mean		
CC–562	Fractured phonolite breccia, Cripple Creek district, Teller County, Colo.	6	0.56	0.34	0.46	0.074	16
567	------do------	8	.072	.024	.046	.016	35
559	------do------	6	.018	.009	.015	.0035	24
ABK–045	Gold and monazite placer sand, Moffat County, Colo.	6	1.24	.31	.88	.34	39

TABLE 2.—*Comparison of gold values obtained by four atomic-absorption methods*

[All samples from North Carolina, and sample numbers are preceded by K–. Fire-assay analyses by O. M. Parker, L. B. Riley, J. D. Mensik, and Claude Huffman, Jr., U.S. Geological Survey; cyanide and hydrobromic acid-bromine analyses by A. E. Hubert, U.S. Geological Survey]

Sample	Description	Gold (ppm)			
		Method of solution			
		Fire assay and aqua regia (15-g sample)	Cyanide (100-g sample)	Hydrobromic acid-bromine (10-g sample)	Bromine-ether (100-g sample)
12	Rock chips and soil	0.7	0.4	0.8	0.62
13	------do------	.3	.2	.4	.20
18	------do------	.3	.3	.7	.28
19	Saprolite	.3	.1	.3	.26
20	Hard saprolite	.2	.08	.4	.14
21	------do------	.2	.2	.2	.12
35	Schistose (sericitic) saprolite	2.	2.4	2.8	3.1
36	------do------	.6	.7	.8	.63
57	Red soil (B zone)	.5	.1	.6	.18
61	Tuff saprolite	.3	.1	.3	.20
100	Bedded tuff	1.	1.	1.	1.2
130	Rhyolitic tuff saprolite	<.05	<.02	<.02	.02
136	Cellular gossan	5.5	3.2	5.6	6.8
109	Pyritic rock	4.	3.8	4.	4.7
135	Sulfide ore	7.	.5	3.9	4.6

CONCLUSIONS

The method presented here is certainly not a replacement for the standard fire assay for gold; however, the simplicity, sensitivity, and lower cost of the method are distinct advantages.

We have emphasized the 100-g sample, but with a few modifications in the procedure and the equipment a much larger sample could be handled. The problems of grinding, roasting, extracting, and waste disposal by using a sample much larger than the suggested 100-g size increase exponentially with the sample size. Therefore, this method is a compromise between the need for analysis of larger samples and the ability to do larger numbers of samples easily. A method for routine analysis of samples as large as 1000 g has been developed by the Office of Marine Geology and Hydrology of the U.S. Geological Survey (H. E. Clifton, written commun, March 1968).

REFERENCES

Antweiler, J. C., and Love, J. D., 1967, Gold-bearing sedimentary rocks in northwest Wyoming—a preliminary report: U.S. Geol. Survey Circ. 541, 12 p.

Clifton, H. E., Hubert, Arthur, and Phillips, R. L.,

J. H. C.

JUN 28 1968

Copy to
RKK 6-28-68
WLK

GEOCHEMICAL EXPLORATION FOR GOLD

A talk presented at the Mining Geology Division
of the Arizona Section of A. I. M. E.
May 20, 1968 Tucson, Arizona

by
Fred W. Tahse
Geochemical Systems Company

In the early 1960's, the mining community and the geologic profession were somewhat startled by the announcement by Newmont Mining Company of a new discovery of gold near Carlin, Nevada. What was particularly startling about this announcement were four things:

1. That such a large deposit of gold, about 12 million tons averaging approximately $10 per ton--remained to be discovered.
2. That the gold contained in the deposit occurs in particles less than 20 microns in diameter with some smaller than one micron in diameter.
3. That not only could the gold not be seen, even by panning, but the usual signs of mineralization were not generally in evidence. By that I mean such things as iron oxide and sulfate staining or pronounced alteration or metasomatism. In fact, the host rock of the ore body is very ordinary looking siltstone and marlstone.
4. That the geology of the deposit was such that similar deposits could be expected to occur elsewhere.

The discovery of the Carlin deposit served to stimulate the U. S. Geological Survey. In 1965, Mr. Udall appropriated some 6 million dollars to the survey to establish what is called the Heavy Metals Exploration Program. The objective of this program is to develop new techniques, particularly geochemical, to aid in the discovery of new deposits and new types of deposits of gold and some other metals. In the four years that this program has been in existence, it has accomplished at least these important things:

1. It has developed moderately successful geochemical analytical techniques for the determination of trace quantities of gold in geologic materials.
2. It has developed analytical facilities capable of many thousands of determinations per year, including 18 small mobile laboratories.
3. It has analyzed at least 200,000 samples since 1966.
4. It has investigated several mining districts, the results of four of which have been reported in U. S. Geological Survey Information Circulars.
5. Through these circulars, it has helped to show that geochemical exploration for gold is both feasible and potentially effective.

The discovery of so-called invisible gold at Carlin, the important advances in exploration technology made by the U. S. G. S., and the international gold crisis all have combined to stimulate private enterprise to initiate or expand their exploration activities for gold. Last year one of this country's largest gold mining companies embarked on an ambitious reconnaisance exploration program for gold in northern Nevada. It's principle exploration tool, outside of geology, is geochemistry, and it is collecting and analyzing thousands of samples per year. This year, other companies have joined the search, several of them major oil companies, who in the past have not seriously been interested in metals of any kind. These companies are placing an unusual emphasis on geochemistry. Knowing that the Carlin type of gold shows little visual indication of its presence, they realize that extensive sampling and assaying and geochemistry are indispensible to success. The tremendous variety of materials that come to our lab, most of which visually appear totally unmineralized, testify to this realization.

While these companies use geochemistry extensively, only a few of them appear to be aware of some very important differences between precious metal geochemistry and base metal geochemistry.

Figure 1 shows those desiderata that are both necessary and common to all geochemical surveys:

1. The determination of the survey area, which is principally the realm of the geologist.
2. A decision as to the objectives of the survey.
3. The sampling density and sampling pattern.
4. The types of materials to be sampled and the size of the sample to be collected.
5. The indicator elements or path-finders to be analyzed for.
6. The required analytical sensitivities.
7. The analytical techniques to be used.
8. The methods of reducing and displaying the analytical data, and
9. The interpretation techniques used.

It is in 3, 4, 5 and 6 where the greatest differences lie between base metal geochemistry and precious metals geochemistry.

Imagine, if you will, that I have in my hand a rock sample. This sample is approximately cubic in shape and three inches on a side. It is any kind of rock, but it contains about 2% by volume of disseminated sulfide particles. These particles are about the size of a pin-head, and I can calculate that my sample contains about 9,000 of these particles. Now, if 3,000 of the 9,000 particles were chalcopyrite, this sample would contain about 0.4 per cent copper and be worth approximately $3.20 per ton. However, if only one of the 9,000 particles were gold, the sample would contain approximately 0.002 per cent gold and be worth $20 per ton. My sample weighs about 3 pounds, and if I

were a lazy prospector, I might have been satisfied to carry back with me a one pound sample. Had I done this, I would have been either very happy, because I might have received an assay report indicating a great deal of gold or, more likely, I would have been very sad, because I would have received a report indicating nil. Even if I had carried the entire 3 pounds back with me, the assayer probably would not have given me an accurate report--for this reason. My sample weighs about 1200 grams. The assayer would crush the entire 1200 grams and quarter it. He would then pulverize 300 grams to, say, 200 mesh. Unfortunately, in pulverizing the sample, he doesn't pulverize the gold, due to its malleability. Now, the assayer takes a standard one-half assay ton, or 15 grams, of the 300 grams and assays it by fire assay. If my gold is in that 15 grams, I receive a report indicating a gold content of almost 50 ounces per ton, or $1750 per ton. Far more likely, however, is that my gold is not in that 15 grams. In fact, the chances of its being there are one in 80, and I receive a report of nil. I'm sure many of you have taken samples showing high gold values, then returned to the sample site for more samples, only to find that the assayer could not reproduce the original results.

At the opposite end of the spectrum is Carlin type gold. Had my sample been $20 Carlin ore, there would have been about one billion particles of gold in the sample. I could have taken a sample the size of a marble and gotten an accurate assay. Figure 2 shows actual determinations by atomic absorption spectroscopy of two types of ore. One type is from the Vanderbilt Mining District, San Bernardino, California, and contains coarse gold. The other type is actual Carlin ore and, of course, contains very, very fine gold. Both ores were pulverized to 100 per cent -325 mesh, which, incidentally, is necessary to recover all the gold from the Carlin ore. Different amounts of

each of these ores were taken for analysis--1 gram, 2 grams, 5 grams, 15 grams, and 30 grams, and triplicate determinations made for each amount. Notice that the same answer was not obtained for any of the Vanderbilt determinations. Furthermore, the average of three 5 gram determinations, or a total of 15 grams, did not equal any of the single 15 gram determinations, and the average of any two of the 15 gram determinations did not equal any of the single 30 gram determinations. On the other hand, for Carlin ore a one gram determination is virtually as accurate as a 30 gram determination. Now I'm sure it's quite obvious that ultra-coarse gold, as well as Carlin-type gold, is unusual. Most gold seems to occur somewhere between these extremes. In fact, Geochemical Systems Company has developed evidence to indicate that gold in some mineralized samples occurs in two modes--a very fine mode, less than about 200 mesh, and a coarse mode, greater than 80 mesh in size. It seems that the old time assayers knew this. Their technique was to, first, pulverize the entire sample to one or two hundred mesh. Second, to screen the entire sample with a 100 mesh screen. Third, to sample part of the -100 mesh fraction and all of the +100 mesh fraction, having weighed both after screening. And, fourth, combine both samples and, after assaying, compute the gold content of the original material. Had this technique been used on my hand sample, the correct answer probably would have been obtained. However, this technique is time consuming and expensive and is not used by today's busy assayer.

So the question arises, how does one obtain absolutely representative samples when sampling for gold? And, how can one be sure that an assay report gives an accurate indication of the gold content? Unfortunately, the answer to both these questions is that he cannot, unless he is willing to pay extra for extra work--unless he is willing to take very large samples and pay for elaborate sample preparation.

So sample representation can be a serious problem. In geochemical sampling, this problem cannot be completely obviated, but it can be minimized--particularly since anomalies or trends, rather than absolute values, are usually the objectives. Here are a number of steps that companies are learning to take to combat this problem, as well as to provide valuable additional information:

1. At a particular sample site, composite samples are taken. By composite, I mean half bed rock and half soil--that part of the soil immediately overlying bedrock and likely to be partially residual.
2. Separate aliquots are taken over several square feet and mixed.
3. The entire sample is crushed and pulverized, during which process a rather thorough mixing occurs.
4. The sample is analyzed using 15 grams of sample, rather than the one to five grams usually analyzed in trace analysis.
5. Replicate determinations are automatically made on significantly anomalous samples, and
6. Other elements are analyzed for, which can be indicators of the presence of gold--commonly called indicator elements or path-finders.

What are the characteristics of a good indicator? Figure 3 shows the principle characteristics:

1. Specificity. The elements should be commonly associated with gold. Many elements can accompany gold during mineralization, but most of them indicate no more than the fact of mineralization, which can, of course, be important. At the Carlin Mine, all these metals and semi-metals are present in anomalous amount: barium, arsenic,

manganese, antimony, boron, nickel, copper, mercury, lanthanum, lead, gallium, scandium, cobalt, molybdenum and silver.

