CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the

James Doyle Sell Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

ASARCO

Southwestern Exploration Division

Copy FEO 7/11/77

July 8, 1977

FILE MEMORANDUM

write file

Hardshell Metallurgy

On a recent trip to Hardshell with S. R. Titley, he informed me that Bart Santos had gone to Australia for Occidental Minerals to review a metallurgical process used by BHP to refine Mn for batteries. The process is an electrolysis reaction in a brine solution at 45°C which yields very pure Mn and a sludge rich in base metals. As used, the process is designed to separate and recover Mn from a base metal-bearing rock, although it might also be viewed as a process to separate and recover Ag and base metals from a Mn-bearing rock. Occidental's interest may stem from their work in the Candelaria district, Nevada where Ag occurs ina Mn-rich gangue. Santos reportedly gave a strong positive recommendation of the process for whatever use it was intended. Perhaps Mr. Crowell could comment on the applicability of such a process to the Hardshell ores.

F. T. Graybeal

FTG:lb

cc: WLKurtz
DECrowell
SRDavis

Hardshell metallurgy

6-15-77

FROM: J. H. COURTRIGHT

TO: WLK - FTG

Ref. to last item!

Segregation + Flotation

DEC say this is the salt roast ($NaCl$) with same old corrosion problems.

DEC favors the Reduction roast + cyanide using coal or other heat source

JHC

ASARCO

RECEIVED
JUN 9 1977
EXPLORATION DEPARTMENT

Central Research Department
Val Kudryk
Manager

June 7, 1977
Re: 3103

Mr. Hans Michel
Bethlehem Steel Corporation
1821 Martin Tower
Bethlehem, Pa. 18016

Dear Mr. Michel:

Under separate cover we are shipping to your attention a 10-pound sample of Hardshell ore which was taken from a composite with the following analysis:

Ag	Mn	Pb	Cu	Insol.
13.3 oz/T	12.9%	2.6%	0.3%	65%

Several methods were investigated to recover silver and are briefly summarized. It should be noted that the feed samples varied.

Magnetic & High Tension Separation

Feed:	Ag - 5.85 oz.	Mn - 11.2%	Insol. - 71.8%
Recovery:	Ag - 68%	Mn - 79%	
Conc. Grade:	Ag - 17 oz.	Mn - 32.5%	

Gravity Separation (Sink-Float)

Feed:	Ag - 10.3 oz.	Mn - 10.8%	Insol. - 74.5%
Recovery:	Ag - 74.8%	Mn - 83%	
Conc. Grade:	Ag - 34.5 oz.	Mn - 34%	

Flotation

Feed:	Same as gravity	
Recovery:	Ag - 69%	Mn - 72%
Conc. Grade:	Ag - 18.7 oz.	Mn - 19%

Direct Cyanidation

Feed: Same as gravity
Recovery: Ag - 15%

SO_2 Leach + Cyanidation

Feed: Same as gravity
Recovery: Ag - 91.5%
Mn is dissolved and can be filtered and recovered as sulfate by crystallization. The salt can be roasted to recover SO_2 and produce MnO_2.

Reduction Roast + Cyanidation

Feed: Same as gravity
Recovery: Ag - 85.4%
Mn remains in residue as MnO or Mn_2O_3 and probably can be concentrated by gravity or flotation.

Segregation + Flotation

Feed: Same as sample shipped
Recovery: 90% of Ag, Pb and Cu
Manganese can probably be separated by classification; testing will be considered.

If you would like any additional information, please let me know.

Very truly yours,

Val Kudryk

VK/lk

cc: CWCampbell
DECrowell
WLKurtz
EMartinez
NVisnes

J. H. C.

AUG 26 1975

ASARCO Incorporated
Tucson Arizona

August 26, 1975

Memo for D. E. Crowell
Building

Hardshell

I suggest the current metallurgical study of the Hardshell deposit should include a test of sulphurous acid leach on the raw ore followed by cyanidation to determine whether we can expect recovery of 86% as indicated in an earlier 1967 test.

You have indicated that present SO_2 costs are too high to consider this type treatment. This may not be true at the time Hardshell is considered for production.

W. L. Kurtz

WLK:lb

cc: JHCourtright
RBCrist

JHC agreed — They did nothing to help us. None of the [redacted] logical studies requested. I've had the samples returned. MINE

RECEIVED
MAY 1 1975
S. W. U. S. EXPL. DIV.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N.J. 07080

JHC file

WILLIAM P. ROE
VICE PRESIDENT
VAL KUDRYK
MANAGER
H. E. HOWE
MANAGER, METALS RESEARCH

W. L. K. MAY 9 1975

April 28, 1975
Re: 3103

Mr. W. L. Kurtz
Manager of Exploration
TUCSON OFFICE

HARDSHELL PROJECT - SILVER MANGANESE ORE

Mineralogical Studies and Instrumental Analyses of Ore Samples (MR-83 and MR-761 A through E)

This memorandum includes some preliminary mineralogical information on lead and silver occurrences in Composite A (MR-83) sample sent from the Minerals Assay Laboratory at El Paso (T. D. Henderson letter to Dr. V. Kudryk, July 9, 1969). In addition, the results of spectrographic and instrumental analyses on five other ore samples are included in this memorandum. These latter samples had the designations HDS-Min #1 through #5 (MR-761 A through E) and were recently sent from the Southwestern Exploration Division at Tucson (W. L. Kurtz letter to Dr. V. Kudryk, March 19, 1975). Further mineralogical work will be conducted on one or more of the most recently received samples as time permits.

Lead and Silver Occurrences in Composite A Ore (MR-83)

Selected particles in polished section were optically chosen for electron microprobe analysis to determine lead and silver occurrences. A sink (2.73 Sp. Gr.) fraction of minus 35 plus 100 mesh ore was used for this phase of the investigation.

Attached Table No. 1 shows the average lead and silver analyses of twenty optically selected individual particles as determined by electron microprobe analysis. All but one of the particles (particle No. 14) were high in manganese. Detectable lead levels ranged from approximately 0.1 to 22 weight percent. Detectable silver levels ranged from about 0.1 to 1.4 weight percent. Respective levels of lead and silver, mutually associated in individual particles, varied quite widely. In some instances the presence of only one of these elements was detected.

Four individual particles (Nos. 2, 7, 11 and 12) were hand-picked from the polished section and analyzed by X-ray diffraction using a Gandolfi camera. Attached Table No. 2 gives the results. Cesarolite (probable $PbMn_3O_7.H_2O$) was identified as the primary crystalline component of two of the particles. X-ray diffraction analysis of the two remaining particles yielded similar patterns of pyrolusite (βMnO_2) or cryptomelane (generally KMn_8O_{16}). The X-ray films from each of the four particles indicated the additional presence of an amorphous component.

Further electron microprobe analyses were performed on a random selection of 50 Hardshell ore particles in polished section. A sink (2.73 Sp. Gr.) fraction of minus 100 plus 200 mesh ore was used for this part of the study. Attached Table No. 3 shows that most of the analyzed particles were high in manganese. Detectable lead levels ranged from approximately 0.1 to 25 weight percent. Detectable silver levels ranged from about 0.1 to 0.5 weight percent. Similar to the coarser particle study, there was quite a wide variation in the respective levels of lead and silver mutually associated in individual particles. Again, the presence of only one of these elements was detected in some of the particles.

The electron microprobe and X-ray diffraction analyses performed on the various individual particles, from the Composite A (MR-83) sample indicate the difficulties involved in the identification of specific lead or silver minerals. The evident presence of amorphous components in several of the particles examined by X-ray diffraction generally serves to point up the mineralogical complexity of the ore.

Instrumental Analyses of Five Hardshell Ore Samples
HDS-Min #1 through #5 (MR-761 A through E)

Spectrographic analyses of the five ore samples are attached. In addition, instrumental analyses obtained to date are shown in attached Table No. 4. These include specific gravity, Satmagan, X-ray diffraction, infrared and thermal analyses. Pyrolusite (βMnO_2) was the only manganese mineral tentatively identified in these five samples.

R. B. Haagensen

RBH:rg
cc: JHCourtright
DECrowell
SRDavis
VKudryk
EMartinez
TCOsborne

TABLE NO. 1

HARDSHELL COMPOSITE A (MR-83)

Minus 35 Plus 100 Mesh, 2.73 Sink Fraction
Selected Particles

Particle No.	Main Optical Characteristics in Polished Section	Electron Microprobe Analyses (1) (Average of Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O
7 (2)	Smooth, light gray, isotropic.	22	<0.08	MC+	MC
18	Banded, medium gray to grayish green, essentially isotropic.	19 to 22	<0.08	MC+ to CMC	MC
12 (2)	Pebbly, medium gray areas, faint anisotropism.	17	<0.08	CMC	MC
12 (2)	Smooth, light gray areas, isotropic.	16	0.2	CMC	MC
10	Smooth, bright white, isotropic.	15	<0.08	MC+	MC
1	Pebbly, medium to dark gray, isotropic.	13	<0.08	MC+	MC
20	Fairly smooth, light gray, isotropic	8	<0.08	CMC	MC+
17	Smooth, light gray areas, essentially isotropic.	3	<0.07	CMC	MC+
14	Banded, slate gray (some green bands), orange-brown under crossed polars.	1 to 2	<0.08	WMC	MC+
17	Dark gray bands, essentially isotropic	0.7	<0.07	MC-	MC+
2 (2)	Pebbly, light to medium gray, isotropic	0.5	1.4	CMC	MC+
19	Rough, dark greenish gray, isotropic.	0.1	<0.07	CMC	MC
9	Coarse stubby blades, faint bireflectance in grays, moderate anisotropism.	<0.1	0.3	CMC	MC+
17	Pebbly, medium gray areas, essentially isotropic.	<0.1	0.1	CMC	MC+
16	Pebbly, medium grays (green bands), faint anisotropism in gray areas.	<0.1	<0.07	CMC	MC
3	Banded, light grayish yellow, faint anisotropism.	<0.1	<0.07	CMC	MC+
4	Banded, light to medium grays with yellow tints, faint radiating anisotropism.	<0.1	<0.07	CMC	MC+
6	Smooth, light gray, faint bireflectance, moderate anisotropism. (defines grains).	<0.1	<0.07	CMC	MC+
13	Fairly smooth (some internal jagged crystal grain outlines), bright white with yellow tint, isotropic.	<0.1	<0.07	CMC	MC
11 (2)	Mosaic grains, moderate bireflectance in grays, strong anisotropism.	<0.1	<0.07	CMC	MC+
8	Silky aggregates, moderate bireflectance in grays, strong anisotropism.	<0.1	<0.07	MC+	MC+
5	Brick-like to fine blade-like, pale cream, weak anisotropism.	<0.1	<0.07	CMC	MC+
15	Pointed medium blades, grayish tan, essentially isotropic.	<0.1	<0.07	CMC	MC+

(1) Code: CMC Chief Major Constituent; MC Major Constituent; WMC Weak Minor Constituent. Less than (<) indicates below minimum detection limit.

(2) Particle or area selected for X-ray diffraction analysis.

TABLE NO. 2

HARDSHELL COMPOSITE A (MR-83)

Minus 35 Plus 100 Mesh, 2.73 Sink Fraction
Selected Particles

Particle No.	Electron Microprobe Analyses[1] (Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O	X-ray Diffraction Patterns[2]
2	0.5	1.4	CMC	MC+	Cesarolite
7	22	<0.08	MC+	MC	Cesarolite
11	<0.1	<0.07	CMC	MC+	Pyrolusite or Cryptomelane
12	16 to 17	<0.08 to 0.2	CMC	MC	Pyrolusite or Cryptomelane

(1) Code: CMC Chief Major Constituent; MC Major Constituent. Less than (<) indicates below minimum detection limit.

(2) Mineral Formulas: Cesarolite = probable $PbMn_3O_7.H_2O$; Pyrolusite = βMnO_2; Cryptomelane = $A\leq B_8O_{16}$ where A = chiefly K(some Na and Ba) and B = chiefly Mn^{4+} (some Mn^{2+}, Zn, Al, Cu, Co, Fe^{3+}). The X-ray diffraction films from each of the four particles indicated the additional presence of an amorphous component.

TABLE NO. 3

HARDSHELL COMPOSITE A (MR-83)

Minus 100 Plus 200 Mesh, 2.73 Sink Fraction
Random Particles

No. of Particles with Similar Analyses	Electron Microprobe Analyses[1] (Average of Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O	Si
1	25	<0.1	MC+	MC	WMC
1	23	<0.1	CMC	MC	WMC
2	22	<0.1	MC+	MC	WMC
1	22	<0.1	MC+	-	-
1	20	<0.07	CMC	-	-
1	20	<0.1	MC+	MC	WMC
1	20	0.2	CMC	-	-
1	14	<0.1	MC	-	-
1	11	<0.1	MC+	MC	WMC
1	10	<0.1	CMC	-	-
1	7	0.1	MC+	MC	WMC
1	6	<0.1	CMC	MC	WMC
1	5	0.5	CMC	MC	WMC
1	2	<0.1	MC+	MC-	WMC
1	2	<0.1	CMC	-	-
1	1	<0.1	LMC-	-	-
2	1	<0.1	CMC	-	-
1	0.8	<0.1	CMC	-	-
1	0.7	<0.1	LMC-	-	-
1	0.4	<0.07	CMC	MC	WMC
1	0.3	0.3	CMC	MC	WMC
1	0.3	<0.1	LMC-	-	-
2	0.2	<0.1	LMC-	-	-
1	0.2	<0.1	MC+	-	-
1	0.1	0.2	CMC	-	-
1	<0.1	0.1	CMC	MC	WMC
1	<0.1	0.1	CMC	-	-
1	<0.1	<0.07	CMC	-	-
1	<0.1	<0.07	CMC	MC	WMC
10	<0.1	<0.1	CMC	-	-
1	<0.1	<0.1	LMC-	-	-
5	<0.1	<0.1	CMC	MC	WMC
2	<0.1	<0.1	MC+	-	-

(1) Code: CMC Chief Major Constituent; MC Major Constituent; LMC Low Major Constituent; WMC Weak Minor Constituent. Dashed lines indicate not analysed. Less than (<) indicates below minimum detection limit.

TABLE NO. 4

HARDSHELL ORE SAMPLES

DMS-Min #1 through #5 (MR-761 A through E)
Instrumental Analyses

Samples		Instrumental Analyses				
Exploration Designation	Research No.	Sp. Gr.(1)	Satmagan(2)	X-ray Diffraction	Infrared	Thermal
HDS-Min #1	MR-761A	3.25	0.33	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #2	MR-761B	2.80	0.46	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #3	MR-761C	3.10	0.35	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #4	MR-761D	2.73	0.48	Quartz	Not Run	
HDS-Min #5	MR-761E	2.72	0.12	Quartz Mica Pyroxene (possible)	Not Run	

(1) Beckman Air Comparison Pycnometer, model 930.
(2) Saturation Magnetic Analyzer - a magnetic balance. (Magnetic readings shown).
Notes: Pyrolusite = βMnO_2; Goethite = $\alpha FeO.OH$; Mica and Pyroxene are silicates.

SPECTROGRAPHIC ANALYSES

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N. J.

HARDSHELL PROJECT - HDS-Min Designated, Ore Samples

SAMPLE No.	#1 MR-761 A	#2 MR-761 B	#2 MR-761 C	#4 MR-761 D	#5 MR-761 E
Si	MC	MC	MC	MC	MC
Fe	MC-	MC-	MC-	MC-	MC-
Mn	LMC+	LMC	LMC+	LMC	L
Al	M+	M	M+	M+	MC
Zn	LMC-	LMC-	MC-	S	N.D.
Na	LMC	S	LMC	M	N.D.
Pb	LMC	S	S	S	S
Ca	L+	L+	L+	L+	M-
Ba	M	M	S-	M	M
Sr	M	M	M	Tr	M
Cr	L+	L+	L+	L+	FTr
Ti	L	L	L	M	S
Cu	M	M-	M-	M-	L
Mo	L-	FTr	L-	FTr	FTr
Sn	L-	FTr	FTr	FTr	FTr
Mg	L	L	L	L	M+
Cd	L-	L-	L-	L-	N.D.
As	L	L	L	L	L
Be	FTr	N.D.	FTr	N.D.	N.D.
B	N.D.	N.D.	N.D.	N.D.	L-
Ni	FTr	FTr	FTr	FTr	FTr
Ag	M-	M-	L	L	Tr
V	VFTr	VFTr	VFTr	VFTr	VFTr

Not Detected - Te, P, Hg, Pt, Au, Tl, W, Ge, In, Bi, Co,

CODE:

CMC	- Chief Major Constituent
MC	- Major Constituent
LMC	- Low Major Constituent
S	- Strong
M	- Moderate
L	- Low
Tr	- Trace
F Tr	- Faint Trace
V F Tr	- Very Faint Trace
N.D.	- Not Detected

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N.J. 07080

WILLIAM P. ROE
VICE PRESIDENT
VAL KUDRYK
MANAGER
H. E. HOWE
MANAGER, METALS RESEARCH

April 28, 1975 J. H. C.
Re: 3103

Mr. W. L. Kurtz
Manager of Exploration
TUCSON OFFICE

HARDSHELL PROJECT - SILVER MANGANESE ORE

Mineralogical Studies and Instrumental Analyses of Ore Samples (MR-83 and MR-761 A through E)

This memorandum includes some preliminary mineralogical information on lead and silver occurrences in Composite A (MR-83) sample sent from the Minerals Assay Laboratory at El Paso (T. D. Henderson letter to Dr. V. Kudryk, July 9, 1969). In addition, the results of spectrographic and instrumental analyses on five other ore samples are included in this memorandum. These latter samples had the designations HDS-Min #1 through #5 (MR-761 A through E) and were recently sent from the Southwestern Exploration Division at Tucson (W. L. Kurtz letter to Dr. V. Kudryk, March 19, 1975). Further mineralogical work will be conducted on one or more of the most recently received samples as time permits.

