CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

CAMBIOR USA, INC.

November 6, 1990

James A. Briscoe, President
JABA, INC.
2100 N. Wilmot Road, #218
Tucson, AZ 85712

RE: Tombstone Project, Cochise County, Arizona
Bullfrog Project, Nye County, Nevada
Randsburg Project, Kern & San Bernardino Counties, California
Painted Hills Project, Humboldt County, Nevada

Dear Mr. Briscoe:

Thank you for your letter of October 21, 1990 to Jean Boissonnault, Cambior's Vice President of Exploration, regarding the availability of the above mentioned properties.

At this time Cambior is unable to consider your properties for further exploration. All of our funds and personnel for exploration in the western United States are currently fully committed.

We thank you for considering Cambior as a potential partner in developing the mineral resources of your properties.

Yours truly,

CAMBIOR USA, INC.

Michel Drouin
Exploration Manager

MD:lat

cc: J. Boissonnault

230 South Rock Blvd., Suite 23, Reno, Nevada 89502-2345
702-786-5189 Fax 702-786-4549

Copie: Michel Drouin

JABA INC.
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-9141
(FAX) 721-2768

REÇU le
29 OCT. 1990
Rép:..................

October 21, 1990

Jean Boissonnault, Vice President Exploration
Cambior, Inc.
1075 3rd Ave. E.
P. O. Box 9999
Val D'Or, Quebec, Canada J9P 6M1

Dear Mr. Boissonnault:

Attached with this letter please find a brief summary of four of our properties that are currently available for lease option, joint venture or purchase. They are located in Cochise County, Arizona, Nye County, Nevada, Kern and San Bernardino Counties, California, and Humboldt County, Nevada. In addition to these properties, we have compiled extensive literature packages on a number of target areas in the western United States (with particular emphasis in Southern Arizona) that we believe will result in discoveries, and are soliciting for a joint venture partner(s) for a grass roots program in southeastern Arizona.

Should any of these targets be of interest to you, we do have detailed summaries prepared, and would be happy to provide you with a copy.

You may contact us in Tucson via telephone at (602) 885-9141, or toll free in the USA, at (800) 999-2348, via fax at (602) 721-2768, or write us at 2100 N. Wilmot Road, Suite 218, Tucson, AZ 85712.

We look forward to the possibility of hearing from you.

Very truly yours,

James A. Briscoe
President

JAB/mas

Attachment

MAP

JABA INC
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-9141
(FAX) 721-2768

JABA, INC. SEEKS VENTURE PARTNER(S)/BUYER(S) FOR:

Tombstone Project, Cochise County, AZ: Briscoe (and Waldrip, since 1978) has been working in this district since 1971. *JABA*, Inc. currently holds 171 mining claims, three State land Prospecting Permits, and is negotiating for other properties. The land position is distributed into four individual blocks in the district. Two of the blocks are proximal to very recent mining activities, and on one of the claim blocks, reconnaissance sample collection revealed up to 80 ounces per ton silver with gold credits. A report has been prepared on a 54 claim block of the 171 mining claims, which indicates a near surface potential of ("Hypothetical Reserves") an aggregate value of precious metals at current metal prices of approximately $680 million, with deeper seated polymetallic reserve potential of $3 billion. ***JABA is actively seeking a partner to help explore and develop the claims. The properties remain open to negotiations, either individually or as a group.***

Rex E. Loesby, P.E.

19288 East Hickock Dr., Parker, CO 80134
Tel: (303) 840-7812 Fax: (303) 840-7816

January 31, 1994

Mr. Randy Moore
Cambior, Inc.
230 South Rock Blvd., Suite 23
Reno, NV 89502

Dear Randy:

Enclosed is a Properties Summary for the Tombstone District Projects near Tombstone, Arizona. The package includes six projects in the Tombstone area, one of which is a surface mineable gold target in more advanced stages of development. The other five properties are earlier stage targets with significant indications of mineralization and merit further investigation.

As usual, I have a finder agreement with the owner that calls for my fee to be paid by the owner. Please let me know if you would like to investigate any or all of the properties. Thank you.

Sincerely,

Rex E. Loesby

Please File
Cochise Co. AZ
Tombstone Dist General
[illegible], T22E R20S
Sec 2, 11
R.

REC - CAMBIOR USA
FEB - 3 1994

TOMBSTONE DISTRICT PROJECTS

PROPERTIES SUMMARY

Prepared by Rex E. Loesby, P. E.

January 1994

For information, contact Rex E. Loesby at 19288 E. Hickock Dr., Parker, CO 80134, Tel: 303-840-7812, Fax: 303-840-7816

I. INTRODUCTION

The Tombstone District Projects, controlled by Excellon Resources of Toronto, consist of six separate mineral properties, all near the town of Tombstone, Cochise County, Arizona (please see the attached map). A seventh, the Robbers Roost Project, was recently optioned by a major mining company. The properties are shown on the attached map. Tombstone is located approximately 70 miles southeast of Tucson, Arizona on US Highway 80. The properties are held by Excellon subject to the terms of a number of lease agreements with the underlying owners. Details of the leases are available to interested parties from Excellon.

The TDC Lease area has had the most significant exploration and mining activity and is in the most advanced stage of development of all of the projects described in this report. Excellon has held the property for a number of years, during which time it and joint venturers have performed extensive geologic evaluations including substantial drilling programs.

The Tombstone district was previously thought to be a mid-Tertiary aged epithermal silver-lead-zinc district of limited size and potential. More recent work shows it to be of Laramide age. Mineralization is associated with volcanism and related caldera formation, and alteration assemblages are characteristic of porphyry copper deposits. Five such potential porphyry copper centers in the Tombstone area have been acquired by Excellon in addition to the core TDC Lease area. Excellon's consultants are Dr. John M. Guilbert, Professor Emeritus, The University of Arizona, and James A. Briscoe, President, JABA, Inc., both recognized authorities on ore deposit geology. A very detailed report on the Tombstone District and Guilbert's/Briscoe's recommendations for development programs on all of Excellon's holdings is available to interested parties from Excellon.

Excellon offers each property separately, or will consider combining some or all of the properties in a single package. Excellon offers these properties to a joint venture partner or purchaser under terms which might include an initial cash payment with minimum spending requirements for development. On full development of any of the properties, Excellon offers a direct interest which could ultimately amount to majority control of that property.

The following two sections describe the properties. The first section concentrates on the TDC Lease Project area as it has had significant past mining activity and the data available from drilling and geologic evaluations are quite extensive. The second section describes each of the outlying properties.

II. TDC LEASES

Property Description: The TDC Leases project area includes the original gold/silver discoveries and mines that were the reason for the building of the town of Tombstone, Arizona in 1877. The property consists of 89 patented and 59 unpatented lode claims just south and immediately adjacent to the town of Tombstone.

Reserves: During the first half of 1993, 86 reverse circulation holes were drilled. Approximately 50 percent of this drilling was adjacent to and within a previously mined open pit area. This drilling suggested a geologic resource of 1.2 million tons grading 0.063 opt gold equivalent. An additional deeper geologic resource of 289,000 tons grading 0.098 opt gold equivalent was also identified. Excellon's partner in the drilling became discouraged when the most prolific gold zone appeared to fade abruptly to the west and chose to abandon their interest in the area. Subsequent analysis by Briscoe revealed there was a failure to take into account a major strike slip fault which offset the gold zone some 400 feet to the south. Further examination of this data plus data from previous work suggest there is the potential to develop in excess of 600,000 ounces of gold equivalent within the disturbed ground in and around the old open pit area. Furthermore, the potential exists on other partially tested and untested ground which, according to Briscoe, could contain more than 1.5 million ounces of gold equivalent.

Metallurgy: Based on prior operators' experience, the gold ores of the project are known to respond favorably to heap leaching with high recovery rates.

History: Initial gold discoveries of gold and silver were made in 1877. From 1877 to 1907, gold production was 194,000 ounces and silver production was 24 million ounces. During the past 20 years, numerous attempts have been made to re-develop mines in the district. The property was developed in 1980 by Tombstone Exploration Inc. (TEI) and it produced an estimated 100,000 ounces of gold equivalent from 1980 to 1984. In 1989 a Merrill Crowe processing plant was installed on the property by Cowichan Resources, Inc., but under-capitalization resulted in a closing of operations late in 1989. Excellon acquired an option on the property in 1990.

Planned Development Work: An exploration program has been recommended by Briscoe. The program is estimated to cost approximately $200,000 and would consist of geochemistry, geophysics, and 10,000 feet of scout drilling to broadly outline ore zones. A follow-up definition drilling program totalling approximately 20,000 feet is estimated to cost $260,000.

Infrastructure: Mine utilities, services and skilled labor are readily available in the area. A 3,000 tpd Merrill-Crowe processing plant was installed on the property in 1989 by a previous owner. The plant remains and could be made operational with minimal expenditures.

Permitting: All permits are in place for both the mining and leaching operation. The people of the town of Tombstone seem very supportive of a mining operation at the sight.

III. OTHER PROPERTIES

The other five properties held by Excellon in the Tombstone area include the Walnut Creek Porphyry Centre, the State of Maine Porphyry Centre, the Johnson Ranch Property, the Zebra Property, and the Prompter Ridge Property. With respect to these five properties, Guilbert writes:

> "Potential in the district is for carbonate-hosted replacement-type porphyry copper mineralization at intermediate to moderate depth and perhaps great depth; shallow chalcocite blanket porphyry type mineralization; statigraphically and structurally controlled carbonate replacement lead-zinc-silver mineralization; similarly controlled gold of low grade to high grade; volcanic-hosted disseminated precious metal mineralization; supergene enriched volcanic and sediment hosted intermediate to high grade precious metal mineralization; and porphyry-copper-associated distal sediment or volcanic hosted gold mineralization."

All of the five properties are early stage exploration targets where there are significant indications of mineralization that merit further investigation. Guilbert and Briscoe have designed integrated exploration programs for all of the properties including geophysics, geochemistry, biogeochemistry, and drilling to test the areas.

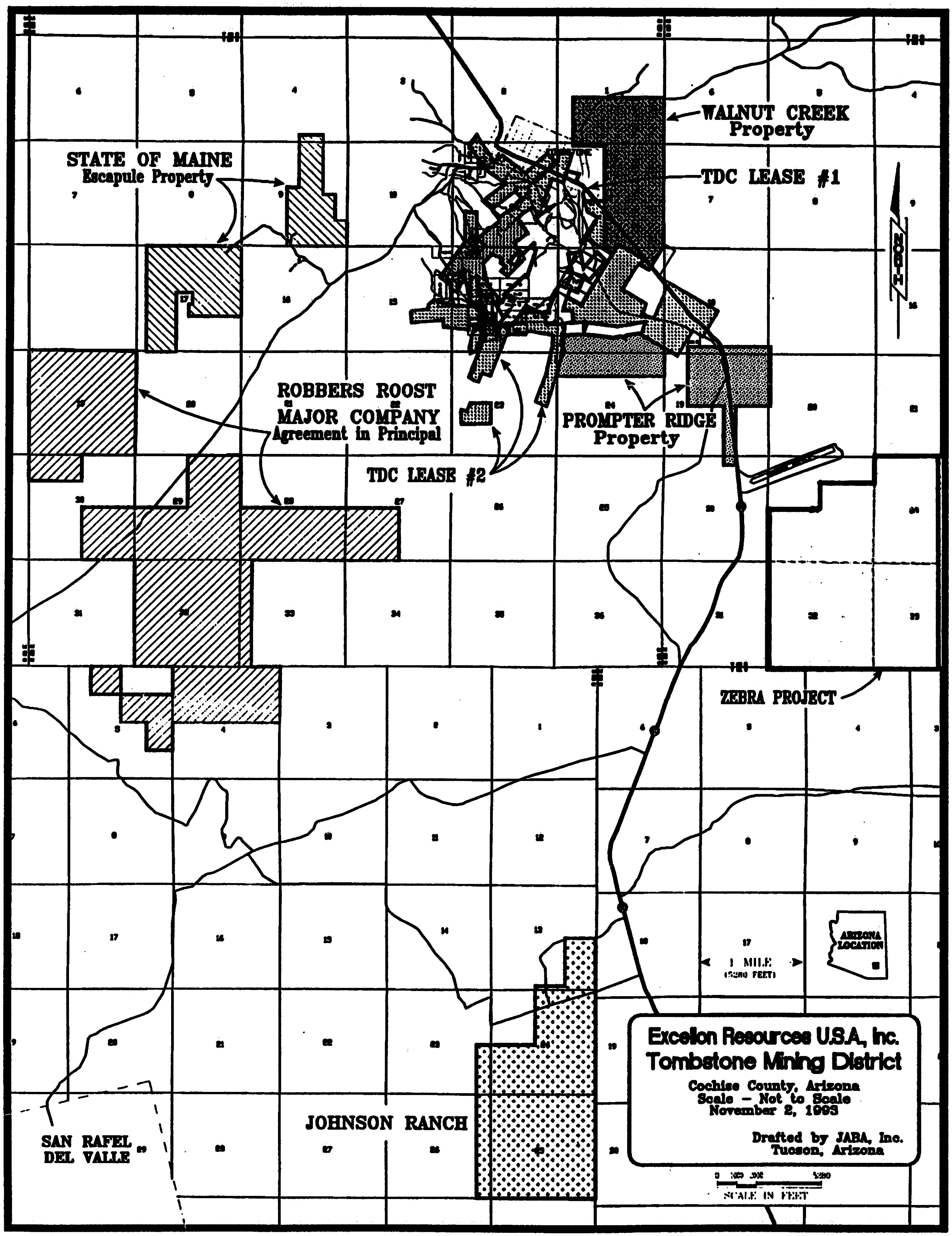
Walnut Creek Porphyry Centre, Prompter Ridge Distal Gold Target: The Walnut Creek property is located east of and immediately adjacent to the town of Tombstone, while the Prompter Ridge property is located southeast of the TDC Lease property. Guilbert writes:

> "Although (the Walnut Creek) suspected porphyry center is under alluvium cover, zonation of precious metals in exposed rocks around the projected center is similar to recently recognized haloes around better exposed porphyries... new orthophotography showed that the Prompter fault is not straight as it has been mapped previously, but rather is concave to the north. It lines up with the north to northeast concave Lucky Cuss fault system. The combination of the two faults describes an arcuate structure, the centroid of which is the projected Walnut Creek Porphyry Center. These faults localize manganese-silver mineralization that may reasonably be interpreted as the outer part of a porphyry alteration zonation. Recent gold discoveries at Chimney Creek, Bingham Canyon, and the adjacent Barney's Canyon, and studies on these and other areas by Osterberg and Guilbert (1989), Sillitoe and Bonham (1990), and Schuh and Guilbert (1993), show that there can be a distal gold zone around porphyry systems hosted by carbonate and pelitic sedimentary rocks. According to Sillitoe and Bonham (1990), these gold halos occur up to a radius of 5 km away from the porphyry center... Such an outer gold center appears to have been discovered by Santa Fe Pacific Mining in the spring of 1992 in the area south of the Prompter Ridge Mine.

State of Maine Mine Porphyry Centre: Located two to three mile west of the town of Tombstone, just north of the Robbers Roost Project Area. Geochemical sampling by Newell (1974) showed a significant molybdenum anomaly over this area and mapping shows wide hydrothermal veins in Uncle Sam tuff. Vein area is greater than in the Tombstone center. The property has a thin veneer of intracaldera tuffs that are mineralized with silver and gold. Copper values increase at shallow depths. A full section of folded Paleozoic and cretaceous sediments is known to underlie the volcanics. Guilbert and Briscoe believe this mineral zone may be the upper portion of a porphyry copper centre. Enriched gold and silver mineralization in broad zones, perhaps of bonanza grades, perhaps underlain at significant depth by porphyry copper mineralization, comprises the potential of the area. Successful exploration could define shallow depth surface mineable silver-gold zones, underlain by polymetallic underground mineable replacement deposits of significant size.

Johnson Ranch Porphyry Anomaly: Located eight to ten miles directly south of the town of Tombstone. The block is comprised of 66 unpatented lode mining claims totalling 1,366 acres. The claims are staked over a silver-molybdenum anomaly defined by Newell (1974) in his mesquite twig geochemical sampling, a pattern similar to that over the main Tombstone porphyry center. This suggests another Tombstone-like porphyry system on the property. If so, it is hidden beneath Quaternary soil and alluvium.

Zebra Property: Located three to four miles southeast of the TDC Lease property. Guilbert writes: "Another significant occurrence of the distal Tombstone gold zone is at the Zebra Property... There, disseminated invisible (Carlin style?) gold of up to an ounce per ton on the surface is disseminated in the Upper Paleozoic Naco formation." Minor jasperoid is associated with gold apparently disseminated in silty limestone along structural features. Anomalous gold in surface samples occurs over several square miles in the Zebra project area. Some geophysics has been done and limited near surface drilling has indicated 100,000 tons of material at 0.09 opt gold in one small area.


WALNUT CREEK
Property
STATE OF MAINE
Escapule Property
TDC LEASE #1
ROBBERS ROOST
MAJOR COMPANY
Agreement in Principal
PROMPTER RIDGE
Property
TDC LEASE #2
ZEBRA PROJECT
1 MILE
ARIZONA LOCATION
Excelon Resources U.S.A., Inc.
Tombstone Mining District
Cochise County, Arizona
Scale - Not to Scale
November 2, 1993
Drafted by JABA, Inc.
Tucson, Arizona
SCALE IN FEET
JOHNSON RANCH
SAN RAFAEL
DEL VALLE

CAMBIOR USA, INC.

MEMORANDUM

To: Michael Gustin

From: Alex Bissett

Date: August 12, 1992

Subject: TOMBSTONE ARIZONA GOLD PROJECT

As I mentioned to you on the phone today, we have been asked if we have any interest in a precious metals project controlled by Camindex (MVP Capital Corp.), our partner in Valdez Creek. Attached is a package of information that was given to me by Richard Brissenden of Camindex.

My feeling is that we shouldn't stretch beyond what we would normally consider appropriate criteria for a project to be of interest by Cambior. I would appreciate it, however, as a courtesy to our partner, if you would at least review the information. Please let me know what your interest level is.

Attachment

Regards,

Alex

REC - CAMBIOR USA

AUG 17 1992

BEMA

RESOURCE MANAGEMENT LTD.

Douglas MacKenzie
Excellon Resources Inc.
Suite 200-20 Adelaide St. East
Toronto, Ontario M5C 2T6
Canada

June 4, 1992

.02 + .05 = .07

Dear Douglas,

Please find enclosed a sketch map of our small rock sampling program in and around the Contention Pit. Also attached are the geochemical results and a sketch X-section through the silicified zone. As I said on the phone, I believe there exists a well defined mineralized zone with a 5 million ton potential at .05 opt Au and 3 opt Ag. This zone is centred on the silicified zone within the Contention Pit. Other zones are likely present;

I believe the property has merit, however Bema would like to stack this property up against other properties I am evaluating in mid June. I will contact you when this evaluation is completed.

Sincerely,
Bema Resources Management Ltd.

Tom Garagan
Exploration Manager

cc: Jim Briscoe

2340 W. Mission Lane, Suite 11, Phoenix, AZ 85021
Phone: (602) 861-2329 Fax: (602) 331-8656

~~BOX 9, SUITE 1000 - 609 WEST HASTINGS STREET, VANCOUVER, BRITISH COLUMBIA, CANADA V6B 4W4 (604) 689-7151~~
~~FAX: (604) 689-7152~~

EXCELLON RESOURCES INC.

TOMBSTONE PROJECT

PROPERTY SUMMARY

March, 1992

TABLE OF CONTENTS

EXCELLON RESOURCES INC.

TOMBSTONE PROJECT

PROPERTY SUMMARY

PROPERTY DESCRIPTION

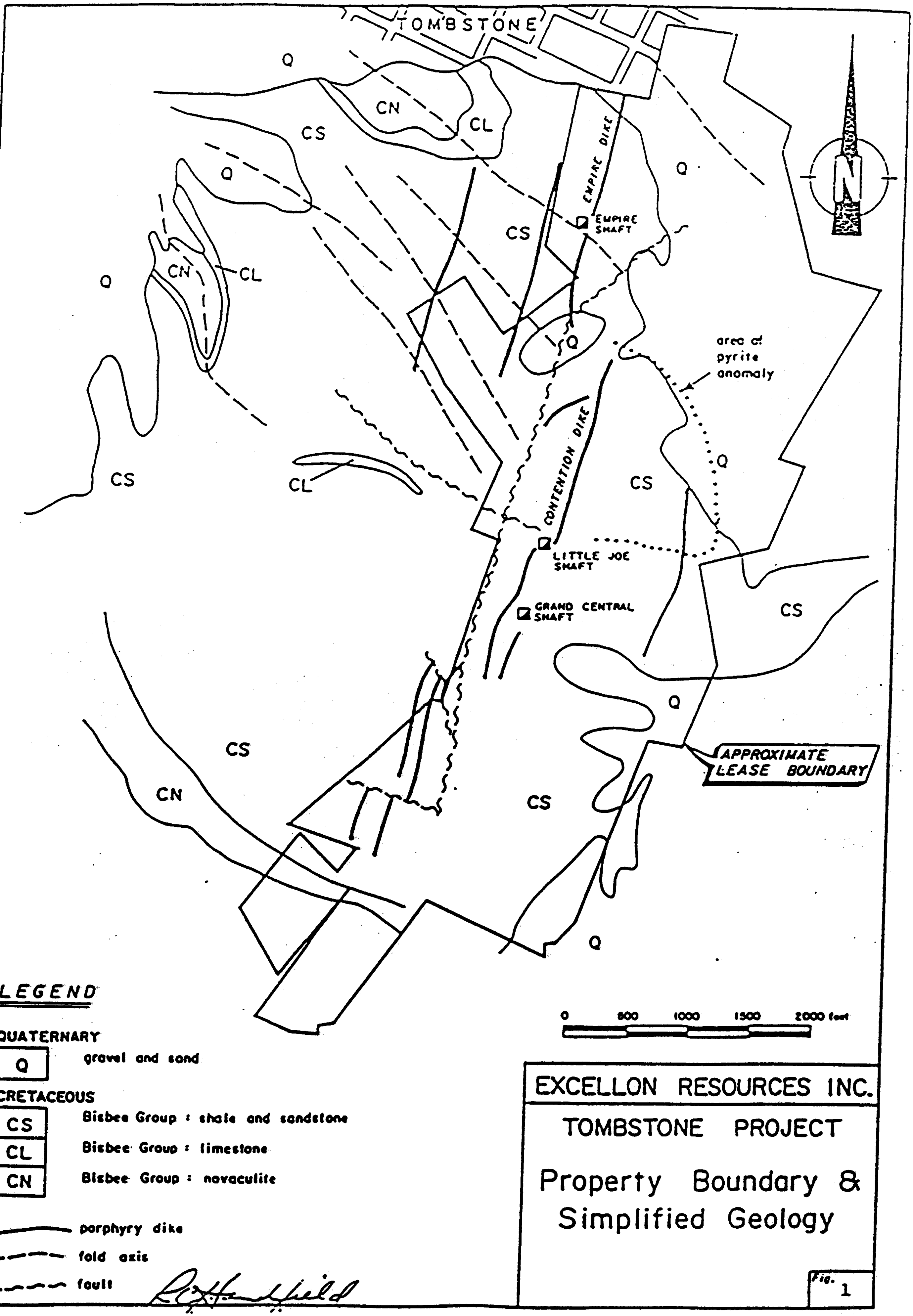
The Properties under option to Excellon Resources Inc. ("Excellon") consists of the original gold/silver discoveries and mines which were the reason for the building of the town of Tombstone, Arizona in 1877. The property consists of 34 patented and five unpatented lode claims (500 acres) known as the Contention Lease (Figure 1).

In addition Excellon has an agreement to acquire additional ground in the area. This ground totals 4,000 acres, including 2,500 acres in the immediate vicinity of the Contention Lease.

The properties are located adjacent to and south of the town of Tombstone, at an elevation of 4,500 feet, which in turn is approximately 70 miles southeast of Tucson, Arizona. Mine utilities, services and skilled labour are readily available in the area. The climate is that of intermediate altitudes of southern Arizona, with only a few light snowfalls in winter, and hot days and cool nights in summer.

REPORTS

A report on the Contention Lease dated May 14, 1990 was prepared for Excellon by Ross Glanville, Glanville Management Ltd. and Robert C. Handfield, RCH Management Services, Independent Mining and Geological Consultants. James A. Briscoe, ("Briscoe") Independent Geological Consultant, of JABA, Inc., Tucson, also prepared a report on the property dated December 2, 1989. The following discussions, in part, summarizes these reports and includes many direct quotes. Copies of the full reports are also attached. In addition Briscoe prepared a letter report dated November 3, 1990 as to why he feels a significant disseminated ore deposit can be expected to be found in the Tombstone Mining District (see Appendix A).


TOMBSTONE
EMPIRE DIKE
EMPIRE SHAFT
CONTENTION DIKE
LITTLE JOE SHAFT
GRAND CENTRAL SHAFT
area of pyrite anomaly
APPROXIMATE LEASE BOUNDARY
Q
CN
CL
CS
0 500 1000 1500 2000 feet
LEGEND
QUATERNARY
Q gravel and sand
CRETACEOUS
CS Bisbee Group : shale and sandstone
CL Bisbee Group : limestone
CN Bisbee Group : novaculite
porphyry dike
fold axis
fault
EXCELLON RESOURCES INC.
TOMBSTONE PROJECT
Property Boundary & Simplified Geology
Fig. 1

HISTORY

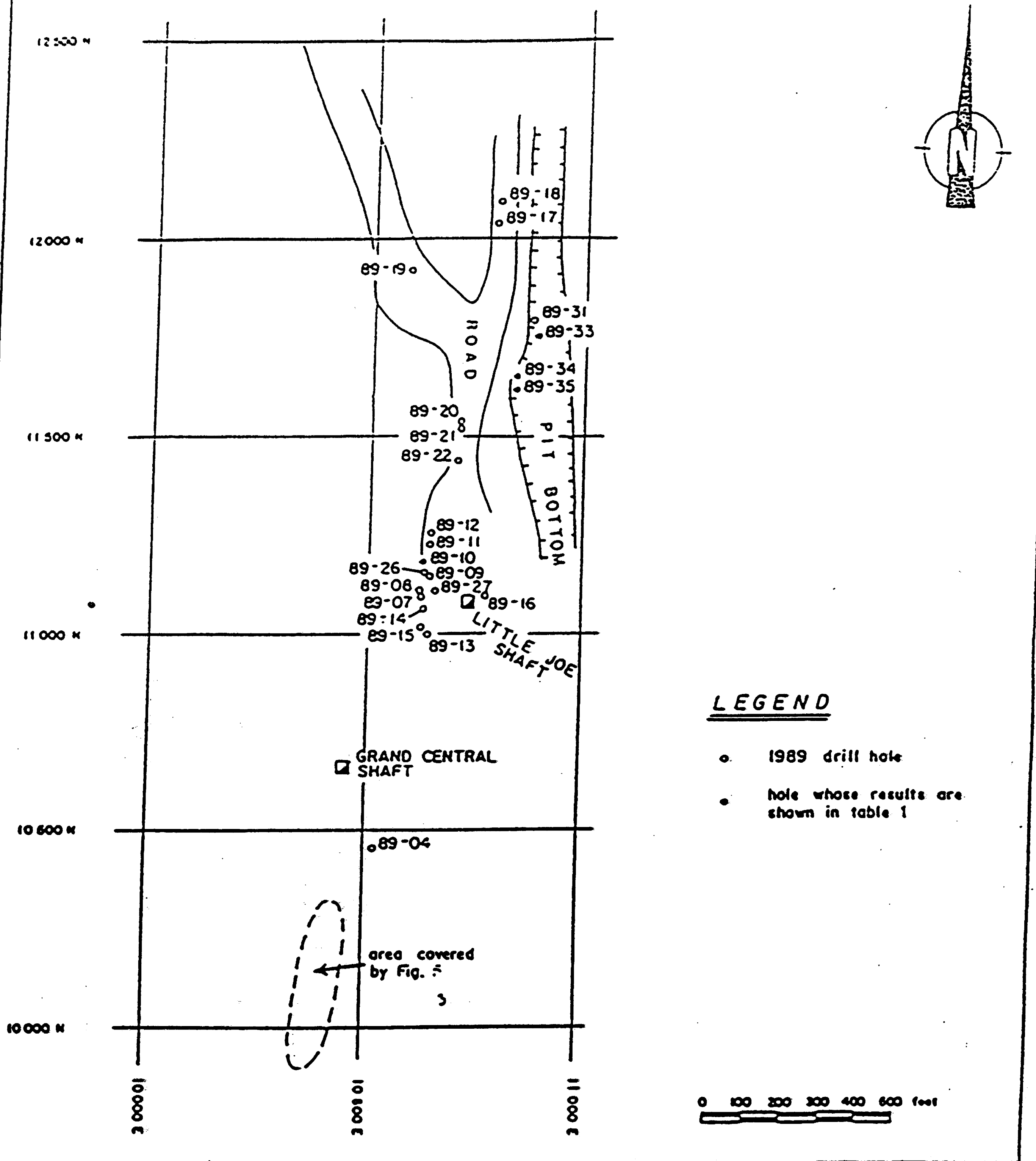
Initial discoveries of gold and silver were made in 1877. From the period between 1877 and 1907, gold production was 194,000 ounces and silver production was 24 million ounces. During the past 20 years, numerous attempts have been made to re-develop mines in the district. The property was developed in 1980 by Tombstone Exploration Inc. ("TEI") and it produced an estimated 100,000 ounces (gold equivalent) during the period from 1980 to 1984 through a heap leach operation. TEI was a private company which kept most of its operating records secret. In 1984, due to a leak in one of the settling ponds which was threatening the local water supply, TEI declared bankruptcy and abandoned the property. Another $700,000 in revenue from gold and silver sales was generated and some development drilling was done in late 1989 by Cowichan Resources Inc. A Merrill-Crowe processing plant was installed on the property by Cowichan at this time. The plant is still on the property and can be made operable with minimal expenses. Under-capitalization resulted in a shut-down of operations late in 1989. Cowichan went into Chapter 11 under U.S. bankruptcy law in June, 1990 (see "Ownership").

RESERVES

At this stage, there are no proven or probable reserves on the property. Mr. Briscoe has worked on the property extensively since the early 1980's for a number of companies. He estimates the property has the potential for over 1 million ounces of gold reserves. Previous exploration has generally been underfunded, but nevertheless has resulted in sufficient information to confirm the high potential for finding significant ore reserves, both surface minable and higher grade underground reserves. Trenching and drilling undertaken in 1989 encountered high grade silver and gold mineralization (see Table I, Figures 2 and 3). One of the 1989 holes averaged .088 opt gold equivalent from surface to a depth of 110 feet. Four other holes drilled to varying depths of 27 to 50 feet averaged .04 to .082 opt gold equivalent. All five of these holes were stopped in ore. The results of this drilling and trenching, the widespread alteration and mineralization, and the extensive past mining all give indications of good potential for finding ore reserves on the property. Assay results of all holes are included in the Glanville report.