2. Low and uniform normal concentrations. Elements which normally occur in relatively high concentrations, or whose concentrations vary widely from one rock type to another, are virtually useless as indicators. An example of this is nickel, whose normal concentration varies from as low as a few parts per million in some acid rocks to as much as 1500 parts per million in some basic rocks.

3. Detectibility. It is highly desirable to be able to detect variations in the background levels of indicator elements, so that as approachment to a mineralized area or zone can be seen from as great a distance as possible. Until recently, with the advent of atomic absorption spectroscopy, it was not possible to obtain reliable measurements of background or near background levels of gold, silver, or mercury--three of the better indicators of gold--on an inexpensive, routine basis. Today, we are performing hundreds of determinations per day, with detection limits equal to or below the normal concentrations.

4. Mobility. It is desirable that an indicator be reasonably chemically mobile, so that it will disperse away from the ore zone and provide a larger target for the geochemical survey. On the other hand, it should not be so mobile that it leaches completely from the ore zone. Copper is an example of a highly mobile element, which sometimes leaches completely.

What then are the good indicator elements for gold? Gold itself is a good indicator. It is the only absolutely specific indicator. Its normal concentration in rocks is very low--from 2 to 10 parts per billion. Its concentration does not vary appreciably from one rock type to another, being almost the same in basic rocks as it is in acid rocks. Near-background levels of gold are now detectible and reproducible within reasonable limits. However, gold suffers from a lack of mobility. Because of the stability of its outer shell of electrons, gold is highly inert, even in strongly acid environments. Strong oxidizing agents are required to oxidize gold, so that it can form a soluble and mobile salt, such as gold chloride. Such oxidizing agents do not normally exist in surficial environments. This inertness of gold precludes secondary chemical dispersion in most cases and limits the size of the geochemical target. On the other hand, because gold seldom leaches from the oxidized outcrop, surface values are ususally indicative of values in the unoxidized rocks at depth.

Silver can be a good indicator for gold. It very often occurs with gold and vice-versa. Its normal concentration is low--about 50 to 150 parts per billion-and this concentration does not vary widely from one rock type to another, although some black shales are known to contain as much as one part per million. Even low background levels of silver are easily detectible by atomic absorption techniques. Consequently, small variations in background can be relied upon. Silver can be surprisingly mobile, particularly in acid sulfate environments. Silver sulfate is appreciably soluble even in fresh water. Surprisingly, silver flouride is almost as soluble as silver nitrate. And even silver chloride has a measurable solubility in fresh water.

Arsenic is commonly associated with gold, though it seems to be less specifically associated than silver. The normal background for arsenic is from 1 to 5 parts per million, though this varies from region to region. In parts of the eastern United States the background concentration is, indeed, one to five parts per million. But, in parts of Idaho, it is 10 to 20 parts per million, and, in north central Nevada, and part of the Mojave Desert region of southern California, it is 10 to 40 parts per million. However, if arsenic concentrations become anomalous at all, they often exceed 500 parts per million. In other words, the discrimination factor is very high. It is a sensitive indicator. Atomic absorption spectroscopy is not a good analytical technique for arsenic because of a lack of a good arsenic hollow cathode lamp. However, colorimetric techniques are extremely sensitive and can easily detect and reproduce background levels. Arsenic is quite soluble in a variety of surficial environments. It is transported in surface waters, probably as sodium or potassium arsenate. However, in iron-rich environments it can form ferric arsenate which is highly insoluble. So arsenic can preferentially concentrate with iron, and anomalies in iron-rich environments can be misleading.

Mercury is a highly publicized indicator for gold--particularly epithermal gold. Without question, it frequently occurs with gold, even in the Carlin deposit. Its normal concentration is low--about 50 to 100 parts per billion--and it seems to be fairly constant from one rock type to another. Background levels are easily detectible by atomic absorption techniques. Mercury is highly mobile as a vapor and as mercury halide. However, mercury has a very strong tendency to adsorb to many different kinds of materials, particularly, quartz, clays and organic matter. Nevertheless, it appears to be a valuable indicator and is the only indicator which has the potential of migrating upward through overlying alluvium or bedrock to indicate a buried or blind deposit.

These, then, are the four most commonly used indicators: gold, silver, arsenic, and mercury. Several companies routinely analyze for all four. Others analyze for perhaps two or three.

Now I would like to collate much of what I have said and describe to you a case history. In this case history, I hope to show you how effective a controlled geochemical survey can be in the exploration for gold, as well as the effects of sampling pattern, sampling procedures, indicator elements, and analytical sensitivities. Figure 4 is an Army Series topographic map of a portion of eastern San Bernardino County, California. It is evident that the topography here is Basin and Range topography, although the region is actually at an intersection between the Mojave Desert, the Colorado Plateau, and the Basin and Range morphologic and geologic provinces. On the peripheries of most ranges, pediments are forming. On one of these pediments is the Vanderbilt Mining District. This district produced close to 5 million dollars worth of gold through about 1905, when it became dormant. In 1966, a small mining company acquired rights to much of the district with the idea of exploring for and developing new reserves and new deposits of gold.

Figure 5 is a geologic map of the same region. It shows a large area of granitic rocks typical of the Mojave region, a large area of Pre-Cambrian gneisses and schists, apparently similar to the Pre-Cambrian rocks of the Colorado plateau, remnants of Paleozoic sediments thrusted and block faulted as they are in the Basin and Range country, and an over-lying series of Tertiary volcanic flows and volcanic sediments. These blanket the older rocks and are currently being stripped from them.

The Vanderbilt district is wholly underlain by Pre-Cambrian gneisses and schists that appear to be meta-sediments. The schistocity and gneissic structure strike uniformly north-northwest throughout the district.

Figure 6 is a map of a portion of the district. Unfortunately, the map is turned on its side and north is in this direction. The map shows topography--the contour interval here is 10 feet--and the location of what appeared visually to the geologist who mapped the area to be mineralized structures. The structures shown here are gouge zones, stained or silicified fractures, and veinlets and veins of quartz and other introduced material.

The most pronounced structures here are two northwest-striking shear zones. Most of the mining in the district was done along these two zones. Other obvious structural directions are a north-northeast direction, a north-northwest direction, a northeast direction and an east-west direction. Now this map was made only recently and was not available at the time the property was acquired nor at the time of the geochemical survey. I show it to you now to illustrate the structural complexity of the district and the general topography.

The company that acquired this property had collected a number of grab samples of bedrock outside the immediate mine areas. Assay results indicated small amounts of gold in many of these samples, but results were somewhat erratic. The company interpreted these results as possibly indicating a large, contiguous area of low-grade gold mineralization. Consequently, they drilled a large number of holes throughout the area to corroborate or deny their suspicion. The results of the drilling were inconclusive. Some results showed appreciable gold, others none--which served only to confuse the company.

At this time Geochemical Systems Company suggested that a detailed geochemical survey might:

1. Determine if there is a large area of low-grade gold.
2. If not, where are the principle concentrations of gold.
3. What are the principle controls of mineralization.

Having spent close to $200,000 in drilling the area, the company felt that an additional $8,000 was justified, if that expense could answer those questions.

So we began our survey. We established a rectilinear grid throughout the area with stakes every 200 feet--the lines running north-south and east-west. Then we collected soil samples--only soil samples--from as close to bedrock as possible. We then screened these samples with a 100 mesh screen and discarded the +100 mesh fractions. Here, we were counting on the fine mode of gold as our indicator and on residual concentration. Then we analyzed the -100 mesh soil for both gold and silver. We did not analyze for arsenic and mercury, because the company wanted to keep costs down. And, finally, we plotted and contoured the results.

Figure 7 is a hypothetical geochemical map of the area surveyed. The area is identical to that of the structure map just shown. Again, the map is oriented with north in this direction. The plot here is gold values in the -100 mesh fraction of the soil. However, the detection limit here is 0.35 parts per million gold. This is the limit of reproducible results of most routine fire assays. The small anomaly detected here is due to mill tailings.

Figure 8 is a second hypothetical geochemical map of the same area and the same samples. The detection limit here is 0.10 parts per million gold, which

is that of the U. S. G. S. Here we see several more anomalies, with an apparently random distribution, but with some linearity to one. The mill tailings are beginning to develop beautifully.

Figure 9 is the actual geochemical map of the same area and the same samples. But now the detection limit is 0.005 parts per million and the contour interval is 0.02 parts per million, or 20 parts per billion. We are now very close to the normal background level of gold. It is evident that considerably more information has developed. The map shows:

1. That there is apparently not a large contiguous area of gold. Rather, gold appears to be confined to discrete zones.
2. That there are three pronounced directions of mineralized zones or structures--a northeast zone, an east-west zone and two broad north-south zones. Now, the survey failed in one regard. While there is a hint of a north-west zone, the grid spacing was too wide to pick up this zone. Later, more detailed sampling on 50 foot centers outlined this zone.
3. The best areas for drilling are well outlined, and some additional areas for prospecting are also indicated.

Figure 10 is a geochemical map of the same area showing silver values. Here, the detection limit was 0.005 parts per million, which turned out to be too sensitive. A contour interval of 0.10 parts per million silver was adequate. Notice that the north-east trend is well indicated, and also the east-west trend. However, again there is only a hint of the north-west trend. Notice, too, that the north-south trend is absent. To us, this, as well as mineralogic data, suggests the possibility of two stages of mineralization--one in which gold was present without silver--probably an auriferrous pyrite phase--and one in which gold and silver occurred together.

The silver anomalies are somewhat broader than the gold anomalies. This is probably due to secondary chemical dispersion. However, this has not been proven and their width could be due to a broader primary dispersion.

As I mentioned earlier, arsenic and mercury were not determined here. However, several of the samples that contain highly anomalous gold were analyzed for arsenic. The results showed greater than 300 parts per million arsenic in all cases.

The areas showing anomalous gold were subsequently sampled in detail and drilled. Sufficient ore was blocked out to justify a mine operation, and this property is just about to go into production.

By way of summary, I'd like to list the more significant points I have tried to make.

1. Sampling techniques are more critical in precious metal exploration than in base metal exploration. Composite bedrock and soil samples are best, but soil samples alone can be adequate, if the soil is partly residual.
2. A fine mode of gold appears to be present in some areas and can result in consistent geochemical results.
3. Gold, silver, arsenic and mercury are currently the most used indicators for gold.
4. Sensitivity down to background levels is necessary to achieve the maximum potential of a geochemical survey.
5. Well designed sampling patterns, proper sampling procedures, and sufficient analytical sensitivities can produce highly informative results, allowing not only for the discovery of ore zones, but also for genetic and structural studies,
6. Mill tailings are easy to find.