Lead and Silver Occurrences in Composite A Ore (MR-83)

Selected particles in polished section were optically chosen for electron microprobe analysis to determine lead and silver occurrences. A sink (2.73 Sp. Gr.) fraction of minus 35 plus 100 mesh ore was used for this phase of the investigation.

Attached Table No. 1 shows the average lead and silver analyses of twenty optically selected individual particles as determined by electron microprobe analysis. All but one of the particles (particle No. 14) were high in manganese. Detectable lead levels ranged from approximately 0.1 to 22 weight percent. Detectable silver levels ranged from about 0.1 to 1.4 weight percent. Respective levels of lead and silver, mutually associated in individual particles, varied quite widely. In some instances the presence of only one of these elements was detected.

Four individual particles (Nos. 2, 7, 11 and 12) were hand-picked from the polished section and analyzed by X-ray diffraction using a Gandolfi camera. Attached Table No. 2 gives the results. Cesarolite (probable $PbMn_3O_7.H_2O$) was identified as the primary crystalline component of two of the particles. X-ray diffraction analysis of the two remaining particles yielded similar patterns of pyrolusite (βMnO_2) or cryptomelane (generally KMn_8O_{16}). The X-ray films from each of the four particles indicated the additional presence of an amorphous component.

Further electron microprobe analyses were performed on a random selection of 50 Hardshell ore particles in polished section. A sink (2.73 Sp. Gr.) fraction of minus 100 plus 200 mesh ore was used for this part of the study. Attached Table No. 3 shows that most of the analyzed particles were high in manganese. Detectable lead levels ranged from approximately 0.1 to 25 weight percent. Detectable silver levels ranged from about 0.1 to 0.5 weight percent. Similar to the coarser particle study, there was quite a wide variation in the respective levels of lead and silver mutually associated in individual particles. Again, the presence of only one of these elements was detected in some of the particles.

The electron microprobe and X-ray diffraction analyses performed on the various individual particles, from the Composite A (MR-83) sample indicate the difficulties involved in the identification of specific lead or silver minerals. The evident presence of amorphous components in several of the particles examined by X-ray diffraction generally serves to point up the mineralogical complexity of the ore.

Instrumental Analyses of Five Hardshell Ore Samples HDS-Min #1 through #5 (MR-761 A through E)

Spectrographic analyses of the five ore samples are attached. In addition, instrumental analyses obtained to date are shown in attached Table No. 4. These include specific gravity, Satmagan, X-ray diffraction, infrared and thermal analyses. Pyrolusite (βMnO_2) was the only manganese mineral tentatively identified in these five samples.

R. B. Haagensen

RBH:rg
cc: JHCourtright
DECrowell
SRDavis
VKudryk
EMartinez
TCOsborne

TABLE NO. 1

HARDSHELL COMPOSITE A (MR-83)

Minus 35 Plus 100 Mesh, 2.73 Sink Fraction
Selected Particles

Particle No.	Main Optical Characteristics in Polished Section	Electron Microprobe Analyses[1] (Average of Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O
7[2]	Smooth, light gray, isotropic.	22	<0.08	MC+	MC
18	Banded, medium gray to grayish green, essentially isotropic.	19 to 22	<0.08	MC+ to CMC	MC
12[2]	Pebbly, medium gray areas, faint anisotropism.	17	<0.08	CMC	MC
12[2]	Smooth, light gray areas, isotropic.	16	0.2	CMC	MC
10	Smooth, bright white, isotropic.	15	<0.08	MC+	MC
1	Pebbly, medium to dark gray, isotropic.	13	<0.08	MC+	MC
20	Fairly smooth, light gray, isotropic	8	<0.08	CMC	MC+
17	Smooth, light gray areas, essentially isotropic.	3	<0.07	CMC	MC+
14	Banded, slate gray (some green bands), orange-brown under crossed polars.	1 to 2	<0.08	WMC	MC+
17	Dark gray bands, essentially isotropic	0.7	<0.07	MC-	MC+
2[2]	Pebbly, light to medium gray, isotropic	0.5	1.4	CMC	MC+
19	Rough, dark greenish gray, isotropic.	0.1	<0.07	CMC	MC
9	Coarse stubby blades, faint bireflectance in grays, moderate anisotropism.	<0.1	0.3	CMC	MC+
17	Pebbly, medium gray areas, essentially isotropic.	<0.1	0.1	CMC	MC+
16	Pebbly, medium grays (green bands), faint anisotropism in gray areas.	<0.1	<0.07	CMC	MC
3	Banded, light grayish yellow, faint anisotropism.	<0.1	<0.07	CMC	MC+
4	Banded, light to medium grays with yellow tints, faint radiating anisotropism.	<0.1	<0.07	CMC	MC+
6	Smooth, light gray, faint bireflectance, moderate anisotropism. (defines grains).	<0.1	<0.07	CMC	MC+
13	Fairly smooth (some internal jagged crystal grain outlines), bright white with yellow tint, isotropic.	<0.1	<0.07	CMC	MC
11[2]	Mosaic grains, moderate bireflectance in grays, strong anisotropism.	<0.1	<0.07	CMC	MC+
8	Silky aggregates, moderate bireflectance in grays, strong anisotropism.	<0.1	<0.07	MC+	MC+
5	Brick-like to fine blade-like, pale cream, weak anisotropism.	<0.1	<0.07	CMC	MC+
15	Pointed medium blades, grayish tan, essentially isotropic.	<0.1	<0.07	CMC	MC+

(1) Code: CMC Chief Major Constituent; MC Major Constituent; WMC Weak Minor Constituent. Less than (<) indicates below minimum detection limit.

(2) Particle or area selected for X-ray diffraction analysis.

TABLE NO. 2

HARDSHELL COMPOSITE A (MR-83)

Minus 35 Plus 100 Mesh, 2.73 Sink Fraction
Selected Particles

Particle No.	Electron Microprobe Analyses[1] (Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O	X-ray Diffraction Patterns[2]
2	0.5	1.4	CMC	MC+	Cesarolite
7	22	<0.08	MC+	MC	Cesarolite
11	<0.1	<0.07	CMC	MC+	Pyrolusite or Cryptomelane
12	16 to 17	<0.08 to 0.2	CMC	MC	Pyrolusite or Cryptomelane

(1) Code: CMC Chief Major Constituent; MC Major Constituent. Less than (<) indicates below minimum detection limit.

(2) Mineral Formulas: Cesarolite = probable $PbMn_3O_7.H_2O$; Pyrolusite = βMnO_2; Cryptomelane = $A\leq B_8O_{16}$ where A = chiefly K(some Na and Ba) and B = chiefly Mn^{4+} (some Mn^{2+}, Zn, Al, Cu, Co, Fe^{3+}). The X-ray diffraction films from each of the four particles indicated the additional presence of an amorphous component.

TABLE NO. 3

HARDSHELL COMPOSITE A (MR-83)

Minus 100 Plus 200 Mesh, 2.73 Sink Fraction
Random Particles

No. of Particles with Similar Analyses	Electron Microprobe Analyses[1] (Average of Several Points of Analysis) Approx. Wt. % Pb	Approx. Wt. % Ag	Mn	O	Si
1	25	<0.1	MC+	MC	WMC
1	23	<0.1	CMC	MC	WMC
2	22	<0.1	MC+	MC	WMC
1	22	<0.1	MC+	-	-
1	20	<0.07	CMC	-	-
1	20	<0.1	MC+	MC	WMC
1	20	0.2	CMC	-	-
1	14	<0.1	MC	-	-
1	11	<0.1	MC+	MC	WMC
1	10	<0.1	CMC	-	-
1	7	0.1	MC+	MC	WMC
1	6	<0.1	CMC	MC	WMC
1	5	0.5	CMC	MC	WMC
1	2	<0.1	MC+	MC-	WMC
1	2	<0.1	CMC	-	-
1	1	<0.1	LMC-	-	-
2	1	<0.1	CMC	-	-
1	0.8	<0.1	CMC	-	-
1	0.7	<0.1	LMC-	-	-
1	0.4	<0.07	CMC	MC	WMC
1	0.3	0.3	CMC	MC	WMC
1	0.3	<0.1	LMC-	-	-
2	0.2	<0.1	LMC-	-	-
1	0.2	<0.1	MC+	-	-
1	0.1	0.2	CMC	-	-
1	<0.1	0.1	CMC	MC	WMC
1	<0.1	0.1	CMC	-	-
1	<0.1	<0.07	CMC	-	-
1	<0.1	<0.07	CMC	MC	WMC
10	<0.1	<0.1	CMC	-	-
1	<0.1	<0.1	LMC-	-	-
5	<0.1	<0.1	CMC	MC	WMC
2	<0.1	<0.1	MC+	-	-

(1) Code: CMC Chief Major Constituent; MC Major Constituent; LMC Low Major Constituent; WMC Weak Minor Constituent. Dashed lines indicate not analysed. Less than (<) indicates below minimum detection limit.

TABLE NO. 4

HARDSHELL ORE SAMPLES

DMS-Min #1 through #5 (MR-761 A through E)
Instrumental Analyses

Samples		Instrumental Analyses				
Exploration Designation	Research No.	Sp. Gr.(1)	Satmagan(2)	X-ray Diffraction	Infrared	Thermal
HDS-Min #1	MR-761A	3.25	0.33	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #2	MR-761B	2.80	0.46	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #3	MR-761C	3.10	0.35	Quartz	Quartz Pyrolusite (possible)	Quartz Pyrolusite (possible) Goethite (possible)
HDS-Min #4	MR-761D	2.73	0.48	Quartz	Not Run	
HDS-Min #5	MR-761E	2.72	0.12	Quartz Mica Pyroxene (possible)	Not Run	

(1) Beckman Air Comparison Pycnometer, model 930.
(2) Saturation Magnetic Analyzer - a magnetic balance. (Magnetic readings shown).
Notes: Pyrolusite = βMnO_2; Goethite = $\alpha FeO.OH$; Mica and Pyroxene are silicates.

SPECTROGRAPHIC ANALYSES

AMERICAN SMELTING AND REFINING COMPANY

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N. J.

HARDSHELL PROJECT - HDS-Min Designated, Ore Samples

SAMPLE No.	#1 MR-761 A	#2 MR-761 B	#2 MR-761 C	#4 MR-761 D	#5 MR-761 E
Si	MC	MC	MC	MC	MC
Fe	MC-	MC-	MC-	MC-	MC-
Mn	LMC+	LMC	LMC+	LMC	L
Al	M+	M	M+	M+	MC
Zn	LMC-	LMC-	MC-	S	N.D.
Na	LMC	S	LMC	M	N.D.
Pb	LMC	S	S	S	S
Ca	L+	L+	L+	L+	M-
Ba	M	M	S-	M	M
Sr	M	M	M	Tr	M
Cr	L+	L+	L+	L+	FTr
Ti	L	L	L	M	S
Cu	M	M-	M-	M-	L
Mo	L-	FTr	L-	FTr	FTr
Sn	L-	FTr	FTr	FTr	FTr
Mg	L	L	L	L	M+
Cd	L-	L-	L-	L-	N.D.
As	L	L	L	L	L
Be	FTr	N.D.	FTr	N.D.	N.D.
B	N.D.	N.D.	N.D.	N.D.	L-
Ni	FTr	FTr	FTr	FTr	FTr
Ag	M-	M-	L	L	Tr
V	VFTr	VFTr	VFTr	VFTr	VFTr

Not Detected - Te, P, Hg, Pt, Au, Tl, W, Ge, In, Bi, Co,

CODE:

CMC	- Chief Major Constituent
MC	- Major Constituent
LMC	- Low Major Constituent
S	- Strong
M	- Moderate
L	- Low
Tr	- Trace
F Tr	- Faint Trace
V F Tr	- Very Faint Trace
N.D.	- Not Detected

JNC

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN EXPLORATION DIVISION
P. O. BOX 5747, TUCSON, ARIZONA 85703

J. H C.

MAR 20 1975

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

March 19, 1975

Dr. V. Kudryk
American Smelting and Refining Company
Central Research Laboratories
South Plainfield, New Jersey 07080

Mineralogical Samples
Hardshell Project
Santa Cruz Co., Arizona

Dear Dr. Kudryk:

Under separate cover Mr. Davis has forwarded your department five (5) samples for mineralogical study from our Hardshell project. The five samples represent what may be different mineralogical and, therefore, metallurgical zones within the Hardshell deposit. A brief description follows:

Sample	Estimated Ag Content	Remarks
HDS-Min #1	17 ozs/ton	High Ag, High Mn content, w/±65% SiO_2
HDS-Min #2	12 ozs/ton	High Ag, Low Mn content, w/±85% SiO_2
HDS-Min #3	4 ozs/ton	Low Ag, High Mn content, w/±55% SiO_2
HDS-Min #4	5 ozs/ton	Low Ag, Low Mn content, w/±90% SiO_2
HDS-Min #5	2 ozs/ton	Low Ag w/hematite & limonite, No Mn & minor SiO_2

We are primarily interested in determining the identity of all silver and lead minerals, the relative percentage of the silver minerals and lead minerals and the ratios of silver and lead occurring in intimate association with manganese and hematite. The identification of the manganese and zinc minerals present would be of interest and might aid in the forthcoming metallurgical study.

Please run a standard emission spectrograph on each sample.

Previous Central Research work on the Hardshell ore is contained in reports No. 4299, 4319, and 4327. Report 4299 contains a section on Mineralogical Studies.

We would like to obtain the results of these mineralogical studies before proceeding with metallurgical testing. Please inform me if you cannot provide the requested information by the 5th of May.

Sincerely yours,

W. L. Kurtz
Manager of Exploration

WLK:lb

cc: TCOsborne
DECrowell
JHCourtright
SRDavis

J. H. C.
MAR 19 1975

RECEIVED
MAR 17 1975
EXPLORATION DEPT.

Air Mail

March 14, 1975

Mr. W. L. Kurtz
Southwestern Division
Tucson Office

Arizona
Hardshell Project

Dear Mr. Kurtz:

Thank you for your letter of March 7 with the map and sections. I note that Mr. Crist is working on an open-pit and underground ore reserve.

It seems to me that previous estimates of metallurgical possibilities have perhaps been too optimistic and I would be reluctant to support recommendations for additional drilling until our metallurgists suggest a working process which has some reasonable chance of economic viability in respect to both capital and operating costs.

Very truly yours,

ORIGINAL SIGNED BY
T. C. OSBORNE
T. C. Osborne

cc: JHCourtright ✓

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

J. H. C.
MAR 10 1975

March 7, 1975

Mr. T. C. Osborne
Assistant Director of Exploration
New York Office

Hardshell
Santa Cruz County, Arizona

Dear Mr. Osborne:

Attached are:

1) Plan Map at 200 scale showing drill holes and higher grade silver intercepts;
2) Two cross sections showing higher grade silver intercepts.

I am sending these so that you can get some idea of the density of drilling and general shape and depth of the higher grade silver zone.

Currently Mr. Crist is working on an open pit and underground ore reserve. Mr. Davis is selecting samples for mineralogical study at Central Research, is making up composites for metallurgical testing at Central Research, is constructing new cross sections, and is relogging certain drill holes.

Recommendations for additional work at Hardshell will await results of above work.

Very truly yours,

W. L. Kurtz

W. L. Kurtz

WLK:lb
Atts.

cc: JHCourtright - w/atts.
RBCrist - w/o atts.
SRDavis - w/o atts.