TABLE I

Drill Hole No.	Interval	Gold (oz/t)	Silver (oz/t)
DH 89-10	0-5	0.002	1.17
	5-10	0.004	2.04
	10-15	0.003	1.79
	15-20	0.001	2.55
	20-24	0.063	5.57
DH 89-24	0-5	0.020	5.00
	5-10	0.068	6.18
	10-15	0.060	4.44
	15-20	0.014	1.83
	20-24	0.034	0.98
DH 89-33	0-5	0.017	0.87
	5-10	0.018	1.06
	10-15	0.005	0.90
	15-20	0.007	1.56
	20-24	0.024	2.34
	24-30	0.015	1.21
	30-35	0.005	0.89
	35-40	0.003	0.74
	40-45	0.018	0.83
	45-50	0.241	0.82
	50-55	0.158	0.56
	55-60	0.149	1.80
	60-65	0.081	2.29
	65-70	0.063	1.44
	70-75	0.021	0.79
	75-80	0.695	1.13
	85-90	0.025	0.63
	90-95	0.013	0.37
	95-100	0.048	2.03
	100-005	0.025	1.74
	105-110	0.035	1.61
DH 89-34	0-5	0.006	0.29
	5-10	0.027	1.29
	10-15	0.020	6.72
	15-20	0.014	4.20
	20-25	0.014	2.25
	25-30	0.013	1.58
	30-35	0.049	1.97
	45-50	0.032	8.01
	50-55	0.014	5.72
DH 89-35	0-5	0.015	1.24
	5-10	0.052	0.79
	10-15	0.039	5.97
	15-25	0.019	3.36
	25-30	0.040	1.54
	30-35	0.021	1.61



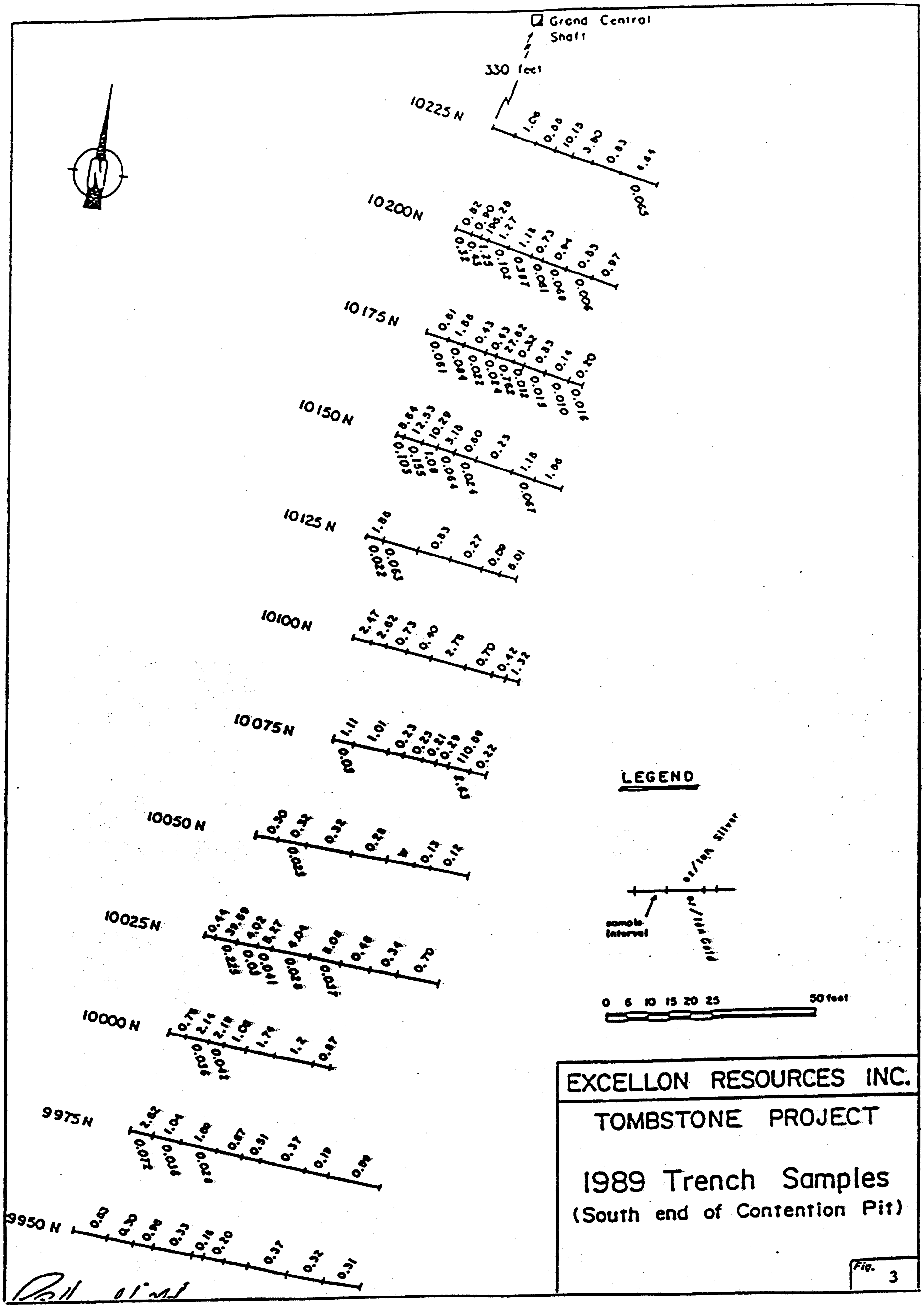
EXCELLON RESOURCES .INC.

TOMBSTONE PROJECT

1989 Cowichan Mines Drill Hole Locations

(North end of Contention Pit)

Fig. 2


Grand Central Shaft
330 feet
10225 N
10200 N
10175 N
10150 N
10125 N
10100 N
10075 N
10050 N
10025 N
10000 N
9975 N
9950 N
LEGEND
oz/ton Silver
sample interval
oz/ton Gold
0 5 10 15 20 25 50 feet
EXCELLON RESOURCES INC.
TOMBSTONE PROJECT
1989 Trench Samples
(South end of Contention Pit)
Fig. 3

GEOLOGY

The Tombstone District lies in the heart of one of the world's great porphyry copper areas with 6 deposits within a 50 mile radius of Tombstone and 12 deposits within a 100 mile radius. Almost all of these deposits are associated with Late Cretaceous of Early Tertiary intrusions. After mapping the District in 1956, a geologist (Gilluly) identified the District's Uncle Sam Porphyry as intrusive, but new work by Newell in 1974, Briscoe in 1983, and Lipman and Sawyer in 1985 identified the formation as a Late Cretaceous welded tuff which is thought to represent the centre of a Cretaceous caldera. The District's silver, gold and base metal deposits mined to date occur in an anticline of the Bisbee Group sediments along the northeast caldera margin. Metal zoning patterns similar to those associated with porphyry copper deposits have been shown to exist in the Tombstone Hills, but on a scale far larger than in the old mining district. The anticlinal axis trends generally northwest and plunges to the southeast. It is flanked by a series of smaller drag folds that trend parallel to the anticline in the northwest direction. The bonanza grade ore bodies mined in the early days occur in these drag folds in the favourable horizons.

The Bisbee Group sediments are cut by a number of highly altered andesite porphyry dikes that strike north to just east of north. Mineralization is closely associated with these dikes and northeast trending fissures. Ore occurs as veins within the sediments and also within the dikes. Replacement zones occur within the sediments where the fissures intersect favourable horizons. One of the largest dikes, the Grand Central-Contention dike is up to 70 feet wide and is now well exposed in the centre of the existing pit. Ore previously mined occurs on both sides of this dike. Nearly all of the rocks within the property exhibit varying degrees of alteration and are highly fractured and oxidized. Although the bulk of past production has been from veins and replacement deposits, ore minerals were also deposited in small fractures, veinlets and joints as well as in the matrix of brecciated portions of the dikes. It is this dispersal of minerals that has made possible the consideration of bulk mining and treatment by heap leaching.

Oxidation of ore minerals has been severe in the upper 200 feet and has occurred on a lesser scale down to and below 600 feet, the depth of the current water table. The practical effects of this oxidation are two-fold. First, silver and gold grades should increase with depth to the water table and then may substantially decrease, although the exact depth at which this will happen depends on the location of the water table over thousands of years, not just the last hundred years. Second, the minerals and rocks are so leached and oxidized that they are quite friable. This intense fracturing makes the rocks particularly amenable to heap leaching. Gold has not been as intensively leached as silver but indeed has been solubilized, leached from the surface and reprecipitated at depth.

METALLURGY

Few records of leach results are available, but observations by Waldrip and Briscoe after analyzing the TEI and Cowichan operations led them to the belief that the ores were readily amenable to heap leaching. This was partially confirmed when Newmont performed bottle tests on the "State of Maine" mine ore in 1985. It is Briscoe's opinion that there remains economically recoverable amounts of gold and silver on the existing spent dumps. This material could easily be used as crushed cover for any new leach pad liner, thus offering the opportunity to recover some of the gold and silver.

The property has been permitted by the appropriate regulatory authorities to operate a heap leach facility. As mentioned previously a 3,000 ton per day Merrill-Crowe Zinc Precipitation Plant has been installed on the property. The plant would be fed by solution from existing 400' x 400' leach pads, divided into four sections. In addition there are three 1.3 million gallon processing ponds, an over flow pond as well as a complete laboratory and refinery located on the property. The attached aerial photograph gives an excellent visual indication of the property as it looked in 1983 during actual mining operations and includes photos of the plant installed in 1989.

OWNERSHIP

Tombstone Development Corporation ("TDC") is the owner of the property. TDC leased the property to Cowichan and TDC retained a minimum 5% sliding scale N.S.R. The property is currently under option from Cowichan Resources Inc., to Excellon Resources Inc. of Vancouver, B.C. The exercise of the option by Excellon will require the approval of the Arizona Bankruptcy Court and creditors of Cowichan.

A revised plan of reorganization was presented by Cowichan Resources Inc. to the Arizona Courts on March 20, 1992. The following summarizes the proposal to creditors.

(1) Pay $50,000 cash to one creditor who has a specific lien on the property;

(2) Spend U.S. $1,250,000 on the property within 30 months of the date of approval of a Reorganization Plan by the United States Bankruptcy Court; U.S. $250,000 in the first 6 months; an additional U.S. $500,000 by the end of 18 months and a further U.S. $500,000 by the end of 30 months. Excellon is only obligated to spend the first $250,000;

(3) During the 30 month period monthly payments of $10,000 per month will be made to the lien holder;

(4) At the end of 30 months, if Excellon wishes to proceed, it would be required to pay $250,000 to the lien holder and $150,000 to the TDC for back property payments;

(5) Ongoing payments would be $5,000 per month to the TDC;

(6) When the property is brought into production, Excellon would receive 100% of the cash flow until it has recouped all its expenditures, twice, including property payments, capital costs and payment to the lien holder, etc. However, a total of $200,000 would be payable to TDC out of 30% of first cash flow. After recovering all expenditures twice, the creditors would receive 40% of net cash flow until paid a maximum of $3.4 million. Thereafter, the net cash flow would be shared 90% to Excellon and 10% to Cowichan Resources.

Excellon does not expect any potential venture partner, investor, or buyer to commit funds to the project before resolution of the above. A portion of the property had been controlled by Santa Fe Minerals below a depth of 500 feet. However Santa Fe has recently dropped its option on the property which will become part of the Excellon property package.

FURTHER INFORMATION

Extensive maps, cross sections, drilling data and production information are available at the offices of Excellon's consultant, JABA, Inc. of Tucson, Arizona.

PROPOSED PROGRAM

Prior operators of the property got into trouble when they did not perform complete evaluation and development work prior to the decision to begin production. At the request of Excellon, J. A. Briscoe has proposed a three stage exploration program (see Appendices B and C). The first stage amounting to U.S. $201,000 would include 3,600 feet of drilling. The second stage amounting to U.S. $299,000 would proceed based on the results of Stage I and would include an additional 15,000 feet of drilling. A Stage III program amounting to an additional U.S. $900,000, including up to 45,000 feet of drilling, would carry the project to final feasibility. Should the above program be successful, it is felt that the property could be developed into a mine rather quickly and at low cost due to the existing infrastructure, equipment and permits.

Appendix A

JABA INC.
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-9141
(FAX) 721-2768

November 3, 1990

A. Douglas MacKenzie
Excellon Resources Inc.
Suite 200-20 Adelaide St. E.
Toronto, Ontario, Canada M5C 2T6

Re: Why disseminated ore is expected in the Excellon Resources Inc., Contention Mine Lease, Tombstone Mining District, Cochise Co. Arizona

Dear Douglas;

There appears to be some lack of clarity on the technical reasons to expect disseminated ore in the Tombstone Mining District in general, and specifically in the Contention lease area. I hope the following brief explanation will help to clarify some of the technical reasons. Further, I would be happy to speak with interested parties and provide additional detail. As you know, we have voluminous data in our offices which could also be reviewed.

The Contention Lease is part of what I believe to be a significantly large porphyry copper system, which geological and geochemical studies suggest is at least 12,000 feet in diameter. For comparison purposes, this description from my recently delivered EXPLORE (news letter of the Society of Exploration Geochemists) is intriguing:

> *"The Mt. Milligan BC porphyry copper-gold ore zone of some 300 million tons (0.3% Cu & 0.02 opt Au) is 4,500 feet long and 3,100 feet wide and up to 880 feet thick, and is associated with an alkaline intrusive (monzodiorite). Seven high grade vein zones averaging 0.3 opt Au radiate outwards from the deposit."*

The Contention Lease lies on what appears to be the southern margin of the porphyry center indicated to be +4,000 feet in diameter (which lies under post-mineral cover), and is along a fault-vein-dike zone (the Contention Zone) of intensely shattered Cretaceous sediments (the Bisbee Group), which in turn overlie Paleozoic limestones. Shattered and faulted granodiorite [monzodiorite(?) like Mt. Milligan(?)] dike(s) - the Contention dike system-forms part of the host rock. Intensely folded and broken Bisbee Group sediments host most of the mineralization above 500 feet. Studies to date show that manganese, silver, copper mineralization at the south end of the Contention Zone grade into silver, gold, zinc, lead, copper, moly mineralization to the north as the porphyry center is approached. This is the same as the metallization zoning at the Bisbee porphyry copper moly-gold deposit 25 miles to the southeast of Tombstone, and in the same geologic environment, - as you and I saw during our trip there last Spring.

Dr. Sidney Williams, consultant in mineralogy and ore microscopy, has spent a substantial amount of time studying minerals at Tombstone, and has identified and named several previously unrecognized minerals he has collected at Tombstone. On April 21 1982 he prepared a report for Tombstone Exploration Inc. (TEI) operators of the Contention Mine from 1979 to 1984, on the characteristics of the mineralization. In it he points out that there was an earlier phase of copper-lead-zinc mineralization with abundant silver but little gold. The second phase was primarily tellurides of gold and silver emplaced with galena. He states *"both mineralizing events affected not only major structures thus producing veins, but occurred disseminated on a myriad of fractures and joints within the Bisbee group beds. Thus, although values were concentrated in larger or more obvious veins, primary values were also dispersed in the wall rocks between them. Recent open pit mining along the (Contention) zone shows clearly that in addition to the larger veins mined in the past, there are numerous small veins and veinlets, and that between them, sulfides were dispersed in small amounts in virtually every joint surface within the Bisbee group rocks."*

The above observations, made as the pit was being mined, are a virtual definition of *"disseminated ore"*. Successful leaching with good recoveries in a very short leach cycle attests to disseminated precious metal values on fracture surfaces.

Later in the same report, in commenting about oxidation and supergene enrichment of the ore, Williams says, *"The grade of silver ore, then, should increase downward from the surface, culminating about in the region of the 400' level, for it must be remembered that all silver leached from the surface has been redeposited during its downward descent. As noted already, the gold shows similar behavior but to a much lesser degree, and grade should increase only slightly."*

If Williams is right, since mining in the Contention Pit has progressed to a maximum depth of 150 feet, the best disseminated ore remains to be mined.

In February 1914, USGS geologist F. L. Ransome, whose earlier Professional Paper on the Bisbee District is still in use today, began study of the Tombstone mines. After about a weeks examination of the so called *"Tombstone quartzite"* exposed on the 600 foot level of the Contention mine, Ransome found that it was a completely and massively silicated replacement of the Naco limestone that directly underlies the Bisbee group sediments. This complete replacement of the Naco is indicative of a large volume of hydrothermal solutions (associated with the porphyry system), which created pervasive and disseminated alteration - and presumably what in 1990 we would call disseminated mineralization.

Two weeks ago, USGS geologist Eric Force and I, in company with John Guilbert's Advanced Ore Deposits class from the University of Arizona, examined outcrops of the Novaculite near the north end of the Contention lease and the south edge of the porphyry center. Eric, as a result of my urging of the USGS, is mapping the northern part of the Tombstone district, while Guilbert's students, supported by JABA, are studying various aspects of the geology and mineralization which will culminate in a publishable report on the Contention zone. The purpose of our visit to the Novaculite outcrop was to determine, if we could, whether the unit might actually be a complete silica replacement of the basal Bisbee group conglomerate - the Glance. We found some outcrops which show definitively that indeed is the case - that the so called Novaculite (an important host for ore) is simply massively, silica replaced limestone conglomerate. In Nevada this unit would be referred to as jasperoid. Yet another example of wide spread disseminated alteration accompanied by disseminated as well as local bonanza grade ore.

The large size of the Tombstone system suggests saturation by hydrothermal solutions and thus dissemination of mineralization. The system of which the Contention Lease is a part, is at least 75% covered so we are at this time uncertain of its precise geometry. What we can see suggests that the entire system is about 2 miles in diameter. But it is part of a much larger linear zone of alteration and mineralization which is in turn part of a large volcanic system - the Tombstone Caldera. The caldera is about 8 miles wide and 10 miles long. The Tombstone zone lies at the northeast end of a mineralized trend which cuts the east or southeast flank of the caldera and is genetically related to it. The altered trend strikes about N 45 E, the typical trend of porphyry mineralization in southeast Arizona. In 1973, I had a color air photo program flown over the Tombstone 15 minute quadrangle (about 350 square miles) and the resulting photos mosaiced. A zone of red coloration from oxidized disseminated pyrite could be seen. The red zone is about 2 miles wide and 10 miles long. In 1978 Roger Newell's PhD dissertation which covers the east half of the Tombstone Caldera was released. His regional geochemical sampling shows anomalous copper, moly, lead, zinc and silver metallization superimposed over the pyritic color anomaly, but with a width of 4 miles and a length of 10 miles, with Tombstone at the northeast end and anomalies trending under cover. Thus, these data show disseminated mineralization over almost 40 square miles. Subsequent work has shown that multiple porphyry polymetallic centers (porphyry coppers) are responsible for this disseminated mineralization. The Robber's Roost porphyry copper system within the Tombstone Caldera has been verified by deep drilling in the early seventies. Tombstone itself is undoubtedly another porphyry center - with a disseminated precious metal halo.

In summary, the Contention lease is a small part of a large porphyry system, which is in turn part of a cluster of porphyry centers aligned along a structural trend associated with a very large volcanic system - the Tombstone Caldera. Similarly, most of the porphyry coppers in southeastern Arizona have, in the past six years, been shown to be associated with calderas. Thus, every line of evidence in the Tombstone geologic environment connotes disseminated alteration and mineralization. Mining in the Contention open pit was for gold-silver ore with values occurring on a myriad of fractures in silty sandy limy sediments. Good recoveries with heap leaching verify disseminated values. The potential for disseminated precious metal values surrounding bonanza grade pods in the Contention Lease appears to be a fore gone conclusion .

Very truly yours

James A. Briscoe

Appendix B

JABA INC
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-9141
(FAX) 721-2768

FACSIMILE TRANSMISSION (416) 867-1109

July 11, 1990

A. Douglas MacKenzie,

Suite 205, 20 Adelaide Street, E.
Toronto, Ontario, Canada M5C 2T6

RE: Fax transmittal of work program and budgets, Contention Mine (PBR-Cowichan), Tombstone Mining District, Cochise County, Arizona

Dear Doug:

As per our telephone conversation this morning, I would be pleased to work with you as Exploration Manager on the Tombstone project.

I am transmitting to you, with this faxed letter, the Work Plan and Objectives, prepared by myself, as of December 1, 1989, as well as a cost proposal taken from that Work Plan, prepared by Robert C. Handfield and Ross Glanville, in their report to Excellon Resources, Inc., dated May 14, 1990. I think that their costs are within reason for Phase I, but a little bit light in Phase II. As you can see in my list of Tasks and Objectives, we would prefer to keep up very closely with three dimensional geology, as well as ore reserve estimates and geostatistics (all done by computer), which would change with each new bit of drilling information. The Handfield/Glanville budget totals $460,000. I think for another $40,000, bringing that total to $500,000 even, the additional geologic detail and ore reserve calculations could be kept up to date with the drill progress. As you can see from my Task list, even though the dates are obsolete, we believe that the entire ore body can be drilled out (Phases I - III) and the ore reserves calculated and mine plan done within a year. Phase III, drilling of an additional ninety 500 foot holes, based on the Glanville estimate of $259,000 per 15,000 feet of drilling, plus my suggested addition of $40,000 for a total of $300,000 per 15,000 feet, suggests that an additional $900,000 would be required for the next 45,000 feet of drilling. We would propose to do the geologic maps and cross-sections, geostatistical studies, ore reserve calculations, mine plan, and financial modeling pretty much as we went along, and would hope to accomplish that within this budget. Metallurgical test work has not been addressed in budgeting so for. However, PBR has done substantial metallurgical test work, and I think for the material between 0' and 500' - all within the oxide zone - minimal additional testing will need to be done.

A. Douglas MacKenzie, President
Camindex Resources, Inc.
July 11, 1990
Page 2 of 2

As I have emphasized to you before, basic data, including available historical information, geology, geochemistry, geophysics, etc., Sequence Tasks 1-9, on my Work Plan (Tasks 1 and 2 have already been completed, I might point out), I believe need to be completed before the commencement of any additional drilling. Because these Tasks have never in the history of the district been done, or if done, they have been done inadequately for the current project, I am optimistic that outcropping ore-grade mineralization may be found, and the geophysics may tie us immediately into near-surface but blind ore bodies, associated with known geologic structures. If these first Tasks are pursued diligently, I feel there is real reason for optimism that significant, near-surface ore bodies, perhaps bonanza in grade, can be discovered, perhaps at much lower costs than that required for my projected three phases of drilling. If this turns out to be the case, because all permitting is in place for the plant on site, production and cash flow could begin quickly. Should bonanza grade, direct shipping ore bodies be discovered, there are three nearby smelters that could receive such material. Two of these smelters, Magma at San Manuel and Asarco at Hayden, are within a 100 mile truck haul, directly north along the San Pedro Valley.

Hope this is helpful. I have tried to be brief so that I could get this material to you quickly. Let me know if there is anything else I can provide for you. As you know, there is voluminous information in our Tucson office available, when necessary.

I look forward to working with you.

Very truly yours,

James A. Briscoe

JAB/mas

Attachments

PROPOSED 1990 WORK PROGRAM AND BUDGET

Phase I

Compilation, logging of 1989 drill cuttings		$ 32,000
Soil and rock geochemistry		25,000
CSAMT geophysical survey		28,000
Preliminary driling (3,600 ft)		72,000
Drill cutting assays		18,000
Analysis and report		8,000
	Sub-Total	$183,000
Contingency @ 10%		18,000
	Total	$201,000

Phase II

Follow up drilling (15,000 ft)		$225,000
Report and project review		10,000
	Sub-Total	$235,000
Contingency @ 10%		24,000
	Total	$259,000

PBR-COWICHAN

WORK PLAN AND PRODUCT

Introduction

The focus of the PBR-Cowichan Program is to bring the PBR-Cowichan Contention Mine into production. The end products are a Mine Plan, Financial Plan, Business Plan and a Plan of Operations.

What follows is a plan for obtaining the above documents. This is not a hard and fast schedule. JABA reserves the right to make, and accepts the responsibility for, deviations from the following plan. Any such deviations would be for the express purpose of furthering the likelihood of a significant economic mineral discovery. JABA, unlike many unsuccessful explorationists, does not operate by rote adherence to a plan. The major advantage to JABA's approach to exploration is the bringing together of the tools and personnel necessary, at the exploration site, to react immediately to changing circumstance. This increases the odds of success and shortens the process without short cutting the procedure.

OBJECTIVES

Preliminary Determination of Ore Quantity (Inferred Tonnage)
Work undertaken to locate ore grade mineral zones or geochemical indicators related to ore targets are suspected to be both exposed and hidden below post or pre-mineral cover. Target zones are suspected to be both exposed and hidden in chemically and/or structurally favorable sedimentary zones or igneous contact zones at depth, and target delineation must be accomplished by direct and indirect method. Inferred Tonnage may be determined by these indirect methods. Ore Type has been inferred by reference to exposed mineralization in the Tombstone District.

Preliminary Determination of Ore Quality (Inferred Grade)

The primary purpose of this Drilling is to gain preliminary geologic information. From the Drill Data, it may be possible to determine Inferred Grade and Process Parameters. If such a determination cannot be made from the Drill Data, it may be possible to Infer the Grade from Tombstone District parameters.

Determination of Inferred Reserves
This is the final classification of Inferred Reserves if not previously accomplished. The results of this stage dictate where on the property to conduct intensive drilling and evaluation.

Determination of Probable and Proven Reserves
Intensive deposit evaluation by Drilling, application of Geological expertise and Geostatistical method. The tasks are conducted concurrently on-site and updated as data becomes available from the Drilling.

Preparation of Mine Plan
A Mine Plan is developed from the Ore Reserve and Geological parameters. In addition to final underground mine plan including shafts, the plan may be extended and amplified to include a schedule of mining activities by month and year for the life of the mine.

Prepare Preliminary Financial Model
A preliminary cost and cash flow analysis for the mine is prepared.

Intermediate Process Parameters
The above information and samples are used to conduct bench scale Metallurgical studies on recovery method and confirm current metallurgical procedures.

Prepare Business Plan
The preparation of the documentation necessary to obtain Financing for Production of ore body.

JABA, Inc.
HELIX CHART

Project Name: PBR-Cowichan
Project Number: 148-01
Date: 12/01/89

ACTIVITY	Completion Status I	II	III	IV	V
A) LITERATURE RESEARCH					
1) Literature Identification & Acquisition					
a) General	■	«θ»			
b) Detailed	■	«θ»			
c) Site Specific	■	«θ»	«θ»	«θ»	«ø»
2) Literature Review & Evaluation					
a) General	■	«θ»			
b) Detailed	■	«θ»			
c) Specific		«θ»	«θ»	«θ»	«ø»
B) REMOTE SENSING					
1) Space Imagery					
a) Acquisition	■				
b) Processing	■	■	«ø»		
2) Color Aerial Photography					
a) Flying Multiscale-Multispectral Photography		■	■		
b) Custom Processing/Printing		■	■	■	
c) Construction of Mosaics		■	■	■	
3) Image/Photo Interpretation		■	■	«ø»	
C) LAND STATUS					
1) Land Data Acquisition					
a) Preliminary Ownership Status (Governmental/Private)	■				
b) Claim Records (Federal/County)		■	■		
c) Private Ownership Status		■	■		
2) Land Research					
a) Owner Identification		■			
b) Owner Location		■	■		
c) Land Map Preparation		■	■	«ø»	
D) FIELD GEOLOGY					
1) Reconnaissance Geology					
a) Air Reconnaissance		■	■		
b) Ground Reconnaissance		■	■		
c) Geochemical Sampling		■	«θ»		
d) Reconnaissance Mapping		■	■		
2) Detailed Geology					
a) Geological Mapping			θ	θ	«ø»
b) Geochemical Sampling			«θ»	«θ»	«θ»
c) Geophysical Surveys				«ø»	«ø»
d) Compilation of Data			θ	«θ»	«θ»
e) Preparation of Maps		θ	θ	«θ»	«θ»
3) Plan of Operations Preparation					
4) Drilling					
a) Site Preparation					θ
b) Drilling Supervision					θ
c) Sampling					θ
d) Logging					θ
e) Assaying					θ
f) Compilation of Data					θ
g) Preparation of Maps					«θ»
E) LAND ACQUISITION					
1) Federal Mining Claims					
a) Claim Staking		■	■	■	■
b) Option/Lease of Claims			■	■	«ø»
c) Claim Maintenance			■	■	■
2) Private and State Leasing			■	«ø»	«ø»
F) EVALUATION					
1) Evaluation of All Inputs	■	O	O	O	O
G) REPORTING					
1) Bimonthly Reports	■	θ	«θ»	«θ»	«θ»
2) Archiving of Information & Data	■	O	O	O	O

LEGEND

Major Emphasis Activity	O
Minor Emphasis Activity	o
Future Activity	«ø» «θ»
Activity in Process	ø θ
Activity Completed	■

	INITIALS	DATE
PREPARED BY:	JAB	12/01/89

Sequence	Tasks	Description	Duration of Effort	Date From	Date To
1		Fly large scale color & black & white aerial photos	0.5 mo.	11/15/89	11/26/89
2		Prepare photo base maps 1" = 40'	0.2 mo.	11/26/89	12/04/89
3		Add computer topography to base - N end of pit to N end of lease block.	0.2 mo.	12/04/89	12/10/89
4	B[IV]	Reinterpretation of color photography.	1 mo.	12/01/89	01/01/90
5	D(2)(b)[V]	Detailed soil & soil gas & rock chip geochem sampling & analysis	2 mo.	12/15/89	02/15/90
6	D(2)(c)[V]	Detailed magnetometer/VLF survey (use Scintrex equip).	1 mo.	12/15/89	01/15/90
7	D(2)(c)[V]	Detailed CSAMT survey.	1 mo.	01/01/90	02/01/90
8	B(1)(a)[I]	Input all historic and recent data (all types) into computer data base	3.8 mo.	12/01/89	03/21/90
9	D(2)(d),(e)[V]	Compile, combine, analyze map data.	5 mo.	12/01/89	04/01/90

Sequence	Tasks	Description	Duration of Effort	Date From	Date To
10	D(3)[V]	Design drill program and apply for permits.	1.5 mo.	02/01/90	03/15/90
11	D(4)(a-g)[V]	Phase I - Shallow hole (50' to 300'), wide spaced drilling to determine geological parameters of bedrock. (approximately 10-15 holes)	1 mo.	03/15/90	04/15/90
12	D(4)f[V]	Input data into computer data base.	0.3 mo.	04/05/90	04/15/90

Sequence	Duration of Task Description	Date Effort	Date From	To
13	Project review.	0.25 mo.	04/15/90	04/22/90
14	Refine targets.	0.1 mo.	04/23/90	04/26/90

Sequence	Task Description	Duration of Effort	Date From	Date To
15	Phase II - Preliminary drilling consisting of approximately 30 500-foot holes.	1.0 mo.	04/27/90	05/27/90

Sequence	Task Description	Duration of Effort	Date From	Date To
16	Phase III - Grid drilling of detailed targets consisting typically of 90 500-foot holes	3.0 mo.	05/28/90	08/28/90
17	Prepare drill logs.	3.0 mo.	05/28/90	08/28/90
18	Prepare geological maps and cross section.	3.0 mo.	05/28/90	08/28/90
19	Construct geostatistical studies.	3.0 mo.	05/28/90	08/28/90
20	Calculation of proven and probable reserves.	1.7 mo.	07/18/90	08/28/90

Sequence	Task Description	Duration of Effort	Date From	Date To
21	Develop mine plan.	1.0 mo.	08/15/90	09/15/90

Sequence	Task Description	Duration of Effort	Date From	Date To
22	Prepare financial model.	0.3 mo.	09/16/90	09/26/90

Sequence	Task Description	Duration of Effort	Date From	Date To
23	Conduct preliminary metallurgical testing.	1.7 mo.	07/18/90	08/28/90

Sequence	Task Description	Duration of Effort	Date From	Date To
24	Prepare business plan.	1.0 mo.	09/26/90	10/26/90

Appendix C

JABA INC.
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-9141
(FAX) 721-2768

October 22, 1990

A. Douglas MacKenzie
Excellon Resources Inc.
Suite 200-20 Adelaide St.E.
Toronto, Ontario, Canada M5C 2T6

Dear Douglas:

You have asked me to comment on the difficult drilling conditions thought to be extant in the Contention Mine area, and how an effective drilling campaign can be mounted inspite of the drilling conditions.