FIGURE 1

DESIDERATA OF GEOCHEMICAL SURVEYS

1. Determination of Survey Area
2. Objectives of Survey
3. Sampling Pattern and Density
4. Type and Size of Sample
5. Indicator Elements
6. Required Analytical Sensitivities
7. Analytical Techniques
8. Reduction and Display of Data
9. Interpretation Techniques

FIGURE 2

ASSAY RESULTS

Aliquot (Grams)	Assay (Troy Ounces Per Ton)		
Vanderbilt Ore			
1	0.12	0.05	0.83
2	0.64	0.18	0.25
5	0.26	0.41	0.20
15	0.42	0.33	0.61
30	0.54	0.39	0.48
Carlin Ore			
1	0.77	0.74	0.78
2	0.76	0.78	0.78
5	0.80	0.79	0.76
15	0.78	--	--
30	0.76	--	--

FIGURE 3

CHARACTERISTICS OF INDICATOR ELEMENTS

1. Specificity
2. Low and Uniform Concentrations
3. Detectibility
4. Mobility

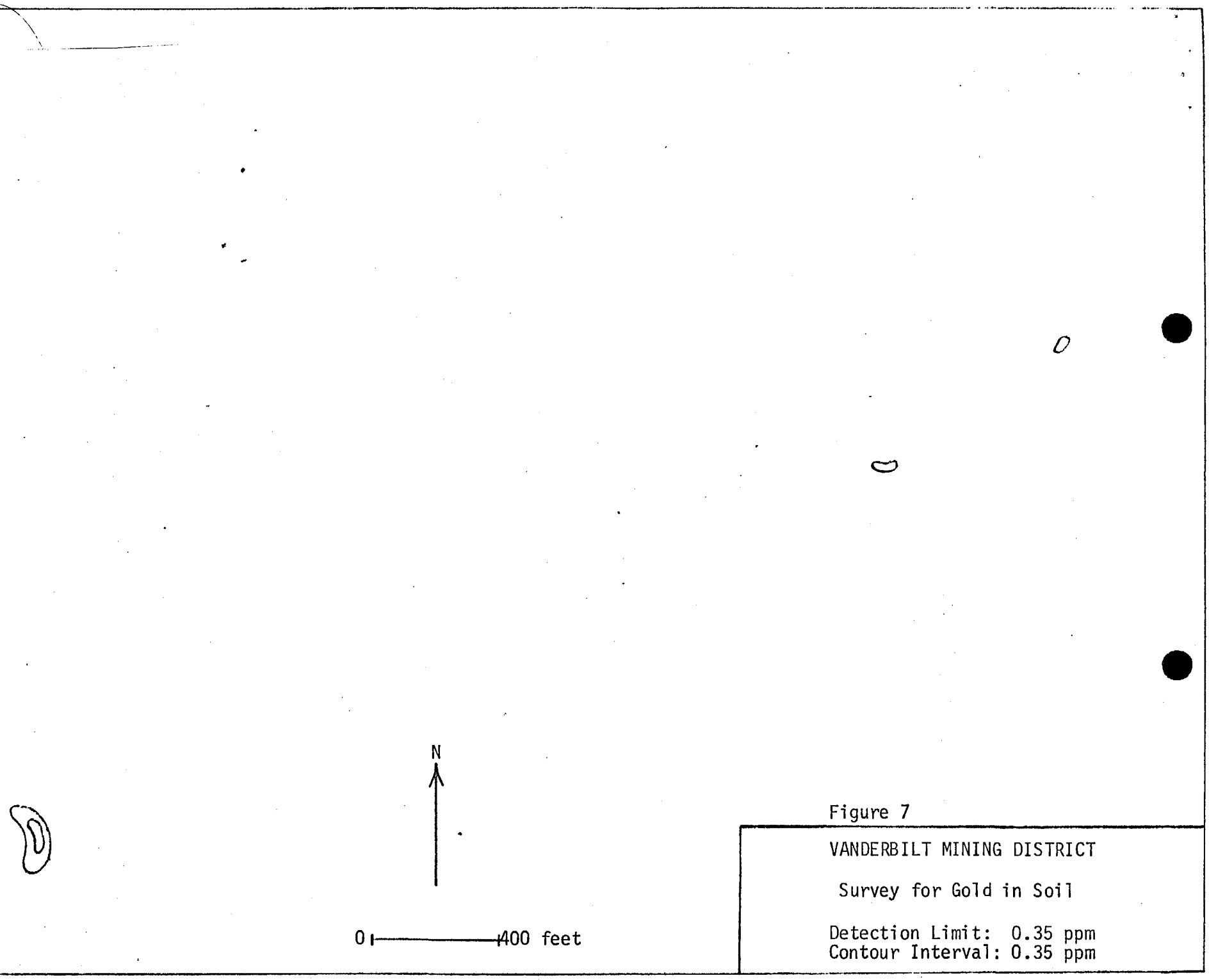


Figure 7

VANDERBILT MINING DISTRICT

Survey for Gold in Soil

Detection Limit: 0.35 ppm
Contour Interval: 0.35 ppm

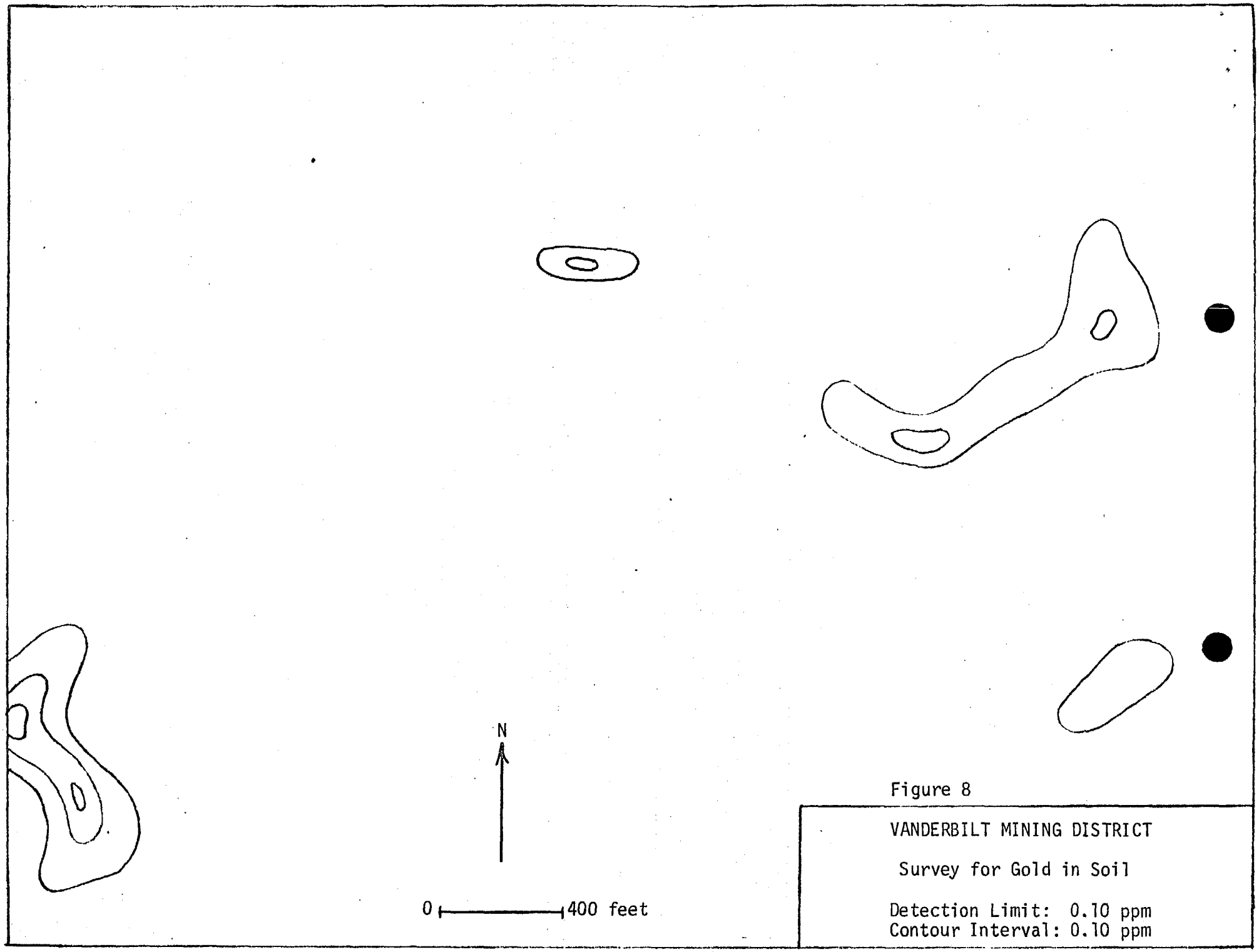


Figure 8

VANDERBILT MINING DISTRICT

Survey for Gold in Soil

Detection Limit: 0.10 ppm
Contour Interval: 0.10 ppm

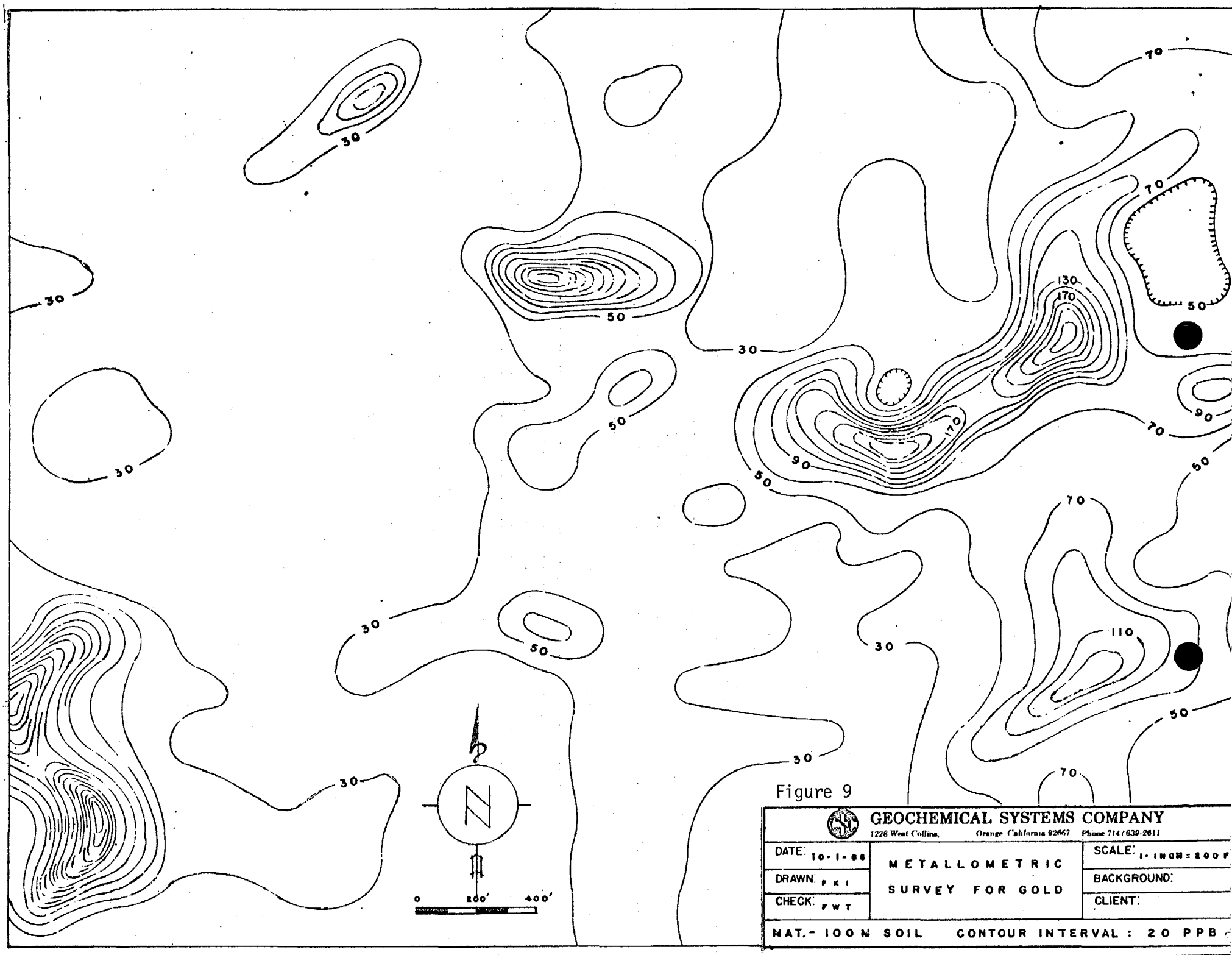
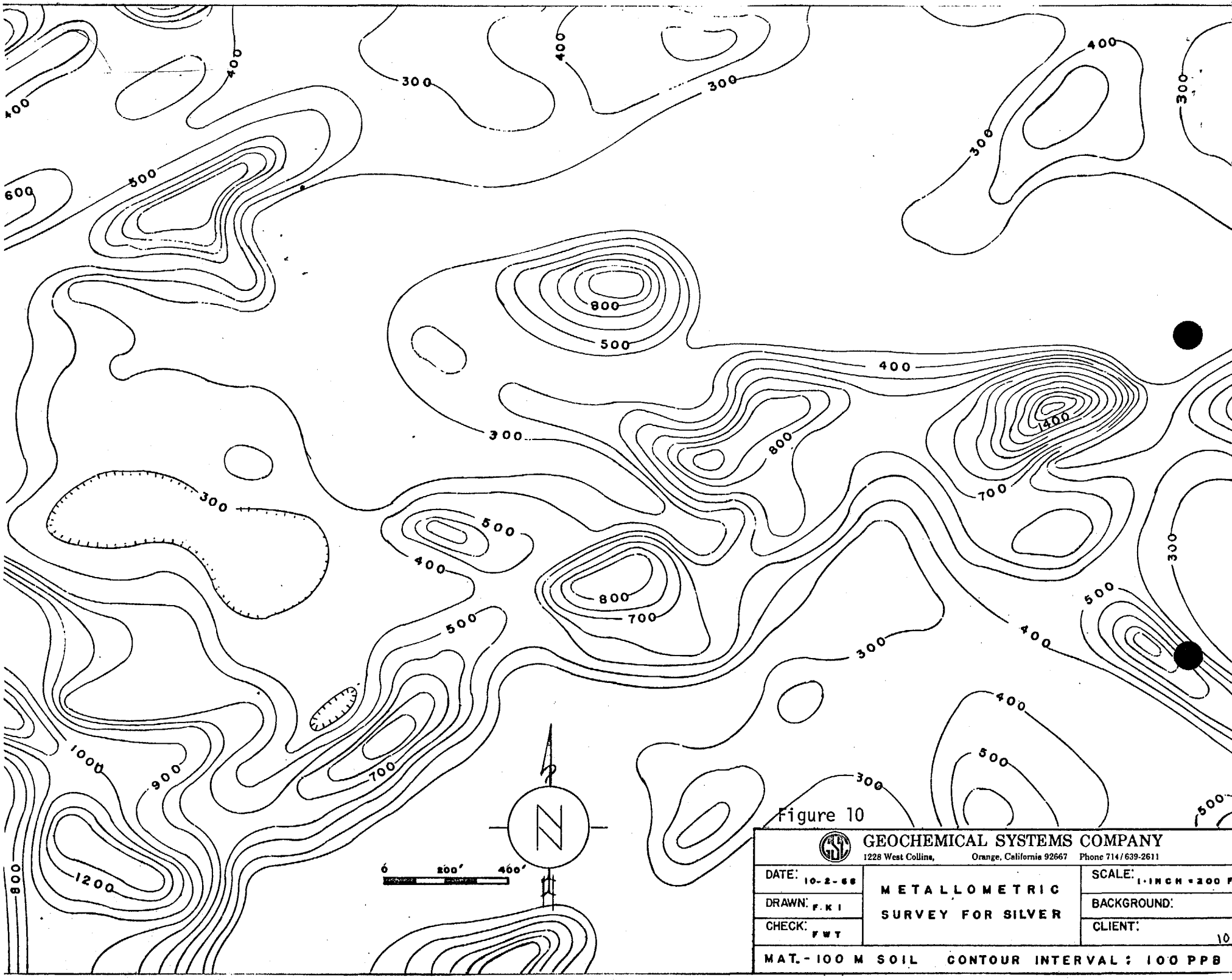


Figure 9

GEOCHEMICAL SYSTEMS COMPANY
1228 West Collins, Orange California 92667 Phone 714/639-2611

DATE: 10-1-88	METALLOMETRIC SURVEY FOR GOLD	SCALE: 1-INCH = 200 F
DRAWN: F K I		BACKGROUND:
CHECK: F W T		CLIENT:

MAT.- 100 M SOIL CONTOUR INTERVAL : 20 PPB


400
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900
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1200
800
300
500
N
0
200'
400'
GEOCHEMICAL SYSTEMS COMPANY
1228 West Collins, Orange, California 92667 Phone 714/639-2611
DATE: 10-2-68
DRAWN: F.K.I
CHECK: FWT
METALLOMETRIC SURVEY FOR SILVER
SCALE: 1-INCH = 200 F
BACKGROUND:
CLIENT:
10
MAT.-100 M SOIL CONTOUR INTERVAL: 100 PPB

Figure 10

ASARCO

J. H. C. TE 8-8725

MAR 25 1968

AMERICAN SMELTING AND REFINING COMPANY
NORTHWESTERN UNITED STATES
EXPLORATION DIVISION

ROOM 1401, W. 422 RIVERSIDE AVENUE
SPOKANE, WASHINGTON 99201

March 22, 1968

MR. BFW
READ AND RETURN BFW
PREPARE ANSWERS ____ HANDLE ____
FILE ✓ INITIALS ____

Mr. J. H. Courtright, Supervisor
American Smelting and Refining Co.
1150 North 7th Avenue
P. O. Box 5795
Tucson, Arizona 85703

Idaho	Idaho
Custer County	Lemhi County
Golden Sunbeam	Grunter Mine

Dear Mr. Courtright:

This is in reply to your letter of March 11th.

Grunter Mine - Our files indicate that Kesten contemplated examining the property but did not. We have no first hand information.

Golden Sunbeam - Yankee Fork. C. P. Pollock examined in 1941. He remarks that the owners claimed 2 million tons of $4. ore. However, he concluded that there was no such tonnage of that grade. He commented that perhaps small narrow shoots could be found by further prospecting similar to those that produced 35,000 tons averaging $9.25 between 1904-1909.

Pamphlet 38, Idaho Bureau of Mines, 1947, mentions extensive fractured zones, stockworks and breccias. This sounds favorable. It appears that an attempt was made to operate in 1947.

We will be in Central Idaho in connection with our Little Boulder Moly project this season and may have a chance to check these properties.

Yours very truly,

Keith Whiting

Keith Whiting

KW/ir

Send to W. L. K.

J. H. C

MAR 6 1968

TO J. H. Courtright

FROM PAUL EIMON

March 4, 1968

DATE

CALIFORNIA MINING REVIEW, 1967

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

File:
"Gold-General"
in Expl. Sec'ys Office

March 11, 1968