ASSAY DATA KEY

Depth — Length — Oz Ag
245' — 30' — 28.26

TO ACCOMPANY Letter
DATED March 7, 1975
BY W. L. Kurtz

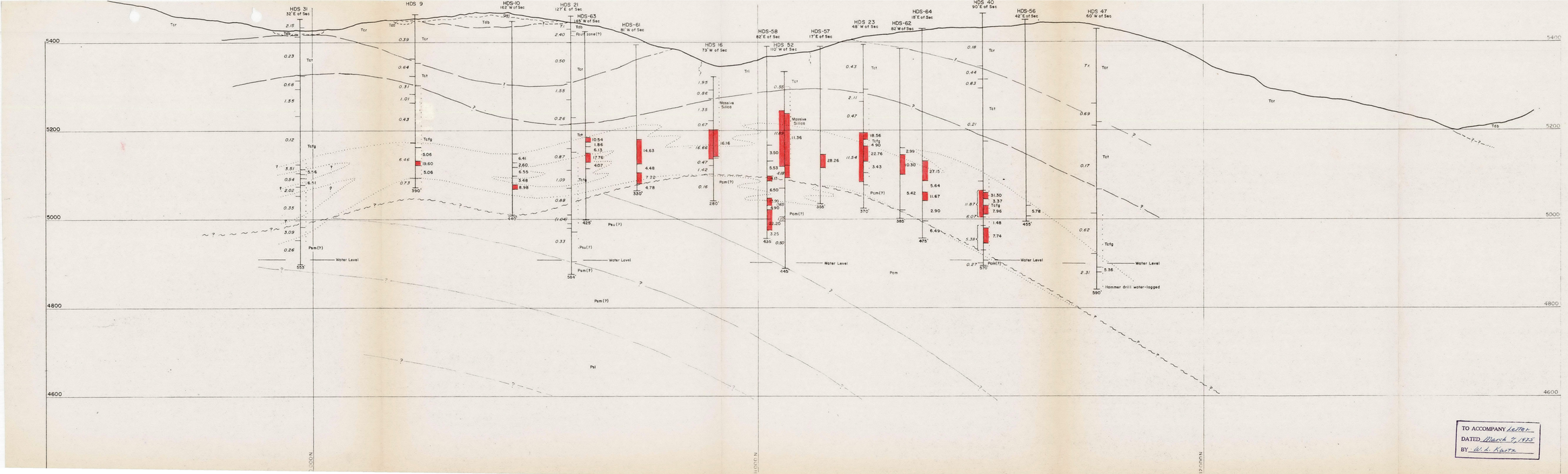
HARDSHELL PROJECT

PATAGONIA MOUNTAINS
SANTA CRUZ CO., ARIZONA

1" = 200'

W.L. Kurtz Feb. 1975

MVK-2775 A



EXPLANATION

- Qal — Quaternary Alluvium
- **TERTIARY**
- Tdb — Diabase Intrusive
- Tlp — Latite Porphyry
- Tri — Rhyolitic Intrusive (Banded)
- CHIRICAHUA FORMATION(?) AND RHYOLITE
  - Tcr — Rhyolite agglomerate
  - Tct — Tuffaceous Conglomerate
  - Tclc — Limestone Conglomerate
  - Tcfg — Fine Grained Sediments
  - Tci — Ignimbrite
- **PALEOZIC**
- Pcm — Permian Concha Limestone
- PERMIAN SCHOEN'N PH (?) MEMBERS
  - Psu — Upper Sandstone
  - Psm — Middle Silty Dolomite
  - Psl — Lower Sandstone
  - Psb — Basal Siltstone
- Pcn — Permian Colina Limestone
- Apparent Silicification
- 2.32 — Oz Ag

TO ACCOMPANY letter
DATED March 7, 1973
BY W. L. Kautz

GEOLOGIC SECTION

HARDSHELL PROJECT

Patagonia Mts, Santa Cruz County, Arizona

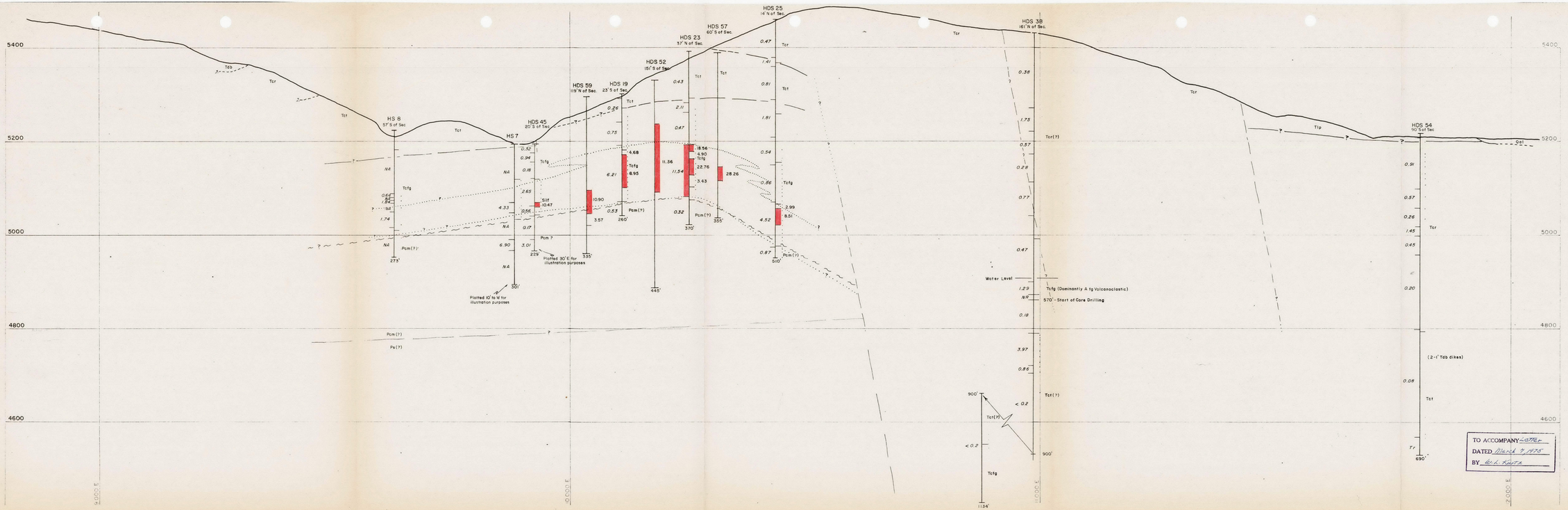
SECTION 10,300 E

Looking West

SCALE 1"=100'

S.R. Davis — March, 1973

MVK 2752-G



EXPLANATION

- Qal — Quaternary Alluvium
- **TERTIARY**
- Tdb — Diabase intrusive
- Tlp — Latite Porphyry
- Tri — Rhyolitic intrusive (Banded)
- CHIEF FORMATION MEMBERS
  - Tcr — Rhyolite agglomerate
  - Tct — Tuffaceous Conglomerate
  - Tc — Tclc — Limestone Conglomerate
  - Tcfg — Fine Grained Sediments
  - Tci — Ignimbrite
- **PALEOZIC**
- Pcm — Permian Concha Limestone
- SYCAMAN SCHERRER FM (Ps) MEMBERS
  - Psu — Upper Sandstone
  - Psm — Middle Silty Dolomite
  - Ps — Psl — Lower Sandstone
  - Psb — Basal Siltstone
- Pco — Permian Colina Limestone
- Apparent Silicification
- 1.2 Oz Ag

TO ACCOMPANY Letter
DATED March 7, 1975
BY W. L. Krutz

GEOLOGIC SECTION

HARDSHELL PROJECT

Patagonia Mts, Santa Cruz County, Arizona

SECTION 11,200 N

Looking North

SCALE 1"=100'

S.R. Davis — March, 1973

MVK 2752-C

CM JHC ✓ SRD

FTG — how do you do all this? I had [illegible] asked Davis to do much of what you point out re relogging [illegible] Ag vs Mn visually; selecting [illegible] for Central Research study. true. This would have bearing on metallurgical recovery process if major difference exists between high silver little Mn and high silver low Mn.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

February 10, 1975

J. H. C.
FEB 14 1975

W. L. K.
FEB 12 1975

TO: W. L. Kurtz

FROM: F. T. Graybeal

Distribution of silver in
HDS-61: Hardshell Project

SUMMARY

Silver in the high grade zone from 215-260 ft. (45 ft. averaging 16.26 oz. Ag) is not closely related to manganese. This suggests that the silver content of cryptomelane is highly variable or that other silver minerals may be present. If this pattern is found in other holes within the high grade zone further detailed core logging and metallurgical testing will be necessary.

INTRODUCTION

Most of the silver in the Hardshell deposit is thought to be contained in the mineral cryptomelane (KMn_8O_{16}). There does not appear to be any data concerning the actual amount of silver in cryptomelane, nor is there any data on what other silver minerals may be present. Von Fay (1965, ASARCO files) noted that silver appeared to show a closer relationship to lead than manganese.

Previous metallurgical test work appears to have been performed on single composite samples of all "ore" grade intervals. This approach assumes that the silver mineralogy and recovery is uniform throughout the ore zone. A recent visual inspection of chips from HDS-61 suggests that either the silver mineralogy is variable or that the silver content of cryptomelane varies over several orders of magnitude.

GEOLOGY

Hole HDS-61 was collared in rhyolite agglomerate, passing into tuffaceous agglomerate at shallow depth. A brief inspection of chips collected at 10-ft. intervals did not reveal much information on the rocks cut at greater depths. Petrographic studies of chip samples indicate that the rock at 50-60 ft. is a tuff. A sample at 180-190 ft. contained several chips of completely silicified limestone. Samples at 230-240 ft. and 300-310 ft. were too strongly altered and mineralized to preserve original rock textures.

Silicification increases abruptly at 135 ft. and appears to decrease somewhat at the bottom of the hole as shown on the attached drill log. The quartz is extremely fine-grained near the surface, but it coarsens rapidly with increasing depth. The abundance of vein-like aggregates of coarse-grained quartz is also greater near the bottom of the hole. Montmorillonite

is present at 50-60 ft., but was not recognized in the more strongly silicified rocks. Fluid inclusions become larger and more abundant and the size of the gas bubble increases toward the bottom of the hole.

Black manganese (oxides) appear at about 200 ft. and increase gradually toward the bottom of the hole (see attached log). Thin sections at 230-240 and 300-310 ft. indicate that the manganese is pervasive at the chip size and thus, the visual estimates are not erroneously high due to coatings of manganese on silicified chips.

SILVER MINERALIZATION

The distribution of silver is shown on the attached log. The silver content of the rock is uniformly low to 210 ft. and is not clearly related to the silicified zone. This suggests that silver is not intimately tied up with the fine-grained silica as is the case at the Waterloo deposit.

From 210-260 ft. the silver content rises sharply to very high levels. This extremely abrupt increase in silver is roughly correlated with the appearance of manganese, but the increase in silver is 5-10 times as rapid as the increase in manganese. Deeper in the hole where manganese is most abundant, silver falls to much lower levels, although still averaging in the vicinity of 6 oz. The pattern suggests to me that in gross aspect the silver is related to the manganese, but within the high grade zone some factor other than the abundance of manganese is controlling the distribution of silver.

There are several possible explanations for the pattern of silver and manganese abundances shown on the attached log. One may relate to the manganese mineralogy, such that cryptomelane forms a much greater percentage of the manganese species at the top of the manganese zone than in the deeper portions. A second explanation may involve wide variations in the amount of silver substitution (or adsorption) in the cryptomelane lattice. A third possibility is that other silver minerals may be present in the high grade zone.

DISCUSSION

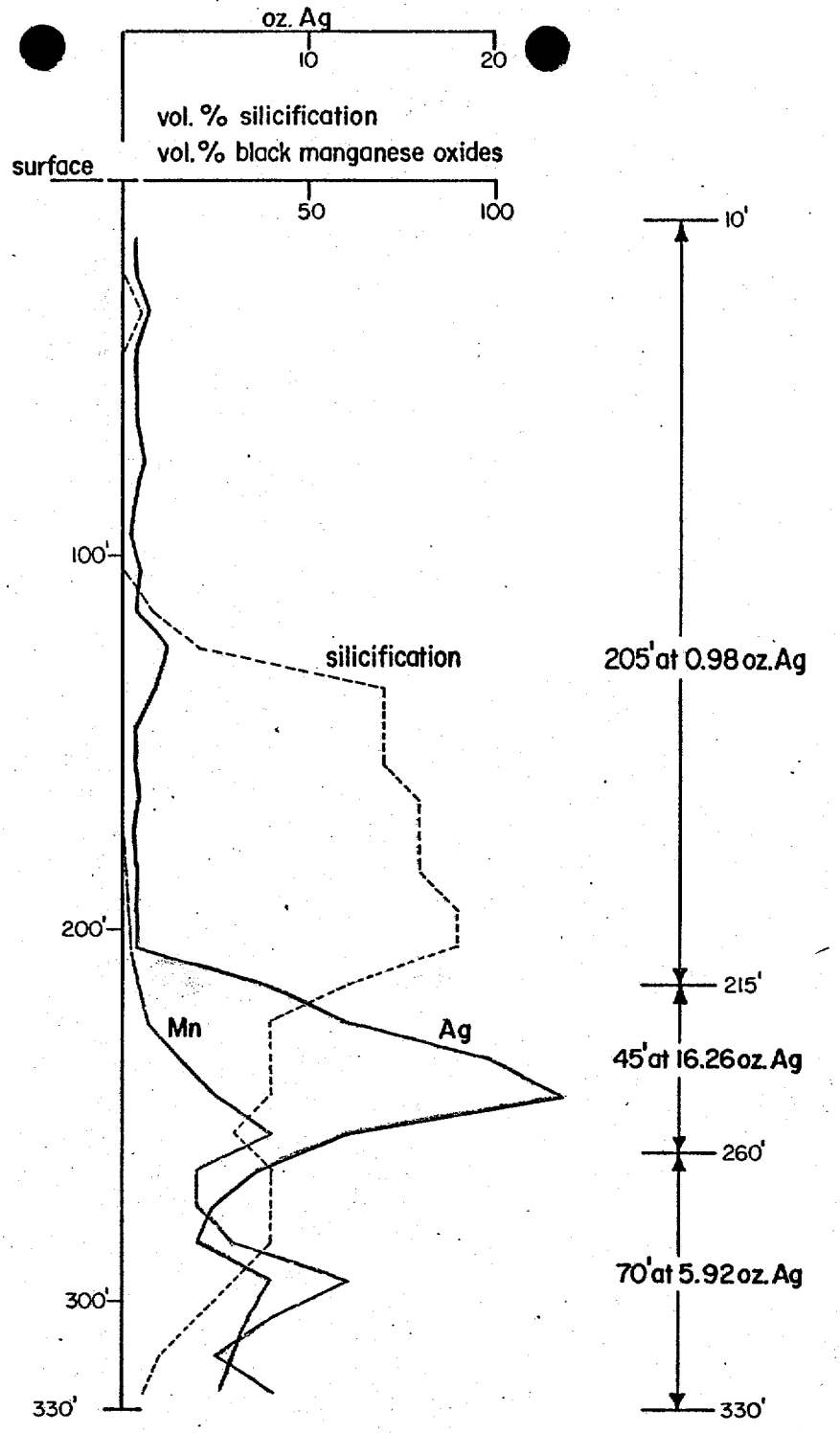
The possibilities of large variations in the silver content of cryptomelane and additional silver minerals in the high grade zone have important metallurgical implications. From a reading of our files it is my impression that test work has been conducted only on large composite samples representative of the overall zone of 5 oz. silver mineralization which could be mined by open pit methods. However, the recent intersections of higher grade mineralization have renewed interest in a smaller, but substantially higher grade, orebody which could be mined underground. Data from HDS-61 suggest that the silver mineralogy from the high grade zone may be substantially different from the overall zone of 5 oz. silver mineralization and, therefore, that silver recoveries might be substantially different as well.

Brief discussions with S. R. Davis indicate that this relationship may also occur in other holes containing high grade silver mineralization. I therefore recommend that the other holes within the high grade zone be studied to determine whether silver-manganese patterns similar to those in HDS-61 are present. If similar patterns are found, the silver mineralogy in the high grade zone should be reinvestigated and additional metallurgical test work should be started.

Speculations on the origin of the mineralization suggest to me that the 6 oz. Ag zone in the lower part of the hole is hypogene, and that a considerable portion of the silver in the high grade zone could be supergene.

F. T. Graybeal

FTG:lb
Attach.



SIMPLIFIED LOG OF HDS-61

HARDSHELL PROJECT

PATAGONIA MTNS., SANTA CRUZ COUNTY, ARIZONA

0 50'

1" = 50'

mp 2828 dam

CM to: TCO JHC SRD with note

AMERICAN SMELTING AND REFINING COMPANY
MINERAL BENEFICIATION DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

D. E. CROWELL
DIRECTOR

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

February 5, 1975

Dr. V. Kudryk
Central Research Department
American Smelting and Refining Co.
South Plainfield, New Jersey 07080

Hardshell Metallurgical Test Work

Dear Dr. Kudryk:

The Exploration Department now has collected sufficient drill cuttings from recent hardshell drilling to be able to furnish us with samples for metallurgical testing. Two types of ore reserves have been delineated - a high grade reserve at ±12 opt Ag and low grade ore at ±5 opt Ag. By copy of this letter to Mr. Kurtz, I am requesting that a 50 lb. sample of each type ore be sent to South Plainfield.

I believe that test work on the low grade ore should be directed at an SO_2 leach followed by cyanidation as discussed in my letter of July 26, 1974, Mr. Henderson's memorandum of July 23, 1974 and reported in CR Report No. 4327. This will be an expensive method of treatment but, to my knowledge, no other process looks feasible. In order to properly evaluate the SO_2 leach/cyanidation process we will need to know silver recoveries, SO_2 consumption and possible methods of regenerating SO_2.

With regard to the high grade ore, there is some evidence that the silver is not completely tied up with manganese. Perhaps a mineralogical examination of this ore should be made before deciding on possible extraction methods.