First let me state that I think the difficulties in drilling in the area have been overstated. The drilling that was done in October and November of 1989 was done in the narrow bottom of the Contention open cut, where mining ended, and in an area of complexedly intertwined underground headings probably dating back to the 1890's, or perhaps somewhat earlier. No mapping and location of these workings was done prior to positioning of the drill holes, so that they could be avoided. Thus, many of the holes went into gob-filled workings within a few feet. After this problem was encountered, we started using a lost circulation polymer that helped substantially. However, the best remedy would have been to locate the old workings, using JABA's maps of them, and placing exploration holes so that they didn't penetrate old workings. This can be done using the new, detailed surface topographic map (in our computer) which is drawn on 1' & 5' contour intervals in the exploration area, combined with JABA's underground maps which we plan on digitizing into the computer. These tasks have been budgeted into the first phase of my exploration plan. Its worthy of note that our best hole, DH 89-33, which intersected significant gold mineralization including one 5' interval of 0.7 oz/ton gold, was drilled in Bisbee formation redbeds, away from old workings, and we had no problems with penetration or circulation.

Most of the rock in the Tombstone Basin is quite competent and stands well as attested by the accessability of a high percentage of the old workings, some of which are more than 110 years old. However, in the igneous Contention Dike (andesite - diorite) there has been substantial clay alteration, faulting and resulting softening of the immediate dike material. This may have been exacerbated by post mine subsidence into old headings. Thus, the

Contention dike itself and the immediate surrounding area, particularly in the vicinity of old workings, will be difficult to drill. However, most of our best targets, as exemplified by DH 89-33, will be in the surrounding, more competent sediments. If we avoid drilling into old headings, as we have planned, I don't anticipate unusual drilling problems. In fact, there are many targets located by JABA's geologic maps which appear to have been missed in the early days, and have no workings in the target areas. Drilling these targets should be routine. The competence of the sediments suggests that underground mining, below open pit levels, will be facilitated.

I hope these comments have addressed your concerns. The key, I believe, is a well planned program including pinpointing of the underground workings. That is our objective, and as we execute the plan, I see no reason to anticipate undue difficulty.

Very truly yours

James A. Briscoe

Tomestone District - Cochise Co. T20S R22E NE 1/4

This property was submitted to USMX by a Mr. Richard Brissenden, president of Excellon Resources, a company based out of Vancouver, B.C. They hold a lease from PBR-Cowichan Resources, another small Canadian company which controls a block of 39 claims owned outright by Tomestone Development Co.(TDC), a firm of private investors headquartered in Grand Island, NE. The leased claims cover most of the central and southeast portion of the main district(Fig 4). On 15 of these claims, Cowichan has the mineral rights to only a depth of 500 feet. Santa Fe Pacific leased the rights below that level and also control several TDC claims around Excellon's ground. Over the last three years they have drilled several deep holes and are now looking for a JV partner. They've had no luck and are reportedly getting ready to pull out.

Most mining activity in the district took place between 1877 and 1910. Because of low metal prices efforts were then sporadic up until 1930, after which underground mining essentially ceased. Although records are sketchy, it is estimated that the district has produced 260,000 ozs. of gold, 33 million ozs. of silver, 65 million lbs. of lead and 2.5 million lbs. of copper from ore averaging 0.21 oz/ton Au, 26 oz/ton Ag, 2.6% Pb and 0.1% Cu. Most mining was done in the oxidized zone from the surface to the water table at about the 600 foot level.

Serious recent activity commenced in 1973 when a Canadian group, 1971 Minerals Ltd., consolidated and successfully leached most of the dump material in the area. Another small company, Tomestone Exploration, Inc.(TEI), then took over a portion of the district in 1980 and began open pit mining and heap leaching along a 3000 foot strike length of the Contention fault and dike zone, a major mineralized northeast structure in the area(Fig 4). Poor management and low metal prices ended their efforts in 1984. Because TEI was a private company financial records are not available, but indications are that more than $40 million of gold and silver were produced.

In 1988 Cowichan Mines Ltd. took over the lease and resumed mining in the Contention pits. They constructed a Merrill-Crowe recovery plant and heap leach complex capable of treating 3000 tons per day of low grade gold-silver ore. A lack of expertise quickly led to a halt in production. In 1989 they hired Jim Briscoe, a consulting geologist out of Tucson who has been involved in the district off and on since 1972, to more fully evaluate ore reserves and help with mine planning. They drilled 35 reverse circ holes and dug several sample trenches mainly within the pit area(Figs 5 and 6). A combination of old workings and intensely broken, clayey ground resulted in most holes being abandoned at depths of less than 50 feet. Assay results from the better mineralized holes are shown in figure 7. The best hole, 89-33, drilled in the bottom of the pit to the west at an angle of 60 , intersected 65 feet of 0.12 oz/ton Au.

The trench samples shown in figure 6 reveal intermittent zones of ore grade gold and silver mineralization.

A lack of funds prevented Cowichan from completing their program. They, therefore, entered into a lease agreement on their holdings with Excellon Resources and have since filed for bankruptcy under Chapter 11.

Excellon has retained Jim Briscoe to find an interested party to take over their lease and subsequently develop the district.

Briscoe spent two days giving me a general overview and field tour of the district. His company, Jaba, Inc., is now compiling voluminous amounts of old and recent data on to a computer map and data base. The resulting product will be detailed topo base map showing surface and underground assay values along with geological and structural features facilitating the location of viable drill targets. They've completed such a map for a small portion of the area.

The Tomestone district is part of a northeast trending mineralized zone which measures 10 miles in length and 3-4 miles in width(Fig. 8). Based on regional geochemical and geological studies, Briscoe and others have concluded that this system is a manifestation of three porphyry copper centers which in turn are part of a large Laramide caldera complex. They determined that the main district represents the outer halo of one of these centers which lies beneath the southeast corner of the town of Tomestone.

Mineralization in the main district is hosted by interbedded shales, quartzites and limestones of the lower Cretaceous Bisbee fm, the Basal Glance conglomerate and the underlying Penn-Perm limestones of the Naco fm. These sediments are cut by numerous pre-mineral north-south trending andesite porphyry dikes which are often mineralized along their contacts. Late Cretaceous igneous rocks, the Schieffelin granodiorite and the Uncle Sam latite tuff are hosts for ores in the western and southern parts of the district.

The bulk of the Tomestone ores are silver chlorides and lead, copper and zinc carbonates with amounts of gold varying from sub economic to high grade bonanza-type values. They are associated with hematitic and limonitic clay-sericite alteration and/or silicification.

The mineralization occurs predominantly along northeast high angle fissures. Where they intersect other high angle shears and/or NW trending tight anticlinal drag folds, more massive bodies are formed. Favorable limy units also play a role in localizing larger bodies of ore.

Briscoe recommends the NE fissure vein-NW drag fold intersection as a viable target for bonanza-type gold-silver deposits. Two such bodies are known to exist in the district. Both contained between 5,000 and 10,000 tons with Au and Ag grades of 2-3 oz/ton and 100's of ozs/ton respectively. His partially completed computer map shows several of these targets, as yet untested.

His other target is a potential bulk tonnage mineable deposit which would lie along the south flank of his proposed buried porphyry copper center along the Contention fault zone near and within the open pit area. Mineralization here is located at high angle shear zone and drag fold intersections. On the basis of old underground data and the recent drilling and trench sampling, Briscoe concludes that there is potential here for occurrence of an open pittable ore body containing in excess of one million ozs. of gold and several million ozs. of silver.

He also feels that other targets exist along outlying vein systems in the Uncle Sam tuff. The underlying contact with the Bisbee sediments may provide a permissive environment for deposition of high grade precious metal deposits. One such area is the State O Maine zone which is situated about 1 1/2 miles south west of the main district. Jaba has a large land position in this area.

On the basis of my observations I feel that these targets described above are viable and rate the district overall as a top priority exploration play. Of course, the area is not without its' problems. The major concerns are: 1) Santa Fe's presence, 2) proximity to the town and presence of 5 or 6 homes in the Bonanza-type target area and 3) Cowichan's bankruptcy status. However, these are not formidable problems - Santa Fe will probably leave; the residences can most likely be bought at depressed real estate prices (the town itself is suffering from recession); and, according to Briscoe the bankruptcy litigation is about to be resolved.

It is unfortunate that at this time, the property cannot compete with other submittals on our plate and has to therefore be moved to "back burner" status. However, when this situation changes, we should move immediately to negotiate for the pertinent available properties in the district.

G. SCHELL
2/5/92

JABA INC.
2100 N. Wilmot Rd. #218
Tucson, AZ 85712
(602) 885-8141
(FAX) 721-2768

Mr. A. Douglas MacKenzie
Vice President
Excellon Resources Inc.
Suite 200 -20 Adelaide St. E.
Toronto, Ontario Canada M5C 2T6

Re: Interim Report on Tombstone to the end of July 1992

Dear Douglas

We have wound up our interim efforts in compilation of geology, mine workings, stopes, drill holes and miscellaneous other data on the computer. To this time, this work has been done using AutoCAD Release 10 on our 386 computer. The data has been compiled in 3 dimensional format. We are probably 20% to 30% done with entry of the existing data on Tombstone. The data so far entered into the computer is presented on a 1" = 200' print out at the same scale as our hand-drawn geology over orthophoto map, both transmitted with this report. This printout has a lot of data in it, much of which is hard to see at this scale. It also shows the extent of the topographic contour map commissioned by PBR Minerals Inc. -and demonstrates its inadequate coverage. We have also provided a printout of the central portion of this map at a scale of 1"= 50' for comparison purposes. Of course the computer can print the data at any appropriate scale. Both of these computer maps are draft copies. A final working print will be printed in a different way for greater crispness and legibility.

Significant data not yet entered include:

Accurate patented claim data compiled by Tom Waldrip from the distance and bearing information on the patent survey from the original GLO (Government Land Office) plats. This data is surveyed from U.S.M.M. (United States Mineral Monument) 1 & 2 and two intermediate survey points that date back to the early days of the district. When we put this data into the computer, it will reveal the true boundaries of the claims.

Surface geochemistry from samples taken by several different companies in the last 18 to 24 months.

Drill hole locations and data obtained during the exploration performed by Santa Fe Minerals in the last 4 to

James A. Briscoe, Registered Professional Geologist, Arizona [illegible], California [illegible]

6 years, peripheral to the Contention Lease.

Newmont underground and surface drilling done in the early 1950's.

Minor rotary drilling done by the Duval Company in the mid-1960's.

Underground mining and exploration done by the Eagle Pitcher Co. in the 1930's & 1940's.

Underground mining and exploration done by the U.S. Smelting & Refining Co. done in the 1940's.

We either have or know the location of all the above except for the U. S. Smelting data, and we think we know where it is located.

We will be upgrading our computer to a 486, 50 megahertz machine using AutoCAD Release 12, just released within the last 2 weeks. We will also probably be using a second program which interfaces with AutoCAD called AutoMINER. This combination of hard and software will increase speed very significantly - perhaps in excess of 20x. It is completely compatible with the data already entered.

However, until we get a 3-dimensional topographic map which we can enter into the computer, we can't take true advantage of its 3-dimensional aspects. Land surveying and photogrammetry has undergone drastic changes in the last two years in response to the availability of powerful microcomputers. Instead of simple graphic topographic maps, essentially all photogrammetric companies have gone to digital elevation model (DEM) maps. These are smart maps, and will interface with our computer so that the terrain can be displayed as a traditional topographic map, or in several other ways. We can add our X-Y-Z three-dimensional data to it, including geology, underground workings, stopes, orebodies, drill holes, etc., and look at it from various angles, calculate volumes, ore reserves, etc. It will also allow us to combine the various surveys that have been performed in the Tombstone District over the last 100 years, and get them all to correspond to the current State datum reference plane. Currently, our maps have as much as 200 feet of "play" in the various surveys. This means we cannot determine within 200 feet where we can expect to encounter targeted, ore-bearing geologic features -- an untenable situation.

I met with Mr. Lyle Slater, VP of The Tucson Orthoshop, a subsidiary of a Canadian firm that supplies photogrammetric mapping and DEMs. They have state-of-the-art equipment, and at the end of July installed the most recent computer driven photogrammetric analyzer available. We designed a new color photo and mapping program that ties in with my recommendation that photography be flown at or before start up at Tombstone. We designed this program so that we can start with just the central Tombstone District, and add to the area incrementally, as our area of exploration and development becomes larger. The added blocks will stitch perfectly and with the same precision to the existing block. This will require a base triangulation survey of 18 points, plus the U.S. Mineral Monuments 1 & 2, and their two secondary points. They will use GPS (Global Positioning Satellites) rather than a ground crew with theodolite to survey in the triangulation base — much less expensive and time consuming. With this triangulation net, all the old surveys and maps done over the last 100+ years can be tied into the same datum plane. Our surface geology will then correspond to the underground data, etc. This survey will need about two weeks notice to schedule, and cost about $15,000.

This topographic and planimetric mapping base should be adequate for all exploration, reserve calculation and mine planning, environmental, land ownership, or thematic mapping into the indefinite future. It will allow us the accuracy and orthophoto base for our exploration efforts, and will transition into all other map base requirements.

UPDATE ON HYPOTHETICAL AND POSSIBLE ORE RESERVES

While there is much compilation work yet to be done to fully take advantage of all the previous work done at Tombstone over the last 100 years (amounting to millions in present dollars), which will save us tens, if not hundreds of thousands of dollars in exploration expense, there is some important conclusions that can be drawn from work in the last 18 months.

The most important recognition, stimulated by David Shaw, recently of Bema Gold, and now a private consultant, was that the high gold zone penetrated by drill hole 89-33 almost certainly represents shattered and mineralized Cretaceous redbeds along the axis of the West Side (Sulphuret) Roll. Once this was recognized, it became immediately apparent that great continuity of this shattered zone was probable along the entire length of the West Side Roll. A check of Ransome's cross-section across the West Side Roll at the West Side Shaft, shows that the redbeds over the Roll and the next Roll to the south - the Boss Terrace - are pervasively mineralized and were mined from the 400 foot level, almost but not quite to the surface. Geologically, it appears that the mineralization can be projected to the 800 foot level -- it was probably not mined in the early days because of the water table. These workings were mined early in the development of the district, and were inaccessible during Ransome's work, and no assay data was extant. However, we know the average grade for the early production was 0.3 oz. gold and 40 oz. silver. The assumption can be made that these stopes are in that grade range. The combination of the two Rolls (Sulphuret and Boss), are 1,000 feet in width.

The Butler Wilson volume states that ore "makes" on the Rolls at the intersection with the Fissures (northeast-trending veins). However, there are so many ore zones on the Rolls not associated with any known Fissure, that no rule can be established. Further, there are many, many more Fissures than have been named or mapped. Thus, I conclude that there is every reason to believe that what we consider open-pitable ore grade mineralization may occur with great continuity in the shattered redbeds along the axis of the Rolls (anticlines) throughout the District, and in particular, along the West Side and Boss Rolls.

On close examination of the geologic map over the orthophoto, we find that most, if not all the shattered rolls, form topographically low areas or gullies, while the compressed non-mineralized synclines between form ridges. This is logical and corresponds to many districts throughout the world where soft mineralized zones are found in soil-covered topographic lows.

The recognition that ore forms topographic lows may explain why no recent ore bodies have been located at Tombstone. All recent workers (certainly those company geologists who have sampled Tombstone in the last 24 months) have low-graded themselves by sampling rock exposures. The best values are probably under soil and alluvium in the bottom of stream channels - not in outcropping rock. Further, surface material, as indicated on the West Side cross-section, is leached of most precious metal values, which are precipitated some feet to tens of feet below the surface. Anecdotal reports of this phenomena were reported to Tom Waldrip during mining along the Contention Zone by T.E.I., in the early 1980's.

The accompanying orthophoto - geologic map shows the extent of the Boss Terrace and the West Side (Sulphuret) Roll. Geologically, the area to the east of the Contention fault has every reason to be as favorable as the area to the west, from whence all the past production has come. However, left lateral dip slip movement along the Contention Fault Zone (apparently previously unrecognized) has displaced productive zones known on the northwest side, beneath cover and dislocated them from underground workings on the west. The east side of the

Contention fault has never been significantly explored.

These ore finding criteria have gone unnoticed and thus no zones that I have outlined on the attached map and sepia overlay have ever been drill tested. These zones are rough approximations and cannot be considered complete until our map base and data compilation is complete. At that time we will be able to be pretty specific about geologically favorable ore targets. These will then have to be followed up with geochemistery, geophysics, fill in geologic and alteration mapping, followed by drilling — the exploration program I designed and have advocated all along.

However, using known criteria such as the known productive Rolls, Fissures and Dikes and their fault offsets, I have sketched out four major blocks which should contain openpitable values. In the case of the major West Side - Boss Rolls block, I have subdivided it into seperate blocks related to mine openings or structural features. These are detailed on the overlay to the Orthophoto-Geologic Map. Except for the "Bema Zone" which runs northwest from drill hole 89-33 in the Contention open pit to the West Side Mine, where geologic data from Ransome suggests ore could go down to 800 feet, the other zones I have projected from the surface to 500 feet. Within the geologic boundaries of the favorable zones and to a depth of 500 feet (except the Bema Zone which goes to 800 feet) there is 389 million tons of potentially ore bearing rock. If 10% of this rock contains 0.04 oz per ton recoverable gold equivalent (I believe a conservative figure) there is a potential tonnage of 38 million tons containing 1.5 million ounces of gold equivalent. The gold equivalent grade is based on Bema's assays along the breccia zone (exposed in the bottom of the Contention Pit) thought to represent the axis of the West Side Roll, showing 0.05 opt gold and 3 opt silver. As we can tell from the old records examined to date, there will be many bonanza grade zones encountered in the mining of this low grade reserve that will contain + 1 opt gold and +100 opt silver. To treat this higher grade material, a mill facility will be necessary, while the lower grade material will be heap leachable. Only a few drill logs are available so far but one of these shows a 6 foot intercept of 16% zinc and 10% lead mineralization. The district has produced significant lead and zinc, and I had a conversation with a knowledgeable geologist some 10 years ago who had a chance to examine the old Eagle Pitcher records. He concluded there was potential for a substantial zinc deposit.

Thus I conclude there will probably be significant lead zinc ore bodies discovered. As we proceed northeastward toward the porphyry copper center, high grade copper skarn mineralization perhaps with associated gold (like that at Battle Mountain Nevada) will be encountered.

Very truly yours

James A. Briscoe

A. D. MacKenzie
August 7, 1992
Interim Tombstone Report
Page 6 of 6

STERLING EXPLORATION

PRECIOUS METALS EXPLORATION CONSULTANTS
3007 LOUISIANA NE, SUITE C
ALBUQUERQUE, NEW MEXICO 87110, U.S.A.
TELEPHONE (505) 884-7262

THE TOMBSTONE SOUTH PROPERTY:

An area of Recently Recognized and Unexplored Mineralized Breccia Masses and Lineaments in a Pediment on the Southern Edge of the Tombstone Mining District.

Cochise County, Arizona

September, 1986

I. INTRODUCTION & BACKGROUND INFORMATION

The Tombstone South Property was located and recognized for what it is as the result of a four year study of carbonate replacement orebodies in the southwestern United States and northern Mexico. The world class carbonate replacement districts of Santa Eulahia and Naica in Chihuahua and the Warren (Bisbee) District in southeastern Arizona, as well as the smaller Bonzana Districts of Tombstone, Lake Valley, Turquoise (Courtland-Gleeson) and Swisshelm were all examined, mapped and sampled underground and on the surface directly over ore and all serve as a valuable geologic-geochemical models.

Jasperoids, where associated with carbonate replacement orebodies, were examined and sampled and the relationship of jasperoid to ore carefully mapped and recorded. The geochemical portion of this study entailed 1,605 individual assays. The results of this study geologically and geochemically distinguished between jasperoids directly associated with ore, jasperoids associated with distal ore and non-ore bearing jasperoids. Most importantly, this study identified the presence of manganese oxide and in particular the geochemistry of this manganese oxide as a reliable indicator of proximity to carbonate replacement ore and of the probable composition of that ore.

MnO soaked limestone, and/or Mn rich pink calcite veinlets and/or black crystalline calcite veinlets anomalous in Ag, Pb and Zn and often Au and Cu commonly overlie carbonate replacement orebodies in all of the districts studied in the southwestern United States and northern Mexico. The manganese-carbonate replacement ore association has also been noted in the Pioche, White Pine and Tybo Districts of Nevada, the Ophir and San Francisco Districts of Utah, as well as many of the orebodies in the Leadville District, Colorado.

Manganese oxide was mined in the Warren and Tombstone Districts of Arizona and the Lake Valley District, New Mexico during World War I and during the 1950's. In all cases this manganese ore overlay the carbonate replacement precious-base metal orebodies. No place is the association of MnO ore carbonate replacement ore more clear and direct as in the Tombstone District. To quote from USGS Bulletin 143 by F. L. Ransome:

> "The association of the manganese ores with silver ores in the Tombstone district is much closer than that of the manganese ores with copper ores at Bisbee. In fact, as already pointed out, no real distinction is recognizable between the manganiferous silver ores and the argentiferous manganese ores. Moreover, their relations as regards position are more intimate, and in some places one kind of ore

> passes into the other. There is apparently some ground for regarding the manganese ores of Tombstone, in part at least, as the oxidized upper portions of silver deposits, from which some materials have been leached or abstracted and in which some of the manganese from formerly existent higher parts of the deposit has been concentrated."

The Tombstone South Property was chosen through an extensive literature search for initial field examination because it was the only property mined for manganese (although on a very superficial scale) that was not known to overlie bonzana grade carbonate replacement silver ore in the Tombstone District.

II. LOCATION & OWNERSHIP

The Tombstone South Property is located 4.5 miles southwest of the town of Tombstone, Arizona. It can be reached by going southwest out of Tombstone on the paved Charleston Road a distance of 4.5 miles from the town limits, then turning left (southeast) on a dirt road and proceeding a distance of 0.7 miles to the old manganese trenches that partially expose the major bodies of mineralized breccia.

The property consists of recently acquired Arizona State leases (the eastern 3/4's of Section 32, T20S, R22E) with a total of 461.89 acres and ten unpatented lode mining claims surrounding the state lease on the north and east (see land maps).

The entire prospect is leased and claimed by:

Manuel Hernandez
P. O. Box 61
Pearce, Arizona 85625

and

Philip J. Sterling
3007 Louisiana Blvd., N.E.
Albuquerque, New Mexico 87110

III. PRELIMINARY GEOLOGY & GEOCHEMISTRY

The Tombstone South Property is a very poorly exposed inlier of the sandstones, shales and limestones of the lower Bisbee formation (Cretaceious) surrounded by younger andesitic volcanics.

Known carbonate replacement orebodies in the Tombstone District were in the lowermost Bisbee Fm. and in the upper Naco group which immediately underlies the Bisbee Fm. The following carbonate units underlie the Bisbee Fm. in decending order in the Tombstone area.

	Formation	Thickness
Naco Group Permian-Penn.	(Epitaph dolo.	783'
	(Colina ls.	633'
	(Earp fm.	584'
	(Horiquilla ls.	999'
Mississippian	(Escabrosa ls.	786'
Devonian	(Martin ls.	230'
Cambrian	(Abrigo ls.	844'
	Total measured thickness	4,859'

All of the above listed carbonate units are potential host rocks and do host carbonate replacement orebodies in nearby mining districts.

The ore controls of carbonate replacement orebodies within the known Tombstone District are quite simple. The ore channels or feeders are high angle northeast striking fissures and the ore controls are the intersection of these feeders with favorable structures and rocks. Stratigraphic and lithologic seals to trap ascending mineralizing solutions and spread them into favorably structurally prepared limestones were provided by shales and intrusives.

Structurally, the Tombstone South is much more intensely faulted than the Tombstone District. Exposures are very poor on the Tombstone South Property but the trenches bulldozed for manganese exploration show large east-west trending breccia masses formed at major structural intersections. Suboutcrop and small prospect pits show major mineralized and altered northeast structures and northeast linear breccias. As in the Tombstone District, these northeast structures are ore channels as evidenced by their high precious and base metals content (see assays under northeast structures).

As outlined under structure above, two types of potential carbonate replacement orebodies are recognized at this early stage; breccia pipe and linear breccia orebodies and orebodies associated with major northeast structures.

1. <u>Breccia Pipe and Linear Breccia Carbonate Replacement Orebodies:</u> The breccia masses in the northern portion of state section 32 were not exposed during the life of the bonanza ores in the Tombstone District. These breccias were at that time

covered with a thin veneer of sand and gravel. The breccias were discovered by a manganese prospector following manganese oxide float and digging prospect pits through the alluvial cover during the late 1940's. In 1954, the Arizona Materials and Service Company did some shallow trenching using bulldozers and shipped a small but unrecorded amount of manganese ore (see Photo 1). A few shallow rotary drillholes were drilled in the vicinity of the breccias probably during the 1950's and probably for manganese.

Two linear breccias and two breccia pipes were exposed by trenching and in small prospects pits and it is possible that other breccias exist under shallow cover.

Breccia #1 (see topo map) is a poorly exposed linear northeast striking breccia. The breccia is develped in sandstone of the Bisbee Fm. and consists principally of angular quartzite and silicified limestone fragments in a matrix of quartz, hematite, manganese oxide, limonite after sulfides and minor cerargyite. The breccia is exposed only in prospect pits where the exposed thickness is 3 feet. Float and suboutcrop from this NE lineament can be traced 300 feet to the southwest where it disappears under thicker cover. One representative sample taken from this linear breccia assayed as follows:

Au	Ag	Cu	Pb	Zn
.006 oz/T	18.6 oz/T	3800ppm	7.0%	2400ppm

Breccia #2 (see topo map and Photo 2) is an east-west trending linear breccia composed of angular fragments of quartzite and silicified limestone in a matrix of MnO, quartz and limonite after sulfides. This breccia is vuggy and the vugs are lined with small quartz crystals. It is poorly exposed and can be seen only in small prospect pits opened up several hundred feet along strike. The hanging and footwall of the breccia was not observed in these pits, however, it is probably no thicker than 10 feet. One representative sample of this breccia assays as follows:

Au	Ag	Cu	Pb	Zn
.001 oz/T	0.145 oz/T	70ppm	3800ppm	2400ppm

Breccia #3 (see topo map and Photo 3) is a major area of brecciation, is exposed over an area of 300 feet east-west and 100 feet north-south, surrounded by thin pediment cover and open in all directions. The breccia is composed of angular fragments of quartzite, silicified limestone and jasperoid in a matrix of manganese oxide, quartz and limonite after sulfides. Much lesser amounts of crackle breccia are exposed containing a strong stockwork system of quartz, quartz-MnO and quartz-limonite after sulfide veinlets. This breccia mass is a major structural intersection and fractures and fracture filled veinlets strike in every direction, however, are strongest east-west, north-south and N50°E. This breccia mass is interpreted as a structural breccia. A sample of this brecciated leached capping assayed as follows:

Au	Ag	Cu	Pb	Zn
.001 oz/T	1.23 oz/T	500ppm	770ppm	2420ppm

Breccia #4 (see topo map and Photo 4) is identical in every respect to Breccia #3 and as the area between Breccias 3 & 4 is covered, they could be the same breccia pipe. Breccia #3 is poorly exposed in trenches and prospect pipes over an area of 100 feet east-west and 50 feet north-south is surrounded by thin alluvial cover, and is open in all directions. A sample of the brecciated leached cappings assayed as follows:

Au	Ag	Cu	Pb	Zn
0.003 oz/T	0.93 oz/T	290ppm	5500ppm	3500ppm

2. Carbonate Replacement Orebodies Associated with Northeast Structures: The other obvious potential of the Tombstone South Property is the major N50° to 60°E lineaments poorly exposed in suboutcrop and in prospect pits in the southern portion of state section 32. Two of these are sketched on the topo map but detailed mapping, geochemical sampling and shallow trenching is needed to define these targets. These lineaments are composed of parallel veins, stockwork veinlets, silicified and argillized limestone, hematite, limonite after sulfides and rare cerargyite. They are in part brecciated.

Linear #1 has two fairly large shafts and dump on it and many small prospect pits and shafts. In none of these workings is an unaltered/unmineralized hanging or footwall exposed. Poor to non-existent exposures confine observations and sampling to these workings, but I have the definite impression that they were in a major structure (100 feet or greater wide) prospecting for small high grade lenses. Trenching, mapping and detailed sampling is needed to determine if this structure has a large tonnage (perhaps bulk mineable) potential. One sample was taken from one of the prospect pits and assays:

Au	Ag	Cu	Pb	Zn
0.002 oz/T	8.84 oz/T	2900ppm	3.26%	5800ppm

Linear #2 has only one small prospect pit within it but is traceable for greater than 600 feet by observing float and suboutcrop. Again, it appears to be a very wide (100'±) zone of alteration and mineralization and requires trenching to define it. The following sample of high grade quartz float (nowhere near a prospect) was found in suboutcrop within the linear:

Au	Ag	Cu	Pb	Zn
0.012 oz/T	26.5 oz/T	3.0%	3.1%	1.67%

IV. EXPLORATION TARGETS AND GENERAL RECOMMENDED EXPLORATION PROCEDURES

I. Exploration Targets:

Two types of exploration targets exist on the Tombstone South Property.