Mr. Keith Whiting, Supervisor
American Smelting and Refining Company
Rm 1401, Old National Bank Building
West 422 Riverside Avenue
Spokane, Washington 99201

Gunter Gold Mine, Idaho

Dear Keith:

Reed Welch has suggested that, at a higher gold price, the Gunter Mine might be of interest. Sometime back, substantial tonnages of gold-bearing pyrite were shipped to the smelter. The Mine is located 30 miles below Salmon, a city near a town called Shoup.

Reed Welch has also suggested as a gold possibility the Sunbeam Mine on Yankee Fork near Sunbeam, Idaho.

If you don't have sufficient information to evaluate these two gold prospects, it appears that they would merit at least a preliminary check.

Yours very truly,

JHC:lml

J. H. Courtright

cc: RFWelch
JJCollins

WES

J.H.C.
JAN 11 1968

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

January 10, 1968

W.E.S.
JAN 19 1968

TO: J. H. Courtright

FROM: J. D.Sell

TUCSON FILE REVIEW
MOTHER LODE GOLD IN
MARIPOSA, TUOLUMNE, AND
CALAVERAS COUNTIES, CALIFORNIA

As requested by yourself, following a letter from W. L. Kurtz of Reno, the available files in the Tucson office were reviewed for tonnage possibilities with gold values.

Although several report low-grade tonnages ($1.50 of 250,000 tons), most are of the vein type with numerous structures; but, several report values in a blanket porphyry and granite.

Reviews of the files which hint at anything interesting are given below which represents half of the current files. The reviews are listed in apparent order of interest.

J. D. Sell

JDS:mc
cc: WLKurtz

3-1.21.13 -- Blanchard District

Burr Mine

An interesting report suggesting $350,000 in pocket gold being removed with $3.50 rock left on dumps. The ore came from a 5-acre area with the values from a 40-foot thick porphyry blanket or sill. The porphyry occurred at a shallow depth below the surface cover.

The report also stated that it was believed that a similar type area lies untouched to the east. The five-acre area had not been completely delineated as to its ore-bearing character, but only that numerous small pockets and golpher-holes covered this area.

If a gold-bearing porphyry sill exists in the area at a shallow depth, as suggested, then the 5-acre area forty feet thick is equivalent to 1/2 million tons of material.

In the same folder, a Mr. Lang suggests that gold accompanies some of the disseminated copper ores in "augitic porphyrite" in the Foothills Copper Belt, especially the Olsen Mine. Oak Hill, Olsen, Golden City Mines, Sec. 31 & 32, T2S, R14E.

In the same folder a report on the Oak Hill Copper Mine (Sec. 32), stated that it had disseminated copper with gold in a large vein cutting porphyrite. The mine workings had a 75-foot chalcocite section just under the oxide zone before passing into chalcopyrite. K. Richard noted that the area is in a sericite alteration zone with kaolin being around the ore zone itself.

3-1.3Q.5 -- Chinese Camp District

Eagle-Shawmut Mine

"The Eagle-Shawmut mine is one of those of intermediate size in the Mother Lode of California whose history is that of intermittent operation since 1876."

The mine has been developed and worked to a depth of 2200 feet. As of 1950, possibly 2-million tons of $3.50 ore (over a width of 20 feet) remained below the adit (400 foot) level.

In the middle 1930's an open pit in oxidized ore was opened but it failed to make a profit. No values given.