Yours truly,

D. E. Crowell
Director

vh
cc: TASnedden
WPRoe
NVisnes
WLKurtz

FROM: W. L. KURTZ

Hardshell
2-7-75

TO: Dr. V. Kudryk

I plan to send you several "special" samples for mineralogical study, which may give insight into the nature and distribution of the silver in the high grade zone.

cc: DER

JHC

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

December 27, 1974

J. H. C.

JAN 3 1975

TO: W. L. Kurtz

FROM: S. R. Davis

Hardshell Project
Santa Cruz Co., Arizona
Monthly Progress Report
December 1974

The CXM Drilling Company rotary drill was remobilized to the Hardshell property November 25th and drilling resumed November 27th. As of December 25th, 1693' had been drilled; this included completion of drill holes HDS-58 through HDS-62 and setup of the drill rig on site HDS-63.

All five drill holes were completed to their proposed total depth; however, assays have only been received on holes HDS-58, 59, and 61. These three holes penetrated one or more high-grade intercepts, and considerable lower grade material was also encountered. The following summary compares intercepts of silver mineralization at cutoffs of 8, 3, & 1 ozs. Ag/ton (top of intercept, feet in intercept, and ounces silver/ton):

	+8 oz.	+3 oz.	+1 oz.
HDS-58	295' - 10' @ 14.13 345' - 15' @ 13.99 370' - 40' @ 24.32	225' - 200' @ 10.78	205' - 230' @ 9.58
HDS-59	220' - 30' @ 14.16	200' - 75' @ 8.46	195' - 100' @ 6.70
HDS-61	215' - 45' @ 16.26	210' - 120' @ 9.74	210' - 120' @ 9.74

Low-grade mineralization overlying the above intercepts frequently contains zones of 1 to 3 ounce silver mineralization but averages near 1 ounce. Also of note was a five-foot zone of high-grade at 315-320' in hole HDS-58 which ran 34.73 ounces silver/ton and was not included in a +8 ounce intercept because of the five-foot total thickness. Drill hole HDS-61 penetrated anomalous silver values of 3 to 8 ounces/ton to the total depth (330') and bottomed in 5.1 ounce material. The lower part of this is presumably as replacement or dissemination in the Paleozoic sediments, as they were projected to occur at ±300' depth. HDS 60?

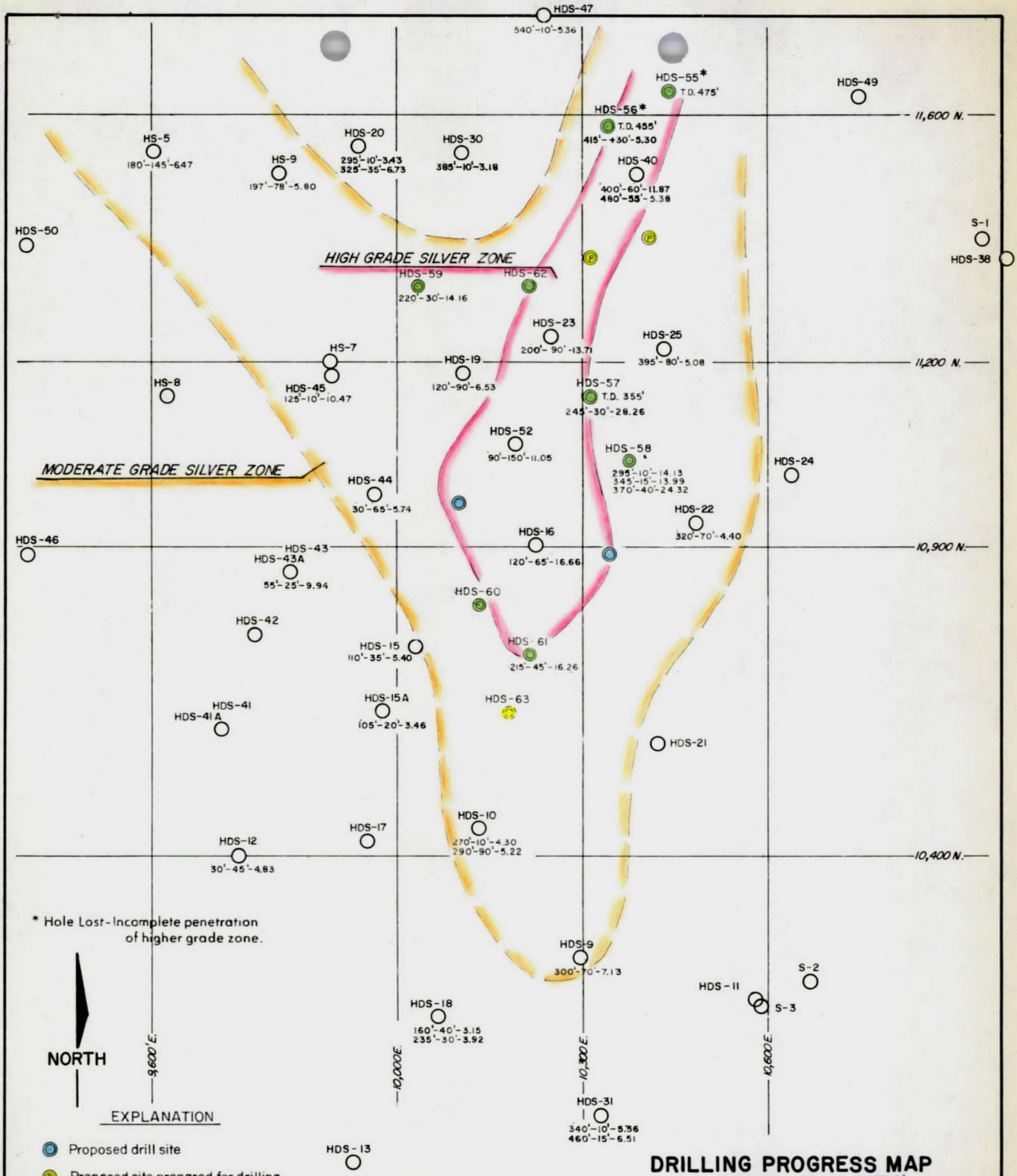
Twenty-four new claims, Shell numbers 111 through 134, were staked south of the existing Shell group during November. The location work for these and the 38 claims staked during the third quarter of 1974 has been completed.

Sample vials have not yet been received for all of the presently completed drill holes. Geologic logs of the sample vials will be compiled in the first quarter of 1975 as the program is completed.

The estimated balance of authorization is $8,500.

S. R. Davis

SRD:lb
Attach.



* Hole Lost - Incomplete penetration of higher grade zone.

EXPLANATION

- Proposed drill site
- Proposed site prepared for drilling
- Completed 1974 holes

ASSAY DATA KEY

Depth — Length — Oz Ag
245' — 30' — 28.26

TO ACCOMPANY Monthly Drilling Report
DATED Dec. 27, 1974
BY S.R. Davis

DRILLING PROGRESS MAP

for the month of DEC. 74

HARDSHELL PROJECT

PATAGONIA MOUNTAINS
SANTA CRUZ CO., ARIZONA

1" = 200'

MVK-2775

ASARCO

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH DEPARTMENT
SOUTH PLAINFIELD, N.J. 07080

WILLIAM P. ROE
VICE PRESIDENT

July 23, 1974

Mr. J. J. Collins
New York Office

T. C. O.
JUL 25 1974
File
JUL 25 1974
+ Hardshell Ariz
Metallurgy

Marine Mining

In response to your letter of July 17, we still have several hundred pounds of marine nodules from the shipment received in 1973. While we have not completed work on this project, there is a sufficient supply of nodules for the remainder of the study. However, should it be possible to obtain a 100 lb. sack of high-grade nodules at a cost of something less than $1,000 it would be useful to obtain this material in order to determine whether the chemical behavior is any different from that experienced with our original shipment.

Metallurgical problems of the Hardshell silver deposit are somewhat at variance with those associated with marine nodules in that it appears to be necessary to extract manganese from the Hardshell ore in order to produce a high silica-silver bearing flux having value to a smelter. With marine nodules the objective is to extract copper, nickel and cobalt selectively, leaving manganese in the residue. As projected for Hardshell, a 1,000 T/day mining operation would yield approximately 100 T/day of manganese in an oxide product requiring a market outlet and 120 T/day of flux. Assuming renewed interest in this deposit, I suggest that Mr. B. L. Davis investigate the technical requirements and tonnage market outlets for manganese dioxide. I also note from a copy of Mr. Courtright's letter of November 13, 1969 that water is apparently available at the mine site. In order to establish a flowsheet based upon wet methods of concentration or dry methods as studied previously we would need a representative sample of approximately 500 lbs. of Hardshell ore.

Marine Nodules

Mr. Loughridge has inquired about the disposition of lead from a minus 70 mesh fraction of flux containing 5% lead to be utilized at Hayden. Consumption of 60 T/day of this flux would add about 90 T/month lead to an existing smelter intake of approximately 200 T/month. While we have not been able to characterize the exact chemical compound of lead, it is reasonable to assume based upon the Hayden material balance study that 20% of this added lead intake will finally be lost in the slag while 80% will report to converter dusts and sludge.

William P. Roe

WPR:mg

cc: Messrs. R. L. Hennebach
W. L. Kurtz
K. D. Loughridge
T. A. Snedden
J. R. Wojcik

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

June 18, 1974

MEMORANDUM FOR: J.J. COLLINS

HARDSHELL
SANTA CRUZ COUNTY,
ARIZONA

Although some untested exploration possibilities remain, it does not appear that the open pit potential of the Hardshell deposit will much exceed that now indicated----around 6 to 7 million tons of 5 ounce silver with an ore-waste ration of 7 to 1.

Extraction by underground methods is an alternative approach worthy of consideration in view of the fact that a number of drill holes contain substantial intercepts (20' to 110') of plus 10 oz. Ag, indicating a fair possibility of 3 million tons grading 8 to 10 oz. which may be mineable by a moderatly low cost method. The ground is firm due to the generally pervasive silicification of the mineralized bed and the overlying volcanics.

As previously reported (November 13, 1969) metallurgical tests showed a 68% recovery of the silver on a 5 ounce head. Presumably a better recovery could be obtained on higher grade ore.

It is recommended that future assessment work requirements be met by interspaced drilling designed to test continuity of the better grade zones.

Attached is a copy of Bill Kurtz's letter of June 16, 1972 with a correction on stated recovery.

J. H. Courtright
J.H. Courtright

JHC:vmh

cc: W.L. Kurtz

JHC, RBC

AMERICAN SMELTING AND REFINING COMPANY
MINERAL BENEFICIATION DEPARTMENT
P. O. BOX 5747, TUCSON, ARIZONA 85703

D. E. CROWELL
DIRECTOR

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

July 26, 1974

Mr. J. J. Collins
American Smelting and Refining Co.
120 Broadway
New York, New York 10005

Hardshell Metallurgy

Dear Mr. Collins:

Reference is made to your recent letter regarding Hardshell metallurgy. More test work will definitely be required since a viable flowsheet for this ore has never been developed. The dry magnetic separation flowsheet developed by Central Research was simply an attempt to get around the water shortage problem, but the results were not encouraging (see below). It is my understanding now that a water supply could be developed and we should approach the problem on this basis.

Mr. Henderson has reviewed the information in our file regarding Hardshell and a copy of his memorandum summarizing the test work done to date is enclosed.

We have the following comments regarding further test work on this ore:

1. Dry concentration processes do not appear to be attractive. Recoveries are low and the product is not saleable at the present time. The concentrate would require SO_2 leaching followed by cyanidation for silver recovery giving an overall recovery of 49%.

2. Heat treating processes (salt roast or reducing roast) do not appear attractive because of high cost and difficulties in obtaining fuel.

3. The best approach appears to be SO_2 leaching followed by cyanidation of the raw ore. This process yields good recoveries and a readily saleable product. There are many details to be worked out, however, the major one being the disposition of the leached manganese. ——— tailings pond

This matter has been discussed with Dr. Kudryk and test work will be initiated shortly. More sample will be required and Mr. Kurtz is presently investigating the amount of core remaining which could be used for metallurgical test work.

Yours truly,

D. E. Crowell

DEC:vh
cc: TASnedden - w/enc.
VKudryk - w/enc.
WKurtz - w/enc.
WPRoe - w/enc.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

July 23, 1974

File Memorandum: Misc. 11A - Hardshell

Subject: Review of Metallurgical Testing of Hardshell Ore and Recommendations for Further Test Work

A review of metallurgical test work done on the Hardshell silver-manganese ore has been made by the undersigned. A summary of test results is included in the Supporting Data attached to this report.

This test work has been done on three different groups of ore samples.

Group I — Preliminary sample tested at El Paso, 5.22 oz./T Ag, 6.45% Mn. Fairly typical of ore body.

Group II — Tested at El Paso, three lower silver-lower manganese ore samples 2.3-3.3 oz. Ag and 0.14-0.18% Mn. Apparently not representative of ore body.

Group III — Tested at Central Research. Hardshell Composite A - Most representative of ore body. 5.85 oz. Ag, 11.2% Mn.

Conclusions:

1. Most of the silver in the Hardshell ore is associated with manganese, with lesser amounts (±10%) in quartz and silicates and a very minor amount in a strongly magnetic fraction.

2. The silver associated with manganese is not amenable to cyanide leaching without prior leaching with SO_2 to break up the manganese-silver complex minerals. This SO_2 leach-cyanide leach treatment has given recoveries as high as 86% on a 5.22 oz. Ag/T ore.

3. Magnetic and electrostatic preconcentration has yielded 68% silver recovery in a concentrate assaying 15 oz./T Ag and 34% Mn. SO_2 leaching followed by cyanidation of this concentrate gave 72% silver recovery, or an overall silver recovery from raw ore of 49%.

4. Salt roasting of 10-mesh raw ore followed by cyanidation, brine leaching, or acidified brine leaching have given silver recoveries of 75-85% (5.22 oz. heads).

Recommendations for Further Testing:

The best silver recoveries to date have been by SO_2 leaching of raw ore followed by cyanidation.

after SO_2 leach — residue is high Ag - high silica flux - for smelter

This approach should be followed up with tests involving agitation leaching at 10-mesh with SO_2 followed by washing of the leach residue, grinding with lime and cyanide, and cyanide leaching. See Flowsheet A in Supporting Data.

Manganese oxide recovery from the SO_2 leach solution might be economic. In any case the leach solutions will have to be treated for removal of manganese before recycle to leaching, and this part of the process needs further study.

Salt roasting followed by cyanidation and brine leaching gave equally good silver recovery, but roasting operations on raw ore would probably not be feasible from the standpoint of (1) capital cost and (2) fuel availability.

Magnetic and electrostatic preconcentration has yielded 68% silver recovery at best. SO_2 leaching followed by cyanidation has given 72% silver recovery from the concentrate or 49% overall recovery. This is much inferior to the 86% silver recovery obtained by SO_2 leaching and cyanidation of the raw ore, and should not be pursued further. It would involve a much more complex flowsheet involving dry crushing and magnetic-electrostatic separation prior to SO_2 leaching and cyanidation.

T. D. Henderson, Jr.

TDH:vh
Attachment
cc: DECrowell

Supporting Data:

The following is a summary of all metallurgical testing of Hardshell ore done at El Paso and the Central Research Laboratory.

A. EPOTL Report of Serial 808 - Preliminary Testing of the Hardshell Project Ore - October 1967 - by F. L. Bazzanella

Sample tested assayed: 5.22 oz./T Ag, 6.45% Mn, 1.15% Pb, 1.08% Zn, 0.10% Cu.

1. Cyanide leaching gave poor (±20%) silver recoveries even with fine grinding.
2. Salt roasting followed by cyanide leaching gave 84% silver recovery.
3. Brine and acidified brine leaches at 10-mesh after salt roasting gave silver recoveries of 75-85%.
4. Magnetic separation of a -65 +200 mesh fraction of the ore gave 69% silver recovery and 93% Mn recovery in the magnetic fraction. However, this size fraction was only 13% of the total -10 mesh sample.
5. Electrostatic separation of a deslimed fraction of the ore gave 40.0% silver and 48% Mn recovery in the concentrate.

B. EPOTL Report of Serial 808 Part II - Testing of the Hardshell Project Ore - December 1967 - by F. L. Bazzanella

(Ore tested same assays as A).

1. Magnetic separation of the +325 mesh fraction of the ore, representing 84% of the total sample, gave 81% silver recovery and 90% manganese in a concentrate assaying 14.7 oz./T Ag and 23.3% Mn. This represents 65% overall silver recovery.
2. One hour leaching with SO_2 followed by filtration, washing, grinding, and 24 hour cyanidation gave +86% silver recoveries.
3. Leaching with SO_2 followed by neutralization with lime without filtration and washing and cyanide leaching gave only 20 percent silver recovery.
4. Flotation of deslimed ore gave 66% silver recovery in the deslimed fraction, 46% overall silver recovery.
5. Leaching of raw ore with HCL (20-40 gpl.) gave only 4 percent silver recovery.

C. EPOTL Report of Project M103 - Raw Cyanidation of Low Manganese Hardshell Project Drill Core Samples - April 1968 - by H. F. Keeler

Three samples, representing three different areas of the ore body, were tested.

No. 1	2.32 oz./T Ag, 0.14% Mn
No. 2	2.26 oz./T Ag, 0.18% Mn
No. 3	3.27 oz./T Ag, 0.17% Mn

1. Raw cyanidation extraction of silver was poor (15-50%).
2. Variations in lime and cyanide concentration, and leach time did not improve silver recovery.
3. Some improvement in silver recoveries resulted from finer grinding, but silver recovery was still poor (55% for Sample No. 3 at 84% minus 200 mesh).