1. Large tonnage, low to moderate tenor, bulk mineable, perhaps heap leachable silver-lead (±gold) orebodies, and

2. Moderate to low tonnage high tenor silver-lead (±gold) orebodies mineable by underground methods.

The exploration effort should concentrate on both of these targets:

1. Bulk Mineable Silver Targets

a. The two large breccia masses (breccias 3 & 4) in the NE/4 of Section 32 have bulk mineable potential. Leached capping assays over 1 oz/T Ag.

b. The major mineralized northeast lineaments in the southern portion of Section 32 have bulk mineable potential in a stockwork system.

c. So much of the property is covered by thin pediment that other large breccia masses and mineralized lineaments are most likely to be present and must be considered discoverable targets.

2. High Tenor Orebodies

a. Most mineralized breccia pipes (breccias 3 & 4) are not uniformly mineralized and often contain a high grade portion.

b. The linear breccias (breccias 1 & 2) show promise of high tenor (breccia 1 assayed 18.6 oz/T Ag and 7% PB) and if traced to an intersecting structure along strike or drilled to the intersection of a favorable bed at depth, the tonnage potential would be improved.

c. High grade veins exist in the mineralized northeast trending lineaments as evidenced by the float found in sub-outcropping northeast Linear 2 which assayed 0.012 oz/T Au, 26.5 zo/T Ag, 3.0% Cu, 3.1% Pb, and 1.67% Zn.

d. Strongly mineralized and altered float is present over much of the property and other lineaments and breccias containing high grade portions are certainly discoverable.

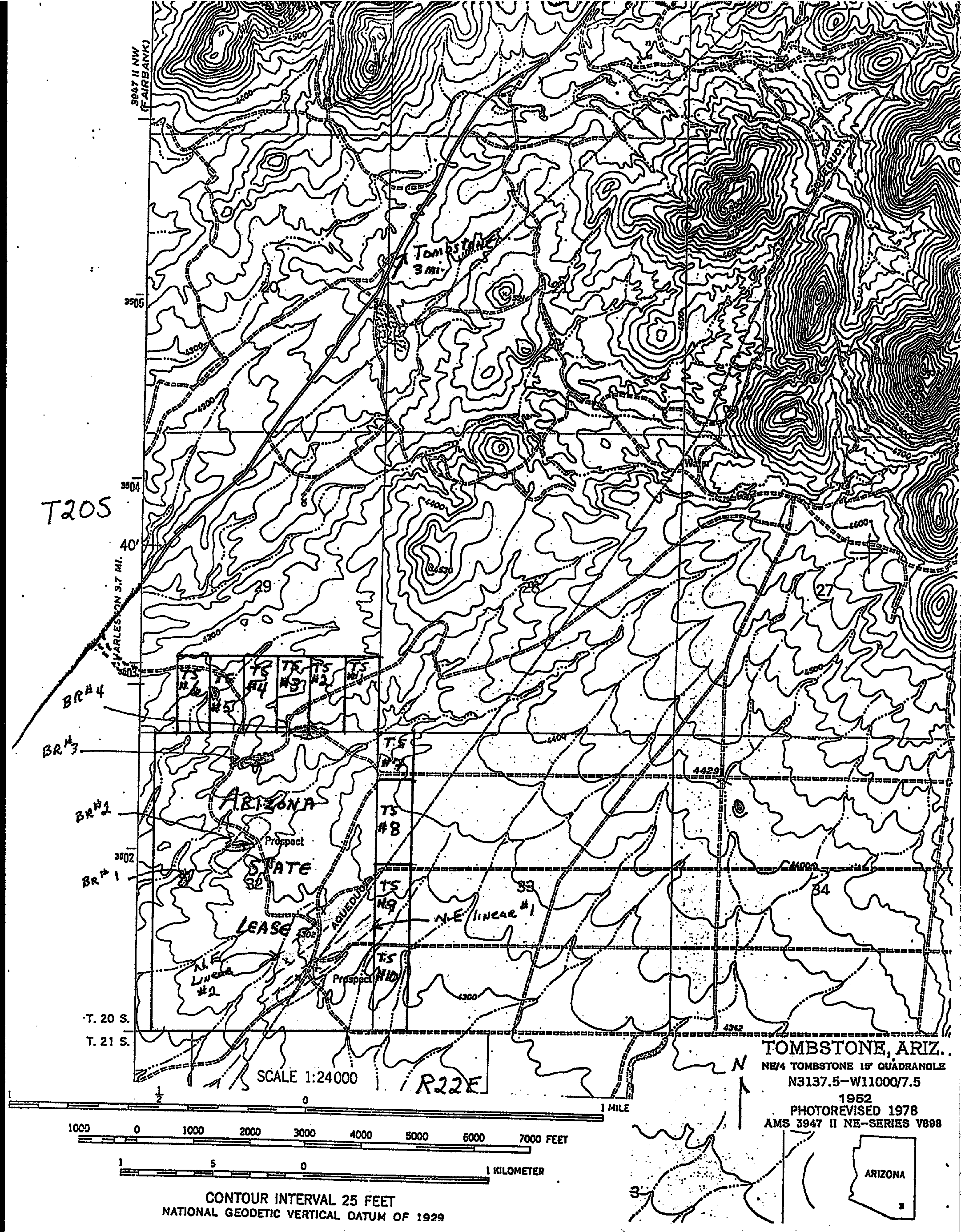
II. Recommended and General Exploration Procedures:

At this early date in the exploration of the Tombstone South Property only general exploration procedures can be recommended. More exact procedures will depend on the results of these recommendations.

1. Geologic mapping at a scale of 1"=500' using a airphoto or grid (the topo map of the area is to featureless to be used) of the workings, outcrop, suboutcrop and float. Geochemical sampling of altered and mineralized rock should accompany the geologic mapping and samples assayed for Au, Ag, Cu, Pb and Zn. Soils over known mineralized areas should be sampled to determine if soil sampling would be a viable tool to locate totally covered mineralized zones.

2. Trenching and detailed geologic mapping (1"=50') and close spaced geochemical sampling of the mineralized zones outline in 1. above.

3. Further trenching and/or drilling as indicated by 2. above.



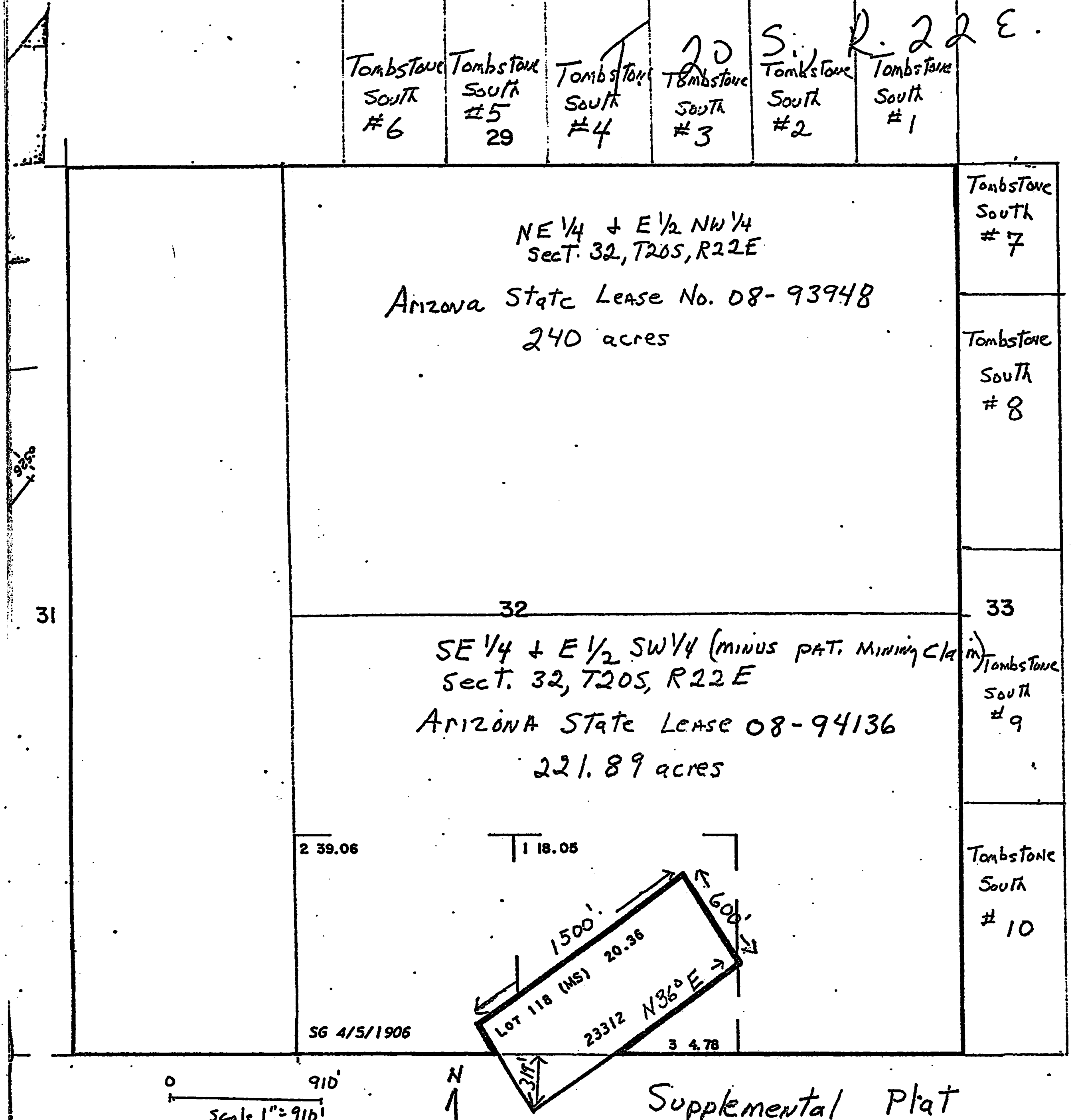
3947 II NW (FAIRBANK)
Tombstone 3 mi.
3505
3504
T20S
40'
CHARLESTON 3.7 MI.
3503
3502
29
28
27
32
33
34
TS #6
TS #5
TS #4
TS #3
TS #2
TS #1
TS #7
TS #8
TS #9
TS #10
BR#4
BR#3
BR#2
BR#1
ARIZONA
STATE
LEASE
Prospect
AQUEDUCT
N.E linear #1
N.E linear #2
Water
4429
4362
4302
T. 20 S.
T. 21 S.
R22E
SCALE 1:24000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
N
TOMBSTONE, ARIZ.
NE/4 TOMBSTONE 15' QUADRANGLE
N3137.5—W11000/7.5
1952
PHOTOREVISED 1978
AMS 3947 II NE—SERIES V898
ARIZONA

RANGE 22 EAST OF THE GILA AND SALT RIVER MERIDIAN, ARIZONA

STATUS OF PUBLIC DOMAIN
LAND AND MINERAL TITLES

MTP

SUPPL Sec 4,9,32



Supplemental Plat
Section 32, T20S, R22E
Cochise County, Arizona

INDEX TO SEGREGATED TRACTS				
RESURVEY	ORIGINAL SURVEY			
TRACT NO	T	R	SEC	SUBDIVISION

FOR ORDERS EFFECTING DISPOSAL OR USE OF UNIDENTIFIED LANDS WITHDRAWN FOR CLASSIFICATION, MINERALS, WATER AND/OR OTHER PUBLIC PURPOSES, REFER TO INDEX OF MISCELLANEOUS DOCUMENTS.

DIST. NO. 4

PHOTO 1. Taken along shallow manganese exploration trench from Breccia #4. Looking northeast with the Tombstone Hills in background. Note pediment cover and very poor exposures. Nearest Ag producer 9000' to the northeast.

PHOTO 2. Breccia #2. East-west trending linear breccia. Quartzite, silicified ls. and jasperoid angular fragments in a matrix of MnO, quartz and limonite after sulfides. Strongly anomalous in Ag & Pb and anomalous in Zn.

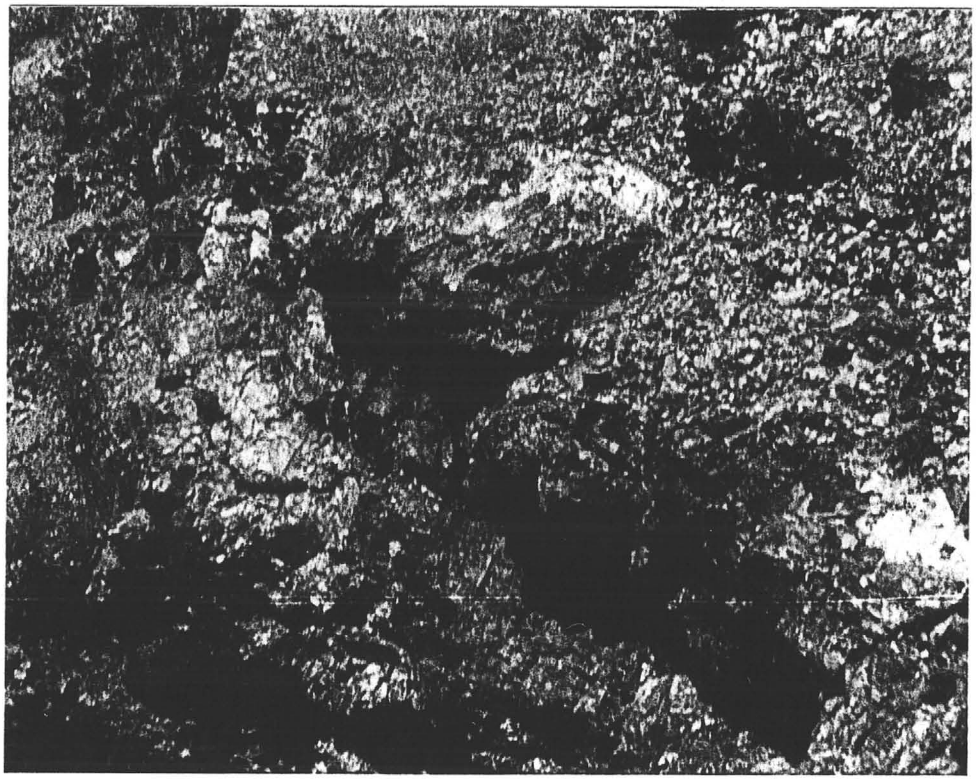


PHOTO 3. Breccia #3. Breccia mass exposed in shallow trenches for 300' east-west and 100' north-south. Surrounded by thin alluvial cover and still open in all directions. Major structural intersection between N-S, E-W and N50E faults. Composed mostly of true breccia with quartzite, silicified ls. and jasperoid angular fragments in a matrix of MnO, quartz and limonite after sulfides with lesser amounts of crackle breccia with stockwork quartz, quartz-MnO and quartz-lm at sulfide veinlets. Interpreted as a structural breccia pipe. Strongly anomalous in Ag (1.23 oz/T) Cu, Pb and Zn.

PHOTO 4. Breccia #4. Exposed in shallow manganese prospect pit and trenches over an area 100' east-west and 50' north-south surrounded by thin alluvial cover and open in all directions. Same composition and structural origin as Breccia #3 with both true breccia and crackle breccia. Interpreted as a structural breccia pipe. Strongly anomalous in Ag (0.93 oz/T) Pb, and Zn. Anomalous in Au and Cu.

TOMBSTONE PROJECT,
COCHISE COUNTY, ARIZONA

Santa Fe Pacific Mining's Tombstone project is located 65 miles southeast of Tucson, and 20 miles northwest of Bisbee, in central Cochise County, Arizona. Patented mining claims, leased from Tombstone Development Company in 1987, cover the bulk of the historic mining district which lies immediately south of the town of Tombstone (Figure 1). Production is estimated to have been 2.9 MMT of ore which yielded, with poor recovery methods, 29.8 MM oz of silver, 248 M oz of gold, 35.7 MM lbs of lead, as well as considerable quantities of copper, zinc, and manganese. Since 1911, exploration in the district has been very limited; the small drilling programs that were undertaken were largely confined to areas above the water table, approximately 500 feet below the surface.

The ores exploited in the district occurred primarily in the Cretaceous Bisbee formation which blankets the entire basin to a depth of 500 to 600 feet. Within the Tombstone basin, the Bisbee is underlain by in excess of 4000 feet of Paleozoic carbonate rocks ranging in age from Cambrian to Permian. Production records verify an increasing gold to silver ratio with depth in several parts of the district.

The style, geometry, mineralogy, and geochemical zoning of the known mineralization in the Tombstone district are typical of the upper or outer fringes of a large CRD system. That the bulk of known mineralization occurs in the thin limestone units of the Bisbee formation, suggests that larger CRD orebodies may have been developed in the thick Paleozoic carbonate section known to underlie the Cretaceous in the Tombstone basin. These carbonates host substantial CRD ore elsewhere in southeastern Arizona, most notably in the Bisbee-Warren district.

The results of surface and underground mapping and sampling, as well as a review of the records and literature, established several types of drill targets: fissure-replacement veins, chimney and manto replacements, and breccia pipe-related ore. These targets are schematically illustrated in figure 2. To date, only a very minimal amount of drilling has been completed in an attempt to evaluate a few of the above target classes. Seven core holes have been completed, with an aggregate footage of 19,041 feet. Basic results demonstrate the presence of ore grade mineralization and general viability of the exploration concept. The best thick intercept to-date is 23.5 feet @ 6.5% Pb, 2.6% Zn, 0.6% Cu and 1.1 oz/T Ag on a replacement vein while a high grade thin, shear bounded intercept on a chimney target assayed 17.3% Zn, 3.2% Pb, 0.8% Cu and 31.0 oz/T Ag over 0.5 feet.

SCHEMATIC BLOCK DIAGRAM OF A PART OF THE TOMBSTONE MINING DISTRICT

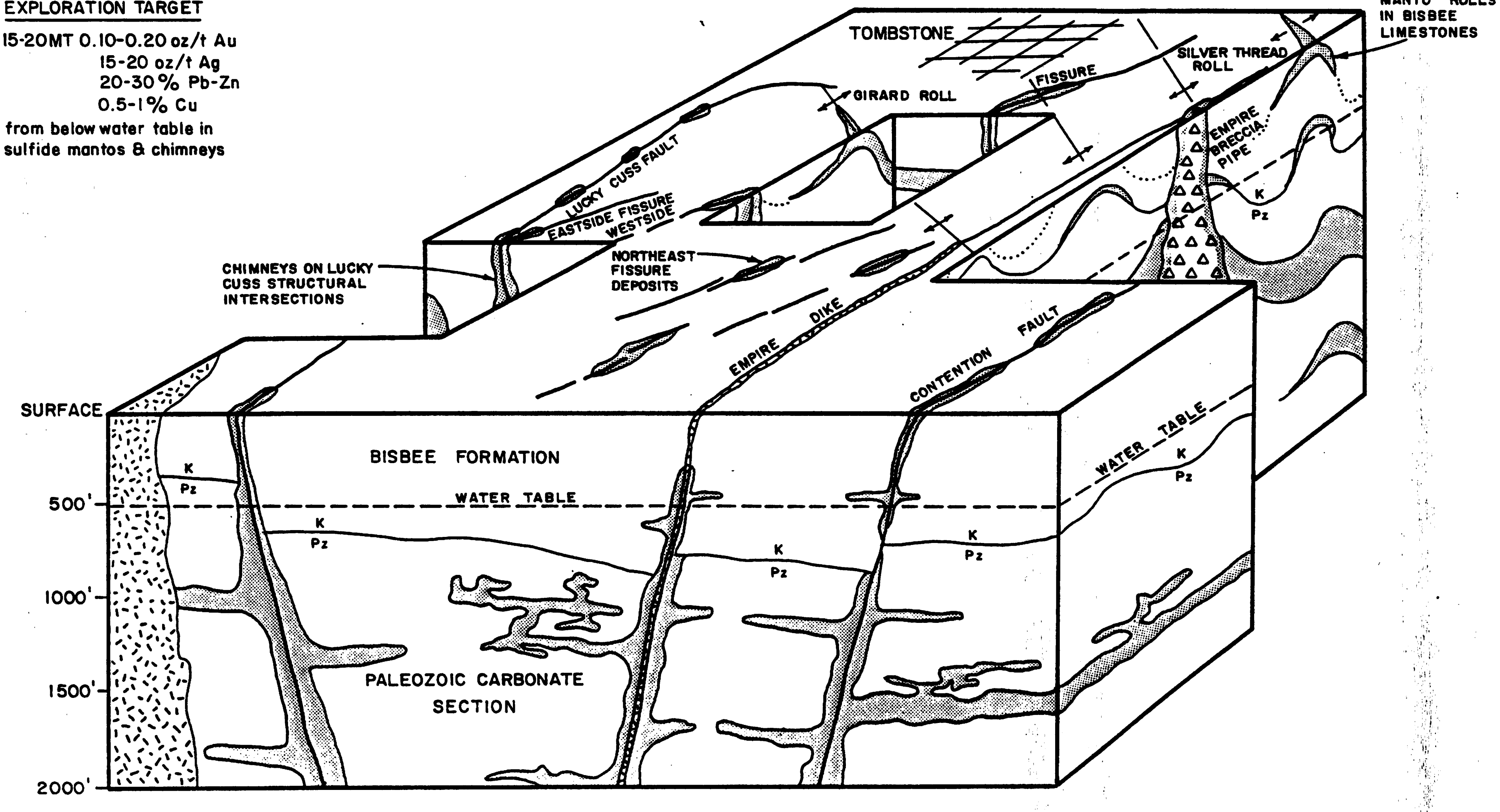
Cochise Co., Arizona

PAST PRODUCTION

3 MT 10.3 oz/t Ag, .09 oz/t Au
from above water table in
oxidized ores

EXPLORATION TARGET

15-20MT 0.10-0.20 oz/t Au
15-20 oz/t Ag
20-30% Pb-Zn
0.5-1% Cu
from below water table in
sulfide mantos & chimneys



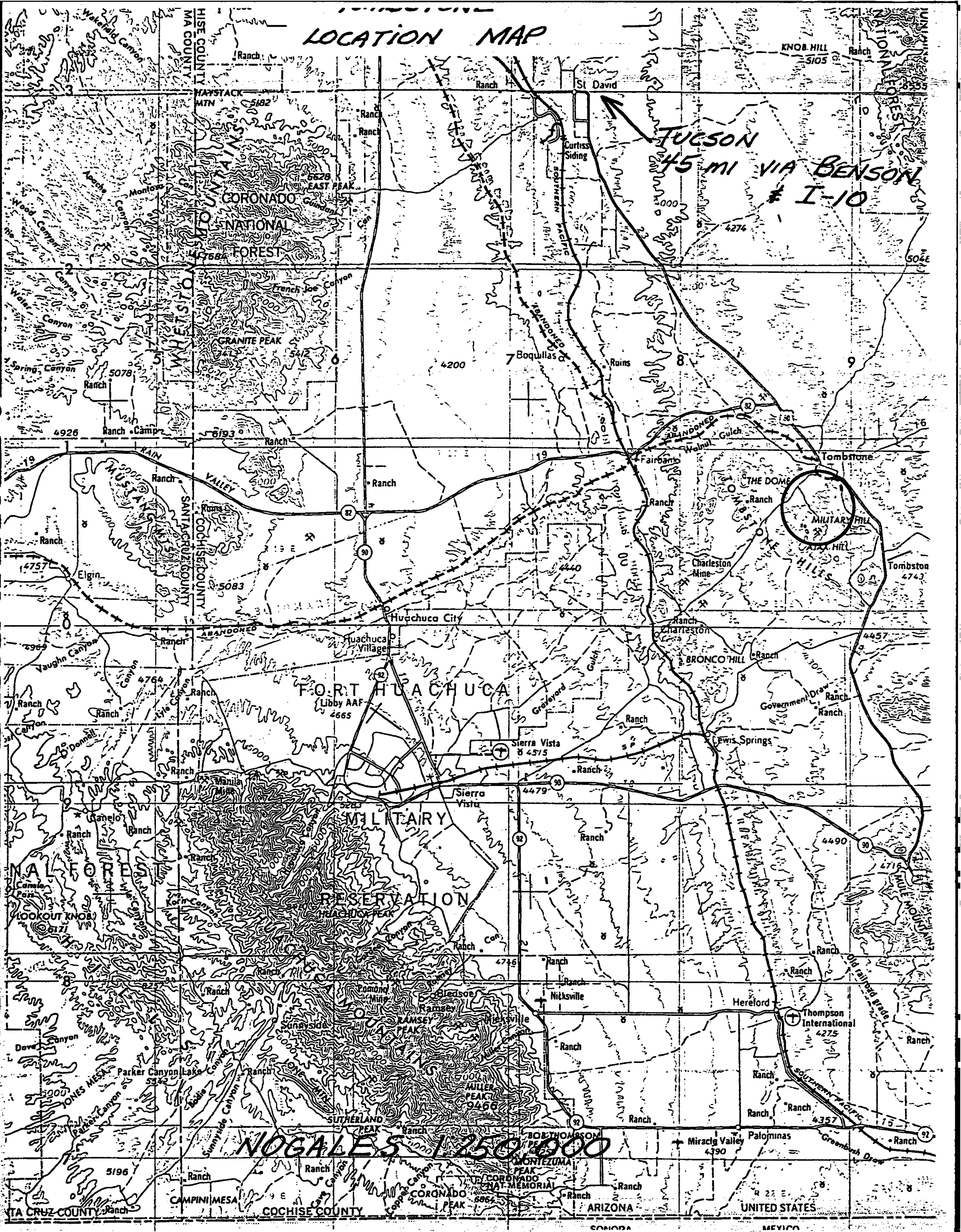
Some potential for shallow high grade mineralization still occurs. A breccia pipe at the 300 level of the Empire Mine appears undeveloped below and exposures suggest a 75 foot diameter. Grab samples of the breccia assayed up to .15 oz/T Au and 21.7 oz/T Ag while proximal CRD mineralization assayed up to .36 oz/T Au and 8.6 oz/T Ag. There is a reasonable chance a mill will be constructed in the next two years at Courtland, 15 miles to the east, on SFPM's Star Hill orebody, thereby providing potential for a short term opportunity while continuing exploration for the deeper Paleozoic hosted mantos or chimneys.

SFPM is looking for a joint venture partner who will continue to explore the property by putting money into the ground, looking at both shallow resources and completing drill holes that offset mineralized intercepts or target other stratigraphic/structural plays. Holding costs for the core of the Tombstone district is $10,000/year plus reclamation costs. In order to earn a 50% interest, the prospective partner should be prepared to spend a negotiated amount over a several year period with the right to back out at the end of any approved program.

GUNNISON GOLD BELT
GUNNISON COUNTY, COLORADO

Santa Fe controls or owns over 100 unpatented mining claims in three target areas within the Gunnison Gold Belt, a 30X15 mile belt of Precambrian volcanosedimendary rocks and intrusives that lie just south of Gunnison, Colorado. During the mid to late 1970's the area was well explored for massive sulfide deposits but not much attention was given to the gold occurrences largely due to their vein-like style. In the late 1980's Santa Fe reexamined the gold potential of the district and has confirmed the presence of mineralization which typifies a model concept that allows for the presence of a world class gold deposit. Very shallow reverse circulation drilling (± 100 feet) and trenching results support this innovative idea. Gold values range from 73 feet of .015 oz/T to 4 feet of 0.7 oz/T in drill holes and 180 feet of .033 oz/T with five foot intervals over 0.2 oz/T in trenches. Mineralization is not vein related and is atypical of previously mined gold.

The property potential is suited to any company who wishes to capitalize early on into a newly proven exploration concept that could result in discovery of a major new gold camp. In addition a small amount of open pittable material (200,000 tons @ .05 oz/T Au) may be available on one property.


LOCATION MAP
TUCSON
45 MI VIA BENSON
& I-10
NOGALES 1:250,000
St David
Curtiss Siding
SOUTHERN PACIFIC
HAYSTACK MTN
5182
CORONADO NATIONAL FOREST
EAST PEAK
6628
French Joe Canyon
GRANITE PEAK
WHETSTONE MOUNTAINS
COCHISE COUNTY
SANTA CRUZ COUNTY
MUSTANG MTS
RAIN VALLEY
Elgin
Boquillas
Ruins
ABANDONED
Fairbank
Walnut Gulch
Tombstone
THE DOME
MILITARY HILL
AJAX HILL
TOMBSTONE HILLS
Charleston Mine
Charleston
BRONCO HILL
Huachuca City
Huachuca Village
FORT HUACHUCA
Libby AAF
4665
Sierra Vista
4515
Lewis Springs
Government Draw
Graveyard Gulch
MILITARY RESERVATION
HUACHUCA PEAK
HUACHUCA MOUNTAINS
Manila Mine
Canelo
Canelo Pass
LOOKOUT KNOB
6171
Korn Canyon
Pomona Mine
Ramsey
RAMSEY PEAK
Bledsoe
Nicksville
Hereford
Thompson International
4275
Old railroad grade
MULE MOUNTAINS
Sunnyside
Parker Canyon Lake
5342
JONES MESA
Dove Canyon
MILLER PEAK
9466
SUTHERLAND PEAK
BOB THOMPSON PEAK
MONTEZUMA PEAK
CORONADO NAT MEMORIAL
CORONADO PEAK
Miracle Valley
4390
Palominas
Greenbush Draw
CAMPINI MESA
COCHISE COUNTY
ARIZONA
UNITED STATES
SONORA
MEXICO
KNOB HILL
5105
NATIONAL FOREST
Tombstone
4743

MANGANESE MINERALIZATION AT TOMBSTONE, ARIZONA.[1]

CHARLES ALFRED RASOR.

ABSTRACT.

Irregular, rudely circular pipe-like bodies of manganese oxides have been mined at the intersection of northeast-trending mineralized fissures and steep faults in Upper Paleozoic limestones. These bodies of ore were mined principally for the silver content, but some were sufficiently large to be mined for manganese alone. The silver values were confined to the core which consisted generally of a soft and porous mass of iron and manganese oxides with variable quantities of lead and zinc oxides. Surrounding this elongated core was a hard, compact envelope of black manganese oxides; chiefly psilomelane and polianite.

The part played by sulphate solutions in the formation of the manganese oxides seems to have been ignored generally. Where deposits of manganese oxides like those at Tombstone, Arizona, are known to have been derived from the sulphide, alabandite, in association with sulphides of iron, copper, lead, and zinc, it is believed by the writer that the manganese sulphide was oxidized, the manganese taken into solution as the sulphate and transported or moved in some manner to the limestone walls to be later deposited as compact masses of psilomelane, polianite, and minor manganese oxides.

INTRODUCTION.

MANGANESE oxides are common constituents of many silver-bearing veins in the Tombstone district. Some bodies of manganese oxides were sufficiently large to be mined for manganese alone, but the greater number were mined principally for their silver content. The silver content of the manganese oxides under discussion is practically nil in comparison to that found in the soft cores of these bodies and consequently little discussion will be given to the silver question.

The original mineral, from which the manganese oxides were derived, was the uncommon manganese sulphide, alabandite. Under the influence of oxidation processes, the manganese went

[1] Published by permission of the Director, U. S. Geological Survey, and the Director, Arizona Bureau of Mines and Geology.