Apparently, the best consistent and profitable work was during 1938-1947 when 730,000 tons of $2.60 rock were mined by block caving methods from above the adit level. This was apparently low-grade material left from the early mining. Gross production of about $2 million was produced from a strike length of 1800 feet in the caving block.

The area is in a zone of alteration with large tabular masses of quartz up to 100 feet in width. Low gold values are reported in the altered wall rocks.

3-1.3Q.3 -- Chinese Camp District

Clio-Kershaw Mine

Sec. 18, T1S, R15E.

Company review of March 1949:

"Ore bodies are lenses in a zone of mineralized members of the Calaveras formation. Zone of mineralization up to one hundred feet wide. In footwall of zone is serpentine dike and this is separated from zone of mineralization by 5-10 feet of black gouge. Whole is intruded by several different types of dikes. Ore defined by assay walls. Some quartz veining -- usually very low grade but a little specimen ore."

"Estimated ore reserves of one-million tons of $3.90 ore at $35.00 gold." (Note: This reserve along the main vein structure to depth of the Clio shaft, 900 feet, but the width is unknown).

In same report, C. L. Conway's sampling in the tunnel level returned $4.58/ton (old price) over a width of 53 feet.

The mine owners suggest a width of 1000 feet of mineralized rock.

3-1.21.13 -- Blanchard District

Salambo (or Washington) Mine

Secs. 30, 31, 32 of T2S, R15E.

In report of February 1946 by K. Richard, he quotes J. Johnson who sampled the dumps in March 1943: "The vein in slate and schist adjacent to porphyry intrusive." Low values (0.01 - 0.13) in quartz veins; and with no samples being taken in the porphyry, it seems that this occurrence should be checked.

3-1.10E.13 - Jamestown District

Summation (excerpts) by J. Fred Johnson dated May 22, 1940:

"3)...the Tonopah Mining Company had an option on the Crystalline-Alabama property . . . . . Five hundred samples on surface and shallow levels averaged $1.73 per ton. This mine may have a chance for low-grade near surface ore bodies comparable to the Harvard, adjoining the Crystalline-Alabama to the south." (Note: The Harvard surface ore bodies were of limited width, 30 feet, and not mined to an extent.)

"4) At the Rawhide Mine . . . . in 1935, Curtis Lindley, Jr., made an examination .... and....in this report the main asset is set forth as 420,000 tons of ore (52 feet wide by 1000 feet long) of a gross value of $2.51 per ton. This he, Curtis, sets forth, can be mined by power shovel with 0.6 tons stripping per ton of ore."

"5) Carson Hill Gold Mining Corporation, with two veins on the property, is likely in the most favorable position for large scale low-grade surface mining...." (See Carson Hill Mines under Melones District, Calaveras County).

3-1.2R.13 -- Big Oak Flat District

Longfellow and Mack Mines

Northside of the village of Big Oak Flat. Sec. 29 (?) T1S, R16E.

To quote from the report: "Into this area of ancient metamorphic rocks has been intruded a rudely elliptical mass of granodiorite, approximately half a mile in diameter."

The veins of the Longfellow and Mack mines are on the east side of the intrusive, and have dikes of granitic material and...."this much altered and silicified granite.... is often found to be gold bearing...."

Low-grade possibilities in the intrusive?

MARIPOSA COUNTY

3-1.3J.13 -- Coulterville District

Virginia Mine

Sec. 13 and 14, T3S, R16E.

Very irregular values over narrow widths as mined.

However, it is reported: " The veins in the Virginia consist of quartz stringers in a zone some 100 feet wide, which zone has serpentine on the footwall, and slate on the hanging strikes N60°W, and dips steeply NE..." (H. P. Hill to P. Locke, November 27, 1934).

3-1.3J.2 -- Coulterville District

Bondurant Mine

Sec. 36, T2S, R17E.

The Bondurant area, on the east belt of the Mother Lode, has the Bondurante, Reynolds and Louisiana as strong parallel structures. Also, mentioned are other quartz veins or streaks.

Possibility of low-grade values in the wall rock between vein structures?

CALAVERAS COUNTY

3-1.13P.3 - Melones District

Carson Hill Mines

Sec. 24, T2N, R13E.

The principal production has been from the Morgan-Melones vein system, but the Calaveras vein is another major system. Four smaller veins are also present: East, Last Chance, Point of Rocks and Stanislaus-Adelaide veins.

The ore bodies are known as the footwall, hanging wall, and flat shoots. All--and especially, the high-grade hanging wall orebody-- are closely associated with a shart bend in the vein where the strike changes from S80°W to N40°W.

The veins are widely separated and chances for low grade values are small; except possibly, if a regional change of stress is present then low grade possibilities may exist within the area of flexure.

J.H.C.
DEC 14 1967

AMERICAN SMELTING AND REFINING COMPANY
RENO NEVADA

December 11, 1967

Mr. J. H. Courtright
Tucson Office

Mother Lode Gold in
Mariposa, Tuolumne, and
Calavaras Counties, Cal

Last week in a telephone conservation with Mr. Saegart I mentioned that I had been doing some literature review of published data on the Mother Lode Gold.

The southern Mother Lode(Calavaras, Tuolumne, and Mariposa Counties) appears from the literature to offer definite open-pit, small tonnage(up to 5million) of two to five dollar gold(gold at $35). Perhaps this "literature indicated tonnage" might be increased.

I think it would be worthwhile for the company files of the above counties to be reviewed to supplement the review of the published literature.

If the files are not too voluminous perhaps they could be sent to Reno to be reviewed by me, or alternatively perhaps someone in Tucson could review them.

W. L. Kurtz

New York, December 8, 1967

MR. WES
READ AND RETURN
PREPARE ANSWERS ..... HANDLE .....
FILE ..... INITIALS .....

J. H. C.
DEC 12 1967

Memorandum to: Mr. J. H. Courtright
W. L. Kurtz W.E.S.

JAN 19 1968

Gold-Nevada

Herewith is a memorandum from Mr. Lord to Mr. Pollock dated December 15th listing some gold prospects in Nevada. Mr. Lord will reconsider the placer deposits in terms of possible higher prices of gold. Anything that you can do to help him determine the present status of ownership for these deposits will be appreciated.

In addition, you are encouraged to reconsider the possibilities of hard-rock gold deposits in terms of double or triple the present price of gold. An essential consideration would be the acquisition of property at small immediate cost and the retention of prospects for long periods of time without commitments to spend large amounts of money. Obviously, we do not know when the price of gold might be raised and the passage of time should not be too costly.

John J. Collins

John J. Collins

W L Kurtz

New York, December 5, 1967

MEMORANDUM FOR:

Mr. C. P. Pollock

NEVADA
POTENTIAL GOLD AREAS

I have been going through my files to determine if any of the areas which have been examined for gold placer deposits may warrant renewed study in view of the recent interest in gold.

Listed below are some deposits or areas in Nevada on which you may wish to have some research done to determine if it appears possible that potential hard rock gold reserves, in addition to the placer gold known to exist, might be located.

It is quite possible that most of the areas noted have been checked by Asarco and/or other companies in the search for deposits similar to the one being mined by Newmont or being developed in part by American Exploration.

As placer gold deposits, under present prices and costs, they do not warrant extensive research, but if you approve it may be advisable to obtain the thinking of Messrs. Courtright and Kurtz in this matter, especially regarding the present ownership status.

Basic information for the following nine areas was originally obtained from the University of Nevada Bull. Vol. XXX No. 4.

1. Name - Ancient Gold Placer Mines Co. (Buckeye Placers) Geo. Slater Minden
   Location - North side of Mt. Siegel, East Douglas Co. 20 miles east of Minden, Nev., Pine Nut Range, Pinto, Dudley, Black Horse Gulch, Mt. Siegel District.
   Remarks - 2440 acres. Source of gold thought to be reconcentration of old tertiary channels and from lodes in area. Some small operations. Lacks water

2. Name - Ambassador Gold Mines Ltd. and Builtd Bovard Placers
   Location - Buckskin District. North end of Singtze Range. 14 miles north of Yerrington, Nev.
   Remarks - Drilling averaged 5 to 103 ¢/cu. yd. Some small operations.

3. Name - Bruneau River, Prunty Ranch
   Location - Charlston District, Elko Co. 55 miles north of Deeth. South side of Copper Mountain
   Remarks - Some tests averaged 75 ¢/cu. yd. Some past production. Lacks water.

4. Name - -
   Location - Tuscarora District, Elko Co. 50 miles NW of Elko along SE slope of Mt. Blitzen in the Independence Range.
   Remarks - U.S.G.S. reports large areas that may average 30¢. Pumping necessary. Some past production

5. Name - Leonard Placer
   Location - Varyville District, NW Humbolt Co., Southern end of Pine Forest Mountains, 100 miles NW Winnemuca
   Remarks - 1500 acres along Leonard Creek. Some hand washing

6. Name - Steiner Canyon, Bobtown Placer
   Location - Midway between Austin and Battle Mountain
   Remarks - Gold said to be present in area

7. Name - Tripplett Mill Gulch
   Location - Tenaboo District, Lander Co., 25 miles SE of Battle Mountain
   Remarks - 15 sq. miles of potential placer ground

8. Name - Iowa Canyon
   Location - 16 miles N of Austin near Joseph Phillips Ranch
   Remarks - No sampling done as water prevented shafting

9. Name - -
   Location - Mud Springs District, Lander Co. 8 miles NW Camp Raleigh, 15 miles SE Battle Mountain

The two following deposits have been examined by Asarco with results as noted.

1. Name - Rawhide Placers
   Location - Rawhide (Regent) District, 48 miles SE of Fallon
   Remarks - Old mining district - production through 1935 49,000 oz. gold - 737,000 oz. silver.
   Sam Bowditch and I examined this deposit in 1951 with the idea that the lode and placers could be worked together as an open pit deposit. The samples taken by Mr. Bowditch were not encouraging, and even though the indicated tenor of the placer ground was favorable, our examination did not show that the combined project would be commercial. I have no idea what the present ownership situation may be, but I believe this should be checked. Formerly owned by Guy Standifer and others in San Francisco. A complete file of our

examination should be in Tucson. I have mine in Toms River. Checked by American Exploration in 1955

2. Name - Philadelphia Canyon Placer
Location - Battle Mountain District, Lander 12 miles SW of Battle Mountain
Remarks - Alluvial fan containing an estimated 60 million cubic yards of 20¢ gravel. I examined this deposit in 1950. Estimated outcome did not justify additional work. Near Copper Canyon dredge operation operated by Natomas Co. which terminated operations about 1951. Present ownership unknown. James O. Greenan, who with George Kerr in Reno, held majority interest at the time of my examination, passed away some years ago. I have not heard of Mr. Kerr for some years.

JOHN F. LORD

JFL:bem

Please copy for staff

New York, December 5, 1967

J.H.C

DEC 7 - 1967

MEMORANDUM FOR: Messrs. J.H. Courtright, D.F. Kent, K. Whiting, R.J. Lacy, R.B. Sprague, D.M. Fletcher, T.C. Osborne, R.S. Gray, L. Salazar

Possible Increase in Gold Price

As you know from discussions at our Exploration Seminars, Mr. Tittmann has a very keen interest in gold particularly in locating and developing substantial reserves mineable by open pit or other low-cost methods.