4. Silver recovery was improved by preliminary leaching with SO_2 followed by cyanidation. This was true whether or not the SO_2 leach tails were filtered and washed prior to cyanidation.
5. Magnetic separation gave a higher concentration of silver in the less magnetic fraction.

D. Central Research Report No. 4299 - Hardshell Project Silver Manganese Ore - November 27, 1968 - by E. Martinez

Ore sample tested: Hardshell Comp. A 5.85 oz./T Ag, 11.2% Mn

1. Preliminary testing of dry magnetic and high tension separations on 10-mesh feed indicated that +60% of the silver could be recovered in a concentrate assaying 16-18 oz./T.
2. Mineralogical studies showed that most of the silver is associated with manganese (cryptomelane, KMn_8O_{16}), about ten percent is associated with quartz or silicates, and a very minor portion is tied up in a strongly magnetic mineral.

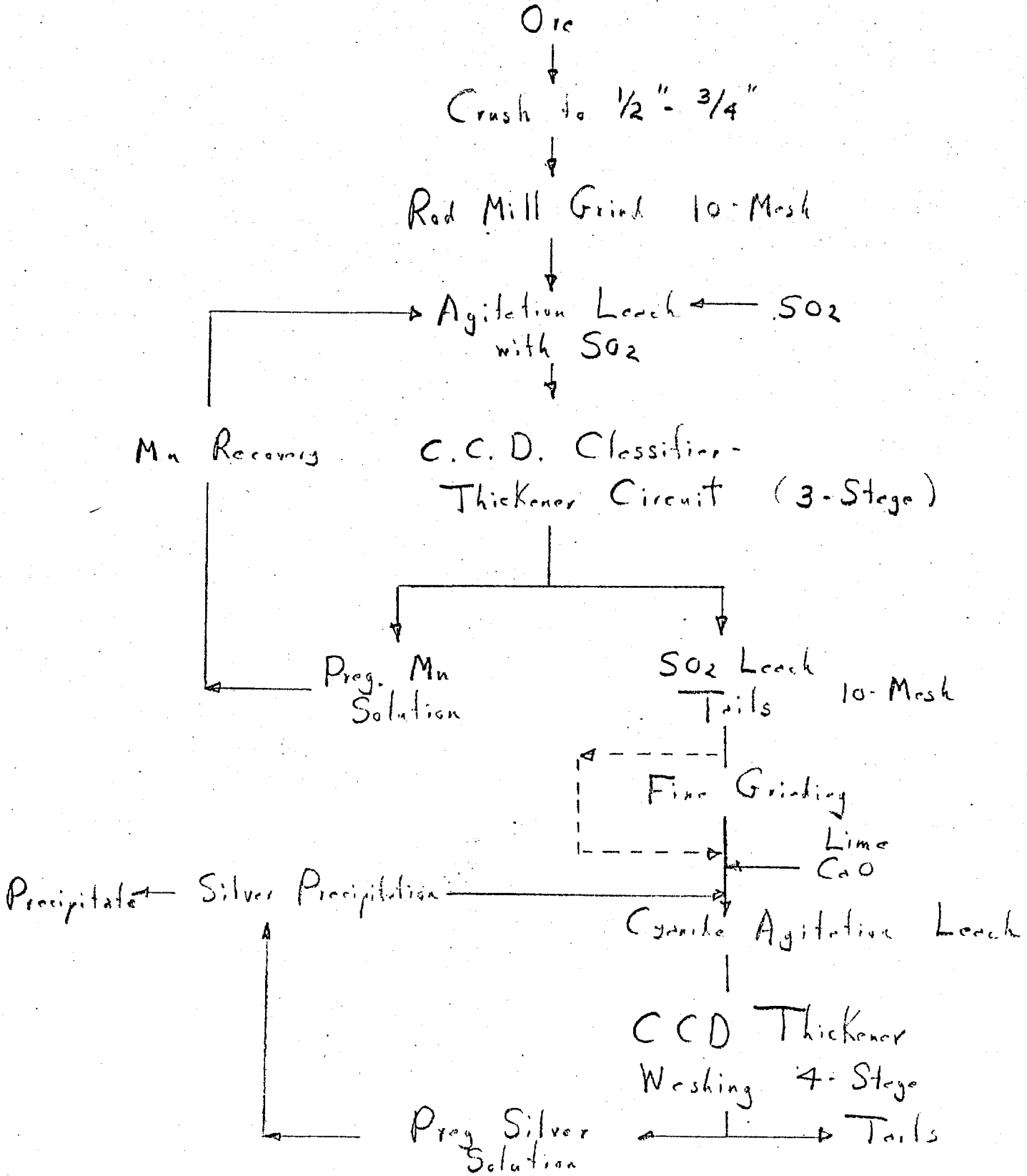
E. Central Research Report No. 4319 - Hardshell Project Silver-Manganese Ore - April 16, 1969 - by E. Martinez

1. Further refinement of dry magnetic and high tension separations on minus 10-mesh Composite A improved silver recovery to 68% in a 15 oz./T concentrate. Ratio of concentration was 3.6.

F. Central Research Report No. 4327 - May 8, 1974 - by A. E. Albrethsen

1. SO_2 leaching at 10-mesh and 100-mesh followed by cyanide leaching gave 72-76 percent silver recovery from raw ore.
2. SO_2 leaching of dry magnetic-electrostatic concentrate followed by cyanidation gave 72% silver recovery.

Flowsheet A - Proposed Treatment for Hardshell Ag-Mn Ore



TDH 7/23/74

AMERICAN SMELTING AND REFINING COMPANY

EL PASO ORE TESTING LABORATORY

A

REPORT

OF

SERIAL 808

PART II

file

TESTING OF

THE HARDSHELL PROJECT ORE

- DECEMBER 1967 -

Heads 5-603

TESTING OF THE HARDSHELL PROJECT ORE

INTRODUCTION

Further testing of the Hardshell Project Ore has included sulfur dioxide leaching of the manganese followed by cyanidation of the residue, hydrochloric acid leaching of the raw ore, additional tests on the magnetic separator and flotation of the raw ore with a fatty acid.

CONCLUSIONS

(1) Cyanidation of the raw ore does not give satisfactory extraction even at very fine grinds. The best recovery obtained with raw cyanidation was 21 percent.

(2) Cyanidation of the ore following a chloridizing roast gave favorable recovery of 84.3 percent of the silver. Brine and acid brine leaching also extract a large percentage of the silver after roasting. The brine and acid brine gave recoveries of 81.8 and 83.3 percent of the silver respectively.

(3) Magnetic separation of sized fractions of the ore gave very good results with recoveries of 80 percent of the silver in the material passed through the separator.

(4) Silver recovery in excess of 80 percent can be obtained by leaching the manganese with sulfur dioxide followed by cyanidation of the silver. Sulfur dioxide consumption ranged from 200 to 300 pounds per ton of ore. This would cost about $3.75 per ton of ore based on $60.00 per ton for sulfur. In tests where the sulfur dioxide was neutralized with lime and the manganese precipitated at the same time, the silver recovery by cyanidation fell to 57 percent on one sample and 20 percent on a ground sample indicating that the manganese must be removed to prevent the reformation of refractory silver-manganese compounds. Lime consumption was approximately 170 pounds per ton of ore.

(5) Silver recovery with hydrochloric acid in strengths of 20, 30, 40 grams per liter was only 4 percent with acid consumption going as high as 125 pounds per ton of ore.

(6) Recovery of the silver by flotation of a deslimed sample was 46 percent with the concentrate assaying 17.3 oz/Tnt silver. When the weight of the slimes is neglected, the silver recovery is 66 percent.

DESCRIPTION OF TEST WORK

Tests performed using sulfur dioxide were carried out by bubbling the gas through the pulp for one hour, then followed by filtering, washing, repulping and filtering. The residue was then cyanided for 24 hours. In later tests a sulfur dioxide solution was made up and standardized and the off solutions were then analyzed for sulfur dioxide to determine consumption.

Other tests carried out using sulfur dioxide involved neutralizing the sulfur dioxide with lime while precipitating the manganese at the same time. The lime was added until a free lime titration of about 3 pounds per ton of solution was attained. Silver recovery was lowered to 20 percent with this method.

The magnetic test performed was done by splitting the minus 10 mesh material into a plus 35 mesh fraction; a minus 35 mesh, plus 100 mesh fraction; a minus 100 mesh, plus 325 mesh fraction; and a minus 325 mesh fraction. Each fraction except the minus 325 mesh fraction was run through the magnetic separator. Complete data are shown in Table No. II.

Flotation test data are shown in Table No. III.

RECOMMENDATIONS FOR FURTHER TEST WORK

Additional test work should include more salt roasting tests followed by brine leaching and cyanidation and also additional work on the magnetic separator with additional treatment of the concentrate and slime fraction. This could include salt roasting followed by cyanidation or sulfur dioxide leaching followed by washing and cyanidation. It may also be desirable to attempt to produce some type of manganese concentrate, possibly by the dithionate process.

F. L. BAZZANELLA

FLB/cb

TABLE I

HARDSHELL PROJECT
Leaching and Precipitation Data

Raw Ore

Test No.	Treatment	Off gpl HCl	Tail Assay oz/T Ag	Tail Assay % Mn	In Soln Recovery Ag	In Soln Recovery Mn	Consumption #/Ton Soln NaCN	CaO	SO_2	HCl	Consumption #/Ton Solids NaCN	CaO	SO_2	HCl
8-1	SO_2 Leach, Filter, Wash. Cy'n24hrs		2.27	1.69	61.1	76.6	.18	2.8			.504	7.9		
8-2	SO_2 Leach, Filter, Wash. Grind 1' Cy'n 24 hrs		1.19	.36	80.3	95.2	.29	2.0			1.23	8.54		
8-3	SO_2 Leach, Filter, Wash. Grind 2' Cy'n 24 hrs		1.08	.26	82.0	96.4	.60	1.85			3.13	9.66		
8-4	SO_2 Leach, Filter, Wash. Grind 3' Cy'n 24 hrs		.82	.10	86.4	98.6	.38	2.40			1.58	9.98		
8-5	SO_2 Leach, Filter, Wash. Grind 4' Cy'n 24 hrs		.89	.07	86.4	99.1	.51	3.82			1.37	10.28		
9-1	1 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs		2.68	2.5	52.7	64.3	.17	1.90			.77	8.59		
9-2	2 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs		2.42	2.2	57.5	68.7	.30	3.17			.93	9.61		
9-3	3 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs		2.43	2.2	57.5	68.8	.24	1.66			1.34	9.80		
10-1	24hr HCl Leach @ 20gpl.Filtered, Washed	5.6	5.16	6.0	2.9	8.7				2.60				72.8
10-2	24hrHCl Leach@30gpl.Filter,Wash	10.5	5.11	6.0	4.0	8.7				2.63				103.1
10-3	24hrHCl Leach@40gpl.Filter,Wash	15.0	5.13	6.1	4.2	7.9				2.64				125.7
11-1	1 hrSO_2Leach. Filter, Wash assay		5.49	1.2	6.7	83.6			59.0				341	
11-2	1 hrSO_2Leach.Filter,Wash.Cy'n24hrs		2.00	1.0	65.3	85.9	1.45	2.76	57.2		5.8	11.0	228	
11-3	1 hrSO_2Leach.Filter,Wash,Grind.Cy'n24hrs		1.48	1.0	74.9	86.2	.32	2.19	55.7		1.4	9.7	247	
11-4	1 hrSO_2Leach.Neutralize with40gmCaO Cy'n 24 hrs		1.96	4.7	57.1	16.9	1.31	45.0	53.7		5.1	176	209	
11-5	1hr SO2 Leach.Neutralize with 40gmCaO Grind. Cy'n 24 hrs		3.51	4.9	20.5	10.1	1.92	27.9	52.9		11.5	167	317	

TABLE II

Magnetic Separation

Sample: The sample was divided into four fractions:

+35 mesh	-	50.60%	of total weight
-35 +100	-	22.26%	" " "
-100 +325	-	11.44%	" " "
-325	-	15.70%	" " "

Procedure:

+35 mesh. Passed through separator 5 times. Speed 24 rpm, current 3 amp.

Individual recovery of Ag - 82.3

-35 +100 Passed through separator 3 times. Speed 28 rpm, current 3 amp.

Individual recovery of Ag - 86.2

-100 +325 Passed through separator 3 times. Speed 35 rpm, current 1 1/2 amp.

Individual recovery of Ag - 70.3

The -325 mesh material was not run through the separator.

Material	Assay oz/T Ag	Assay % Mn	% Wt	Recovery with Slimes Ag	Recovery without Slimes Ag
+35 mesh conc	16.16	25.5	9.9	34.5)	42.9)
-35 " +100 conc	14.22	22.8	6.3	19.2)65.3	23.6) 80.9
-100 +325 conc	12.25	19.0	4.4	11.6)	14.4)
+35 mesh tail	.84	.59	40.7	7.3	9.2
-35 +100 tail	.89	.83	16.0	3.0	3.8
-100 +325 tail	3.29	2.3	7.0	5.0	6.1
-325 Slime	5.75	7.3	15.7		

TABLE III
Flotation Data

Grind: 10% +65 mesh

Reagents: 28 lb/Ton Na_2CO_3
.74 lb/Ton Na_2SiO_3
1.1 lb/Ton Oleic Acid
.006 lb/Ton Pine Oil

32.3 percent of the total sample weight was removed as slimes by decantation.

		Assays		Recovery			
				With Slimes		Without Slimes	
Product	Wt %	oz/T Ag	% Mn	Ag	Mn	Ag	Mn
Slimes	32.3	4.99	6.95	30.3	33.5	-	-
Concentrate	53.6	17.27	23.3	45.8	49.3	65.9	74.1
Tailing	14.1	2.37	2.15	23.9	17.2	34.1	25.9

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C.
JUN 19 1972

June 16, 1972

Mr. J. J. Collins
Director of Exploration
New York Office

Hardshell
Metallurgy-Water Requirements

Dear Sir:

Mr. Courtright summarized the metallurgical work, and included copies of all pertinent data, in a letter to you dated November 13, 1969.

Tests to date indicate that dry magnetic concentration with a 4:1 concentration ratio recovers at least 60% of the silver in a high manganese concentrate containing 16-18 oz. silver per ton.

Treatment of this concentrate with a sulphurous acid leach produces a flux containing 73% silica, 35 oz. per ton silver, and 8% lead.

Assuming treatment of 1000 tpd of ore, water requirements (estimated at 250-300 gallons per ton of concentrate) would be between 40 and 52 gallons per minute. This, according to Mr. Courtright, is available at the Welch shaft which provided the Trench Mill with around 60-70 gpm for several years. Additional water supply should be available two to three miles east of the Hardshell in the deep gravels of Santa Cruz drainage basin (no figures available since all wells in area are shallow stock wells).

W. L. Kurtz

WLK:lad
Encls.

cc: JHCourtright - w/o enc.
GWBossard - w/o enc.

NEWS LETTER

NEVADA MINING ASSOCIATION
RENO, NEVADA 89505

L.P.F.
NOV 24 1969

1969

ROOM 602
ONE EAST FIRST STREET

NOVEMBER 15, 1969

POST OFFICE BOX 2498
TELEPHONE 323-8575

PAUL GEMMILL, Executive Secretary

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

NUMBER 200

NOV 25 1969 NOV 24 1969

TECHNICAL DEVELOPMENTS

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

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

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

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

NEVADA MINES, COMPANY REPORTS, ETC.

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

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

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 4, 1969

Memo to: Mr. R. F. Welch

Value of Hardshell Flux

Mr. K. D. Loughridge has requested in his letter of May 15 that we determine the value of Hardshell SO_2 leach residue when used as a flux at either the Selby, El Paso, or Hayden Smelters. This residue is the portion that remains after the manganese has been leached by SO_2 from Hardshell magnetic/electrostatic concentrate. The smelter at which they would be sold and the approximate assay of the various fluxes is given below. These assays have been taken from CR Report No. 4327.

(A.) Total residue - Selby, El Paso, or Hayden.

120 otpd

Ag	- 35.4 oz/ton
Pb	- 8.3 %
Zn	- 0.54 %
Mn	- 1.7 %
SiO_2	- 73.2 %
Fe	- 3.2 %
Al_2O_3	- 1.75 %
CaO	- $\leq$.05 %
MgO	- $\leq$.11 %

(B.) Minus 70 mesh fraction of residue - Selby, El Paso.

50%

Ag	- 61.82 oz/ton
Pb	- 13.0 %
Mn	- 0.45
SiO_2	- 62.0
Al_2O_3	- 2.1
K	- 0.18
S	- 2.1
Fe	- 4.8

(C.) Plus 70 mesh fraction of residue - Hayden.

50%

Ag	- 3.21 oz/ton
Pb	- 4.62 %
Mn	- 2.48
SiO_2	- 81.6

A rough estimate of the freight rates from Nogales, Arizona to the Selby, Hayden, or El Paso Smelters would also be required.