In conclusion, quoting almost verbatim from E. Y. Dougherty [7]

Everyone concerned with economic geology feels the need of more facts, more established principles, more correlation and co-ordination, more synthesis. "Where it is there it is" expresses the uncertainty regarding causes of gold localization, and this is due to incomplete accumulation of facts and inadequate correlation of known facts. We should collect and compare facts from area to area and from mine to mine. To make phenomena of metasomatism of use in mining it is necessary that we should correlate gold occurrence with such well known processes as carbonatization, albitization, sericitization, and chloritization of wall rocks. It is believed that the relative intensity and character of these alterations is reflected in the variable gold-content of many mines and districts. Comparative study would bring to light more clearly the extent to which various alterations can be regarded as indicative of the productivity of ore-bodies. Comparison of gold-content where wall rock alteration has been weak with gold-content where such alteration has been strong and correlation of gold-content with kinds of alteration should be made between districts, mines, and mineral bodies in the same mine.

University of Western Australia,

and

Geological Survey of Western Australia,

June 12, 1939.

[7] Econ. Geol. 30: 879, 1935.

into solution as a sulphate, rather than a bicarbonate as is generally considered and moved downward and laterally as the sulphate until precipitated by reaction with the limestone walls into the various manganese oxides.

GENERAL DISTRIBUTION.

Manganese-oxide ore bodies are found in two narrow zones,[2] partially surrounding the rich gold-silver-lead center of mineralization. The Lucky Cuss, Escondido, Wedge, McCann, and Luck Sure ore bodies form a north-south zone near the contact with a granodiorite intrusive and were mined for both manganese and silver-bearing manganese ores. The Oregon-Prompter, Telephone, Emerald, Bunker Hill, and Mammoth ore bodies form a second group along the east-west Oregon-Prompter fault. Little mineralization extends beyond these two zones.

The semi-peripheral arrangement of the manganese deposits around the gold-silver-lead center is not treated here, but it is known that localization of the manganese ore bodies was caused by a definite structural control. Irregular but rudely circular, pipe-like bodies of manganese oxides occur at the intersection of northeast ore-bearing fissures with both the east-trending Oregon-Prompter fault and the north-trending Lucky Cuss fault in the steeply folded Upper Paleozoic limestones. Smaller ore bodies occur at the intersection of the same ore-bearing fissures with less conspicuous slip planes parallel to the two major faults.

Many of the larger ore bodies ranged from 10 to 20 feet in diameter and extended from the surface to depths of more than 700 feet. Underground workings did not reveal any mineralization such as traces of manganese oxides, that would suggest nearness to an ore body. It seems, therefore, that the manganese solutions did not travel far from the local centers of mineralization.

Psilomelane is the abundant mineral of the pipe-like ore bodies, but polianite, pyrolusite, manganite, hetærolite, and earthy black

[2] Butler, B. S., Wilson, E. D., and Rasor, C. A.: Geology and ore deposits of the Tombstone district, Arizona. Arizona Bur. Mines and Geol. Bull. 143, 1938. See Plate VII.

wad occur in minor quantities. Quartz, calcite, and hydrous iron oxides are common minerals that are found in the soft, porous cores.

MINERALOGY.

The mineral assemblage is much the same in most of the manganese deposits, consisting of the same manganese oxides. In the Lucky Cuss mine, however, geological conditions were more favorable for survival of the original minerals. They are the rare mineral alabandite, galena, tetrahedrite, sphalerite, pyrite, and chalcopyrite. Oxidation products of all these minerals are, also, present. Only the manganese minerals will be discussed.

Alabandite, MnS, is the only know hypogene manganese mineral from the district. Moses and Luquer [3] described it as occurring in large masses along the footwall of the Lucky Cuss fault fissure in pure white crystalline limestone. Specimens of alabandite found recently on the dump of the mine show much oxidation to brown and black coatings indistinguishable from the common manganese oxides. On freshly broken surfaces, the alabandite appears as brilliant black grains disseminated in a gray calcite. Microscopic examination of the specimens and of two other specimens in the Mineralogical Museum at the University of Arizona revealed the absence of other sulphides except tiny blebs of chalcopyrite. It is likely that alabandite is a late sulphide in the hypogene mineral sequence of the district.

A rare zinc manganate, *hetærolite,* $ZnO.Mn_2O_3$, was identified by the writer in ore specimens from the Lucky Cuss mine. Polished sections and microchemical analysis aided in its identification. Its occurrence as irregular veinlets and stringers in manganite and in another manganese oxide still unidentified (Figs. 1, 2, and 5) indicate a late order of deposition. It is dark gray, has high relief and reddish-brown internal reflection. Etch reactions for the Tombstone hetærolite agree closely with those given by Orcel and Pavlovitch.[4] Since there is a lack of

[3] Moses, A. J., and Luquer, L. McI.: Alabandite from Tombstone. School of Mines Quart., 13: 236–239, 1892.

[4] Orcel, J., and Pavlovitch, St.: Les caractères microscopiques des oxydes de manganèse et des manganites naturels. Soc. franç. miner. Bull., LIV: 108–179, 1931.

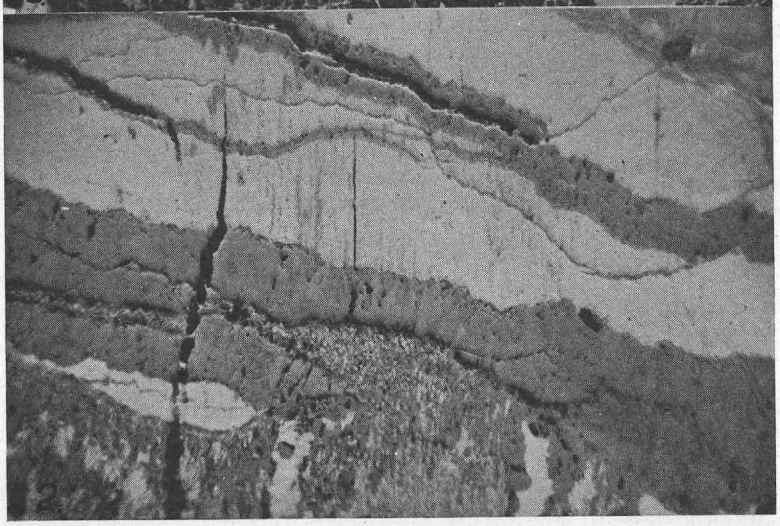


FIG. 1. Heterogeneous manganese oxides in a specimen that appeared to be homogeneous. Replacement of manganite (light gray) by hetærolite (dark gray). Unknown manganese oxide, *X*, may, also, be replaced by hetærolite. × 40.

FIG. 2. Stringer-like character of hetærolite (dark gray) in relation to manganite. × 120.

etch reactions which serve to distinguish hetærolite from hydrohetærolite, the following are recorded by the writer on the Tombstone material. It has been assumed that the material is hetærolite because of the negative test for water. The mineral associations, however, suggest that it may be hydrohetærolite.

Negative: Conc. HNO_3, KCN, $FeCl_3$, H_2SO_4.

Positive: Conc. HCl, etches instantaneously turning the mineral reddish-brown.

Conc. $SnCl_2$ etches instantaneously turning the mineral reddish-brown.

H_2O_2, effervesces.

Polianite and pyrolusite are common minerals in the ore from many of the mines. Identification is based on hardness, as it is thought they are two separate minerals. In hand specimens, the compact fine-grained manganese dioxide generally has the greater hardness and is identified as polianite. Polished sections reveal it to have a characteristic grain pattern (Fig. 3). Associated with polianite is an unknown manganese oxide containing arsenic (Fig. 4). It may belong to the hollandite group.

Pyrolusite is a soft sooty mineral easily scratched with a needle. Its occurrence as fine-grained dispersed aggregates and as elongated streaks in fibrous manganite (Fig. 5) suggest a later deposition than manganite. Other minerals associated with pyrolusite are psilomelane, various hydrous iron oxides, and cellular quartz.

Crystals with the external form of manganite, $Mn_2O_3 . H_2O$, occur in parallel groups of prismatic needles and soft fibers in many druses and cavities. These crystals, however, may be pseudomorphs of pyrolusite produced by the dehydration and oxidation of manganite.

Psilomelane, H_4MnO_5, occurs as hard, compact masses, commonly intergrown with polianite and other undetermined manganese oxides and is the most abundant and widespread of the manganese minerals at Tombstone. Examination of representative specimens in polished section brings out the truly typical structures of psilomelane (Fig. 6) and shows the difficulty of



FIG. 3. Grain pattern of polianite. ×40.

FIG. 4. Polianite (white) replaced by unknown manganese oxide (gray). ×40.

FIG. 5. Manganite (light gray) replaced by fine stringers of pyrolusite (white) and cut by stringers of hetærolite (dark gray). ×75.

distinguishing it from others because of its variable reflecting power and hardness. Apparently, psilomelane was deposited as nodular and botryoidal crusts about different nuclei to form irregular concentric masses with varying degrees of hardness. Some concentric masses were fractured and the cracks later filled with a harder variety of the same mineral.

A mineral with distinct bluish tint under the microscope and commonly associated with polianite (Fig. 4) was at first determined as *hausmannite*. Since the mineral is isotropic it can not be hausmannite. Etch reactions suggested hetærolite, but microchemical tests gave arsenic instead of zinc. These characteristics may be those of a manganese arsenate, but suitable material for analysis is lacking. The mineral takes an excellent polish and is slightly softer than polianite. Etch reactions on the mineral are recorded by the writer.

Negative: Conc. HNO_3, KCN, H_2SO_4, KOH, $HgCl_2$

Positive: Conc. HCl, etches gray.

Conc. $SnCl_2$, etches gray; in oblique light the mineral appears reddish-brown.

$FeCl_3$, etches light brown.

H_2SO_4, slight etch, may be negative.

H_2O_2, effervesces vigorously; leaves a brown stain.

Manganese carbonates are represented by small quantities of reddish-brown rhodochrosite associated with oxidized alabandite and abundant quantities of manganiferous calcite known as "black calcite." There are numerous veins of coarse crystalline "black calcite" which vary from a few inches to two feet in thickness whose origin is uncertain. Some are definitely supergene in origin as they occur in caverns and "water channels." The study of "black calcite" has been limited to the zone of oxidation, through the lack of exposures, and so far as known it may change to ordinary white calcite below that zone. Thin sections of some of the coarse, cleavable "black calcite" indicate that the coloring is due to disseminated feathery and arborescent growths of a brownish to black oxide of manganese (Figs. 7 and

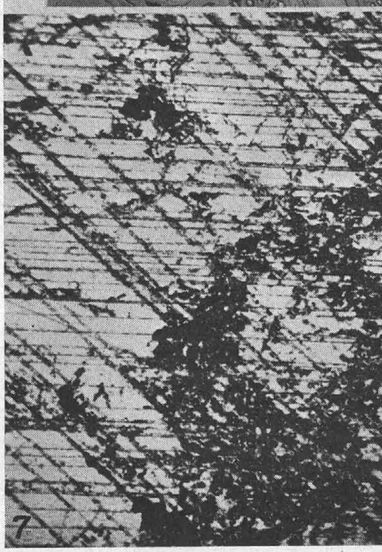


FIG. 6. Nodular and botryoidal psilomelane. Different colors probably represent layers of varying hardness. × 40.

FIG. 7. Thin section of "black calcite" showing replacement of calcite by manganese oxide along cleavage cracks. Plain light. × 24.

FIG. 8. Concentration of feathery and spherulitic brown oxide at intersection of cleavage planes. Plain light. × 320.

8) replacing the calcite along the cleavage cracks, more in one cleavage than in the other.

Samples of the typical "black calcite" dissolved in a 10 per cent solution of hydrochloric acid left a brownish-black residue when filtered. The residue effervesced and was completely dissolved by hydrogen peroxide. It probably represents some hydrated oxide of manganese. From the solution only calcium and manganese were obtained.

What is the origin of the manganese oxide in the "black calcite"? Is the manganese oxide hypogene or supergene? Hewett and Pardee[5] have considered "black calcite" from other districts as hypogene, and at least part of it may be hypogene at Tombstone. Thin sections indicate that the manganese oxide is later than the calcite, which it replaces along the cleavages. Should the "black calcite" veins below the zone of oxidation change to white calcite veins the original manganese mineral could be one of the light colored manganese oxides, manganosite, MnO or pyrochroite, $Mn(OH)_2$, which turn dark on exposure to air. These minerals are thought to be hypogene in other districts where they occur. If the black oxide had been formed from the alteration of hypogene carbonate, silicate, or sulphide, relics or other evidence of an earlier mineral would have been recognized. Positive evidence may be obtained when mining is undertaken below the zone of oxidation.

SOURCE AND ORIGIN OF THE MANGANESE OXIDES.

The source of the manganese oxides at Tombstone has received little discussion. Church[6] and Ransome[7] considered the Carboniferous limestones as the source of the manganese oxides and the pipe-like deposits as secondary depositions from these lime-

[5] Hewett, D. F., and Pardee, J. T.: Manganese in western hydrothermal ore deposits. Ore Deposits of the Western States (Lindgren volume), A. I. M. E., pp. 680–681, 1933.

[6] Church, J. A.: The Tombstone, Arizona, mining district. Trans. A. I. M. E., 33: 29, 1903.

[7] Ransome, F. L.: Bisbee and Tombstone districts, Conchise county, Arizona. U. S. Geol. Surv. Bull. 710: 119, 1920.

stones. Goodale[8] showed that the country rock exposed by cross-cuts and drifts near the ore chimneys did not contain manganese in appreciable quantities, and did not believe that the limestones were the source for the origin of the ore.

As alabandite is the only definitely established hypogene manganese mineral in the district, it is believed by the writer that the manganese oxides have been derived solely from the oxidation of alabandite and not in part from the Carboniferous limestones. Possibly, some of the oxides may have resulted from the decomposition of "black calcite." Moreover, Hewett and Rove[9] have suggested that the oxidized manganese ore bodies at Bisbee, Arizona, which are similar to those at Tombstone, were derived from the oxidation of alabandite, not only because of its presence but because the resulting deposits showed few voids, a feature not characteristic of deposits resulting from carbonates or silicates, which show abundant voids or drusy cavities. The Tombstone deposits are, likewise, free of voids. Since alabandite oxidizes much more readily and rapidly than either the silicate or carbonate and all the other sulphides, it would not leave residual relics.

Considering alabandite as the primary source of the manganese in the oxides from the Lucky Cuss mine, it is reasonable to assume that it is the source for all manganese oxides from other mines in the district. The oxidation of alabandite has been little studied in contrast to the extensive investigations of the oxidation of copper and iron sulphides. This is because of its rarity. Likewise, its rarity in certain western lode deposits may be due to its more rapid decomposition than the sulphides of any other common metal. At Tombstone, alabandite from the Lucky Cuss mine dumps has oxidized rapidly since it was mined. Unless one knows what to look for, the weathered specimens are easily overlooked.

[8] Goodale, C. W.: The occurrence and treatment of the argentiferous manganese ores of the Tombstone district, Arizona. Trans. A. I. M. E., 17: 700, 1888–89 and 18: 910, 1889–90.

[9] Hewett, D. F., and Rove, O. N.: Occurrence and relations of alabandite. ECON. GEOL., 25: 41, 1930.

What are the chemical processes involved in its oxidation and the precipitation of the manganese as the oxides? Freshly broken surfaces of a number of oxidized alabandite specimens showed unaffected pyrite grains. Hence, alabandite seems to have oxidized earlier than pyrite, possibly by the following reaction:

$$MnS + 4O = MnSO_4.$$

Polished specimens show small amounts of galena, sphalerite, tetrahedrite and chalcopyrite also, associated with alabandite. During the oxidation of this sulphide ore body, alabandite may have oxidized to manganous sulphate through the action of sulphuric acid formed by the oxidation of pyrite.

Since all sulphide ore bodies are highly acid when oxidizing, it is held by the writer that sulphate solutions played a dominant part in the solution and transportation of the manganese at Tombstone. It is also held that manganous sulphate became neutral without involving the formation of manganese bicarbonate, which, also, must become neutral before precipitation can take place. Furthermore, manganese bicarbonate in the presence of limestone would likely precipitate manganese carbonate as has been suggested by Savage.[10] It is likely that manganese carbonate can be precipitated only from a neutral or slightly alkaline solution and would not be found in an oxidizing ore body. Therefore, to quote Emmons:[11]

> As sulphuric acid tends to drive carbon dioxide out of solution, it would not be supposed that highly carbonated waters would be common in oxidizing zones of mines where the ore carried much pyrite. That small amounts of sulphuric acid and carbonates may exist in the same solution is shown, however, by several analyses.

That mine waters in limestone areas are strongly acid can be shown in the composition of mine waters of the Joplin region.[12]

> The table on page 103 gives analyses of mine waters of the Joplin district, Missouri. . . . These waters closely resemble those obtained in

10 Savage, W. S.: Solution, transportation, and precipitation of manganese. Econ. Geol., 31: 288, 1936.

11 Emmons, W. H.: The enrichment of ore deposits. U. S. Geol. Surv. Bull. 625: 94, 1917.

12 Emmons, W. H.: *Op cit.*, p. 102.

mines of lode ores in the Western States. They are strong sulphate solutions. . . . In view of the fact that the deposits are in calcareous rocks the acidity is noteworthy.

The lack of analyses of mine waters from the Tombstone district does not preclude the belief that they are not acid, for ettringite, a rare calcium-aluminium sulphate, was thought by Moses [13] to have been formed by the action of sulphuric acids of supergene origin upon limestone and silicate-bearing rocks.

Since the pipe-like manganese ore bodies at Tombstone consisted of alabandite with pyrite, galena, sphalerite, and sulphides of copper, exposure of the ore body to erosion and fluctuations of the water table would cause the manganese sulphide to be oxidized to manganous sulphate and the pyrite to ferrous and sulphuric acid. Sulphuric acid would act upon the other sulphides to change them to sulphates, but more readily on manganese because of its decided solubility in acid solutions. At the same time ferric sulphate solutions would form under favorable conditions. The ferric sulphate would react immediately on the calcium carbonate to form soluble calcium sulphate, carbonic acid, and ferric hydroxide. Sulphuric acid would tend to drive out any carbon dioxide that would form. Intermingling of solutions and reactions with minerals and wall rock would cause precipitation of the minerals out of solution. Examination of the old stopes has shown a definite separation of the iron and manganese minerals. In the central core of the ore bodies, the mass consisted of iron oxides associated with oxidized minerals of lead, zinc, copper, and silver with small amounts of manganese oxides. Surrounding this core there was an envelope of hard, massive manganese oxides with few other associated minerals. This separation of manganese and iron took place in the presence of limestone as the sulphates of the two metals percolated downward and laterally. Experiments [14] have shown that when ferrous sulphate and manganous sulphate are together in the presence of calcite and air,

13 Moses, A. J.: Ettringite from Tombstone, Arizona, and a formula for ettringite. Am. Jour. Sci., 3d ser., 45: 489–492, 1893.

14 Emmons, W. H.: The agency of manganese in the superficial alteration and secondary enrichment of gold deposits in the United States. Trans. A. I. M. E., 42: 39, 1912.

the iron is by far the more easily precipitated, whereas the manganese will remain in solution until all the iron has been precipitated. Manganese sulphate acts but little upon calcium carbonate, if protected from access of air, but is precipitated as the oxide on neutralization in the presence of both air and calcium carbonate.

Dunnington [15] was probably the first to suggest that many deposits of manganese oxides in calcite rocks owe their formation to the action of sulphates. He reached this conclusion from a series of experiments in which he subjected manganese oxides, chiefly psilomelane, to the action of ferrous sulphate and sulphuric acid in about the proportions that would form from the oxidation of pyrite. The rate of solution of a lump of compact psilomelane was equivalent to 3.78 inches in one year. If the rate of solution is so great on relatively insoluble oxide, what might it be on the relatively soluble manganese sulphide? So far as known, there has been no laboratory experiment on the oxidation of manganese sulphide by any agents that approach those found in an ore body undergoing oxidation.

Thus, when ore bodies or rocks containing manganese undergo weathering, the manganese is taken into solution by the solvent action of waters containing sulphuric or carbonic acid. The manganese at Tombstone went into solution as the sulphate, because sulphides are present to form the sulphuric acid or sulphates. The sulphates readily hydrolyze and form acid solutions in water. The great depth to which manganese oxides have been found suggests that the manganese was carried downward as an acid, for the sulphates are more stable in acid solutions than in neutral or alkaline. Thus on neutralization of a manganese sulphate solution through the action of oxygen in the presence of calcite, the oxides will be precipitated. Suggested reactions are as follows:

$$MnSO_4 + 2H_2O = Mn(OH)_2 + H_2SO_4.$$

15 Dunnington, F. P.: On the formation of deposits of oxides of manganese. Am. Jour. Sci., 3d ser., 36: 175–178, 1888.

Some of the manganous hydroxide is oxidized by the air to manganous acid,

$$Mn(OH)_2 + O = H_2MnO_3 \text{ or } MnO_2 + H_2O,$$

which on coming in contact with manganous hydroxide immediately forms a salt with it.

$$H_2MnO_3 + Mn(OH)_2 = Mn_2O_3 + H_2O.$$

ACKNOWLEDGMENTS.

This paper represents a portion of a dissertation on the mineralogy of the Tombstone mining district, submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Arizona. The writer gratefully acknowledges the guidance and criticisms of Dr. B. S. Butler in the preparation of the manuscript and to Dr. M. N. Short for aid on the polished sections of manganese minerals. To Dr. D. F. Hewett, Dr. W. T. Schaller, and Dr. R. C. Wells of the U. S. Geological Survey the writer is especially grateful for their criticisms and suggestions.

BOISE, IDAHO,
May 4, 1939.

NOTES ON THE USES OF METHYL METHACRYLATE "LUCITE" IN A GEOLOGICAL LABORATORY.

JAMES FORBES BELL.

ABSTRACT.

Methyl methacrylate "Lucite" is a colorless transparent plastic which has been found useful for mounting and impregnating specimens in a geological laboratory. Various applications and the technique of handling this material are described.

THE polymerization of monomeric methyl methacrylate to form a clear, colorless, hard, tough solid has been found useful in handling many geological and mineralogical specimens. This material has been used for several years in mounting and impregnating textiles, woods, paper and various biological and botanical specimens. It is thought that the properties and methods of handling this material should be brought to the attention of geologists.

The writer is indebted to Cortland S. Pearsall of the Metropolitan District Water Supply Commission, Boston, who introduced him to the possibilities of using methyl methacrylate and who made the first geological specimen mounts with this material in the laboratories at the Massachusetts Institute of Technology.

Tables I and II [1] show the physical properties of liquid (mono-

TABLE I.

PROPERTIES OF MONOMERIC METHYL METHACRYLATE.

Sp. gr. 60°/60° F. (15.6°/15.6° C.)	0.9497
Refractive index $n\frac{15.6}{D}$	1.4168
B.p., ° C.:	
760 mm.	100.3
200 mm.	61
1000 mm.	46
M.p., ° C.	−48
Relative Viscosity, 22° C.	0.588
Latent heat of vaporization, cal./gram:	
765 mm.	77
200 mm.	88
Sp. heat, cal./gram/° C.	0.49
Solubility: Soluble in typical organic solvents; insoluble in water and formamide; slightly soluble in glycerol and ethylene glycol.	

[1] E. I. duPont de Nemours Co. Contribution "Methacrylate resins." Ind. Eng. Chem., 28: 1160–1163, 1936.

RASOR	ARIZONA B/17

AUTHOR
Manganese mineralization at

TITLE
Tombstone, Arizona.

DATE LOANED	BORROWER'S NAME	DATE RETURNED

Report to Cobb Resources, 1983   Sent by Kerry Stanaway - obtained from Cobb's files ??

TOMBSTONE PROPERTIES

PRELIMINARY EXPLORATION REPORT

LOCATION

The Tombstone mining district is located in central Cochise County, southeastern Arizona, about 25 miles north-northwest of Bisbee and 70 miles southeast of Tuscon. Tombstone lies on the east flank of the Tombstone Hills, a low rounded range on the north end of the Mule Mountains. The town is at 4550 feet in elevation and the peaks rise to nearly 5440 feet. It is situated between the valley of the San Pedro River on the west, and Sulphur Springs valley, a tributary of the Yaqui River, on the east. The Dragoon Mountains rise to the east of the district and the Huachuca Range is found to the west of the San Pedro River.

The district is in a high desert environment with only scrub brush, mesquite, cacti, ocotio, and sparse grasses for vegetation. The area is arid and no permanent surface streams exist. Flash flooding occurs in the dry washes and arroyos during the summer thunderstorm season. Water is encountered at varied levels in the mines of the district, from 200 feet to 600 feet below the surface. The water table is elevated in the northwest part of the district.

The Cobb Resources claims are located in the northwestern Tombstone mining district on the flanks of Uncle Sam Hill and Three Brothers Hills. The mines are located on a series of nearly parallel, steeply dipping veins, and the workings are typically inclined shafts. Access to the mines is by improved dirt roads which lead about two miles north of the Charleston highway, at a point about one and three quarter miles west of Tombstone.

HISTORY-PRODUCTION

The first discovery of ore at Tombstone was in 1877, by Edward L. Scheffelin, and by 1880 the district was in full production. Milling facilities were first constructed on the San Pedro River and later, several plants were located at the mine sites as water became available. By 1882 the water level had been reached in some of the mines and pumping operations began on a small scale, with ore production continuing in the unoxidized ore below that level. The orebodies were veins and associated limestone replacement deposits which were located at favorable structural locations. The veins were mined by cut and fill, shrink, and stull stoping methods, and the flat-lying replacement ores were mined by cut and fill methods. Milling of the oxidized ores was originally by gravity concentration on tables with later improvements in recovery by use of cyanidization.

By 1886 many of the orebodies had been mined out to the water level or had been mined out to economic limits, and the district production was greatly reduced. Efforts to organize the mines and systamatically pump out the water failed and the major mines closed except for lessee operations. Between 1886 and 1900 the district was nearly idle, until the major mines were consolidated in 1901 and pumps installed to drain the water. The Tombstone Consolidated Mining Company, Ltd., was formed to manage the properties and the workings were rehabilitated and explored over the next ten years. The lower levels were extensively sampled and minor production was taken from below the water level and from old gob and pillars, but the operation proved uneconomic. The pumps were shut down in 1911 and the mines reflooded. About 6,500,000 gallons of water were pumped from the mines per day before the closing of operations (Shaw, 1909).

Phelps Dodge Corporation acquired much of the district in 1914 and operated the Bunker Hill Mining Company until 1918, producing smelting ore as well as milling locally. Small operations have produced ore since the twenties, including the Tombstone Mining Company, A.S.&R., Tombstone Development Company, and others. Many small heap leach operations have been recently run in the district, treating old dumps and gob.

The largest present operation is the Tombstone Exploration, Inc., open pit mine located at the old Contention and Grand Central mines. The ore is stripped and heap leached on five 5,000 ton capacity leach pads, with low and mid-grades also leached on a three million ton pile. Approximately 2,000 tons per day of ore is leached at the operations, of an average grade of about 0.04 oz/ton Au and 1.5 oz/ton Ag. Recoveries are 60 to 70% of the silver and 75 to 80% of the gold.

Production estimates for the district are summarized by Butler, Wilson, and Rasor (1938) and total $37,000,000 worth of gold and silver to 1936. The primary product of the district has been silver, with gold only found in minor amount within the heart of the district. Lead, zinc, copper, and manganese have also been produced in minor amounts. About one half of the district production value was mined from 1878 to 1886 and one half between 1886 and 1936. District production between 1908 and 1934 totalled 6,650,000 ounces of silver in 608,000 tons of ore. The ore had an average grade of 0.11 oz/ton Au, 10.95 oz/ton Ag, 1.95% Pb, and 0.19% Cu.

Production records from the State of Maine mine are unavailable, although Butler, et al. (1938) report about $200,000 worth of ore and Church (1903) gives $600,000 as an estimated production figure. No records or estimates are reported for the San Pedro, Merrimac, Free Coinage, or Mountain View mines.

Earliest reports of work at the State of Maine mine are from the period from 1883 to 1886 when "considerable" work was done, including stoping of ore above the 2nd level (Butler, et al., 1938). The State of Maine mine was sunk on an incline to the 375 foot level (240 feet vertical) by 1903 (Church, 1903). By 1936 the shaft was 480 feet deep (325 feet vertical) and extensive work had been done on the lowest level (Butler, et al., 1938). The vein was developed for 900 feet on strike, although most of the production came from an area 500 feet long. Extensive sampling and exploration of the mine was done in 1915 by Phelps Dodge, when they controlled the majority of the district. Lessees operated the mine during the period form 1903 to 1936, and an unknown amount of production was taken from the stopes. Recently, the mine dumps were heap leached by the State of Maine Mining Company, but production figures are not available.

The San Pedro mine also operated in the 1880's and most work was probably done in this mine before the turn of the century. As stated above, no production records exist for the San Pedro mine, but recent exploration by Southwest Resources show that the workings extend to the water level, about four levels (180 feet) down. Extensive stoping has been done on the vein above the water level and there is evidence of stoping from levels below the water level.

The dumps on the Free Coinage claim contain large tonnages, suggesting extensive workings, and stopes come to the surface along 650 feet of strike length on the claim. An additional 650 feet of workings extend from the Free Coinage claim onto the Merrimac claim. These workings and those of hte Mountain View mine have only been explored in reconnaisance.

The most recent exploration of the San Pedro-Mountain View group of claims was a deep drilling program by Occidental Minerals, totalling four diamond drill holes between 1100 and 1560 feet in depth. A surface geochemical sampling program was also conducted. Austral Oil Company evaluated the State of Maine mine in the 1970's and mapped and sampled the workings. Sampling of the mine workings has also been recently done by Can Am Mining Company and by Southwest Resources, Inc. Much of this recent work needs to be located and evaluated before the present exploration program proceeds.

The mine workings are in varied states of repair and some rehabilitation is required to safely inspect the workings. The State of Maine mine is now rehabilitated to the third level with work progressing. The other workings are all shafts, with no surface structures remaining and typically with poor collar conditions, although all workings are open. The San Pedro shaft is in good condition, with only a few missing ladders and loose timbers. Several of the Free Coinage shafts are cratered, with only the northeast shaft in useable condition for exploration. The same is true for the Mountain View workings, only one or two of the shafts have the collar timbers in good condition, and most of the ladders are broken or lost. Water is found in several of the shafts, including the San Pedro, although the State of Maine mine is dry.

GEOLOGY

Regional:

The Tombstone mining district is found within complexly deformed terrain typical of southeastern Arizona. The structural history of the region has been summarized by Drewes (1981) and Gilluly (1956) and is a record of repeated orogenic deformations with inter-related pulses of igneous activity throughout geologic time. Major tectonic deformations occurred in the Precambrian (Mazatzal Revolution), in the late Triassic and early Cretaceous, and in the late Cretaceous and Paleocene Cordilleron Orogeny. During the late Precambrian and early to middle Paleozoic, the area was submerged by repeated transgressions and regressions of the oceans. Compressive deformation associated with the Cordilleron orogeny produced large scale thrust faulting and related folding. Widespread intrusion of granitic magmas, silicic volcanism and related mineralization occurred following the compressive deformation, as Tertiary Basin and Range extensional tectonics became the controlling structural process.