You will recall, Mr. Tittmann has indicated, on several occasions, his belief that the price of gold would be increased eventually; the timing,of course, is impossible to predict. However, devaluation of the pound sterling, recently, along with scores of other currencies could conceivably bring about a serious run on the dollar and possibly eventual devaluation.

Mr. Tittmann thinks the price of gold in such an eventuality would be pegged at $100 per ounce. Such a price would make a substantial difference in our evaluation of gold occurrences. An average of .05 ounces gold per ton at the higher price would have a value of $5 per ton instead of the present $1.75 value.

In view of this possibility, each of you should review gold deposits in your respective areas to determine if there may be any that would become economic at the higher price.

C. P. Pollock

CC:EMcLTittmann

Copies for: WESaegart
LPEntwistle
SIBowditch
DPCadwell
BJDevere
WGFarley
WGHoskins
JEKinnison
RALuning
JDSell
BNWatson - J. Briscoe
NPWhaley
JRWojcik
RCummings
RKKirkpatrick

W.E.S.
JUL 13 1966
A.C.H.
JUN 28 1966
A.C.H.

THE MACKAY MINER

Mackay School of Mines, University of Nevada

VOL. 14, NO. 1 RENO, NEVADA JUNE 1966

Personal file — "Gold"

J. H. C.

MAY 10 1966

GOLD AND GOLD SHARES

ML RESEARCH REPORT
NDR R 550 1/23/76

THE GOLD MARKET HAS BEEN DULL IN RECENT MONTHS AND HAS BEEN IN A STATE OF DISTRESS IN RECENT DAYS . A NUMBER OF FACTORS SEEM TO BE AT WORK .

1. ALTHOUGH DRAMATIC NEW DEVELOPMENTS AT THE I . M . F . MEETING IN JAMAICA , WERE CONSPICUOUS BY THEIR ABSENCE , A NUMBER OF TECHNICAL DETAILS APPEAR TO HAVE HAD BEARISH MARKET IMPLICATIONS . THE FIRST GOLD SALE BY THE IMF WILL TAKE PLACE WITHIN TWO MONTHS , SOMEWHAT EARLIER THAN HAD BEEN EXPECTED . IN ADDITION , THE FRENCH FINANCE MINISTER M . JEAN - PIERRE FOURCADE HAS INDICATED THAT FRANCE WILL BE A BUYER OF ONLY A SMALL PORTION OF THE 25 MILLION OUNCES OF IMF GOLD BEING SOLD . FINALLY , M . RENE LARRE OF THE BANK OF INTERNATIONAL SETTLEMENTS HAS STRESSED THE PROBLEMS OF SELLING SUCH LARGE QUANTITIES OF GOLD TO THE CENTRAL BANKING COMMUNITY . ONLY RESERVE - RICH COUNTRIES WILL REALLY BE IN A POSITION TO BUY IN SIZE .

2. THERE DOES SEEM TO HAVE BEEN A DISTINCT EASING IN WORLD INFLATION RATES ALTHOUGH PROGRESS HAS NOT BEEN NEARLY AS DRAMATIC AS IN THE U .S .

3. BUOYANT EQUITY AND FIXED INCOME MARKETS IN WALL STREET AND LONDON HAVE OFFERED AN ATTRACTIVE ALTERNATIVE FOR INVESTMENT . ALTHOUGH IT IS RATHER AN OVERSIMPLIFICATION TO LOOK FOR WEAK INDUSTRIALS AND STRONG GOLD , IT IS CLEAR THAT MANY BULL -S OF THE METAL , PARTICULARLY IN CONTINENTAL EUROPE , WERE SELLERS IN THE LAST FEW DAYS .

4. THE U . S . DOLLAR CONTINUES TO PERFORM WELL IN FOREIGN EXCHANGE MARKETS .

5. REPORTEDLY THERE WAS SOME INCREASE IN FAR - EAST BUYING OF THE METAL ON THE DEATH OF THE COMMUNIST CHINESE LEADER CHOU EN LAI . SUCH BUYING NOW APPEARS TO HAVE DRIED UP .

6. A RECENT ESTIMATE IN LONDON SUGGESTED THAT THE SOVIET UNION SOLD AS MUCH AS 400 TONS OF GOLD IN THE FREE MARKET IN 1975. NOT MERELY WAS THIS ESTIMATE MUCH HIGHER THAN EARLIER ONES , MORE IMPORTANTLY IT UNDERLINED FEARS OF HEAVY RUSSIAN GOLD SALES IN 1976. OUR VIEW IS THAT THE 400 TON FIGURE IS EXAGGERATION OF RUSSIAN SALES .

JOSEPH G. POLCHINSKI
MERRILL LYNCH,
PIERCE,
FENNER & SMITH INC
5151 E. BROADWAY
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TUCSON, ARIZ. 85732
602-790-4300

ADD - MERRILL LY[illegible]H RESEARCH REPORT NBR 550[illegible]23/76
GOLD AND GOLD SHARES

CONFIRMATION HAS RECENTLY COME FROM THE BANK OF PORTUGAL THAT THAT COUNTRY HAS BEEN MAKING SALES FROM ITS RESERVES . THE FRENCH NEWSPAPER LE MONDE SUGGESTED THAT AS MUCH AS 100 TONS COULD HAVE BEEN INVOLED . THE PORTUGUESE AUTHORITIES HAVE VIGOROUSLY DENIED THE STORY . THEY CLAIM THE VOLUME INVOLVED WAS NEARER 4 TONS . / MARKET SOURCES HAVE INDICATED TO US THAT THE ACTUAL FIGURE MAY BE NEARER TO 20 TONS ./ GOLD SHARE , NOT SURISINGLY , WEAKENED ON THE ABOVE DEVELOPMENTS .

THE OVERWHELMING IMPORTANCE OF THE METALS MOVEMENT IN DETERMINING GOLD SHARES PRICE MOVEMENTS WAS DEMONSTRATED CLEARLY ON JANUARY 14TH . THE PUBLICATION OF VARIOUS GOLD SHARE QUARTERLY RESULTS ON THAT DAY INDICATED SIGNIFICANTLY HIGHER PROFITS IN SOUTH AFRICAN RAND TERMS , AND TO A LESS EXTENT U . S . DOLLAR TERMS , FOR THE 4TH QUARTER OF 1975 AND WAS LARGELY IGNORED BY THE MARKET .

MR . ROBERT GUY CHAIRMAN OF THE LONDON GOLD MARKET HAS ARGUED THAT THE METAL SHOULD TRADE WITHING THE $120-145 RANGE IN THE NEXT THREE MONTHS . THE LOWER FIGURE IS BASED ON THE DESIRE OF SOME CONTINENTAL EUROPEANS TO MAINTAIN A REASONABLY HIGH GOLD PRICE TO EMPHASIZE THE VALUE OF THEIR EXTERNAL RESERVES . THE HIGHER PRICE OF $145 IS BASED ON THE VIEW THAT U . S . AUTHORITIES WOULD BE UNWILLING TO SEE A SHARP RISE IN THE PRICE OF GOLD . IF THIS WERE TO OCCUR THEN MR . GUY BELIEVES A THIRD G . S . A . GOLD AUCTION WOULD BECOME A DISTINCT POSSIBILITY .

OUR CAUTIOUSLY BULLISH VIEW OF GOLD AS AN INVESTMENT VEHICLE IS BASED ON THE LONG TERM INSURANCE POSSIBILITIES IT COULD OFFER AGAINST THE EMERGENCE OF INTERNATIONAL AND NATIONAL ECONOMIC STRESSES IN THE NEXT TWO YEARS . WE WOULD NOTE HOWEVER THAT THE METAL HISTORICALLY MOVES IN STEP FORMATIONS I . E . FOR CONSIDERABLE PERIODS ONE CAN HAVE FAIRLY NARROW PRICE MOVEMENTS FOLLOWED BY THE OCCASIONAL FLAIR UPS ON POLITICAL AND ECONOMIC ICIDENTS . RELATIVE TO THE SHORT TERM RATES OF INTEREST AVAILABLE ON MONEY MARKET INSTRUMENTS WE BELIEVE GOLD COULD OFFER A USEFUL RISK REWARD RATIO ON A TWO YEAR BASIS EVEN IF THE METAL WERE TO WEAKEN IN THE SHORT TERM . A SIMILAR CONCLUSION CAN BE MADE ON THE GOLD SHARES WITH THE POLITICAL UNCERTAINTIES OF ANGOLA BALANCED BY THE IMPROVED PROFIT MARGINS NOW FLOWING FROM THE 18 PC DEVALUATION OF THE SOUTH AFRICAN RAND AND THE IMPROVED DIVIDEND YIELDS .-SEC RCH

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J. H. C.
JUL 18 1975

COMMODITY RESEARCH REPORT

file

GOLD

RSI

995.0

Reynolds Securities Inc.
MEMBERS NEW YORK STOCK EXCHANGE INC.
AND PRINCIPAL COMMODITY
EXCHANGES

GOLD — AN INTRODUCTORY REPORT

November 26, 1974

Source: International Monetary Market.

INTRODUCTION

GOLD, GOLD, GOLD — once again, after a 40-year ban, American citizens will be permitted to own this "barbarous relic." When legalization occurs, on Dec. 31, 1974 will a new gold rush develop? Or has this metal outlived its usefulness as a store of wealth?

During these forty years the world's monetary structure, and our attitudes towards gold, have undergone radical changes. Because of its position as a store of wealth, gold has occupied a central role in monetary policy and international exchange. Despite recent developments which have somewhat reduced gold's importance as a reserve for the world's currencies (or perhaps because of those developments), the free market price of gold in recent years has undergone unprecedented fluctuations. Whether or not gold is considered an acceptable monetary foundation, this fact points up its reputation as an ultimate storehouse of value. Also, industrial usage of this precious metal has increased substantially as new applications for gold have been found,

primarily in electronic and space-related industries. Thus far, however, such fundamental price factors are taking a back seat to the less readily identifiable impact of economic conditions, floating currency exchange rates and ordinary human psychology.

Now that the legalization of gold is a fact (unless repealed by Congress), U.S. futures markets in gold will be opened in New York and Chicago. What follows is an explanation of the factors which are central to the understanding of world gold markets. A brief and necessarily selective historical synopsis is included to give prospective participants a vital evolutionary perspective.

MONETARY ASPECTS

At the end of World War II the widespread devastation of industrialized economies necessitated a restructuring of the world's monetary system. Because of a massive inflow of gold in payment for war debts the U.S. dollar had become the world's strongest currency. At the Bretton Woods Agreement of 1944 the gold standard was supplanted by the dollar exchange standard. Under the new system, the exchange rates of all other currencies were pegged to the dollar, which was itself tied to gold at the still prevailing rate of $35/oz. In essence the dollar became the reserve for the world's monetary system and foreign-held dollars were redeemable in gold.