D. E. CROWELL

DEC/mg

Dum
X 47

Salt Lake City, Utah
May 15, 1969

Mr. J. S. Smart, Jr., Vice President
Central Research Laboratories
South Plainfield, N. J.

HARDSHELL PROJECT - SILVER-MANGANESE ORE

I have studied the report dated May 9, 1969, and I am quite encouraged by the test results. The residue analysis shown on page 5 would be a good flux for both our lead and copper circuits.

As you may or may not be aware, the Selby Plant is in dire straits for flux and we are using practically barren flux at some of the other plants. Both the Selby Plant and the El Paso leadplant could use approximately 1,000 tons per month of this flux which would consume the minus 70 mesh fraction as reported on page 8 containing 92% of the lead and 89.5% of the silver. The plus 70 mesh fraction could be used as furnace flux at Hayden.

By copy of this letter to Mr. Bossard, I am asking that he get in touch with Reed Welch to determine the value of these products, handled as noted above. The Smelting Department is quite anxious to have a constant supply of silicious flux for both lead plants.

K. D. LOUGHRIDGE

KDL/rp

cc: R.L.Hennebach
F.W.Archibald/R.M.McGeorge w/att
V.Kudryk
A.E.Albrethsen
G.W.Bossard
T.D.Henderson
E.Martinez
R.B.Meen
C.E.Nelson
W.P.Roe
T.A.Snedden
R.F.Welch w/att

RECEIVED
MAY 16 19
REED F. WELCH

MAY 14 1969

AMERICAN SMELTING AND REFINING COMPANY

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N. J.

May 9, 1969
Project No. 3103

Mr. J. S. Smart, Jr.
B U I L D I N G

HARDSHELL PROJECT - SILVER-MANGANESE ORE

PROJECT NO. 3103

The attached Report No. 4327 by Dr. A. E. Albrethsen represents the second phase of an investigation to develop a suitable process for recovering silver from the Hardshell ore taking into account the scarcity of water at the mine site. Mr. E. Martinez has reported on a method for concentrating the silver in the ore by dry magnetic and electrostatic means. The concentrate thus produced would be shipped to a smelter for further treatment.

Utilizing SO_2 for leaching the manganese proved successful and a high silica flux resulted retaining all of the silver present in the concentrate. This flux could be used for a copper smelter or in a lead smelter. Approximately 120 tons per day of flux would be produced with 73% SiO_2 and 35 oz. per ton of silver. Attempts to cyanide the silver in the residue from the SO_2 leaching were not as successful as only 70% of the silver was leached. Further work would be necessary to determine the reason for the low recovery.

Since a great proportion of the manganese is solubilized, the resulting manganese sulfate solution poses a disposal problem. It would be possible to recover MnO_2 from the solutions; however, the economics would have to be evaluated to see whether this is justified.

AMERICAN SMELTING AND REFINING COMPANY

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N. J.

Results in the two reports are based on a single sample and should be substantiated using a representative sample. The process would have to be piloted to develop the optimum conditions.

V. Kudryk

VK/lk

cc: Library
AEAlbrethsen
GWBossard
TDHenderson
RLHennebach
KDLoughridge
EMartinez
RBMeen
CENelson
WPRoe
TASnedden

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, NEW JERSEY

REPORT NO. 4327
May 8, 1969

HARDSHELL PROJECT - SILVER-MANGANESE ORE

PROJECT NO. 3103

Sulfurous Acid Leaching Studies for Removal of Manganese

A B S T R A C T

Removal of manganese from the Hardshall ore and concentrate was studied by using a sulfurous acid leach. The manganese was recovered in the leach leaving a residue containing the silver values. The residue appears suitable for use as a silica flux. Lead and silver values are concentrated in the finer size fractions of the residue.

Only 70% silver recovery was obtained in cyaniding the residue so further work would be necessary to determine whether this could be improved.

A E Albrethsen

A. E. Albrethsen

AEA/lk

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, NEW JERSEY

REPORT NO. 4327
COPY NO. 14
May 8, 1969

HARDSHELL PROJECT - SILVER-MANGANESE ORE

PROJECT NO. 3103

Sulfurous Acid Leaching Studies for Removal of Manganese

OBJECT:

To study sulfurous acid leaching of manganese-silver ore and concentrate as a means of manganese removal in order to facilitate the recovery of silver.

INTRODUCTION:

The silver in the Hardshell deposit is incorporated in the mineral cryptomelane (KMn_8O_{16}) and is not recoverable by direct leaching. With the high manganese content of the ore (11.2%) and the relatively low silver content (4.85 oz./T) the ore is not suitable as a smelter flux. A method of concentrating the silver from the ore has been developed by Mr. E. Martinez (Research Report No. 4319).(1) This process involves magnetic and electrostatic separations and produces a product containing about 33% Mn and 15 oz./T Ag with a silver recovery of 68%. This product contains far too much manganese to use as a smelter flux. The removal of manganese would leave a product containing sufficient free silica to use as a flux, thus placing the silver values in a product where a high recovery could be expected.

Two methods of recovering silver from manganese-silver ores that appear to be applicable to the Hardshell ore are reported by Clevenger and Caron. (Bureau of Mines Bulletin 226)(2). 1) Sulfurous acid leaching of the manganese and subsequent cyanide leaching of the residue. 2) A reducing roast of the ore to convert MnO_2 to MnO followed by a cyanide leach.

Since there is no water available for leaching at the Hardshell deposit, it appears that it would be practical to ship the ore or concentrate to a smelter where there would be an adequate supply of SO_2 and the silicate residue

can be consumed as flux. Another possibility would be to ship the ore or concentrate to a source of water, subject the material to a reducing roast followed by cyanidation and discard the residue. This study is devoted only to the sulfurous acid leaching to produce a leach residue for cyanidation or smelter flux, cyanidation tests on the residue, and characterization of the residue for possible flux uses.

EXPERIMENTAL:

Materials Used. Samples of Hardshell ore (MR-10) and Hardshell concentrate were split into approximately 50 gram samples for use in the tests. Both concentrate and ore were supplied by E. Martinez and were the same materials used and produced in his tests--Research Report No. 4319(1). Analyses of these materials are given in Table I.

TABLE I

Composition of Manganese-Silver Material

	Hardshell Ore MR-10	Concentrate
Mn	11.2%	33.54%
Ag	5.85 oz./T	14.84 oz./T
Pb	1.8%	3.98%
Zn	1.0%	3.37%
Fe	2.0%	3.10%
Insol.	71.2%	--
SiO_2	--	31.3%
CaO	1.0%	--
Cu	--	0.42%

PROCEDURES:

All sulfurous acid leaches were conducted in 600 ml tall beakers. The pulp was stirred with motor driven glass rods. Sulfur dioxide was bubbled continuously during the leach. Unless a deviation is mentioned in the specific test procedure, 200 ml water and approximately 50 grams of the ore or concentrate were used in the leaches.

For the cyanide leaches the same volume and stirring apparatus was used. The pulp was brought to a pH of 12.4 with lime and after 1/2 hour the pH was again checked to insure that all acid had been neutralized. Then the cyanide (2 g/l NaCN) was added and the pulp leached for 24 hours. The residues were washed and submitted for fire assay.

Ore Leach Test #1

A sample of -10 mesh ore was leached for one hour with SO_2. The pulp was filtered and washed and the residue given a cyanide leach.

Ore Leach Test #2

A sample of -10 mesh ore was leached for two hours with SO_2. The residue was then ground to -100 mesh and leached for one hour. The residue was then given a cyanide leach.

Ore Leach Test #3

A sample of -10 mesh ore was leached for 3 hours with SO_2. This was followed by a cyanide leach.

Ore Leach Test #4

A sample of -10 mesh ore was ground to -100 mesh and then leached for one hour with SO_2. This was followed by a cyanide leach.

Ore Leach Test #5

A 105 gram sample of -10 mesh ore was leached for 2 hours with SO_2. This was followed by a 2 hour releach and a second releach in which the pulp was allowed to stand 18 hours before filtration. The residue was then separated into the size fractions---- +30, -30 +70, and -70 mesh. Each size fraction was analyzed for Pb, SiO_2, Mn, and Ag.

Concentrate Leach Test #1

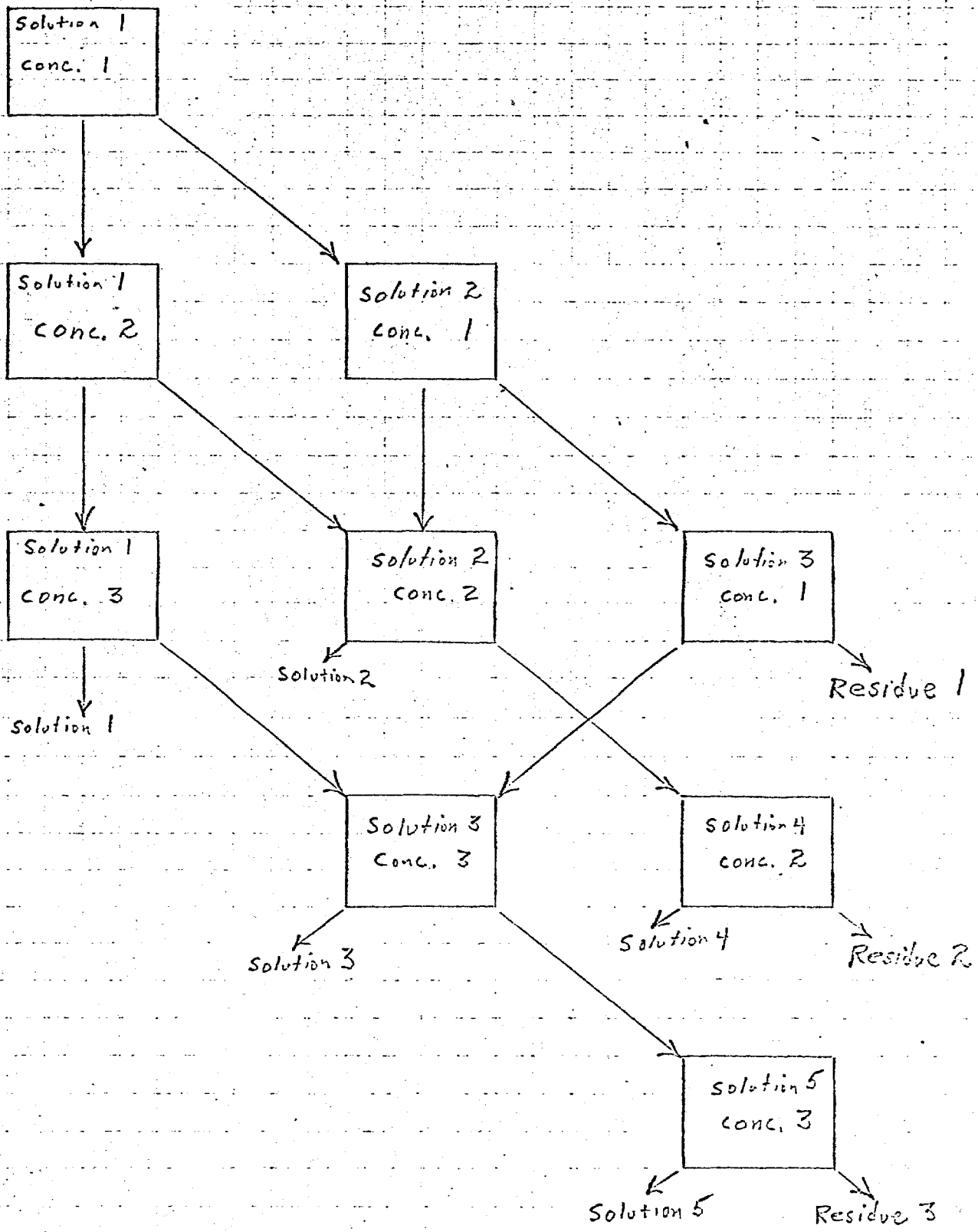
This was a counter current leach on three samples of -10 mesh concentrate. The one-hour leaches were conducted according to the flowsheet shown in Figure I. Leaches were started with 200 ml water and 50 grams of concentrate. Each leach was filtered and the residue washed. After the counter current test, all of the residues were releached for one hour. The exit solutions and intermediate solutions were analyzed. Residue #1 was submitted for chemical analysis. Residue 2 was again releached with SO_2 and then residues 2 and 3 were given cyanide leaches.

Concentrate Leach Test #2

A sample of -10 mesh concentrate was leached 2 hours with SO_2. This was followed by a long releach consisting of 2 hours gassing, standing overnight, and one additional hour of gassing with SO_2. The residue was then separated into size fractions of +30, -30 +70, and -70 mesh. Each size fraction was chemically analyzed.

FIGURE 1.

FLOW SHEET FOR COUNTER CURRENT LEACH



RESULTS:

A summary of all of the leaching tests is given in Table II. In the tests where the residues were analyzed for possible value as smelter flux, the results are given in more detail in the form of data sheets. These tests were concentrate leach test No. 1, concentrate leach test No. 2, and ore leach test No. 5.

TABLE II

Summary of Leaching Tests

Test	Mn recovered in solution %	Wt. Loss %	Silver extraction in cyanide %	Silver assay of residue oz./T.
Ore Leach 1.	83.5	22	72.2	2.08
Ore Leach 2a.	85.3			
b.	2.0			
Total	87.3	21.9	36.2	4.78
Ore Leach 3.	85.6	21.9	76.6	1.75
Ore Leach 4.	84	20.7	73.0	1.99
Ore Leach 5a.	90.5			
b.	6.9			
c.	1.2		-	--
Total	98.6	13.7	--	--
Concentrate Leach 1. (overall results of counter current leach test)	89.6	58	72.3	9.78
Concentrate Leach 2a.	78.0			
b.	11.1			
Total	89.1	56.4	--	

DATA FOR CONCENTRATE LEACH TEST NO. 1
(Counter Current Leach of Concentrate)

	Sulfurous Acid Leach		Cyanide Leach	
	Mn recovery in leach %	Wt. Loss %	Ag extraction %	Ag in residue oz./T
Concentrate No. 1	89	58	--	--
Concentrate No. 2	93	59	72.6	9.92
Concentrate No. 3	86	57	72.1	9.64

Overall Results of Sulfurous Acid Leach

Weight loss	58%
Mn recovered in leach solution	89.6%
Mn in residue	2.1%
Mn unaccounted for	8.3%
Maximum Mn concentration in leach solution	70 g/l

Analysis of Residue No. 1

	%
SiO_2	73.2
Mn	1.7
Fe	3.2
CaO	<0.05
MgO	0.11
Al_2O_3	1.75
Pb	8.3
Zn	0.54
Ag(calc.)	0.1214 = 35.4 oz./T

DATA FOR CONCENTRATE LEACH TEST NO. 2

Feed Concentrate 50.2g (Data Calculated for 100g)

Leach Solution Recovery

Mn	29.8 g	= 89% of feed	Leach Residue = 43.6g
Cu	1.23g		Wt. Loss = 56.4g
Zn	2.28g		
K	0.99g		

Size Distribution of Residue

+30 mesh	12.35g
-30 +70 mesh	9.55g
-70 mesh	21.7g

43.6

Analyses of Feed, Residue, and Residue Fractions

	Feed	Total Residue (calc.)	+30	-30 +70	-70
	%	%	%	%	%
Pb	3.98	7.93	2.6	3.3	13.0
SiO_2	31.3	71.5	81.2	81.2	62.0
Ag	0.0510	0.113	0.0119	0.0187	0.212
Mn	33.54	1.75	4.0	1.8	0.45
Al_2O_3	--	--	--	--	2.1
K	--	--	--	--	0.18
S	--	--	--	--	2.1
Fe	--	--	--	--	4.8

61.3 ppt

Distribution of Material in Residue (% of Feed)

	Total Residue	+30	-30 +70	-70
Pb	86.8	8.05	7.92	70.83
SiO_2	99.5	31.9	24.7	42.9
Ag	96.8	2.88	3.49	90.43
Mn	2.28	1.48	0.51	0.29

DATA FOR ORE LEACH TEST NO. 5

Feed Ore 105g (Data Calculated for 100g Feed)

Leach Solution Recovery

Mn	11.05g = 98.7%	Residue =	86.3g
Fe	.72g	Wt. Loss	13.7g
K	0.36g		

Size Distribution of Residue

+30 mesh	18.5g
-30 +70 mesh	11.8g
-70 mesh	56.0g

Analyses of Feed, Residue and Residue Fractions

	Feed	Total Residue (calc.)	+30	-30 +70	-70
	%	%	%	%	%
Pb	1.80	1.68	0.34	0.45	2.4
SiO_2	71.2	85.5	88.0	90.4	82.8
Ag	0.020	0.0234	0.00716	0.00825	0.032
Mn	11.2	0.162	0.36	0.15	0.09

Distribution of Material in Residue
(% of Feed)

	Total Residue	+30	-30 +70	-70
Pb	81.0	3.5	3.0	74.5
SiO_2	103.3	22.8	15.0	65.5
Ag	101.0	6.6	4.9	89.5
Mn	1.26	0.62	0.2	0.44

DISCUSSION:

Residue

The analyses of the sulfurous acid leach residues indicate that the bulk of the manganese was sucessfully removed leaving the silica and silver with the residue. While this residue could probably be used directly as converter flux it may be practical to recover the lead so it won't be lost in the copper circuit. An examination of the residues indicates that the bulk of the lead is concentrated in the finer size fraction. The -70 mesh fraction of the concentrate residue which represented 50% of the residue, contains 81% of the lead and 90% of the silver. The -70 mesh fraction of the ore residue, 65% of the residue, contains 92% of the lead and 89.5% of the silver. The lead content of the two fractions was 13.0% and 2.4%, and the silver content 61.8 oz./T and 9.3 oz./T respectively. No further tests were made concerning lead concentration; however, it is believed that the lead could be concentrated further by flotation and/or gravity techniques. Also it may be possible to leach the lead.