Three major fault systems are developed in the region. The most prominent are northwest trending high-angle normal faults with Precambrian to Cenozoic movement. The second fault system includes the low-angle thrust faults which have cut the region into extensive allochthonous sheets, primarily of Paleozoic and Mesozoic rocks, but locally including the Precambrian basement rocks. These thrust faults in the Tombstone area typically follow bedding planes and are hard to recognize. Late, north trending normal faults have cut the older structures during the Tertiary Basin and Range deformation. Movement of mineralizing fluids and magmas were controlled by the northwest trending faults, with second order faults and favorable rock types also having some control, especially in the Tombstone district (Drewes, 1981).

The structure of the Tombstone district is complex and the features have been reinterpreted since the early work of Church (1882, 1903), Ransome (1920), and Butler, Wilson, and Rasor (1938). Because of the reactivation of faults and the deformation associated with igneous intrusions, the sequence is somewhat obscurred. Recent mapping (Drewes, 1981) has shown that bedding plane faulting has also played a role in the deformation of the rocks and in the formation of the orebodies.

The mining district is larglely within the Tombstone syncline, whose axis trends nearly west and plunges gently to the east. The syncline is complicated by tight folds and associated faulting which trend west-northwest. The syncline is cut off by the east trending, steep reverse Prompter fault, with overturning of the beds along the fault contact. The northwest trending Ajax fault cuts the syncline off on the west and is in turn cut off by intrusion of the Scheffelin granodiorite. The granodiorite cuts across the axis of the syncline, and is younger than the folding. (Gilluly, 1956).

The block south of the Prompter fault is referred to as the Ajax Hill horst (Butler, et al., 1938 and Gilluly, 1956) and forms an area of about six square miles. The core of this block is Precambrian in age and the overlying sediments exhibit folding in a northwest trending and plunging anticline which parallels the Prompter fault. This Ajax Hill block is separated from the western part of the district by the Ajax Hill fault, along which a late Uncle Sam porphyry dike has intruded.

The western part of the Tombstone district is less complex than the central part of the district structurally and lithologically. The State of Maine, San Pedro, Mountain View, Free Coinage and associated mines are driven in the Uncle Sam quartz latite porphyry which forms most of the surface outcrop of the western part of the district. This porphyry is believed to be intrusive in nature, injected as a thick, sill-like laccolith along a southwest dipping thrust fault plane (Gilluly, 1945, 1956). The underlying sediments were brecciated by the faulting and then thermally altered by the intrusive. A window of this breccia is seen between the San Pedro shaft and the Mountain View workings in an embayment eroded into the porphyry sheet. The breccia is sheared by shallow (+/- 35^{o}), westward dipping fractures which parallel the thrust fault. The porphyry contact was site of several prospects on the north bank of the arroyo that cuts the area, with iron and manganese oxides and clays along the contact. The remainder of the claims have Uncle Sam porphyry at the surface or Quaternary pediment and alluvium.

The fractures which cut the State of Maine, San Pedro, Mountain View, and Free Coinage are generally northeast trending, steeply dipping structures. Subordinate west-northwest and east-west faults are also present, although none of these are known to mineralized.

The State of Maine mine is on a series of flat-dipping structures which form a system of cymoid loops within the quartz latite. The veins dip about 45^{o} northwest and the average strike is N35E. The workings were primarily on two major veins which intersect at about a 20 degree angle on the south, and which increase in separation with depth. Parallel, en echelon veins were discovered in the long westward cross-cut driven on the 7 level. Many of these hanging wall fractures also form cymoid loops, with intersections of fractures forming ore shoots.

Several square set stopes were located in areas of wide mineralization. Many subordinate fractures cut the wallrock between the major veins, and may carry sufficient values to allow bulk mining of the entire block of ground between the bounding structures.

The Merrimac and Free Coinage veins are probably along the same fracture system as the State of Maine mine. The Free Coinage vein also exhibits splitting and braiding of the veins, with at least two parallel veins. The San Pedro vein is paralleled by at least four related veins on the True Blue and Mountain View unpatented claims.

A major west-northwest trending fault cuts the claims from the saddle of the mountain known as The Dome, southeast across the San Pedro and Mountain View claims. This fault may have had some control over mineralization on the veins it crosses. Some right lateral movement on this fault is suggested by the San Pedro surface workings.

Stratigraphy:

The rocks exposed in the Tombstone district range in age from Precambrian to Recent and include a thick sequence of Paleozoic clastic and carbonate rocks intruded by late Cretaceous and early Tertiary igneous stocks, dikes, and sills. The formations found in the district are summarized on the following stratigraphic column (Table 1). The units found in the Cobb Resources claims area are discussed in more detail below.

Naco Group:

The Permian-Pennsylvanian Naco Group is found in the subsurface of the claims, as seen in the Occidental Minerals drilling. The Naco Group consists of the Pennsylvanian Horquilla limestone and Earp limestone; and the Permian Colina limestone, Epitath dolomite, Scherrer quartzite, and Concha limestone. In the Tombstone district the upper two formations, the Concha and Scherrer, have been eroded away before deposition of the overlying Bisbee Group (Gilluly, 1956).

The Naco formation is present at the surface in the central part of the district where it is a sequence of thin-bedded limestones, dolomites and shales with a few thick beds of reddish, fossiliferous limestone. Much of the upper part of the formation is dolomitic, and many of the orebodies of the Luck Sure, Lucky Cuss, and Oregon-Prompter mines were within these carbonates (Butler, et al., 1938). Some of these pink and red limestones and dolomites, altered in part to hornfels, were seen in the Occidental drill holes.

Bisbee Group:

The Bisbee Group is comprised of a series of fine-grained clastic rocks of both marine and terrestrial origin, lying on an irregularly distributed basal conglomerate (Gilluly, 1956). The basal conglomerate is found in channels carved into the underlying Naco Group. This unconformity has some angular discordance in the southern part of the district. The Bisbee Group, as recognized in southeastern Arizona, totals over 15,000 feet of sediments. In the Tombstone district the formation is about 3,100 feet thick.

The basal conglomerate (Glance conglomerate of Ransome, 1920) is overlain by a thick sequence of thin-bedded mudstones, cross-bedded sandstones, and a few thin beds of limestone and sandy dolomite. The mudstones are usually maroon, with occasional black and green beds. The sandstones are brown to buff, cross-bedded, and gritty, averaging in thickness from 2 to 10 feet. Some beds reach 60 to 80 feet in thickness. The Bisbee formation beds are probably estuarine in origin, and the units are therefore lenticular, traceable for only short lateral distances. The six or seven limestone beds which are found near the base of the formation are blue-grey, silty limestone which contain abundant marine fossils. These beds were the primary zones of mineralization in the central and southeast part fo the Tombstone district.

Most of the orebodies in the limestone were related to anticlinal and monoclinal flexures, where cut by the vein systems. The Bisbee formation in the Cobb Resources claims area has undergone extensive thermal alteration due to the intrusion of the Uncle Sam porphyry and Scheffelin granodiorite. The units have been altered to aphanitic hornfels, novaculite, jasperoid, quartzite and silicic conglomerate, and alteration increases towards the igneous contacts. Tremolite, grossularite, sericite, epidote, pyrite and calcite are common; as are their oxidation products. Table 2 shows a composite section of the Bisbee formation in the Tombstone Hills (Gilluly, 1956).

The top of the Bisbee formation is usually an angular unconformity in the region, but on the Cobb Resources claims, the Bisbee is overlain by a thrust fault surface, which has in turn been intruded by the Uncle Sam porphyry (Gilluly, 1945, 1956). The brecciated zone below the porphyry which lies in the embayment between the San Pedro and Mountain View workings contains not only Bisbee formation fragments but Naco formation clasts as well. Gilluly (1945) states that the fragments are

Generalized composite section, Bisbee formation, Tombstone Hills.

		Feet
	Erosion surface.	
1.	Sandstone and shale, alternating; a few 10-foot limestone conglomerate beds; shale members chiefly red or maroon; sandstone beds buff to brown, a few gray or white; sandstone members range from 20 to 170 feet in thickness, predominate over the shale	1,040±
2.	Sandstone, buff, gray, and white, some interbedded gray-green hard shale; thick bedded	220
3.	Shale, gray to green, hard and siliceous, a few thin buff sandstone beds	540
4.	Sandstone, buff, white, and brown, a few green shale beds, at least one thin bed of limestone	422±
5.	Shale, green and bluish, some conglomerate	58
6.	Limestone, massive, blue, cherty	25
7.	Shale, green, mottled red and green, brown, and yellow	345
8.	Limestone	10
9.	Shale, some sandy beds	29
10.	Shale and limestone, alternating in thin beds	15
11.	Shale, greenish, some limy beds	30
12.	Limestone	5
13.	Shale, poorly exposed	53
14.	Limestone	4
15.	Shale, gray, green, and black	43
16.	Sandstone, yellow	9
17.	Shale, red and brown	65
18.	Shale, black	14
19.	Shale, green and gray, siliceous	42
20.	Limestone, "Ten-foot bed" of miners	10
21.	Shale, with arkose at base	24
22.	Limestone, "Blue limestone" of miners	34
23.	"Novaculite," silicified shale, local intercalations of limestone conglomerate	60
	Total	3,097±

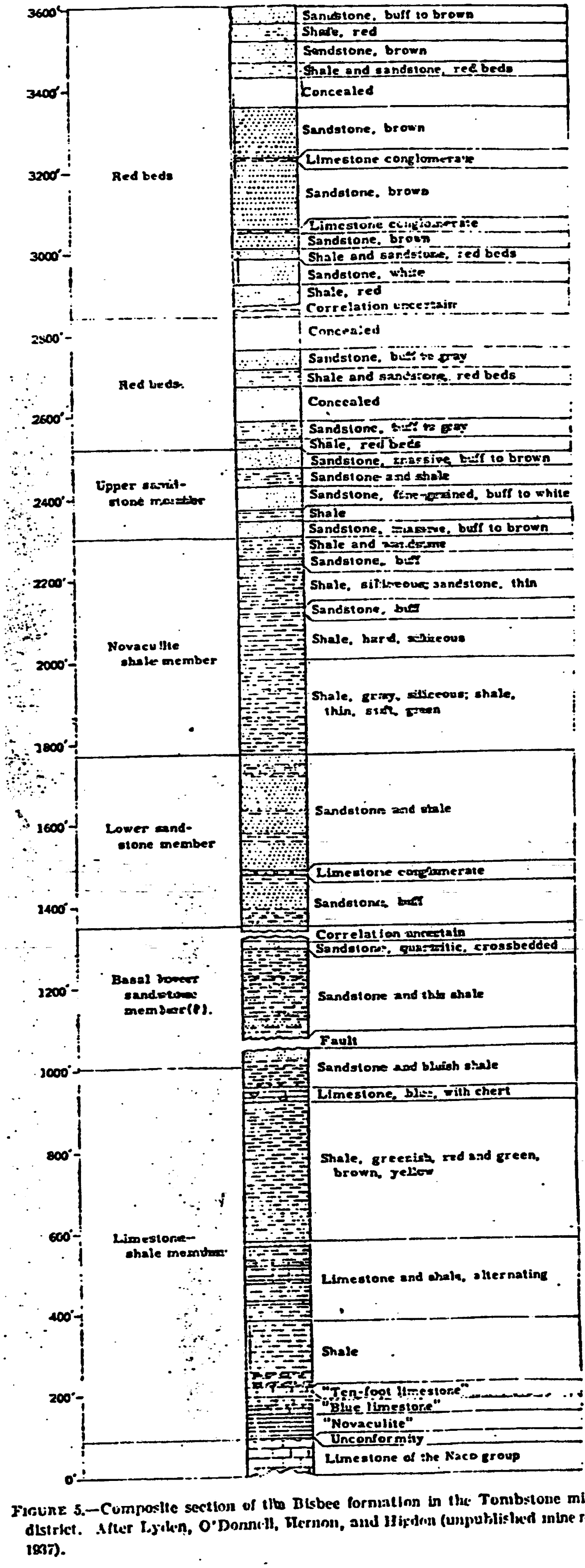


FIGURE 5.—Composite section of the Bisbee formation in the Tombstone mining district. After Lyden, O'Donnell, Hernon, and Higdon (unpublished mine rept., 1937).

primarily Bisbee formation to the northeast and are predominantly Naco formation along the contact with the porphyry. The Bisbee formation is found on the lower level of the State of Maine mine 325 feet below the surface and varies in the Occidental drill holes from 84 to 337 feet deep.

Uncle Sam Porphyry:

The Uncle Sam porphyry is a quartz-poor latite porphyry which has been dated at 71.9 +/- 2.4 m.y. (Drewes, 1981). It is believed to be intrusive in origin, and reaches a thickness of at least 300 feet in the State of Maine workings. Contact relationships described above suggest intrusion along a pre-existing thrust fault plane as a moderately thick laccolith, with dikes and sills branching off the main intrusive mass. Petrographically, the rock is comprised of medium to fine-grain phenocrysts in a fine-grained, almost vitophyric groundmass, with up to five percent of foreign rock inclusions. Phenocrysts are from 1 to 8 mm in length and include crystals of zoned plagioclase (An_{50}-An_{30}), biotite and subordinate hornblende. Quartz and orthoclase are sparsely included in the groundmass. The lack of reaction between the porphyry and inclusions is suggested as evidence of a low level of volatiles in the magma during intrusion (Gilluly, 1945).

The porphyry has undergone variable alteration, and is typically partially propylitized. Epidote, potassium feldspar, sericite, chlorite, hematite, and quartz are common products of this regional alteration. Close to the veins the porphyry is highly altered, usually bleached, with iron and manganese oxides, and nearly complete alteration of the feldspars to clays. Local silicification is also found along the San Pedro vein. Oxidation of the ore minerals has lead to the deposition of exotic and local varieties of iron and manganese oxides. Samples of highly altered porphyry from adjacent to the veins usually assay low in precious metals, although one clay rich sample cut by quartz/pyrite veinlets ran 15.39 oz/ton Ag at the San Pedro shaft. The ore values in the wall rock may therefore be controlled by microfracturing and by dissemination of silver-bearing minerals with the pyrite in the altered porphyry.

Scheffelin Granodiorite:

The Scheffelin granodiorite outcrops to the east and northeast of the Cobb Resources claims block, along the crest of the northeastern Tombstone Hills. The rock erodes to a sandy soil, leaving a low, knobby, topography with slight relief. The granodiorite is chemically about intermediate between a quartz monzonite and a granodiorite, and is petrographically similar to a quartz monzonite, although referred to in most literature as a granodiorite (Gilluly, 1956 and Butler, et al., 1938). The rock is fine-grained, light grey to reddish, and is locally porphyritic. It is composed of about equal proportions of plagioclase and orthoclase phenocrysts, with quartz, biotite, hornblende, and minor augite, apatite, and magnetite. Contact metamorphism of adjacent sedimentary formations has produced silicate alteration minerals such as wollastonite, garnet, vesuvianite, pyroxene, tourmaline, and rarer hydrosilicates (Butler, et al., 1938).

The Scheffelin granodiorite does not come into contact with the Uncle Sam porphyry in the district, and there is no direct evidence of age relationships between the two intrusives. Butler, et al., (1938) quote Gilluly as stating that the Scheffelin granodiorite cuts off dikes which intrude the Uncle Sam porphyry near Bronco Peak, southwest of Tombstone. Recent radiometric data for the two intrusives does not prove or disprove this relationship due to the overlap in ages. The Uncle Sam porphyry has been dated at 71.9 +/- 2.4 m.y. and the Scheffelin granodiorite has been dated at 72.0 m.y. (Drewes, 1981).

Other Intrusive Rocks:

A series of intermediate to silicic igneous intrusions also cut the region, and are probably related to the same magma as the Scheffelin granodiorite and the Uncle Sam porphyry. These dikes were important in the formation of the orebodies in the Grand Central, Contention, Boss, and other mines in the heart of the district, and were often mineralized sufficiently to constitute ore. The dikes vary in composition from granodiorite to diorite, and occur as a series of nearly parallel intrusions, located along the same northeast trending structures as the principal veins of the district. They are typically highly altered to gougy clays and iron oxides. In the western part of the district there are numerous dikes which cut the Uncle Sam porphyry and Bisbee formation. These dikes are dark, fine-grained intrusives, and are typically highly altered. Most are basaltic in composition, but some are monzonitic to rhyolitic. Their strike is generally northeastward although some trend east-west. Several of these dikes are seen on Uncle Sam Hill and on the east flank of the hill.

Ore Deposits:

A model ore deposit may be defined for the Cobb properties based upon data available in reports, previous mapping, research and from on-going exploration. The orebodies in the State of Maine mine were located in areas of extensional stress along the arcuate fractures which formed conduits for the mineralizing fluids. Butler, et al., (1938) state that the ore was confined to narrow stringers in the crushed and altered rock along the faults. Vein quartz is generally absent, and the ore is highly oxidized, consisting of iron and manganese oxides, clays, and pockets of lead carbonate, horn silver, and copper carbonates. The sulfide ore zone was never reached in the old workings, so the mineralogy of the parent ore can only be estimated from the oxidation products. Cerrusite, anglesite, chlorargyrite, bromargyrite, embolite, azurite, malachite, and the ubiquitous iron and manganese oxides are the primary minerals seen in the ore. The iron oxides probably include argentojarosite and plumbojarosite, as well as jarosite and geothite. The primary ore was probably silver-rich galena and tetrahedrite with associated pyrite, and with possible tellurides and rhodocrosite (Williams, 1982). Williams (1982) has postulated two episodes of mineralization in the district: first, a base-metal rich, silver-bearing pulse of mineralization, and secondly, a gold-bearing telluride episode, so far only recognized in the heart of the district.

Wall rock alteration has changed the porphyry at the State of Maine mine into sericite gouge adjacent to the vein, with the intensity of alteration gradational away from the vein. Intense alteration extends only a few feet away from the major veins. The porphyry in the vicinity of the veins is reddish-brown in color, probably due to the oxidation of disseminated pyrite within the rock and along fractures cutting the wallrock.

Most of the ore at the State of Maine mine was taken from the hanging wall vein, above the fifth level. Ore was mined from the footwall vein south of the shaft to the intersection of the two veins. The vein was mined south of the junction of the two vein splits. In the north end of the the mine, the ore was concentrated on the hanging wall vein. Square set stopes were located on the hanging and foot wall junctions where mineralization spread out into the brecciated wall rock. Exploration will concentrate on evaluating the grade of the wallrock in the shattered zone between the two major veins. The hanging wall will also be sampled to evaluate the grade of the fractured zone beyond the main hanging wall vein.

Replacement ore within the Bisbee formation limestones is the secondary exploration target in the State of Maine mine. The Bisbee formation is seen in the lowest level of the mine, where a 225 foot wide block of altered and brecciated shales is exposed in the cross-cut. The potential ore zone in the basal limestone beds lies at an unknown depth below the lowest level of the mine. These limestones are encountered in the Occidental Minerals drill holes to the north of the mine, at a depth of 400 to 600 feet below the collar of the holes. This would suggest that the ore-bearing horizon is still at least one hundred feet below the seven level. The dip of the Bisbee group is uncertain in this area due to lack of exposures and the intensely disrupted nature of the unit in the few exposures seen.

The Bisbee-Naco breccia zone beneath the Uncle Sam porphyry sill may also be host to mineralization in the San Pedro and Mountain View claims area. The breccia contains limestone, sandstone, shale, and porphyry clasts in a calcareous or silicic matrix. The breccia may have been mineralized adjacent to the San Pedro and Mountain View vein systems if the shattered zone was permiable during the ore fluid transport through the veins. Alteration of the breccia by contact thermal metamorphism or by regional tectonic metamorphism before the mineralizing episode may have sealed the rock to the ore fluids.

The San Pedro vein system appears to have similar trends to the State of Maine and Mountain View vein systems, forming a series of nearly parallel, braided veins. The en enchelon system of fractures through the region have ore shoots formed where the veins junction or change in strike or dip. The San Pedro vein contains more silica and manganese than the State of Maine, although the Free Coinage end of the State of Maine vein system contains appreciable manganese as well. Barite, pyrite, quartz, and copper staining was also noted in the ore at the San Pedro. The lack of these minerals at the other mines may be due to the hand sorting methods used in the past. Barite was also noticed with the high grade ore from the Brother Jonathan, adjacent to the State of Maine mine.

EXPLORATION RECOMMENDATIONS

The exploration goal for the Tombstone properties is to locate a large tonnage silver orebody amenable to either open pit or underground bulk mining methods. As outlined above, this goal may be found in several types of potential orebodies on the claims block. The primary target is within the brecciated block of ground in the State of Maine mine found between the two major veins. Of secondary interest are similar targets in the San Pedro and Mountain View mines. The Bisbee formation and Bisbee-Naco breccias are also potential hosts for large scale replacement orebodies.

Sampling of all crosscuts in the mine workings within the Uncle Sam porphyry should be done to evaluate the potential for widespread silver disseminations between the major veins. Wallrock and veins should be treated equally, except where the vein has obviously been stoped out by previous miners. Care should be taken to not high grade the samples by including vein samples where pillars may be located in the cross-cuts. The enclosed composite level plan (map pocket) shows the location he major cross-cuts in the State of Maine mine which should be systematically sampled to evaluate the zone between the two bounding veins.

Once this channel sampling data has been analyzed, target areas for further sampling would be defined. The geology, mineralization, and alteration would be mapped during the sampling program, with the data plotted in plan and section. Longholes would then be drilled at given intervals from the footwall drifts across the zone, perpendicular to the prevalent structural attitude. These holes would be typically 45 degree upholes and would reach up to 150 feet in length, averaging about 75 feet long. The geology, alteration, and mineralization of the longholes would be logged, and the rock sampled for silver values. Should the channel sampling fail to define promising areas of disseminated mineralization, the drilling would either be limited in scope or the project would be dropped from consideration. The location of small, high grade ore shoots will not meet the economic requirements for development of the property, and therefore these vein deposits will not be evaluated on a small tonnage, shrink stoping mining method basis.

Because of the deep nature of the Bisbee limestone and Bisbee-Naco breccia ore targets, the exploration methods required for these deposits would include geochemical soil sampling, geophysics, and diamond or rotary drilling. The tonnage of these types of orebodies is low to moderate in size (10,000 to 250,000 tons) as seen in the old records of mines in the district. The depth of the ore horizon is, of course, critical to the mining methods and economics of the operations, and these ore types should be evaluated carefully. All available data should be evaluated, the mines and surface exposures thoroughly mapped prior to any drilling programs. An E.M. or I.P. geophysical survey of the area should be run to locate targets for closer examination. As the San Pedro and Mountain View veins are the major mineralized fractures in the area, they would be the most likely sources for ore fluids to form replacement deposits in these beds. The limestone replacement ore potential would be best explored from the lowest level of the State of Maine mine, as this is the closest accesible location to the lower Bisbee formation on the properties.

BIBLIOGRAPHY

Blake, W.P., 1882a, "The Geology and Veins of Tombstone, Arizona": AIME Trans., v. 10, pp.334-345; also Eng. Min. Jour., v. 33, pp. 145-146, 157, 231-232, 328.

______, 1882b, "Porphyry Dike, Tombstone District, Arizona": Eng. Min. Jour., v. 34, p. 29-30.

______, 1902, Tombstone and It's Mines, A Report on the Past and Present Conditions of the Mines of Tombstone, Cochise County, Arizona: to the Development Company of America, 83 pp., New York.

______, 1904, "Tombstone and It's Mines": AIME Trans., v. 34, pp. 371-374.

Brinsmade, R.B., 1907, "Tombstone, Arizona Restored": Mines and Minerals, v. 27, no. 8, pp. 371-374.

Butler, B.S., and Wilson, E.D., 1937, "Structural Control of Ore Deposits at Tombstone, Arizona": Econ. Geol., v. 32, pp. 196-197, (abstract).

______, 1942, "Ore Deposits at Tombstone, Arizona"; Ore Deposits as Related to Structural Features, pp. 201-203, (Princeton University Press).

Butler, B.S., Wilson, E.D., and Rasor, C.A., 1938a, Geology and Ore Deposits of the Tombstone District, Arizona: Univ. of Ariz., Arizona Bur. Mines Bull. 143, 114 p.

______, 1938b, Structural Control of Ore Deposits at Tombstone, Arizona: Univ. of Ariz., Arizona Bur. Mines Bull. 145, pp. 104-110.

Church, J.A., 1882, "The Geology and Veins of Tombstone, Arizona": Eng. Min. Jour., v. 33, pp. 218-219.

______, 1903, "The Tombstone, Arizona Mining District": AIME Trans., v. 33, pp. 3-37.

Clark, F.W., 1914, Water Analysis From the 1000 Foot Level, Contention Mine, Tombstone, Arizona: USGS Water Supply Paper 364, p. 39.

Devere, J., 1960,: "The Tombstone Bonanza, 1878-1886": Arizoniana, v. 1, no. 3, pp. 16-20.

Drewes, H.D., 1981, Tectonics of Southeastern Arizona: USGS Prof. Paper 1144.

Gilluly, J., 1945, "Emplacement of the Uncle Sam Porphyry, Tombstone, Arizona": Am. Jour. Sci., v. 243, no. 15, pp. 643-666.

______, 1956, "General Geology of Central Cochise County, Arizona": USGS Prof. Paper 281, 169 p.

Gilluly, J., Cooper, J.R., and Williams, J.S., 1954, "Late Paleozoic Stratigraphy of Central Cochise County, Arizona": USGS Prof. Paper 266, 49 p.

Goodale, C.W., 1889, "The Occurance and Treatment of the Argentiferous Manganese Ores of the Tombstone District, Arizona": AIME Trans., v. 17, pp. 767-774.

______, 1890, idem, v. 18, pp. 910-912.

______, 1927, "Reminiscences of Early Days in Tombstone, Arizona": Ariz. Min. Jour., v. 10, no. 23, pp. 3-4, 60-62.

Hewett, D.F., and Radtke, A.S., 1967, "Silver-bearing Black Calcite in Western Mining Districts": Econ. Geol., v. 62, no. 1, pp. 1-21.

Hillebrand, W.F., 1886, "Emmonsite, a Ferric Tellurite": Colo. Sci. Soc. Proc., v. 2, pp. 20-23.

Hollyday, E.F., 1963, A Geohydrologic Analysis of Mine Dewatering and Water Development, Tombstone, Arizona: Univ. of Arizona M.Sc. Thesis, 90 p.

Jones, E.L., and Ransome, F.L., 1920, Deposits of Manganese Ore in Arizona: USGS Bull. 710, pp. 96-119.

Jones, R.W., 1966, "Discussion--"General Geology and Some Structural Features of the Courtland-Gleeson Area, Cochise County, Arizona", by O.M. McRae": Soc. Min. Eng. Trans., v. 235, no. 4, pp. 446-449.

Lakes, A., 1904, "Ore in Anticlines, as at Bendigo, Australia, and Tombstone, Arizona": Min. Sci. Press, v. 88, p. 193.

Moses, A.J., 1893, "Mineralogic Notes; Ettringite from Tombstone, Arizona, and a Formula for Ettringite": Am. Jour. Sci., 3rd ser., v. 45, pp. 488-492.

Needham, A.B., 1956, Investigation of Tombstone District Manganese Deposits, Cochise County, Arizona: USBM RI-5188, 34 p.

Ransome, F.L., 1916, Some Paleozoic Sections in Arizona and Their Correlation: USGS Prof. Paper 98K, pp 133-166.

Rasor, C.A., 1937a, Mineralogy and Petrography of the Tombstone Mining District, Arizona: Univ. of Ariz. Ph.D. Thesis, 115 p.

_____, 1937b, idem, Univ. Arizona, Arizona Bur. Mines Bull. 143, pp. 50-66 (abstract).

_____, 1938, "Bromyerite from Tombstone, Arizona": Am. Mineralogist, v. 23, pp. 157-159.

_____, 1939, "Manganese Mineralization at Tombstone, Arizona": Econ. Geol., v. 34, pp. 790-803.

_____, 1946, "Loellingite from Arizona": Am. Mineralogist, v. 31, no. 7-8, pp. 406-408.

Shaw, S.F., 1909, "Mining and Milling in the Tombstone District, Arizona": Min. World, v. 30, pp. 589-590.

Silver, L.T., 1963, "U-Pb Isotopic Variations in Zircon--A Case Study": Jour. Geol., v. 71, no. 6, pp. 721-758.

Staunton, W.F., 1918, "Effects of an Earthquake in a Mine at Tombstone, Arizona": Seismol. Soc. Am. Bull., v. 8, pp. 25-27.

Stoyanow, A.A., 1936, "Correlation of Arizona Paleozoic Formations": Geol. Soc. Am. Bull., v. 47, no. 4, pp. 459-540.

_____, 1949, "Lower Cretaceous Stratigraphy in Southeastern Arizona": Geol. Soc. Am. Mem. 38, pp. 1-169.

Tenney, J.B., 1938, "Geology and Ore Deposits of the Tombstone District, Arizona (Review)": Econ. Geol., v. 33, pp. 675-678.

Williams, S.A., 1982, Memorandum on the Mineralogy of the Grand Central Contention Ore Zone, Tombstone, AZ: Unpublished report to Tombstone Exploration, Inc.

Wilson, E.D., and Moore, R.T., 1963, "Cretaceous and Tertiary Ore Deposition in Arizona": Arizona Geol. Soc. Digest, v. 6, pp. 1-6.

MINERALS PRESENT IN THE TOMBSTONE MINING DISTRICT

H designates hypogene mineralization

S designates supergene mineralization

Silver Minerals		
argentite (acanthite)	Ag_2S	S
stromeyerite	$Ag_2S.Cu_2S$	S
hessite	Ag_2Te	H
argentojarosite		S
native silver	Ag	S
cerargyrite	AgCl	S
embolite	AgBr	S
argentiferous tetrahedrite		H
argentiferous galena		H
Gold Mineral		
native gold	Au	
Lead Minerals		
galena	PbS	H
bournonite	$Cu_2S.2PbS.Sb_2S_3$	
cerrussite	$PbCO_3$	
pyromorphite	$9PbO.3P_2O_5.PbCl_2$	
vanadite	$9PbO.3V_2O_5.PbCl_2$	
descloizite	$4(Pb,Zn)O.V_2O_5.H_2O$	
mottramite (cuprodescloizite)	$4(Cu,Zn)OH.(VO_4)_3$	

anglesite	$PbSO_4$
wulfentite	PbMoO
plumbojarosite	$PbO.3Fe_2O_3.4SiO_3.6H_2$

bindheimite--hydrous antimonate of lead

Copper Minerals

native copper	Cu	
chalcocite	Cu_2S	
stromeyerite	$Ag_2S.CuS$	
covellite	CuS	
bornite	Cu_5FeS_4	
chalcopyrite	CuFeS	H
bournonite	$Cu_2S.2PbS.Sb_2S_3$	
tetrahedrite	$5Cu_2S.2(Cu,Fe)S.2Sb_2S_3$	H
famatinite	$3Cu_2S,Sb_2S_5$	
cuprite	Cu_2O	
tenorite	CuO	
malachite	$CuCO_3.Cu(OH)_2$	
azurite	$2CuCO_3.Cu(OH)_2$	
rosasite	$(Cu,Zn)CO_3.(Cu,Zn)OH_2$	
aurichalcite	$2(Zn,Cu)CO_3.3(Zn,Cu)OH_2$	
chrysocolla	$CuSiO_3.2H_2O$	
connellite	$CuSO_4.2CuCl_2.19Cu(OH)_2.H_2O$	
brochantite	$CuSO_4.3Cu(OH)_2$	
beaverite	$CuO.PbO.Fe_2O_3,2/SO_3.4H_2O$	

Manganese Minerals

alabandite	MnS	H
hataerolite	$ZnO.Mn_2O_3$	
polianite	MnO_2	
pyrolusite	MnO_2	
manganite	$Mn_2O_3.H_2O$	S
psilomelene	H_4MnO_5	
rhodocrosite	$MnCO_3$	

"black" calcite contains minute Mn oxides

Zinc Minerals

sphalerite	ZnS	H
smithsonite	$ZnCO_3$	
hydrozincite	$ZnCO_3.2Zn(OH)_2$	
rosasite	$(Cu,Zn)CO_3.(Cu,Zn)(OH)_2$	
aurichalcite	$2(Zn,Cu)CO_3.3(Zn,Cu)(OH)_2$	
calamine (hemimorphite)	$2ZnO.SiO_2.H_2O$	

Generalized composite section, Bisbee formation, Tombstone Hills.