The Bretton Woods Agreement was initially a success and provided the stability necessary for the rebuilding of post-war Europe. But with the geometric growth in international trade during the 1960's the fault in the new system became evident. It was again the same story — too many dollars and too little gold. Overextension of American economic investment abroad and huge military expeditures, notably in Vietnam, led to a persistent balance of payments deficit for the U.S. At the same time, with the price of gold fixed at $35/oz., there was no incentive to develop new supplies in an inflationary period. As dollars began to pile up abroad, foreign countries began calling them in for gold. From 1957 U.S. gold stocks steadily declined under continued European demand until the buying of gold reached panic proportions in March of 1968. At that point the U.S., together with other leading monetary nations, established the two-tier gold market which separated monetary and commercial transactions. A free market was established for private and industrial use in which the price of gold was allowed to fluctuate freely based on supply/demand considerations without any government intervention. Central banks, however, agreed to continue their transactions at the then official rate of $35/oz.

The result was that privately held foreign dollars were no longer redeemable in gold, but foreign bank dollars were still convertible into gold. Despite these moves, the outflow of gold from the U.S. continued; and in August of 1971 this privilege was terminated when the U.S. announced that its new economic policy would no longer allow redemption of foreign-held U.S. dollars for gold. Just prior to this announcement outstanding foreign-held U.S. dollars totaled some 50 billion while U.S. gold stocks had declined to only 10 billion. With this step the dollar was cut free from its ties to gold and its exchange rate was permitted to "float" freely against that of other currencies. The Bretton Woods Agreement, seriously weakened by the two-tier market, had now completely collapsed.

The suspension of dollar convertability necessitated the establishment of a new monetary system. The Washington Agreement of December, 1971, fixed new currency alignments with the provision that the U.S. dollar be devalued to $38/oz. in terms of gold from the previous $35/oz. This devaluation became effective in early 1972. Persistent weakness in the dollar, however, necessitated further devaluation to a gold equivalent of $42.22/oz. in February of 1973.

Despite the rise in the official gold price via successive dollar devaluations, the discrepancy between free and monetary gold prices continued to widen placing new strains on the system. Monetary gold stocks were essentially frozen as governments were loathe to part with their reserves of last resort. Meanwhile the prohibition against central bank purchases was considered still in effect. For example, when the Italian government verged on bankruptcy early in 1974, the central banks agreed to allow that nation to pledge its gold as collateral for a loan at a mutually agreed upon price in between the official and free market prices, reportedly $120/oz.

SUPPLY SOURCES

While gold is found in widely scattered areas throughout the earth's crust, world gold production is concentrated in four nations. Of these, the Republic of South Africa occupies by far the dominant position, accounting for roughly two-thirds of yearly gold output. (See Table I.) The U.S., U.S.S.R. and Canada are the other major gold producing nations. In 1973, the last year for which statistics have been compiled, total world gold production amounted to some 1120 metric tons.

TABLE I

GOLD: SUPPLY/DEMAND BALANCE
(Metric tons)

	1968	1969	1970	1971	1972	1973	1974*	1975+
PRODUCTION								
Free World mine production	1,245	1,252	1,273	1,236	1,182	1,120	1,075	1,000
Supply from Communist countries	-29	-15	0	60	220	280	250	250
Central Bank purchases (-) or Sales	620	-90	-236	96	-151	6	25	25
Total supply to free market	1,836	1,147	1,037	1,392	1,251	1,407	1,350	1,275
DISTRIBUTION Return to market (-)								
Fabrication	1,227	1,205	1,381	1,391	1,350	853	725	600
Hoarding	72	60	88	80	-8	46	(625)	(675)
Speculation or Investment	537	-118	-432	-79	-91	508		
Total distribution	1,836	1,147	1,037	1,392	1,251	1,407	1,350	1,275

*Preliminary forecast +RSI tentative forecast

Source: Consolidated Gold Fields, Ltd. (1 metric ton = 32,150 troy ounces)

Current data suggests that world gold output peaked in 1970, with only Soviet production showing gains since that time. The primary reason behind diminishing gold production is that steadily rising labor and operating costs, together with increasing scarcity of high percentage gold ores, has made gold mining a more expensive undertaking. As high quality ores are depleted, less efficient mining procedures become necessary. The result is that a larger volume of processed ore will yield a correspondingly lower portion of refined gold. In the case of South Africa, new mines will undoubtedly be brought into production but at the same time older mines will be shut down. According to current estimates it seems likely that the present level of South African gold production should be sustained for the balance of the seventies. After that point production levels from that country should begin to trend downward. However, a sustained period of high gold prices coupled with possible advances in mining technology could modify the expected downtrend in gold output.

In addition to primary mining operations, gold is also derived as a co-product in the extraction of copper and other base metals. This procedure accounts for 40% of annual gold output. In recent years, co-product operations have been emphasized, especially in the U.S., as a method of generating an increase in supply. Secondary scrap recovery, which includes the melting of jewelry and the influx of gold from government and/or private holdings, accounts for the remainder of gold output. However, in the U.S. secondary scrap recovery has been declining since 1967. Domestic mine production of gold has also been declining in recent years. (See Table II.) Gold output for the U.S. is concentrated in four states with South Dakota accounting for 35% of total domestic production. Utah, Nevada and Arizona are rated next in importance. U.S. production is only about 3% of the world total.

According to the most recent assessment published by the Department of the Interior, domestic recoverable gold resources at $150/oz. are estimated at 240 million ounces total. At higher prices larger amounts of gold could prove to be economically feasible for extraction. These totals do not include about 60 million ounces estimated to be recoverable as a co-product from base metal ores. However, higher gold prices would have little effect on this source, nor would they increase estimated co-product gold reserves. Sufficient information to assess worldwide gold reserves is scarce, but it is estimated that 60% of recoverable gold is located in South Africa and 20% in the U.S.S.R.

Since gold occupies a unique position as a monetary metal and a storehouse of wealth in addition to its industrial applications, mine production and scrap recovery account for only a small portion of available supplies. Gold held by governments in the form of monetary reserves (as well as stocks of privately held gold) provide a source of supply vastly in excess of production capabilities or demand requirements. While no absolute figures for private gold holdings are available, it is estimated that world gold stocks in private and public hands may total approximately four billion ounces. Of this, official gold holdings in monetary reserves account for 1.2 billion ounces, of which U.S. holdings approximate 275 million ounces or 8,582 metric tons (see Table III).

It is evident that the huge overhang of gold supplies in private and government hands is more significant than in any other commodity. Thus far, despite the spectacular recent increase in free market gold prices, very little of this supply has been drawn out onto the market place. The reason is simply that hoarders of gold are reluctant to part with their holdings of last resort. The gold held by central banks is perhaps the most readily available source of the surplus supply. These holdings were accumulated for the most part when gold was valued at $35/oz. At current levels, the temptation to take profits is large; and in fact, rumors of central bank sales have on several occasions held gold prices in check. On the other hand, no large-scale sales by central banks have materialized although such sales are now permitted. The reasoning here is the same — gold is valued as an ultimate storehouse of wealth. Nevertheless, despite the reluctance of the central banks to sell gold, their huge holdings cannot be ignored. Policies of major nations in managing their gold stockpiles can have a major effect on short term supply/demand relationships, and therefore, prices.

TABLE II

WORLD PRIMARY GOLD PRODUCTION
(Metric tons)

	1970	1971	1972	1973	1974
Republic of South Africa	1000.0	976.0	908.7	852.3	
Canada	74.9	68.7	64.7	60.0	
U.S.	54.2	46.4	45.1	36.2	
Ghana	21.9	21.7	22.5	25.0	
Australia	19.5	20.9	23.5	18.4	
Other	102.7	102.2	117.4	128.1	
Total Free World	1273.2	1235.9	1181.9	1120.0	1075.0*
U.S.S.R.	335.5	344.8	360.2	370.6	
Total World	1608.7	1580.7	1542.1	1490.6	

*Estimated (1 metric ton = 32,150 troy ounces)

Source: Consolidated Gold Fields, Ltd.

TABLE III

OFFICIAL FREE WORLD GOLD RESERVES
(Metric tons)

United States	8582
West Germany	3658
France	3138
Switzerland	2588
Italy	2566
Holland	1688
Belgium	1313
Latin America	939
Middle East	880
Canada	681
Britain	663
Japan	656
South Africa	588
Other Europe	2519
Other Asia	572
Other Africa	358
Rest of World	442
International Organizations	4983
Total World	36814

Source: International Monetary Fund

CONSUMPTION PATTERNS

Demand for gold originates from three primary sources: Usage by gold fabricators such as the jewelry and electronics industry as well as dentistry, hoarding by individuals in the belief that the metal will appreciate in value and act as a hedge against inflation, and acquisition by central banks as a monetary reserve. Total consumption in 1973 was 854 metric tons.

Jewelry usage in both advanced and developing nations accounts for the largest segment of gold consumption by far. In recent years, until 1973, the fabrication of jewelry consumed about 75% of all gold used on an annual basis. However due to the high price of gold in 1973, the pattern of absorption changed dramatically. Consumption of gold for jewelry which had totaled 992 metric tons in 1972, fell to only 505 metric tons in 1973. Jewelry's share of the total gold usage fell from 73.5% in 1972 to only 59.2% in 1973 (Table IV). This decline was worldwide. The high price of gold, high interest rates and generally poor economic conditions in industrialized nations brought about this trend change in demand.

In the electronics industry gold usage continues to show gains with about 130 metric tons consumed in 1973, an increase of some 17% over the 110 metric tons used a year earlier. This industry utilizes gold's unique physical properties of malleability, durability and high conductivity to greatest advantage. Recent high prices have prompted the electronics industry to reduce the quantity of gold consumed per unit. However, the general growth trend in this industry has resulted in an increase in the number of units produced and also in the total amount of gold consumed.

Gold usage in dentistry has shown little change; but the minting of official coins has dropped off by about 15% due to high gold prices and added taxes in some countries. The minting of medallions was sharply lower in 1973 for the same reasons. However, demand for official coins is expected to rise in 1974 and 1975, partially due to anticipated American demand, and a larger portion of gold supplies may be used for this purpose in the coming years.

Private hoarding, on the other hand, escalated dramatically in 1973. According to one unofficial report, the rush into gold and away from other investments resulted in the acquisition of a total of 508 tons of the yellow metal for speculation and/or investment by private holders in advanced nations last year. Added to this was a disappearance of 46 tons attributed to hoarding in developing nations. This combined figure of 554 hoarded tons is truly remarkable when compared with the total available gold supplies of about 1,407 tons in 1973. Hoarding of gold was the largest single segment of gold usage in 1973, outstripping even the consumption of gold in jewelry. Furthermore, the major dimensions of hoarding activity have reversed the trend of the past few years during which dishoarding had occurred. (See Table I.) Not since 1968's rampant speculation based on the formation of the two-tier market has the acquisition of gold for speculation or investment purposes reached such proportions. Renewed inflationary pressures last year together with the beginnings of the oil crisis and the resultant currency instability, all combined to increase the demand for gold by private individuals. Such pressures contributed to the legalization of private gold ownership in the U.S. as of Dec. 31, 1974.

The future impact of hoarding, speculative and investment buying on overall gold usage patterns is difficult to determine It is clear that gold becomes a logical refuge for capital in times of economic imbalance, high rates of inflation and depreciating currencies. This trend has been particularly evident in the advanced nations whose economies have been hard hit by recent inflationary pressures. But gold does not earn interest and can be expensive to store. Therefore should the economic picture improve, private demand for gold should decrease.