Cyanide leaching of the residues recovered about 73% of the silver with one exception--ore leach no. 2--where only 37% was recovered. In this case it is believed that incomplete washing of the sulfurous acid leach residue was responsible for the low recovery. The recovery of silver does not appear to be dependent on the feed size to the cyanide leach. This is indicated by ore leach no. 1 (-10 mesh) and ore leach no. 4 (-100 mesh), and also by the concentration of silver in the fine size fraction. Because of the relatively low silver recovery and the high silver content of the cyanide leach residue, especially the concentrate residue (9.8 oz./T), additional work would determine whether this method of recovery is practical.

Manganese Product

Because of the high content of manganese in both ore and concentrate, disposal of a manganese product will be a major consideration. Assuming a 1000-ton per day mining operation, 112 tons of manganese will be mined. By making concentrate at the rate of 280 tons per day, 94 tons of manganese are involved. With a 90% recovery into the leach solution, the ore would yield 100 tpd and the concentrate 84.5 tpd. Manganese is contained in the leach solution as manganese sulfate ($MnSO_4$). Thus, these yields represent 275 and 232 tons of $MnSO_4$ respectively.

There is a discrepancy in the amount of manganese leached depending upon whether the manganese in solution or remaining in the residue is used as a basis. Analytical error and mechanical losses can account for the difference, particular in view of the small scale. There was a small amount of precipitate formed in the leach solution upon standing. This was neglected because it appeared to be insignificant. The weight loss in ore leach no. 5 is not in agreement with the other leaches. The procedure for this leach differed from the others in that the pulp was held overnight before filtering and some salts may have precipitated out.

Other Considerations

Pure SO_2 was used in these leach tests. The use of smelter gas can be expected to produce different results in that free sulfuric acid is generated when a sufficient amount of oxygen is present with the SO_2. A pilot plant study by the Bureau of Mines (R.I. 5508)(3) found that the SO_2 to oxygen ratio in the gas had an effect on the amount of acid produced and also the amount of dithionate produced.

If the disposal of the manganese turns out to be non-economical, then another possibility for silver recovery would be to subject the ore or concentrate to a reducing roast and then leach the silver with cyanide. A test to determine silver recovery from this technique is planned.

CONCLUSION:

1. It is possible to remove the manganese from the Hardshell ore and concentrate by means of a sulfurous acid leach, th thus producing a smelter flux containing the silver values.

2. Cyanide leaching of the concentrate residue resulted in recovering around 70% silver which is less than anticipated. Further work is needed to determine the reason for the low recovery.

REFERENCES:

1. Martinez, Edward. Research Report No. 4319, April 15, 1969, "Hardshell Project - Silver Manganese Ore, Project No. 3103-247, Magnetic and High Tension Concentration - Part II."

2. Clevenger, G. H., and Caron, M.H. Bureau of Mines Bulletin 226, "The Treatment of Manganese-Silver Ores," Washington, Government Printing Office, 1925.

3. Rampacek, C., Fuller, H.C., and Clemmer, J.B., Bureau of Mines Report of Investigations 5508, Washington, United States Department of Interior, 1959.

A. E. Albrethsen

AEA/lk

AMERICAN SMELTING AND REFINING COMPANY

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N. J.

M.sc 11A

APR 21 1969

April 16, 1969
Proj. 3103-247

Mr. J. S. Smart, Jr.
B U I L D I N G

The attached Research Report No. 4319 by Mr. E. Martinez summarizes the preliminary investigation to develop a method for dry concentration of the Hardshell silver-manganese ore. Results indicate that a 68% recovery of silver can be obtained with a concentration ratio of 3.6 utilizing dry magnetic and electrostatic techniques. This would mean shipping approximately 280 tons per day of concentrate to some other location for further processing. The concentrate is too high in manganese to be suitable for a flux in a reverberatory furnace. The concentrate could be subjected to a reducing roast, then cyanided for silver recovery. Another possible approach is to leach the concentrate with waste SO_2 gas at a smelter to remove the manganese and then the resulting silica with the silver could be used as a flux.

Tests are presently being completed on this leaching method and results will be reported shortly.

V. Kudryk

V. Kudryk

VK/lk

cc: Library
AEAlbrethsen
GWBossard
TDHenderson
EMartinez
RBMeen
CENelson
WPRoe
TASnedden
RLHennebach

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, NEW JERSEY

REPORT NO. 4319
April 15, 1969

HARDSHELL PROJECT - SILVER MANGANESE ORE

PROJECT NO. 3103-247

MAGNETIC AND HIGH TENSION CONCENTRATION - PART II

A B S T R A C T

Recovery of silver in Hardshell ore by dry concentration was investigated further. Magnetic and high tension separations were run on two minus 10 mesh samples. One was submitted to air classification and the other to dry screening prior to running on the separators. Recoveries of over 68% of the silver were obtained with both samples in a concentrate containing approximately 15 oz./ton of silver. The ratio of concentrate was 3.6 so that 280 tons per day of concentrate would be produced from a mill handling 1000 tons per day of ore.

It is recommended that larger scale tests be run to determine required equipment and estimated operating costs. These tests should be run with a sample that is believed to be most representative of the Hardshell deposit.

Edward Martinez

Edward Martinez

EM/lk

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, NEW JERSEY

REPORT NO. 4319
COPY NO. 6
April 15, 1969

HARDSHELL PROJECT - SILVER MANGANESE ORE

PROJECT NO. 3103-247

MAGNETIC AND HIGH TENSION CONCENTRATION - PART II

OBJECTIVE:

This report is a continuation of the investigation into the recovery of silver from Hardshell ore by dry magnetic and high tension separation.

INTRODUCTION:

In Research Report No. 4299 the results of preliminary magnetic and high tension separation of a Hardshell ore sample were reported. Although the highest recovery obtained in the initial tests was only 53.2%, analysis of the test data indicated that recoveries of over 60% were possible with modifications in the operating variables of the separators. Because of the association of the silver with the manganese mineral cryptomelane, concentration ratios of approximately 4:1 were obtained and the concentrates contained about 16 oz. per ton of silver.

Additional tests have been run varying some of the operating settings to try to determine the optimum conditions for the recovery of silver.

SAMPLE:

The same Hardshell ore sample (MR-10) tested previously was used in the present investigation. The assay of the sample is as follows:

Oz./Ton		Percent					
Ag	Au	Mn	Pb	Zn	Fe	Insol.	CaO
5.85	0.005	11.2	1.8	1.0	2.0	71.2	1.0

TEST RESULTS AND DISCUSSION:

Two samples of ore were crushed to minus 10 mesh. The first was dry screened at 30 mesh and the minus 30 mesh fraction run through the Federal Air Classifier. The classifier split the minus 30 mesh ore into coarse, medium, and dust fractions. The weight distribution is shown in Table I. Each fraction, with the exception of the dust, was run on the magnetic and high tension separators.

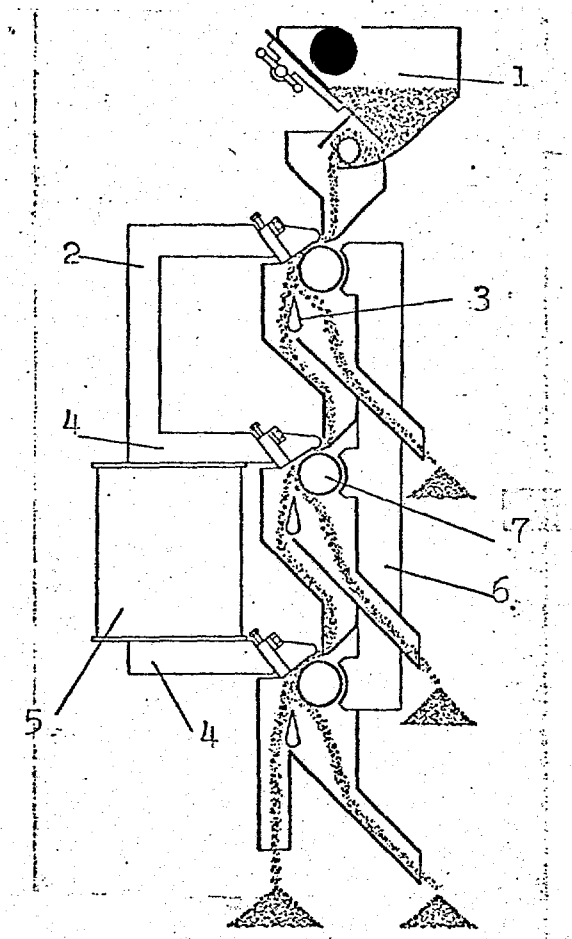
The other sample was dry screened using 30, 70, 100, 200, and 325 mesh sieves. The weight distribution, along with silver and manganese analyses, is given in Table I. The sized fractions, with the exception of the minus 325 mesh, were run on the magnetic and high tension separators.

In order to achieve a good silver recovery, it has been found that the ore must be passed several times through the magnetic and high tension separators. Figure 1 shows a diagram of a typical commercial induced roll magnetic separator. Each roll revolves in an individual magnetic circuit, the strength of which can be controlled accurately.

A diagram of a high tension separator is also shown in Figure 1. In the tests run, the electrodes were negatively charged at 29 to 30 kilovolts. The cryptomelane was lifted and the quartz pinned to the drum. The middlings (not shown in diagram) were recirculated. Commercial high tension separators are available with 2 or 4 rolls.

As noted in the previous report, the only guide that could be used during the testing was the color of the concentrate. The cryptomelane is dark and an attempt was made to obtain a dark colored concentrate for each separation.

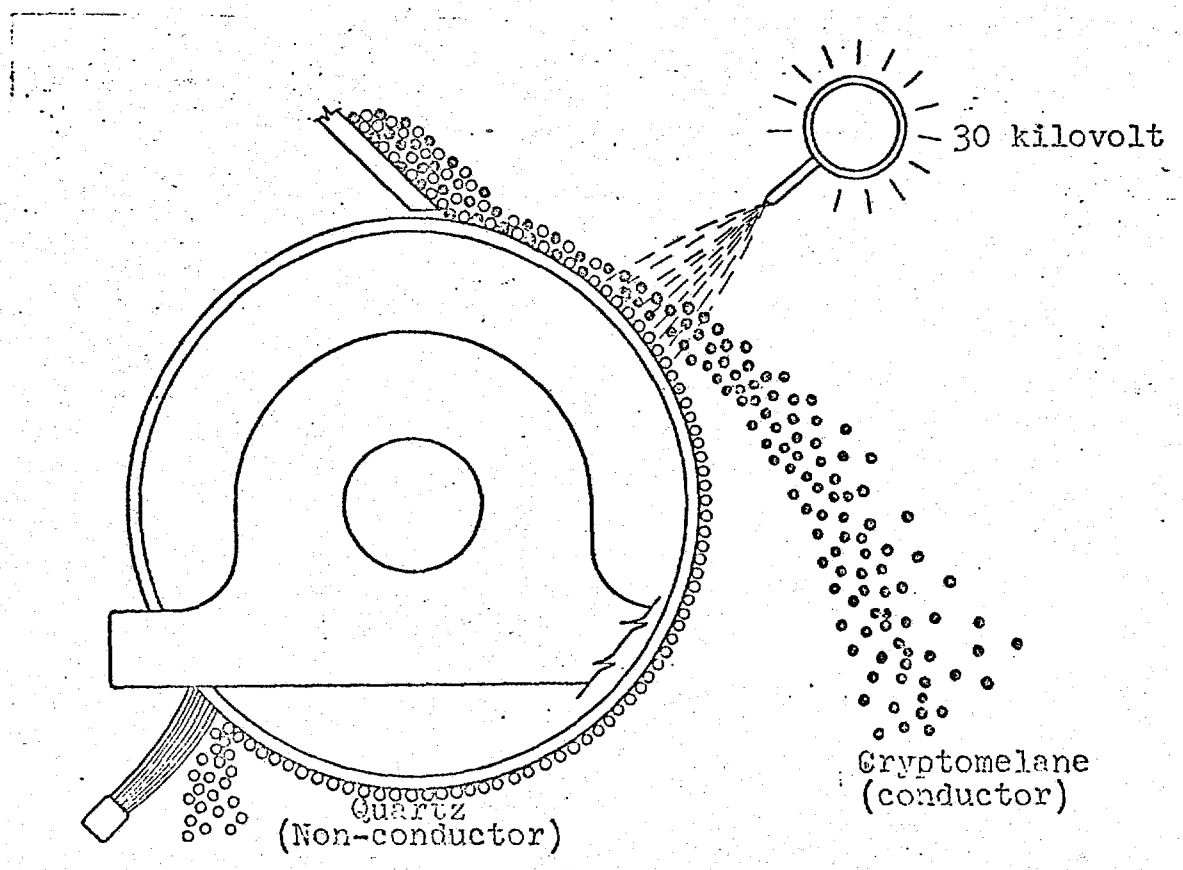
The generalized flowsheet and operating conditions used in the test with the screened sample are given in Figure 2. The conditions used with the air classified sample differed only slightly from those in Figure 2. It was found that the speed of rotation had to be increased as the particle size decreased with both types of separators to obtain good concentrations. With the finer sizes it was necessary to pass the feed through the magnetic separator one time at low intensities to remove highly magnetic material. The concentration of the coarser sizes appeared to be improved by heating prior to the high tension separation, although all of the fractions from the air classified sample were run at room temperature.



1 Feeder Hopper
2 Roughing Pole
3 Splitter
4 Primary Magnet Pole
5 Magnet Coil
6 Yoke
7 Inductively Magnetized Roll

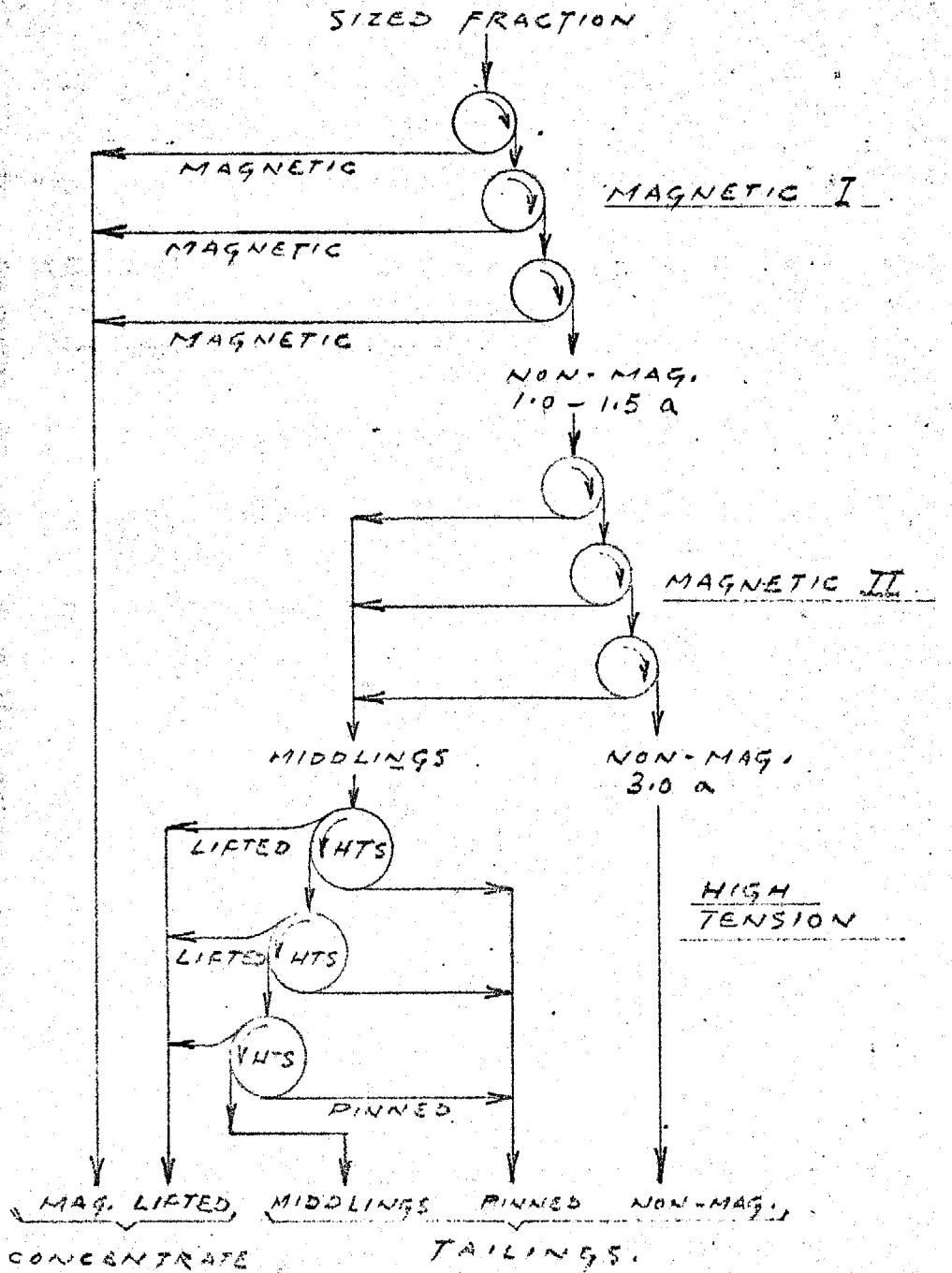
Non-magnetic Magnetic

MAGNETIC SEPARATION



HIGH TENSION SEPARATION

GENERALIZED FLOWSHEET AND OPERATING CONDITIONS USED IN TESTS WITH SIZED FRACTIONS OF HARDSHELL, ORE.