	Feet
Erosion surface.	
1. Sandstone and shale, alternating; a few 10-foot limestone conglomerate beds; shale members chiefly red or maroon; sandstone beds buff to brown, a few gray or white; sandstone members range from 20 to 170 feet in thickness, predominate over the shale	1,010±
2. Sandstone, buff, gray, and white, some interbedded gray-green hard shale; thick bedded	220
3. Shale, gray to green, hard and siliceous, a few thin buff sandstone beds	540
4. Sandstone, buff, white, and brown, a few green shale beds, at least one thin bed of limestone	422±
5. Shale, green and bluish some conglomerate	58
6. Limestone, massive, blue, cherty	25
7. Shale, green, mottled red and green, brown, and yellow	345
8. Limestone	10
9. Shale, some sandy beds	29
10. Shale and limestone, alternating in thin beds	15
11. Shale, greenish, some limy beds	30
12. Limestone	5
13. Shale, poorly exposed	53
14. Limestone	4
15. Shale, gray, green, and black	43
16. Sandstone, yellow	9
17. Shale, red and brown	65
18. Shale, black	14
19. Shale, green and gray, siliceous	42
20. Limestone, "Ten-foot bed" of miners	10
21. Shale, with arkose at base	24
22. Limestone, "Blue limestone" of miners	34
23. "Novaculite," silicified shale, local intercalations of limestone conglomerate	60
Total	3,097±

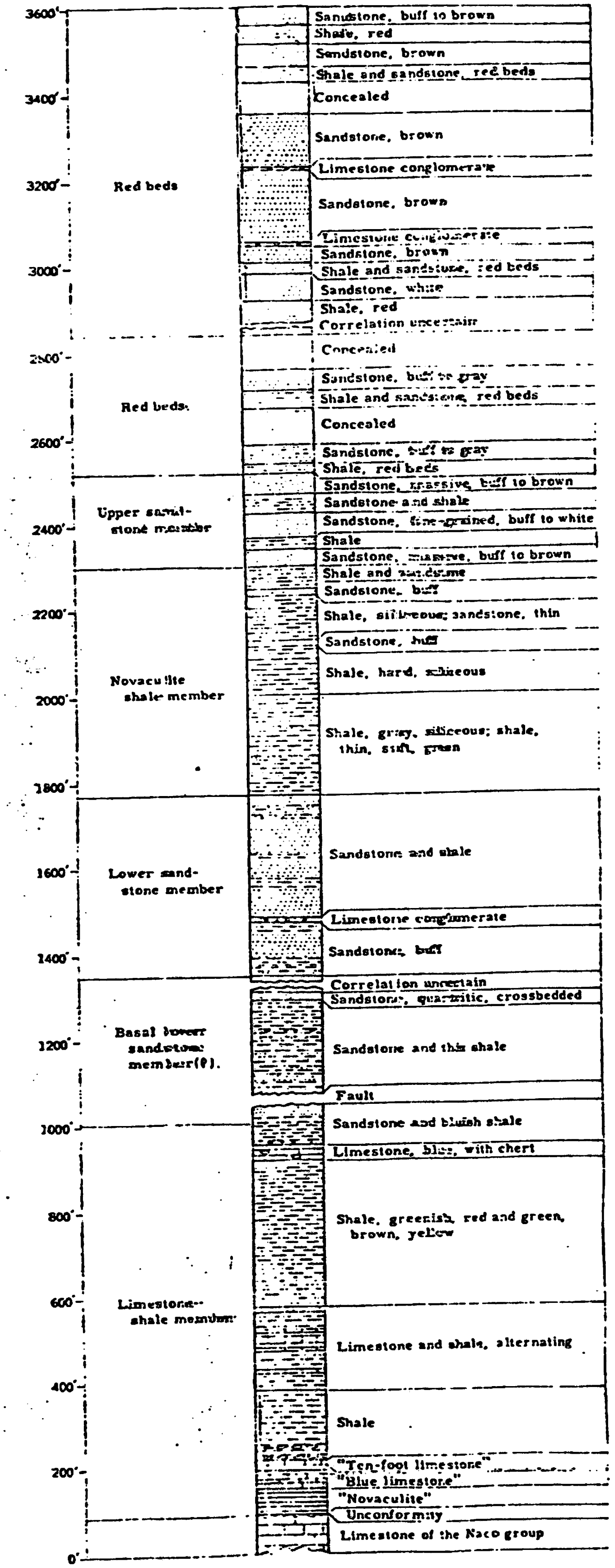


FIGURE 5.—Composite section of the Bisbee formation in the Tombstone mining district. After Lyden, O'Donnell, Hernon, and Higdon (unpublished mine rept., 1937).

THE TOMBSTONE MINING DISTRICT
HISTORY, GEOLOGY AND ORE DEPOSITS

Structural Control of the Ore Deposits at Tombstone, Arizona[61]

By

B. S. Butler and Eldred D. Wilson

Introduction

Tombstone, Arizona, from its discovery by Ed. Schieffelin in 1877 through the eighties, was the best-known mining camp in the Southwest. During this period it produced the larger part of the approximately $37,000,000 worth of metals that it had yielded. Since those boom days it has been a consistent producer in a small way and during 1933-36 yielded more than a million dollars' worth of metals.

Geologic History

Rocks ranging in age from early pre-Cambrian to present are exposed at Tombstone. The geologic section (Pl. III) shows the general character of the sedimentary rocks, and the map (Pl. XXVIII) the distribution of the rocks.

The exposure of pre-Cambrian rock is too limited to reveal much of its history, though the schist indicates the long period of sedimentation and deformation common to the early pre-Cambrian of the Southwest.

Between early pre-Cambrian and Paleozoic the area was deeply eroded, and on this erosion surface of little relief was deposited a thick series of Paleozoic sediments, prevailingly limestone. During long periods, notably the Ordovician, Silurian, and early Devonian, sediments were not deposited, but little or no angular discordance appears in the Paleozoic section.

From Paleozoic to Mesozoic the sedimentation changed from prevailingly limestone to prevailingly sandstone and shale with subordinate limestone. No pronounced angular discordance marks this change, although, as Ransome has shown, faulting and extensive erosion occurred between the deposition of late Paleozoic and Mesozoic rocks in the neighboring Bisbee district. Pebbles of volcanic rocks in the Mesozoic beds at Tombstone indicate igneous activity in the interval between the deposition of the two series of sedimentary rocks, but igneous rocks of this age have not been recognized within the Tombstone area.

The deposition of the Mesozoic sedimentary rocks was followed by a period of deformation and igneous activity, the age of which is not closely known but which may be essentially the same as that of the Laramide revolution in the Rocky Mountain region. The ore deposits are associated with the folding, faulting, igneous intrusions, and fissuring of this period.

[61] For a more detailed description, with numerous structure sections, see B. S. Butler, E. D. Wilson, and C. A. Rasor, *Geology and Ore Deposits of the Tombstone District, Arizona* (Univ. of Ariz., Ariz. Bureau of Mines Bull. 143, 1938).
Paper prepared for the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

Both faulting and igneous activity also occurred, in a mild degree, after deposition of the Cenozoic sediments that occupy the valley floors.

One of the early structures is the uplifted, eastward-tilted Ajax Hill block which is bounded on the north by the Prompter fault and on the south and west by faults. The west boundary fault, which brings Mesozoic rocks against pre-Cambrian, represents a throw greater than the total thickness of the Paleozoic rocks. The north and probably the south boundary faults decrease in throw eastward from the junction with the west boundary fault. The eastward tilting is confined to the western part of the block. Within the block are open east-west folds.

The east-west folds within the Ajax block, the generally southeast-northwest trending Tombstone basin north of the Ajax block, and the folds within that basin were possibly formed at nearly the same time as the Ajax block structure. Following and possibly overlapping the folding and faulting were north-south fissures of steep westerly dip and small displacement. The west boundary fault of the Ajax Hill block, however, with large displacement, has this attitude. The north-south fissuring was followed by igneous activity both extrusive and intrusive. Southwest of the district an area of volcanic breccia and flows is intruded by quartz latite porphyry that, within the Tombstone area, intrudes the Mesozoic sedimentary rocks. Similar porphyry occupies some of the north-south fault fissures that cut both the Paleozoic and Mesozoic sedimentary rocks. In the northwestern part of the district a mass of granodiorite, probably intruded along a fault, separates the Mesozoic and Paleozoic rocks. Dikes of similar composition are present in the sedimentary rocks.

The relative age of the main intrusive bodies is not definitely known. They were probably of one general period, but it seems likely that the granodiorite is later. Dikes intrude both the quartz latite porphyry and the granodiorite, and basaltic rocks are younger than the late sediments of the valley fill.

Fissures of generally northeastward strike and steep dip cut the pre-Tertiary sedimentary rocks, the earlier intrusive rocks, and the earlier structures. These northeasterly striking fissures are the main ore channels, and their intersection with favorable structures and favorable rocks determines the location of ore shoots.

Later than the ore fissures are faults with north to northeasterly strike, represented by the Tranquility fault, and faults with northwesterly strike, represented by the Grand Central fault.

Summary of Structural Events

1. Generally southeast-northwest and east-west folds and faults.
2. North-south faults and fissures (dike fissures).
3. Intrusion of quartz latite porphyry, granodiorite, and allied rocks.

4. Northeast-southwest fissures.
5. North to northeast and northwest faults.

Influence of Rock Character on the Structure

The different response of the massive Paleozoic limestone series and the weak Mesozoic shaly series to stresses is well shown in Tombstone basin, an asymmetrical synclinal fold with easterly to southeasterly pitch, which occupies the northern, most productive part of the district. The rocks along the southern border of the basin dip steeply, and near the Prompter fault are slightly overturned. Within the basin are open secondary anticlines and synclines on the larger Tombstone basin syncline.

Folds of a third order occur as corrugations on the secondary anticlines and synclines. The third-order anticlines are locally termed "rolls," and on them are located many ore shoots. The "rolls" are better developed on anticlines than on synclines, and better on close, steep anticlines than on more open anticlines. Characteristically the "rolls" are asymmetrical, tending to overturn towards the crests of the anticlines. These features indicate drag folds produced by slipping of the beds during folding. This type of folding is much more pronounced in the relatively thin-bedded Mesozoic sandstone-shale-limestone series than in the massive Paleozoic limestone.

Where drag folding is most pronounced the folds have broken and the rocks slipped towards the crests of the anticlines along thrust faults that duplicate the beds (Pl. XXIX, A, B). Somewhat similar faults occur on the sharp turns around the margin of Tombstone basin, as the Lucky Cuss fault. Here, folding of the beds has been accompanied by faulting at a slight angle with the bedding which has in places duplicated strata.

Structural Classification of Deposits

Factors other than structure influenced ore deposition, but here structure is considered. It is apparent from the preceding discussion that the different structures are interrelated. Many of the deposits are associated with more than one structure. Nearly all are associated with northeast-southwest fissures. The deposits may be classified, on the basis of the next most important associated structure, in the following groups:

Deposits associated with north-south (dike) fissures.
Deposits associated with faults.
Deposits associated with anticlines and "rolls."
Deposits with no obvious control other than northeast-southwest fissures.

It may be noted here that the most productive part of the Tombstone sedimentary section extends from somewhat below the top of the Naco limestone to a few hundred feet above the base of the Mesozoic beds. Much of the production has come from within 200 feet stratigraphically of the boundary of the Paleozoic and Mesozoic rocks. The productive Oregon-Prompter horizon

is deeper in the Naco limestone. There are some deposits deep in the Paleozoic and some high in the Mesozoic section.

Deposits Associated with North-South (Dike) Fissures

The deposits associated with north-south (dike) fissures have been most productive in the Empire-Contention-Grand Central dike zone, which crosses Tombstone basin and the anticlines, synclines, and "rolls" of the southeastern part of that basin. Others, notably the Tribute and the Tombstone Extension, belong to this type.

The north-south fissuring added to the fracturing produced by folding, and the rocks were still further disturbed by the introduction of the dikes. The final preparation of the ground was by the northeast fissuring.

The ore shoots are localized within the zone at the crossing of the northeast fissures. The ore is in fissures within the dikes, in the fissure zones occupied by the dikes, and in replaced beds, especially limestone beds extending away from the dikes. The ore shoots extend to several hundred feet stratigraphically above the Paleozoic-Mesozoic contact. There has been little prospecting of this type of deposit below that contact. The higher part of the Empire-Contention-Grand Central zone has been displaced down and to the east by the Tranquility fault and its branches.

The northeast fissures do not cross the north-south (dike) fissures directly on the strike but tend to swing into and follow them for some distance and to appear on the opposite side on the normal strike, but apparently offset. This change of attitude of the fissures in crossing the dikes is similar to the refraction of fissures in passing from one formation to another, described by Knopf[62] for the Mother Lode veins. It may also be due in part to actual offset by later movement in the zone.

Deposits Associated with Faults

The production from deposits associated with faults has come mainly from two groups of mines, one along the Lucky Cuss fault zone and the other along the Oregon-Prompter fault zone.

In both cases the deposits are associated with faults that have caused slipping along the beds near limestone-shale contacts. The Lucky Cuss zone is near the Paleozoic-Mesozoic contact, and the Oregon-Prompter zone is at the base of a shaly horizon deeper in the Naco limestone. The slipping resulted in fracturing the rocks and thickening or duplication of some of the beds, partly by faulting, partly by drag folding. Within the fault zones the ore shoots are at and near the crossing of northeast fissures. The fissures do not cross the fault zones on their normal strike but seem to swing into and follow the fault zone for some distance and appear on the opposite side with normal strike.

[62] Adolph Knopf, *The Mother Lode System of California* (U.S. Geol. Survey Prof. Paper 157, 1929), p. 24.

The deposits of the Oregon-Prompter zone are near, but only partly in, a reverse fault of large stratigraphic throw.

Deposits Associated with Rolls

"Rolls" or drag folds on the anticlines of the Tombstone basin are the sites of many ore shoots. Location of ore shoots on the "rolls" is influenced by several structures and combinations of structures so that prediction of shoots is not certain. The factors that localize ore shoots may be given in the following order, with due allowance for variation:

1. The overlying shale is a relatively impermeable cap.
2. The "novaculite" (siliceous shale) is the most brecciated and the most permeable rock.
3. The upper portion of the Naco limestone, the "novaculite" and the Blue limestone are chemically favorable to replacement.
4. Fissuring, brecciation, and permeability are generally greatest where the bends in the beds are sharpest. As the folds are not symmetrical, the sharpest bends may or may not be at the apexes. In some folds slipping along the beds produced permeable zones in a limb, down which mineralization extends for long distances.
5. After folding, the north-south (dike) fissuring and the intrusion of dikes further brecciated the rocks.
6. Northeast fissuring completed the preparation of the ground for mineralization. The mineralizing solutions rose through the northeast fissures and passed into the permeable zones.

The result of the several controls has been variable, but some generalizations may be ventured.

Mineralization is greatest in and near the northeast fissures and at or near the crests of anticlines (subject to exceptions). It is least at or near the troughs of synclines.

The most favorable beds are near the base of the "novaculite" and in the upper part of the Blue limestone. Other horizons in the "novaculite" as well as the limestone beds in the shale series above the Blue limestone are mineralized near strongly mineralizing fissures. Where the "novaculite" contains ore, the overlying Blue limestone may or may not be barren.

Mineralization extends outward along favorable beds from fissures crossing a roll. That from one fissure may meet that from another and thus form a continuous shoot along a roll. Such shoots have been followed for several hundred feet and are generally regarded as units, although really composed of several shoots.

Deposits Associated with Northeast Fissures Only

Deposits in northeast-southwest fissures have been productive in the quartz latite porphyry and in the Mesozoic sedimentary rocks. In the quartz latite porphyry they are simple fissure filling. In the Mesozoic sedimentary rocks mineralization is in the fissures and extends outward from the fissures along favorable beds.

In the Tombstone basin it is notable that the northeast-southwest fissures have been more productive in the anticlinal areas than in the synclinal areas (Pl. XXIX, A, B), but such are not the fissure deposits in their simplest form.

Relation to Causal Stresses

It is the purpose of this paper to present the relation of the ore shoots to structures without a discussion of the causal forces that produced either. It may be noted, however, that the structures probably resulted from stress from a north to northeasterly direction, and that the different structures can with some doubts and uncertainties be fitted to the idea of the strain ellipsoid.

The source of the metals is likely the same as that of the igneous rocks of the district, though the connection is inferred rather than obvious.

Distribution of Metals

Tombstone is essentially a precious-metal district. Of the production by value from 1879 to 1933, silver amounted to about 81 per cent and gold about 14 per cent of the total.[63] The remaining 5 per cent was mainly lead with some copper, manganese, and zinc.

The ores in different parts of the district range greatly in content of the different metals, and whether they were recovered or not depended somewhat on the degree of oxidation. Zinc has been recovered only from sulphide ores, and the distribution of the oxidized zinc minerals is little known. Manganese, on the other hand, has been recovered only from oxidized ores.

The distribution of metals suggests an area of most intense mineralization in the northeastern part of the district with a rough zoning outward. The most definite of the metal zones are the central gold zone and the marginal manganese-silver zone.

Acknowledgments

During 1906 and 1911, F. L. Ransome carried on detailed mapping of the surface rocks of the district and much underground mapping for the U.S. Geological Survey. His report was not completed, and the work of the writers is a continuation of that study.

In 1936-37 James Gilluly, of the U.S. Geological Survey, contributed to the mapping of the Tombstone area and also to the interpretation of the geologic relations.

The writers are greatly indebted to the officials of the Tombstone Development Company, especially Ed Holderness; to R. T. Walker and E. P. Jeanes, of the United States Smelting, Refining, and Mining Company; and to C. M. d'Autremont and Harry Hasselgren, of the Tombstone Mining Company. J. H. Macia has

[63] M. J. Elsing and R. E. S. Heineman, *Arizona Metal Production* (Univ. of Ariz., Ariz. Bureau of Mines Bull. 140, 1936), p. 91.

been of great help to us and was similarly helpful to Dr. Ransome. During 1936-37 the Eagle Picher Lead Company made an examination of the area under the direction of George M. Fowler and generously contributed to the data collected. Acknowledgment is made of the contribution of Dr. C. A. Rasor, who assisted in the work.

Bibliography

Blake, W. P., The Geology and Veins of Tombstone, Arizona, Am. Inst. Min. Eng., Trans., Vol. 10, pp. 334-45, 1882.

Church, J. A., The Tombstone, Arizona, Mining District, Am. Inst. Min. Eng., Trans., Vol. 33, pp. 3-37, 1903.

Ransome, F. L., Deposits of Manganese Ore in Arizona, U.S. Geol. Survey Bull. 710, pp. 96-103, 113-19, Pl. V, 1920.

Butler, B. S., Wilson, E. D., and Rasor, C. A., Geology and Ore Deposits of the Tombstone District, Arizona, Univ. of Ariz., Ariz. Bureau of Mines Bull. 143, 1938.

Cerbat Mountains[64]

By Robert M. Hernon[65]

Introduction

Geography.—The Cerbat Mountains, in Mohave County, Arizona, extend for about 30 miles northward from Kingman, a town about 70 miles southeast of Boulder Dam. It is a desert range that attains altitudes of 5,000 to 7,000 feet and rises sharply for 1,500 to 3,500 feet above detritus-filled desert valleys. The erosion forms in this range are typical of granite and gneiss masses, except where remnants of lava flows cap mesas of the familiar southwestern type.

Water supply.—Water is not abundant in either the mountains or valleys. Some springs and wells are in volcanic rocks as at Kingman. The crystalline complex of the mountains has little primary porosity, and the small amounts of water generally found in it occur in fault fractures and joints. According to reports, wells in the detrital valley fills have yielded little water.

Literature.—The most extensive publication that deals with the Cerbat Mountains is by Schrader.[66]

Bastin[67] studied some of the rich silver ores during the secondary

[64] Paper prepared for, and originally presented at, the regional meeting of the A.I.M.&M.E. held at Tucson, Arizona, November 1-5, 1938.

[65] Assistant Professor of Geology, University of Arizona.

[66] F. C. Schrader, *Mineral Deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona* (U.S. Geol. Surv. Bull. 397, 1909).

[67] E. S. Bastin, *Origin of Certain Rich Silver Ores Near Chloride and Kingman, Arizona* (U.S. Geol. Surv. Bull. 750, 1924), pp. 17-39.

sulphide-enrichment investigations. Brief summaries of the geology and ore deposits have been given by others.[68]

Production.—The production[69] of the Cerbat Range through 1930 is given as follows:

Copper (lbs.)	Zinc (lbs.)	Lead (lbs.)	Gold	Silver	Total
2,900,000	95,587,344	55,350,000	$2,339,000	$5,038,000	$20,270,000

To this should be added approximately $170,000 for 1931-36, inclusive, and an unknown amount for some early production which, because of marketing conditions, was not credited to the Cerbat Range. The value of the total production is estimated at $21,000,000 to $25,000,000. Nolan[70] records that the mines of the Wallapai district produced 548,035 tons of ore valued at $13,955,473 during 1902-32.

The largest past producers by far have been the Tennessee and Golconda mines. The important producers at present are the Tennessee-Schuylkill and the Arizona-Magma mines near Chloride, and Keystone, Inc., which operates in Mineral Park and in and near the "Top of Stockton Hill" area. Some custom milling ore was produced in 1937-38 by the Minnesota-Connor Mine. Numerous other mines are yielding shipping ore and custom mill ore to small operators and lessees.

The larger mills include those of the previously mentioned main active operations, besides the Oro Plata mill (now idle), and the General Ores Reduction custom mill.

History.—Most of the mines of the Cerbat Mountains were discovered between 1863 and 1900. The metals sought in the earlier days were gold, silver, and lead. Rich silver chloride, silver sulphide, and native gold ores were exploited first. With cheaper transportation, base-metal ores were mined for lead with low silver. Subsequent improvement in milling methods led to exploitation of complex lead-zinc ores. The later history of the area is essentially the history of the Golconda and Tennessee mines, as they were affected by metal prices and marketing conditions and by milling methods.

The area reached its peak production in the years 1915-17, when the annual yield averaged nearly $3,000,000. This peak coincided with high metal prices. After the World War, production was small until 1936 when the Tennessee-Schuylkill Corporation began operations.

[68] R. T. Mason, *Mining in Northwestern Arizona* (Min. and Sci. Press, 1917), pp. 627-28.
N. H. Darton, *A Résumé of Arizona Geology* (Univ. of Ariz., Ariz. Bur. of Mines Bull. 119, 1925), p. 180.
W. Lindgren, *Mineral Deposits* (4th ed., 1933), pp. 578-79.
E. T. McKnight, *Mesothermal Silver-Lead-Zinc Deposits* (Am. Inst. Min. Eng., Lindgren Volume, 1933).
T. B. Nolan and others, *Mineral Resources of the Region around Boulder Dam* (U.S. Geol. Surv. Bull. 871, 1936), pp. 18-19.

[69] Morris J. Elsing and Robert E. S. Heineman, *Arizona Metal Production* (Univ. of Ariz., Ariz. Bureau of Mines Bull. 140, 1936), pp. 73, 95.

[70] *Op. cit.*

A BRIEF HISTORY AND REVIEW OF ORE GRADES AND PRODUCTION IN THE TOMBSTONE MINING DISTRICT WITH EMPHASIS ON THE CONTENTION MINE AREA

BY
Michael N. Greeley
Field Engineer
June 1984

ARIZONA DEPARTMENT OF MINERAL RESOURCES
John H. Jett
Director

PHOENIX OFFICE

Mineral Resources Building
Fairgrounds
Phoenix, Arizona 85007
(602) 255-3791

TUCSON OFFICE

State Office Building
416 W. Congress, Rm. 161
Tucson, Arizona 85701
(602) 628-5399

ARIZONA DEPARTMENT OF MINERAL RESOURCES

BOARD OF GOVERNORS

PREFACE

Accelerated interest in precious-metal occurrences in Arizona prompted the review of production records of the Tombstone mining district. The Tombstone area was, and continues to be, the largest producer of primary silver in the state. A significant amount of "by-product" gold has also been produced. At present two producing companies are active in the district.

This report represents an attempt to gather data from several sources and tabulate the annual production of each mine, beginning with the Tough Nut in 1879. The production tables generally give the tons of ore, or other material, treated and the amount of precious and base metals recovered. Based on this information, average (recovered) grades have been calculated and added to the tables.

Two final compilations of the annual grade of gold and annual grade of silver are given for each mine at the end of the report. Since the earliest precious-metal production was reported as doré or precious-metal bullion, with no separation of silver and gold, the amount of silver produced during the early years and the corresponding silver grade are exaggerated. Gold is included with the silver in these early production and grade figures.

The strongest zone of metallization exploited in the Tombstone district was the Contention-Head Center-Grand Central area. Although this zone is emphasized in this report, production figures and calculated ore grades are tabulated for most of the other major district mines. The western-most deposits are not discussed.

This report should be viewed as a base of information that can be expanded and improved as more data is obtained. The interested reader is encouraged to review individual mine files, maintained by the Department, for other engineering and geologic reports.

Attached are tables of production of the Tombstone mining district and tables showing yearly precious metal grades of ore treated. The grades are based on recovered metal only. Silver production figures for the earliest years were obtained from U.S. Bureau of Mines data. These "silver" figures probably represent troy ounces of precious metal bullion, or doré, containing both silver and gold, shipped to the U.S. Mint for refining. Whenever gold production is not shown, therefore, it may be generally assumed the amount of silver and the recovered grade of silver are erroneously high.

Although the production figures are not complete, they probably do represent some 90 to 95 percent of the total ore produced from the heart of the district. Much of the production since the early 1930's is not tabulated because it has not been segregated according to mine or operating entity. This later production includes that of the Tombstone Development Co., the Tombstone Mining Co., and other companies and leaseholders. In addition to the production-grade tables, there are several smaller tables showing metal produced from non-ore sources such as mill tailings and smelter slag.

The Contention--Head Center--Grand Central area is the strongest metallized zone exploited in the district. Since startup in 1880, production from this zone was nearly continuous for about fifty years, and intermittent for another twenty-five years. Recently, significant production from this zone is attributed to the mining and heap leaching operation of Tombstone Exploration, Inc.

The Contention--Grand Central ore zone is about 3,300 feet long. Within this zone the richest ore bodies occurred between the surface and the fourth level. Generally, the rock was soft and the mining costs were low (Butler and others, 1938, p. 69-70).

Development of the Contention, Head Center, and Grand Central mines was rapid during the earliest years. By July, 1881, mine workings had reached the water table at a depth of 560 feet. Although ore extended at least 100 feet below the water, pumping was not sufficient to allow extensive drifting or stoping in this region. Fire destroyed the hoist house and pumping facility at the Grand Central mine in 1886 and later that year the Contention works were also destroyed.

Much of the production by the Grand Central Mining Co. from 1884 to 1888 was actually from the Emerald mine. The Emerald is approximately 4,000 feet to the southwest of the Grand Central shaft. Like the Contention--Grand Central deposits, the Emerald is associated with a north-trending fissure.

Between startup and 1887, the Contention, Grand Central (and Emerald), and Head Center mines had reportedly treated 272,545 tons of ore, yielding 10,969,929 ounces of silver and 6,092 ounces of gold. Using these figures, the recovered grades were about 40.25 oz Ag/ton and 0.022 oz Au/ton.

Although usually not specific, early written accounts of ore grade in the district suggest that gold assays were significantly higher than 0.022 oz/ton. Church (1903, p. 34) states the proportion of gold was 0.827%, by weight, of the precious metals (district-wide) and the Contention--Grand Central zone produced about 1 ounce gold to 80 ounces silver. Extraction rates for near-surface, or chloride ores throughout the district were about 85% silver and 45% gold (Church, 1887, p. 602).

Combining all silver (doré) and gold reported from the Contention--Grand Central zone, between 1880 and 1887, gives a total of 10,976,021 ounces of bullion. Assuming an original ratio of 80 ounces of silver to one ounce of gold in the ore and recoveries of 85% and 45% respectively, there would be approximately 84.51% of the available precious metal extracted. The total amount of gold and silver in the ore, therefore, may have been about 12,987,836 ounces.

Applying the 80:1 ratio to the total precious metal content indicates 12,825,488 ounces of silver and 162,348 ounces of gold were sent, in 272,545 tons of ore, to the company mills. The tenor of the ore, therefore, may have been about 47.06 oz Ag/ton and 0.596 oz Au/ton. It should be emphasized that several assumptions have been made in deriving these figures. The ore grades, though reasonable approximations, may not be completely accurate.

During the period, 1899-1914, most of the district mines were operated by lessees or by the Tombstone Consolidated Mines Co. Individual mine production is not given in the records studied. A majority of the ore produced, however, probably came from the Contention--Grand Central area. Certainly the bulk of the production originated above the water table even though significant development was made down to the 1,000-foot level during the more successful years of dewatering. The average recovered grade was 10.90 oz Ag/ton and 0.140 oz Au/ton. The silver to gold ratio (recovered) was approximately 79:1.

Between 1915 to 1918 the Bunker Hill Mines Company, a subsidiary of the Phelps Dodge Corp., operated the defunct Tombstone Consolidated Mines property. On April 1, 1918, the property was turned over to lessees. The mines were managed in this manner until the end of 1931.

Undoubtedly numerous mines throughout the district frequently contributed to the total production credited to Bunker Hill Mines. As many as 60 lessees operated the company mines in one year. In general, therefore, no specific sources of ore have been identified with the exception of that mined during 1930 which, according to a Phelps Dodge annual report, came chiefly from the Contention--Head Center area, a "high" gold zone. The recovered grade, 0.274 oz Au/ton, that year was the highest on the company property since 1916. No ore was produced from below the water table during the Bunker Hill Mines management.