TABLE IV

GOLD FABRICATION BY END USE

	1970 Metric Tons	1970 %	1971 Metric Tons	1971 %	1972 Metric Tons	1972 %	1973 Metric Tons	1973 %
Jewelry in advanced nations	500.1	36.2	551.7	39.6	700.1	51.9	419.0	49.1
Jewelry in developing nations*	562.5	40.7	507.0	36.4	292.6	21.7	86.2	10.1
Total jewelry	1,062.6	76.9	1,058.7	76.1	992.7	73.5	505.2	59.2
Electronics	93.6	6.8	90.6	6.5	110.2	8.2	129.5	15.1
Dentistry*	63.9	4.6	70.0	5.0	72.5	5.4	72.7	8.5
Other industrial and decorative	61.9	4.5	68.2	4.9	71.2	5.3	71.0	8.3
Official coins	45.9	3.3	52.3	3.8	62.0	4.6	53.2	6.3
Fake coins, medals and medallions	53.6	3.9	51.7	3.7	41.2	3.0	21.8	2.6
Total	1,381.5	100.0	1,391.5	100.0	1,349.8	100.0	853.4	100.0

*About 10 tons of the gold attributed to jewelry usage in developing countries probably is used in dental applications.

Source: Consolidated Gold Fields, Ltd. (1 metric ton = 32,150 troy ounces)

THE FUNDAMENTAL BALANCE IN 1974 AND 1975

Although final figures for world production and consumption of gold for the 1974 current year are not yet available, initial trade estimates indicate that the downtrend in both output and distribution which was recorded in 1973 is expected to continue through 1974. If we look at the available domestic supply/demand statistics for the first half of 1974, we can see that this trend is very evident in the U.S. Production is down by 4% and usage has declined sharply by 42%.

Total free world mine production in 1974 is forecast at 1,075 metric tons, down from 1,120 metric tons in 1973. The depletion of existing gold-bearing ores and the operation of less productive mines to take advantage of higher gold prices is responsible for this decline. Gold consumption is expected to drop to 725 metric tons in 1974 from 853 a year earlier. Declines in all major sectors of gold usage are forecast due to continued high gold prices and generally stagnant current economic conditions.

The major unknowns in the balance sheet for 1974 and 1975 are central bank policies, including that of the U.S. Treasury, and the possibility of increased Soviet sales. In recent years the amount of Soviet gold coming onto the free world market has been increasing and the price of gold has been rising. Additional gold supplies from this source can be anticipated during 1974, especially if the free world gold price is maintained over $180/oz. Given recent trends, we would assume that some 250 tons may be sold by the U.S.S.R. this year. As we have mentioned earlier, central bank activity on the gold market fell off sharply in 1973. Some sales at high prices may have come about, but not officially reported as yet. We think that any central bank sales in 1974 are apt to be minimal; and we estimate such sales, very tentatively, at 25 metric tons. Adding the estimated mine production to Soviet and central bank sales, the total available gold supplies during 1974 could reach some 1,375 metric tons. With gold usage for fabrication estimated at 725 tons, the remaining 625 tons should be available for investment, speculation and hoarding.

Due to inflationary pressures, currency instability and general economic uncertainty, investment pressure during 1974 has been quite strong as measured by the high price of gold prevalent through most of the year. It can therefore be assumed that there should have been a net addition to gold absorption by the "public" in 1974 for the second year in succession.

Looking ahead to 1975, supply/demand estimates are at present very tentative. However, most trade observers expect production and consumption figures to remain near 1974 levels. Mine operations have not yet had time to expand by any sizable degree and continued high gold prices should restrict jewelry and industrial demand. As a result, continued sizable amounts of gold should be available to supply public demand again in 1975. But with the addition of the previously untapped American market, the demand for gold for investment and hoarding should increase and could place new strains on the fundamental supply/demand balance in the coming year.

RECENT PRICE TRENDS

The world-shaking economic and political developments during the past year have had profound effects on the free market price of gold. Just prior to the Arab-Israeli conflict in October, 1973, the London gold price had stabilized at around $100/oz. Prices were driven higher on the outbreak of hostilities but speculators soon lost interest when it was announced that the prohibition of central bank sales had been terminated in November. In anticipation that some sales would occur, the price fell back to around $90/oz. When only small quantities of monetary gold came onto the market, the upward trend in prices resumed. (See chart, page 1.)

Meanwhile the Arab oil embargo and the resultant energy crisis had begun, and its severity began to be appreciated. Oil prices skyrocketed, inducing huge balance of payments deficits among industrialized nations. As a result currency values became increasingly unstable. Vast amounts of currency began flowing to Arab nations in payment for oil and some of these funds found their way onto the monetary markets sparking speculative activity of unprecedented proportions. At the same time, high oil prices had a sharp effect on the basic economic fabric of the developed nations. Inflation, which had been progressing at an already unacceptable rate, increased sharply. The Western nations, with the exception of West Germany, experienced "double digit inflation." Japan and Britain, heavily dependent on oil imports and foreign exchange earnings, were particularly hard hit. Shortages of key industrial products and rapidly rising prices became a way of life. With confidence in the economic outlook ebbing, inflation rampant, and currencies increasingly unstable, the concept of gold as the ultimate store of wealth in harsh times gained renewed acceptance. Many investors turned to the precious metal as a haven from currencies and as a hedge against inflation. Speculators jumped on the bull bandwagon and prices then skyrocketed to reach a peak of just under $180/oz. in early April, 1974 (basis London).

At that point record interest rates were posted in an attempt to cope with inflation by tightening the money supply. In the U.S. the prime rate reached 12%, an unheard of level. At such astronomic rates the holding of gold, which earns no interest, became more and more expensive to the discouragement of speculators. Then the release of economic statistics, indicating that the U.S. economy had not been as badly hurt during the first quarter of 1974 as had been feared, led to some renewed confidence and a consequent decline in the price of gold. Profit taking and technical considerations added to the downtrend in which the gold price reached $130/oz. in early July, 1974.

The Soviet Union then announced a temporary restriction on its gold sales. This news, added to the realization that the inflationary pressures had in fact not been halted, led to another rally in gold prices. Also the mounting pressures related to former President Nixon's resignation underlined political and economic uncertainties. Gold prices surged to around $155/oz. by August 1974. Prices remained essentially stable at that level, until late October except for a short lived technical pullback in September. With the legalization date for private gold ownership in the U.S. on December 31, 1974 fast approaching, gold prices began a sharp rally. Many observers felt that the buying pressure had developed in anticipation of American demand for gold at the start of the new year. Various sources have estimated that U.S. citizen demand for gold could exceed 200 metric tons. Continuing inflationary pressure also added to bullish sentiment, as well as slightly reduced interest rates which made the holding of gold more attractive. As a result the London price of gold had reached a new historic record high of $190/oz. as of this writing.

THE IMPACT OF U.S. LEGALIZATION

How, then, can we expect the gold market to develop when futures trading begins? The outlook hinges on two basic factors: The prosective demand by U.S. citizens for the precious metal, and the policies likely to be followed by the U.S. Treasury, foreign central banks and primary producers to supply the marketplace.

Now that U.S. citizens will be legally able to own gold on Dec. 31, the amount of the precious metal which will be absorbed by the American market has been widely estimated at between 100-200 metric tons, some of which could be in the form of coins. Some observers feel that the long awaited gold rush may not reach these proportions. They base their argument on the fact that no mystique surrounds the hoarding of gold in the U.S., as it does in other countries, particularly in Europe. Furthermore, many Americans already own gold in the form of jewelry, coins and gold mining stocks, so that at least part of the prospective demand has already been filled. Also with the cost of money presently so high, the holding of gold particularly at high price levels is less attractive, especially in view of the dangers of speculative price movements. All these factors would seem to discourage gold ownership at present.

Yet the psychological impact of continuing high rates of inflation, currency instability and generally pessimistic economic conditions cannot be ignored. It is precisely under these conditions that a stampede towards gold as a haven of last resort could develop.

Furthermore, the supply/demand balance for 1975 is estimated to be essentially the same as in 1974. We have seen that hoarders and investors have easily absorbed excess gold in the past two years. Where then will additional supplies originate to fill American demand? As we have seen, central banks have been reluctant to part with their monetary reserves even at attractive price levels. However, sales from the Soviet Union have been increasing in recent years and this trend should continue, especially if prices remain high. The Soviet Union is one of the few nations in which gold production has been increasing, and that nation has a continuing need for Western currency to finance its growing international trade. But if strong American demand develops, the influx of foreign gold could trigger an unacceptable currency drain for the U.S. and may lead, in our opinion, to timely gold sales by the U.S. Treasury.

SUMMARY

1. Gold, once the kingpin of the world's monetary system, has been essentially cut free from its ties to currency. Since 1968 the free market price has soared to $190/oz. while the "official" price has remained at $42.22/oz.

2. World gold output has stabilized in recent years. However, private and government holdings constitute a vast reserve source of supply estimated at some four billion ounces (125,000 metric tons).

3. Gold consumption for fabrication has declined due to the high price of gold. However, the demand for gold for speculative, investment and hoarding has increased dramatically.

4. The impact of the new U.S. market for gold beginning on Dec. 31, 1974, could add as much as 3-6 million ounces (100 to 200 metric tons) to the demand from the "public" sector. This total includes coinage.

CONCLUSION

The most likely scenario for gold prices, therefore is that Treasury intervention and/or Soviet sales will enter the market as prices exceed the $180/oz. level and dampen speculative enthusiasm. This supply overhang of gold held by governments is so large that even the threat of sales can have an effect on prices.

Ordinarily we would have expected these factors to restrain gold prices during 1975 within a range roughly comparable to 1974: $150 to $180 per ounce. However, over the near term, the upcoming legalization of domestic ownership could cause anticipatory buying in hopes of strong U.S. demand after the new year (whether it materializes or not). This could drive gold prices to new record highs — perhaps $200/oz. or over — before fears of overpricing and possible government intervention bring on a more sobering reassessment.

Finally, it is our view that the gold market should eventually develop trading patterns similar to those of other commodities. That is, advances and declines, according to current conditions, should be the rule; and make the gold market as attractive for traders as for investors.

GOLD FUTURES TRADING FACTS

	Trading Hours (EST)	Trading Units	Minimum Fluctuation	Maximum Fluctuation
Intl. Monetary Market (IMM)	9:50AM to 2:10PM	100 troy oz.	10¢/oz. ($10/contract)	$10/oz. ($1,000/contract)
New York Mercantile Exchange (NYME)	9:25AM to 2:30PM	1 Kilogram (32.15 troy oz.)	10¢/oz. (under $100/oz.) ($3.20/contract) 20¢/oz. (over $100/oz.) ($6.40/contract)	$10/oz. ($320/contract)
Commodity Exchange (Comex)	9:45AM to 2:10PM	100 troy oz.	5¢/oz. ($5.00/contract)	$8/oz. ($800/contract)
Chicago Board of Trade (CBT)	10:10AM to 2:10PM	3 kilograms (96.45 troy oz.)	10¢/oz. ($9.60/contract)	$8/oz ($770/contract)

Trading to begin on December 31, 1974.

All contract details subject to change.

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