Several observations taken from the literature may be made concerning the changes in character of the ore, grade, and precious metal ratios occurring with depth in the Contention--Grand Central ore zone. No attempt is made to predict actual grades of mineralization remaining in the ground.

Ore occurs (1) in the faulted segments of the Contention dike, (2) in brecciated footwall zones of these segments, and (3) in limestone beds of the shaley Bisbee Group. Where the dike is in place and unfaulted, very little ore has been found (Butler and others, 1938, p. 70). In general, the ore bodies appear to be genetically related to northeast fissures. Though not well documented, Church (1903) shows that some of the deposits in the Contention--Grand Central zone are associated with anticilinal flexures in the sediments.

The ore of the upper levels of the zone was rich in silver, gold, and lead. Most of this ore was strongly oxidized. Church (1887, p. 601) describes the mineral suite as one comprised chiefly of horn silver (probably also bromyrite--AgBr) enclosed in a gangue of quartz, iron and manganese oxides, with lead carbonate and some sulfides of silver, iron, copper, lead and zinc. Gold occurred in the native form as well as in various sulfide minerals where, according to Butler and others (1938, p. 51), it may be present as a telluride.

With increasing depth in the mines, the proportion of silver sulfide increased and the silver haloid decreased. Fissure-veins usually had a higher gold value than the anticlinal deposits, and Church (1903, p. 34-35) believed that the gold content increased with depth in all occurrences. He reports an anticlinal deposit located in the Contention mine that was drifted on 90 feet below the water table. The drift, 140 feet long, assayed more than 4.8 ounces per ton in gold. It is not known if this deposit was chiefly oxide or sulfide in character.

Only very general comments may be made concerning distribution trends of other metals. Lead is widely distributed but its presence does not necessarily indicate high silver values. It is generally low in deposits that are high in manganese.

Distribution of copper and zinc is not well known. Copper appears to be most abundant in and near strong northeast fissures, according to Butler and others (1938, p. 104), and the largest body of copper ore probably occurred deep (9th level?) in the Emerald mine. The largest deposit of zinc ore was probably mined in the Silver Thread area north of the Contention--Grand Central zone.

Although manganese is widely distributed it is most abundant on the margins of the more productive parts of the district. The Prompter fault area, south of the Contention--Grand Central ore zone and between this zone and the Emerald mine, is noted for its manganiferous silver occurrences. The Bunker Hill--Rattlesnake property, south of the Grand Central mine and associated with the Prompter fault, had abundant manganese ore. High gold areas generally carry small amounts of manganese.

For the most part oxidation has improved the grade of the ores, and oxidation is known to extend below water level. The water table may have been lower at some time before the Tombstone district was discovered. The deeper ores, however, are generally less altered and Butler and others (1938, p. 107) suggest the probability that the deeper ore, on the average, will be of lower grade than that above the water level.

SELECTED REFERENCES

Austin, W.L., 1883, Silver Milling in Arizona: Trans. AIME, v. 11, p. 91-106.

Blake, W.P., 1882, The Geology and Views of Tombstone, Arizona: Trans. AIME, v. 10, p. 334-345.

Butler, B.S., Wilson, E.D., and Rasor, C.A., 1938, Geology and Ore Deposits of the Tombstone District, Arizona: Az. Bur. Mines Bull. 143, 114 p.

Church, J.A., 1887, Concentration and Smelting at Tombstone, Arizona: Trans. AIME, v. 15, p. 601-613.

Church, J.A., 1903, The Tombstone, Arizona, Mining District: Trans. AIME, v. 33, p. 3-37.

Goodale, C.W., 1889, The Occurrence and Treatment of the Argentiferous Manganese Ores of Tombstone District, Arizona: Trans. AIME, v. 17, p. 767-777.

Staunton, W.F., Personal Papers, Special Collections, Univ. of Az.

Tenney, J.B., 1927-29, History of Mining in Arizona: Unpublished manuscript, Special Collections, Univ. of Az., 401 p.

				ORE			
Contention	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1880	15,000	1,055,630					USBM
81	20,000	1,317,848					"
82	22,390	1,474,160					"
83	26,107	890,050					"
84	8,720	297,300					"
85	6,035	205,733					"
1910	1,640	42,976		9,222	125,312		"
11	5,265	150,119	1,313	45,479	694,563		"
1928	16	64	1	74	1,211		"
	105,173	5,433,880	1,314	54,775	819,875		
Average		51.67	0.012	0.03%	0.39%		
Grand Central							
1881	18,000	929,978					USBM
82	34,180	1,191,947					"
83	29,240	769,840					"
84	16,560	465,930					"
85	22,650	596,334					"
86	20,675	500,000					"
87	14,500	518,360	4,777				J B Tenney
88		(212,766)					"
1917	74			11,862			USBM
29	45	510	1	182			"
1956	15	9		200	2,400		"
	155,939	5,185,674	4,778	12,244	2,400		
Average		31.89	0.031	0.004%	0.0008%		
Head Center							
1881	5,878	169,487					USBM
82	3,800	109,718					"
83	1,200	48,650					"
84	555	22,520					"
1893-96 (?)							J B Tenney
	11,433	350,375					
Average		30.65					

Feb. '84

MISCELLANEOUS

Contention	Material	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1940	AuAg tails	1,337	4,533	94	4,950			USBM
Average			3.39	0.070	0.19%			
Grand Central								
1924	Pb tails	15,000	30,000	484	15,000	1,000,000		J B Tenney
25	Pb tails	10,575	37,463	506	17,344	1,170,286		"
1926	Pb tails	25,923	44,146	543	17,304	1,104,160		"
		51,498	111,609	1,533	49,648	3,274,446		
Average			2.17	0.030	0.05%	3.18%		

ORE

Tough Nut	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1879	5,210	213,875					USBM
1880	19,350	794,298					"
81	33,435	1,372,572					"
82	30,800	1,263,942					"
83	16,322	550,526	2,918		747,200		"
1892	1,102	97,455	603		248,956		W F Staunton
93	2,096	116,201	1,289		541,208		"
94	1,671	105,014	1,687		582,731		"
1935	1,833	36,079	643	22,000	340,000		USBM
36	1,747	28,820	445	10,850	135,200		"
53	65	1,927	20	440	3,560		"
1957	565	6,994	98	3,220	60,000		"
	114,196	4,587,703	7,703	36,510	2,658,855		
Average		40.17	0.067	0.02%	1.16%		
Vizina							
1880	1,906	40,543					USBM
81	2,725	57,941					"
1886-88(?)							J B Tenney
	4,631	98,484					
Average		21.27					
Way Up							
1883	550	5,631					J B Tenney
Average		10.24					

Feb. '84

ORE

Lucky Cuss	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1888	2,566	107,979	1,519		68,501		W F Staunton
89	687	25,707	356				"
1890	2,488	110,954	1,162		61,193		"
91	2,271	124,682	1,682		145,313		"
92	2,684	116,973	1,254		280,606		"
93	3,729	93,802	431		193,328		"
1894	31	1,708	52		1,283		"
	14,456	581,805	6,456		750,224		
Average		40.25	0.447		2.59%		
		[90Ag : 1Au]					

West Side	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1888	481	40,674	893		70,298		W F Staunton
89	151	12,664	241		13,980		"
1890	500	42,411	966		44,828		"
91	1,105	81,005	1,527		316,136		"
92	1,490	99,026	1,689		318,912		"
93	1,184	57,548	971		179,659		"
1894	246	14,362	279		66,383		"
	5,157	347,690	6,566		1,010,196		
Average		67.42	1.273		9.79%		
		[53Ag : 1Au]					

Northwest	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1890	274	23,895	39		58,674		W F Staunton
91	458	30,751	99		116,836		"
92	1,413	124,062	501		262,407		"
93	1,427	124,253	257		288,990		"
1894	310	29,730	2		51,960		"
	3,882	332,691	898		778,867		
Average		85.70	0.231		10.03%		
		[370Ag : 1Au]					

ORE

Good Enough	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1884	10,610	357,951	1,875				USBM
85	11,900	401,630	111		1,108,600		"
86	12,000	400,000					"
87	11,750	396,139	1,713		451,500		"
88	9,500	319,150					"
89				SHUT DOWN			J B Tenney
1890	20,000	571,430					USBM
91	16,500	465,647	3,861				"
92	19,600	563,218					"
93	19,500	517,240					"
94	13,600	471,900					"
95	14,300	461,540					"
1896	15,000	441,175					"
1913	187	27		14,503			"
	174,447	5,367,047	7,559	14,503	1,560,100		
Average		30.77	0.043	0.004%	0.45%		

Feb. '84

MISCELLANEOUS

	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
Tombstone Mill & Mining Assay Office Dump							
1891	17	899	9		2,476		W F Staunton
Average		52.88	0.529		7.28%		
Tombstone Mill & Mining Charleston Slag Dump Cleanings							
1891	42	2,590	24		6,066		W F Staunton
92	323	22,090	152		86,469		"
93	17	362	3		1,824		"
	382	25,042	179		94,359		
Average		65.55	0.469		12.35%		

ORE

Bob Ingersol	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1881		(13,274)					J B Tenney
82 (?)							"
1883	950	23,874					"
1884 (?)							"
1922	190	2,899	14	2,069	8,530		USBM
23	220	3,166	22	1,158	12,433		"
29	51	270	2	257			"
1930	379	16,121	124	3,181	118,996		"
31	293	10,051	137	2,697	73,739		"
1932	226	6,766	79	2,327	13,695		"
	2,309	76,421	378	11,689	227,393		
Average		27.35	0.164	0.25%	4.92%		

Herchel	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1903-04 (?)							J B Tenney
1905	1,800	90,000			900,000		USBM
06	367	30,276	170		13,680		"
07	201	25,934	174	3,045	19,075		"
08	955	54,440	292	7,461	45,761		"
1910	2,636	41,768	551	10,282	60,424		"
11	2,701	50,886	640	10,060	120,165		"
13	77	1,257	15		3,285		"
19	80	2,098	9	340	1,796		"
1920	27	1,126	9	582			"
1933	280	5,292	42	300	1,200		"
34	597	5,492	36	279	1,134		"
1935	680	652	4	328	750		"
	10,401	309,221	1,942	32,677	1,167,270		
Average		29.73	0.187	0.16%	5.61%		

MISCELLANEOUS

Herschel	Material	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1919	Ag tails	777	5,781	34	2,998			USBM
Average			7.44	0.044	0.19%			

ORE

Old Guard	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1903-04 (?)							J B Tenney
1905	320	16,000			160,000		USBM
1910	381	18,877		54,086			"
11	63	1,348	26	504	6,549		"
14	154	2,736	32	240	4,476		"
15	105	291	33	580	599		"
16	168	1,928	21		1,033		"
17	52	24	18	494	7,684		"
1920	69	1,900	30	320	6,912		"
22	383	4,155	46				"
23	65	830	17				"
26	376	4,938	72	2,158	4,422		"
27	262	2,051	38	1,700			"
28	107	1,074	19	806			"
1929	32	704	11	381	592		"
1933	52	751	13	359	724		"
34	67	1,499	19	279	1,026		"
1935	40	434	6	161	554		"
	2,696	59,540	401	62,068	194,571		
Average		22.08	0.149	1.15%	3.61%		

ORE

Oregon	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1882	4,450	223,300					USBM
83	2,250	128,245					"
84	1,210	60,520					"
1885-90(?)							J B Tenney
1891	185	6,530					USBM
	8,095	417,595					
Average		51.59					
Bunker Hill							
1883	1,980	88,297					J B Tenney
88(?)							"
89	7,000	230,000					USBM
1890-92(?)							J B Tenney
1903	100	7,500	10	12,000	66,000		USBM
1910	450	6,541	15	4,856	48,718		"
	9,530	332,338	25	16,856	114,718		
Average		34.87	0.003	0.09%	0.60%		
San Diego							
1883	415	10,698					J B Tenney
1918(?)							"
1934	80	323	3	306	11,715		USBM
1943	60	34			1,833		"
	555	11,055	3	306	13,548		
Average		19.92	0.005	0.03%	1.22%		

ORE

Tombstone Consolidated	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1899-1902	967	105,077	1,062		190,869		W F Staunton
1903	11,295	189,744	3,750		291,972		"
04	35,720	491,871	8,140		699,174		"
05	31,508	420,712	6,523		1,748,887		"
06	67,121	586,804	7,143		2,142,748		"
07	71,477	506,455	5,818	10,780	2,509,215		J B Tenney
08	51,266	357,414	4,106	7,608	1,770,794	173,313	"
09	27,123	201,700	2,280	27,706	1,535,637	713,716	"
1910	5,249	116,520	1,062	31,163	305,876		"
11	8,797	224,098	2,155	68,209	982,010		"
12	7,405	158,377	1,363	27,723	617,820		"
13	5,760	126,392	1,230	10,657	334,923	36,503	"
1914	6,093	108,868	1,380	14,217	234,345	39,324	"
	329,781	3,594,032	46,012	198,063	13,364,270	962,856	
Average		10.90	0.140	0.03%	2.03%	0.15%	

Bunker Hill Mines (PD)	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1915	9,003	100,115	1,216	36,075	164,135	63,386	J B Tenney
16	57,200	435,931	3,950	131,546	983,983		"
17	42,837	330,354	3,119	142,482	1,278,754		"
18	19,507	283,412	1,389	41,503	457,183		"
19	27,445	450,366	1,946	209,182	289,424		"
1920	28,980	446,721	1,788	144,010	243,946		"
21	18,594	409,234	1,503	132,688	678,946		"
22	44,347	613,700	2,322	196,740	744,529		"
23	32,770	495,943	3,093	195,485	465,914		"
24	15,448	247,642	2,459	72,836	465,323		"
25	17,185	203,918	2,171	57,996	356,733	32,592	"
26	21,785	176,433	2,446	96,172	866,826		"
27	9,831	95,688	2,169	36,098	134,240		USBM
28	21,452	151,400	2,200	1,316,373	155,840		"
29	6,947	60,569	1,082	27,180	135,425		"
1930	5,570	35,061	1,528	780	42,440		"
1931	5,728	52,051	1,384	21,564	3,407		"
	384,629	4,588,538	35,764	2,858,710	7,467,048	95,978	
Average		11.93	0.093	0.37%	0.97%	0.01%	

MISCELLANEOUS

	Material	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
Bunker Hill Mines (PD)								
1917	Ag tails	14,637	113,785	254	87,006			J B Tenney
18	AgMn tails	3,952	34,971	2	5,526			Phelps Dodge
19	AgMn tails	1,117	5,853	31				"
1920	Mn tails	2,027	10,134	54				"
26	Ag tails	376	3,292		4,148	28,589		USBM
27	Pb tails	11,460	18,667	201	1,000	70,300		"
28	Pb tails	2,500	2,762	51	1,202	71,755		"
1929	Pb tails	8,155	35,331	570	48,434	695,098		"
1931	Pb tails	9,139	32,746	635	37,221	190,687		"
Tombstone Development Co. (?)								
1932	AuAg tails	2,286	7,118	131	12,765	42,730		USBM
		55,649	264,659	1,929	197,302	1,099,159		
Average			4.76	0.035	0.18%	0.99%		
71 Minerals								
1974	Dump	5,000	2,240					USBM
75	"	293,276	60,436	2,591				"
76	"	940,000	124,700	3,661				"
1977		-	77,000	1,900				"
		1,238,276	187,376	8,152				
Average			0.15	0.007				

				ORE			
Tombstone Extension	Tons	oz Ag	oz Au	lbs Cu	lbs Pb	lbs Zn	Reference
1930	2,760	21,997	205		887,952		B S Butler
31	5,801	5,801	44		232,099		"
32	3,096	41,485	286		1,563,532		"
33	2,819	37,840	224		1,145,565		"
34	3,129	35,632	196		1,280,550		"
35	2,458	30,439	90		970,857		"
36	222	2,860	10		87,228		"
37	412	4,437	28		167,949		"
1938-49 (?)							USBM
1950	160	2,134	13		65,600		"
1951-52 (?)							"
1954 (?)							"
	20,857	182,625	1,096		6,401,332		
Average		8.76	0.053		15.35%		

WEIGHTED AVERAGE RECOVERED SILVER GRADE (oz/short ton) OF ORE

Year	Tough Nut	Contention	Vizina	Grand Central	Head Center	Bob Ingersol	Oregon (Knoxville)	Luck Sure	Bunker Hill	San Diego	Way Up	Good Enough	Lucky Cuss	West Side	North West	Tombstone Consolidated	Tranquility	Herschel	Old Guard	Tombstone Extension
1879	41.05																			
1880	41.05	70.39	21.27																	
81	41.05	65.89	21.26	51.67	28.83	?		46.82												
82	41.04	65.84		34.87	28.87	?	50.18													
83	33.73	34.09		26.32	40.54	25.13	57.00		44.59	25.78	10.24									
84		34.09		28.14	40.57		50.02					33.74								
85		34.09		26.33			?					33.75								
86			?	24.18			?					33.33								
87			?	35.75			?					33.71								
88			?	?			?		?			33.59	42.08	84.56						
89							?		32.86				37.42	83.87						
1890							?		?			28.57	44.60	84.82	87.21					
91							35.30		?			28.22	54.90	73.31	67.14					
92	88.43								?			28.74	43.58	66.46	87.80					
93	55.44				?							26.53	25.15	48.60	87.07					
94	62.85				?							34.70	55.10	58.38	95.90					
95					?							32.28								
96					?							29.41								
97																				
98																?				
99																?				
1900																?	121.66			
01																108.70				
02																16.80		?	?	
03									75.00(?)							13.77		?	?	
04																13.35		50.00	50.00	
05																8.74		82.50		
06																7.09		129.02		
07																6.97		57.01		
08																7.44				
09																22.20		15.85	49.55	
1910		26.20(?)							14.54							25.47		18.84	21.40	
11		28.51(?)														21.40				
12												0.14(?)				21.94		16.32		
13																17.87			17.77	
14																11.12			2.77	
15																7.62			11.48	
16																7.71			0.46	
17																14.53				12.08
18																16.41		26.23		
19																15.41		41.70	27.54	
1920																22.01				
21																13.84			10.85	
22						15.26										15.13			12.77	
23						14.39										16.03				
24																11.87				
25																8.10			13.13	
26																9.73			7.83	
27																7.06			10.04	
28																8.72			22.00	
29						5.29 (?)										6.29				7.97
1930						42.54										9.09				19.36
31						34.30										?				13.40
32						29.94										?		18.90	14.44	13.42
33																?		9.20	22.37	11.39
34										4.04						?		0.96	10.85	12.38
35	19.68									0.57						?				12.91
36	16.50															?				10.76
37																?				?
38																?				?
39																?				?
1940																?				?
41																?				?
42																?				?
43																?				?
44																?	121.00			?
45																?				?
46																?				?
47																?				?
48																?				?
49																?				13.34
1950																?				?
51																?				
52																?				
53	29.65															?				
1954																				
1957	12.38																			
Average: 1879-1900	41.04	53.34	21.27	31.91	30.65	25.13	51.59	46.82	35.45	25.78	10.24	30.80	40.25	67.42	85.67	11.45	121.66	29.73	22.08	8.76
Average: 1901-1957	17.53	27.96				28.90			25.53	2.55										
Average: 1879-1957	40.17	51.67	21.27	31.91	30.65	27.35	51.59	46.82	34.87	19.92	10.24	30.80	40.25	67.42	85.67	11.45	121.66	29.73	22.08	8.76

Feb. '84

WEIGHTED AVERAGE RECOVERED GOLD GRADE (oz/short ton) OF ORE

Year	Tough Nut	Contention	Vizina	Grand Central	Head Center	Bob Ingersol	Oregon (Knoxville)	Luck Sure	Bunker Hill	San Diego	Way Up	Good Enough	Lucky Cuss	West Side	North West	Tombstone Consolidated	Tranquility	Herschel	Old Guard	Tombstone Extension
1879-1882	?	?	?	?	?	?	?	?												
1883	0.179	?		?	?	?	?	?	?	?	?									
84		?		?	?	?	?					0.176								
85		?		?			?					0.009								
86			?	?			?					?								
87			?	0.329			?					0.146								
88			?	?			?		?			?	0.592	1.857						
89							?		?			?	0.518	1.596						
1890							?		?			?	0.467	1.932	0.142					
91							?		?			0.234	0.741	1.382	0.216					
92	0.547								?			?	0.467	1.134	0.355					
93	0.615				?							?	0.116	0.820	0.180					
94	1.010				?							?	1.677	1.134	0.006					
95					?							?								
96					?							?								
97																				
98																				
99																				
1900																?				
01																?				
02																?	?			
03									0.100							1.098				
04																0.332		?	?	
05																0.228		?	?	
06								?								0.207		?	?	
07																0.106		0.463		
08																0.081		0.866		
09																0.080		0.306		
1910		?							0.033							0.084				
11		0.249														0.202		0.209		
12																0.245		0.237	0.413	
13																0.184				
14																0.214				
15																0.226			0.208	
16																0.135			0.314	
17				?												0.069			0.125	
18										?						0.073			0.346	
19																0.071				
1920																0.071		0.113		
21																0.062		0.333	0.435	
22						0.074										0.081				
23						0.100										0.052			0.120	
24																0.094			0.262	
25																0.159				
26																0.126				
27																0.112			0.191	
28		0.063														0.221			0.145	
29				0.022		0.039										0.103			0.178	
1930						0.327										0.156			0.344	
31						0.468										0.274				0.074
32						0.350										0.242				0.008
33																				0.092
34										0.038								0.150	0.250	0.079
35	0.351																	0.060	0.284	0.063
36	0.255																	0.006	0.150	0.037
37																				0.045
38																				0.068
39																				?
1940																				?
41																				?
42																				?
43										?										?
44																				?
45																				?
46																	?			?
47																				?
48																				?
49																				?
1950																				?
51																				0.081
52																				?
53	0.308																			?
1954																				
1956				?																?
1957	0.173																			
Average: 1879-1900	0.059			0.329								0.043	0.447	1.273	0.231					
Average: 1901-1957	0.286	0.012		0.022		0.164			0.003	0.038						0.057		0.187	0.149	0.053
Average: 1879-1957	0.067	0.012	?	0.031	?	0.164	?	?	0.003	0.005	?	0.043	0.447	1.273	0.231	0.057	?	0.187	0.149	0.053

Feb. '84

ALANCO

PROPERTY ABSTRACT SUMMARY SHEET
KEY INFORMATION

1. **PROPERTY NAME: Tombstone Property**

2. **COMMODITIES: Gold, Silver, Lead, Zinc, Copper, Manganese, and Limestone (Both Chemical and Industrial Grade Limestone).**

3. **INDEX and PROJECT NUMBER**: Alanco Tombstone Property

4. **LOCATION:** **State of Arizona** **County of Cochise**
   SECTION(s): 14, 15, 20, 21, 23, 26, 27, 28, 29, & 30.
   TOWNSHIP: 20 South RANGE 22 East
   BASE & MERIDIAN: Gila and Salt River Base and Meridian.
   NEAREST TOWN: Located in the Southeast portion of the state between Tombstone and Sierra Vista, Arizona.
   MINING DISTRICT: Tombstone Mining District

5. **NUMBER OF FEDERAL CLAIMS** (Bureau of Land Management Land)
   LODE: 247
   PLACER: None
   MILLSITES: 15 **TOTAL ACREAGE OF PROPERTY:** Excess of 5,000 acres.

   CLAIM GROUPS OWNED BY ALANCO ENVIRONMENTAL (refer to claim map)
   1. **SRC Claim Group** . . . Portion of the group leased to Excellon Resources (refer to claim map)
   2. **MS Claim Group**
   3. **STC Claim Group**
   4. **9 Claims Group**
   5. **ARMCO Millsites**

6. **NUMBER OF STATE CLAIMS:**
   PROSPECTING PERMITS: None needed at this time for lode development.
   MINERAL LEASES: None needed at this time for lode development.

7. **TYPE OF WORKINGS:** Underground operations (from 100 feet to 1400 feet in depth) from 1870's to the mid 1980's. Open pit operations during the early and mid 1980's. Area can be mined either by underground operations on high grade veins which are predominant in the Tombstone area or by low grade open pit operations.

8. **RESERVES:**
   PROVEN: 200,000 Tons (Low grade Ag. & Au.)
   PROBABLE: 100,000 Tons (Low grade Ag. & Au.)
   INFERRED: 6,000,000 Tons of potential Base & Precious Metals
   INFERRED: In excess of 40,000,000 Tons of Industrial & Chemical Grade Limestone

4110 North Scottsdale Road, Suite 200 • Scottsdale, Arizona 85251 • OFF 602 874-0448 FAX 602 946-2800

9. **GEOLOGY:** The Tombstone area is characterized by Sedimentary beds in contact with intrusive and eruptive masses of granodiorite and rhyolite rocks. The mineralized zones in the area are characterized by North-South dikes and sills, Northeast-Southwest fault fissures and anticlines. Many of the high-grade ore zones are a combination of the intersect areas of the N-S dikes and the NE-SW fault zones. With the amount of brecciation associated with structural control of the area, moderate to large low grade Ag. & Au. deposits have been identified with the potential for a large deep seated porphyry copper deposit or deposits below the sedimentary formations. The general consensus is that they were the source of the mineral bearing solutions associated with the Tombstone district.

The Tombstone area is also characterized by exposures of Naco (Permian-Pennsylvanian Age) and Escabrosa (Mississippian Age) Limestone formations. Both formations are sources of and are currently being mined for their industrial and chemical grade calcium carbonate content in other locations within the State of Arizona. Known surface exposures of both formations indicate in excess of 40,000,000 tons of limestone with a very good possibility of additional tonnage being developed.

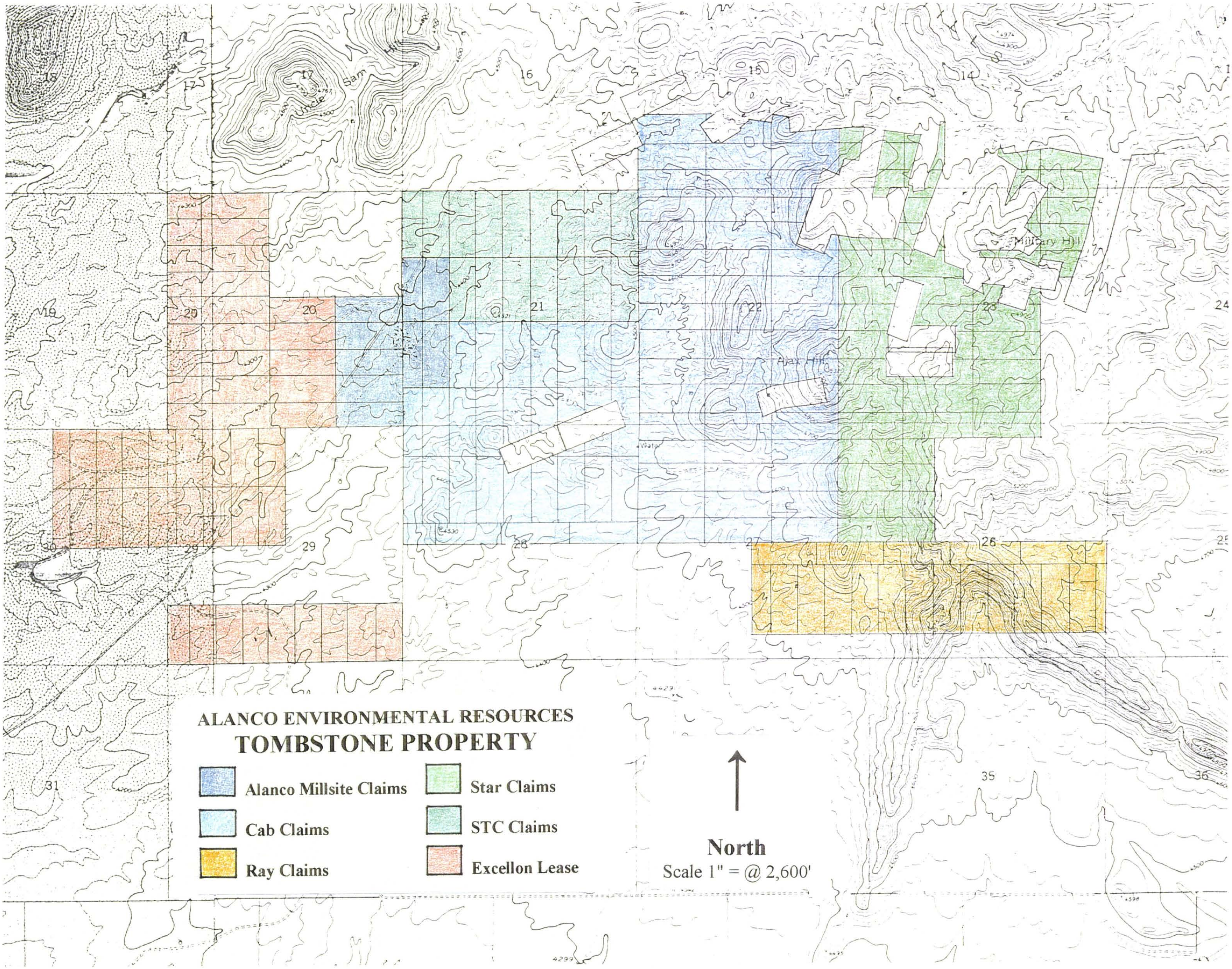
10. **DATE OF EXAMINATION:** Ongoing by Alanco Environmental Resources Corp.

11. **POTENTIAL:** Significant Gold and Silver mineralization observed on property to warrant a detailed exploration program to prove economic value. Approximately 200,000 tons of small low grade silver deposits have been identified. The potential for a large porphyry copper deposit is good, with associated lead and zinc mineralization. Excellon Resources Inc., who have a lease on the West portion of the SRC Claim group, have identified the potential for a porphyry copper deposit at depth in the area.

Preliminary investigations indicate the potential for developing a viable economic limestone project is good. Results to date indicate that both industrial and chemical grade limestone reserves could be developed on the Alanco Tombstone Property.

12. **OWNERS OF THE PROPERTY:** Alanco Environmental Resources Corporation, locate at 4110 North Scottsdale Road, Suite 200, Scottsdale, Arizona, 85251; Phone (602) 874-0448; Fax Number (602 946-2800.

13. **NAMES OF PERSONNEL TO CONTACT FOR FURTHER INFORMATION REGARDING THE PROPERTY:** Larry Kersey (Manager, Mining Projects) of Alanco Environmental Resources Corporation to interested parties. Phone (602) 874-0448. Additional contact regarding the property can be made to Mr. Dean Douglas, V.P. of Operations.



ALANCO ENVIRONMENTAL RESOURCES
TOMBSTONE PROPERTY
Alanco Millsite Claims
Star Claims
Cab Claims
STC Claims
Ray Claims
Excellon Lease
North
Scale 1" = @ 2,600'
Uncle Sam Hill
Military Hill
Apex Hill