SIZE FRACTION	MAGNETIC SEPARATION			HIGH TENSION SEPARATION		
		AMPS	RPM	RPM □	FEED T, °F	VOLTS
10 x 30 MESH	I	1.5	20	50	180	30 Kv
	II	3.0	20			
30 x 70 MESH	I	0.5*, 1.2	70	50	180	30
	II	3.0	70			
70 x 200 MESH	I	0.0*, 1.0	85	350	68	30 Kv
	II	3.0	60			
200 x 325 MESH	I	0.0*, 1.0	85	450	68	30 Kv
	II	3.0	60			
	* FIRST PASS TO REMOVE HIGHLY MAGNETIC PARTICLES			□ 14" DIAM. DRUM USED IN ALL TESTS		

MAGNETIC SEPARATOR: CARPCO MODEL MS-1265, LABORATORY SUPER HIGH INTENSITY INDUCED ROLL SEPARATOR.

HIGH TENSION SEPARATOR: CARPCO MODEL HP 16-114, LABORATORY RESEARCH SEPARATOR.

(4)

FIG. 2

The test results on the screened-air classified sample are given in Table II, and those obtained with the sized fractions are shown in Table III. The data from the two tests have been recast to obtain a composite concentrate and tailings to determine the overall recovery, including the untreated dust or minus 325 mesh fractions, for each test (Table IV).

Silver recoveries of over 68% were obtained in the two tests in concentrates containing approximately 15 oz. per ton of silver. The ratio of concentration was about 3.6 so that approximately 280 tons per day of concentrate would be produced from treating 1000 tons per day of ore.

The improved recoveries obtained compared to the initial runs described in Research Report No. 4299 were due principally to changes made in the settings of the separators, particularly with the coarser sizes. The changes resulted in a larger weight fraction being recovered without a serious decrease in the silver content.

Since the silver recovered is principally in a manganese oxide mineral, the concentrate contained over 30% Mn. Also present in the cryptomelane crystal structure are copper, lead, and zinc which are concentrated with the silver. The composited concentrate from the screened sample test analyzed as follows:

Oz.T	Percent					
Ag	Mn	SiO_2	Cu	Pb	Zn	Fe
14.84	33.5	31.3	0.42	3.98	3.37	3.10

A sample of the concentrate was submitted to Dr. A. E. Albrethsen to run tests on removal of manganese.

RECOMMENDATIONS:

The results of this laboratory investigation indicate that the silver can be concentrated by a dry magnetic-electrostatic separation process. In order to evaluate the commercial feasibility, it is recommended that a large representative sample be obtained from the ore body for larger scale test

work. As part of this future program, ore samples would be sent to manufacturers of equipment suitable for this application. The information and data developed in this investigation would be used for determining the equipment needed, and capital and operating costs for an economic evaluation of the process.

The two Hardshell samples tested at the El Paso Ore Testing Laboratory and South Plainfield had approximately the same silver assays but differed in the manganese contents, as follows:

	EPOTL Composite	Research Composite
Ag	5.22 oz./T.	5.85 oz./T.
Mn	6.45%	11.2%
Ag Oz./T.:Mn%	0.81	0.52

As discussed in Research Report No. 4299, the ratio of silver to manganese in the ore will affect the grade of concentrate, ratio of concentration, and the silver recovery obtained in a separation. Therefore, an effort should be made to run the tests recommended above on a sample that is believed to be most representative of the deposit.

Edward Martinez

EM/lk

REPORT NO. 4319

TABLE I

Silver and Manganese Assays of Sized Fractions of Hardshell Ore

		Silver		Manganese	
Mesh	% Wt.	Oz./T	Dist.	%	Dist.
-10 +30	36.4	5.23	32.2	9.23	30.8
-30 +70	32.0	5.77	30.5	10.47	30.7
-70 +200	16.8	7.14	20.3	13.81	21.2
-200 +325	5.8	7.54	6.8	13.90	7.4
-325	9.0	6.71	10.2	12.02	9.9
	100.0		100.0		100.0
Head		5.85		11.2	

Weight Distribution of Screen and Air Classified Hardshell Ore

Fraction	% Wt.
-10 +30 Mesh	42.3
Classifier Coarse	42.0
" Medium	6.0
" Dust	9.7
	100.0

Ore crushed to -10 mesh and dry screened at 30 mesh. The -30 mesh fraction was run through the Federal air classifier.

REPORT NO. 4319

TABLE II

Magnetic-High Tension Separation
Screened and Air Classified Hardshell Sample

		Silver		Manganese	
	% Wt.	Oz./T	Dist.	%	Dist.
-10 +30 Mesh(42.3%)					
Magnetic	18.3	16.06	58.5	30.0	71.0
HTS Lifted	8.1	8.20	13.1	15.5	16.3
Tailings	73.6	1.94*	28.4	1.33*	12.7
	100.0		100.0		100.0
-30 Mesh Class. Coarse(42.0%)					
Magnetic	19.0	18.20	49.5	34.6	53.7
HTS Lifted	16.1	13.25	30.5	28.2	37.1
Tailings	64.9	2,16*	20.0	1.74*	9.2
	100.0		100.0		100.0
-30 Mesh Class.Fine(6.0%)					
Magnetic	28.6	15.92	63.7	34.6	73.6
HTS Lifted	5.6	16.00	12.6	35.1	14.6
Tailings	65.8	2.57*	23.7	2.40*	11.8
	100.0		100.0		100.0
Classifier Dust(9.7%)		6.7+		12.0+	

Composite of Data

		Silver		Manganese	
Product	% Wt.	Oz./T.	Dist.	%	Dist.
Magnetic	17.4	17.1*	48.3	32.5*	54.7
Lifted	10.5	11.7*	20.0	24.5*	24.6
Tailings	62.4	2.1*	21.1	1.57*	9.5
Dust	9.7	6.7+	10.6	12.0+	11.2
	100.0		100.0		100.0

* Assays calculated from values obtained from several fractions.

\+ Estimated assays.

REPORT NO. 4319

TABLE III

Magnetic-High Tension Separation Sized Fractions of Hardshell Ore

			Silver			Manganese	
	% Wt.		Oz./T	Dist.		%	Dist.
-10 +30 Mesh (36.4%)							
Mag. 1.5a. & Lifted	28.9		14.23	77.4		30.95	88.1
Non-magnetic 3.0a.	49.5		1.26	11.3		0.41	2.0
HTS Middlings	11.4	1.69*	3.82	7.5	1.69*	8.05	8.9
HTS Pinned	10.2		2.20	3.8		0.82	1.0
	100.0			100.0			100.0
-30 +70 Mesh(32.0%)							
Mag. 1.2a. & Lifted	27.7		16.30	75.0		34.80	95.0
Non-magnetic 3.0a.	44.7		1.25	10.0		0.48	2.0
HTS Middlings	10.2	2.07*	5.70	10.0	0.69*	11.15	1.0
HTS Pinned	17.4		1.88	5.0		0.90	2.0
	100.0			100.0			100.0
-70 +200 Mesh(16.8%)							
Mag. 1.0a. & Lifted	35.7		16.14	79.5		35.75	89.5
Non-mag. 3.0a.	49.6		1.72	12.3		0.90	2.8
HTS Middlings	12.2	2.33*	4.34	6.8	2.33*	7.30	6.3
HTS Pinned	2.5		4.10	1.4		6.05	1.4
	100.0			100.0			100.0
-200 +325 Mesh(5.8%)							
Mag. 1.0a. & Lifted	34.7		14.00	62.8		29.75	71.0
Non-mag. 3.0a.	31.4		2.80	11.5		2.25	4.8
HTS Middlings	30.2	4.44*	5.80	23.1	6.43*	10.45	22.1
HTS Pinned	3.7		4.60	2.6		7.13	2.1
	100.0			100.0			100.0
-325 Mesh (9.0%)			6.71			12.02	

* Assays calculated from values obtained from several fractions.

REPORT NO. 4319

TABLE IV

Composite of Data on Magnetic and High Tension Separation of Hardshell Ore

Screened-Air Classified Sample

Fraction	% Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.
Magnetic & Lifted	27.9	15.1*	68.3	29.5*	79.3
Mag. & HTS Tails	62.4	2.1*	21.1	1.57*	9.5
Class. Dust	9.7	6.7	10.6	12.0	11.2
	100.0		100.0		100.0

Screened Sample

Fraction	% Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.
Magnetic & Lifted	27.4	15.3*	68.5	33.1*	80.7
Mag. & HTS Tails	63.6	2.1*	21.7	1.7*	9.7
-325 Mesh	9.0	6.7	9.8	12.0	9.6
	100.0		100.0		100.0

Analysis of concentrate (magnetic & lifted), as follows:

Oz./T	Percent					
Ag	Mn	SiO2	Cu	Pb	Zn	Fe
14.84	33.54	31.3	0.42	3.98	3.37	3.10

* Composite assays were calculated from values obtained for individual fractions.

Hardshell

KD Loughridge letter of 12-16-'68

A con of 45% silica, 30% mn would require additional silica (mn much like iron as slag forming material) 1:1 ratio of iron to silica required in charge.

also there would be a loss of 10 lbs Cu in slag.

Lead Smelter?

V. Kudryk letter of 11-27-'68 Central Research So. Plainfield

recov. of 60% - concentrates 4:1 -

250 tpd to smelter.

"Otherwise will investigate leaching conc with SO_2 for removal of ~~Mn~~ Mn - subquent cyanidation of residue. This could be carried out at smelter using SO_2 from stack gases.

"In the event that a suitable water supply is discovered — process at mine site.

KMnO

Martinez Rept - 11-27-68

Recov 60% of Ag in con of 16 to 18 oz

major part of Ag in cyplomelane which is weakly magnetic. A highly magnetic phase contained high Ag but only a small part of total Ag.

The remainder (10%) may be assoc. w/ gtz

J.H.COURTRIGHT

J.H.C

DEC 19 1968

U. S. MINING DEPT. DEC 19 1968 TUCSON

Salt Lake City, Utah
December 16, 1968

M103-247

Pls Note Noted
RFM
ACH
EvGS
FS
Return to MINING DEPT.

Mr. Val Kudryk
Manager, Minerals Research
Central Research Laboratories
South Plainfield, N. J. 07080

T A S

HARDSHELL PROJECT - SILVER MANGANESE ORE

Please be advised that a concentrate containing roughly 45% silica and 30% manganese would be of little or no value as flux in a copper smelter, this for the reason that manganese acts very much like iron as a slag forming material. In calculating charges we always calculate the iron plus manganese against silica in determining the required amount of silica, and obviously, with the roughly one-to-one ratio iron to silica required in the charge, there is very little available silica in this concentrate.

Further, the lead and zinc would both be lost in the process and the resultant slag from this material would carry about 10 pounds of copper per ton which would give a metal loss of approximately $4.00 per ton of concentrate. I believe it is obvious that the copper smelter is not the place for this product.

K. D. LOUGHRIDGE

KDL/rp

cc: F.W.Archibald w/cc
G.W.Bossard
C.E.Nelson
J.S.Smart,Jr.
T.A.Snedden

J. H. C.

NOV 27 1968

AMERICAN SMELTING AND REFINING COMPANY

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N. J.

S. I. B.

NOV 29 1968

November 27, 1968

W.E.S.

JAN 7 1969

Mr. J. S. Smart, Jr.
B U I L D I N G

HARDSHELL PROJECT - SILVER-MANGANESE ORE

PROJECT NO. M103-247

The attached Research Report No. 4299 by Mr. E. Martinez summarizes the work carried out to date on concentrating silver in the Hardshell ore by dry physical methods. Because of the mode of association, it appears that a recovery of 60% can be obtained with a concentration ratio of 4:1. Tests are underway with the necessary refinement to determine the optimum conditions for the particular sample on hand. Tailings could be segregated and stockpiled for future processing if conditions become favorable. Under these conditions, approximately 250 tons per day of a high manganese bearing concentrate would have to be processed through a smelter.

In case this is untenable, the possibility of leaching the concentrate with SO_2 for manganese removal with subsequent cyanidation of the residue for silver recovery will be investigated. This could be carried out at a smelter by utilizing the SO_2 in stock gases. Preliminary tests on SO_2 leaching and reduction roasting prior to cyanidation will also be carried out on the ore for comparison purposes. In the event that a suitable water supply is discovered, consideration could then be given to processing at the mine site.

V. Kudryk

VK/lk
Attach.

cc: Library, GWBossard, JHCourtright, TDHenderson, EMartinez, CENelson, WPRoe, TASnedden, EMcL. Tittmann

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N. J.

REPORT NO. 4299
COPY NO. 5
November 27, 1968

HARDSHELL PROJECT - SILVER-MANGANESE ORE

Project No. M103-247

Magnetic and High Tension Concentration

A B S T R A C T

Concentration of the silver in Hardshell ore by dry magnetic separation and high tension separation was investigated. The results from the preliminary tests indicate that it will be possible to recover at least 60% of the silver in a concentrate containing 16 to 18 oz. per ton of silver by a combination magnetic-high tension separation.

It was found that the silver in the sample under investigation was present in several forms. The major portion is associated with manganese in the mineral cryptomelane which is weakly magnetic. A highly magnetic phase contained high silver values but represents only a small fraction of the total silver. Magnetic and high tension separation will recover these two forms of silver. The remainder of the silver, possibly 10% of the total, may be associated with quartz and is not recovered by the methods investigated.

The ratio of the silver to manganese assays found in the various samples tested to date and the possible influence on the separations obtained are discussed.

Edward Martinez

EM/lk

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, NEW JERSEY

Research Report 4299
Date:
November 27, 1968

HARDSHELL PROJECT - SILVER-MANGANESE ORE

Project No. M103-247

Magnetic and High Tension Concentration

OBJECTIVES

To investigate the recovery of silver from Hardshell ore by dry magnetic and high tension separation.

To investigate the mineralization of Hardshell ore with particular emphasis on the form in which the silver is found.

PREVIOUS TESTS

Several samples from the Hardshell deposit have been tested at the El Paso Ore Testing Laboratory and reports of these investigations have been issued (1,2,3). The following is a summary of the results obtained by magnetic and electrostatic separation.

The preliminary testing was done on a sample of Hardshell project composite forwarded to El Paso on September 15, 1967 (4). The assay of the sample was as follows:

Ag oz/T	Mn	Pb	Zn	Fe	Insol.	As	Sb	Cu
5.22	6.45	1.15	1.08	2.8	78.0	0.17	0.06	0.10

Sized fractions down to 325 mesh were separated magnetically (2). Compositing all the magnetic and non-magnetic fractions and including the minus 325 mesh size that was not treated gave the following:

		Silver		Manganese	
	% wt.	oz/T	Dist.	%	Dist.
Magnetic	20.6	14.8	65.3	21.8	75.0
Non-magnetic	63.7	1.1	15.3	0.6	6.7
-325 mesh	15.7	5.75	19.4	7.3	18.3
	100.0		100.0		100.0

A magnetic separation of a minus 65 plus 200 mesh fraction, representing about 13% of the whole sample, gave the following results (1):

		Assays				Distribution			
	% wt.	Ag	Mn	Zn	Pb	Ag	Mn	Zn	Pb
Magnetic	18.8	19.00	31.5	3.5	2.3	68.7	92.8	72.9	63.2
Non-magnetic	81.2	2.00	0.57	0.3	0.31	31.3	7.2	27.1	36.8
	100.0								

A deslimed fraction of the sample was submitted to electrostatic separation, giving the following:

		Assays		Distribution	
	% wt.	Ag	Mn	Ag	Mn
Concentrate	4.6	29.15	(41.5)	26.3	30.4
Tailings	59.5	3.39	3.45	39.3	32.4
Slimes	35.9	4.93	6.55	34.4	37.2
	100.0			100.0	100.0

Three composite samples representing 410 feet of drill hole intercepts in three areas of the Hardshell prospect were received at El Paso on March 15, 1968 (3). The following are the assays of the samples:

Sample	Ag oz/T	Mn	Pb	Zn	Fe	Cu	SiO_2	CaO	Al_2O_3
No.1	2.32	0.14	0.21	0	3.35	0.021	69.8	0.1	1.29
No.2	2.26	0.18	0.18	0	3.15	0.017	68.4	0.1	1.19
No.3	3.27	0.17	0.34	0	2.60	0.01	70.0	0.1	1.47

All three of the low silver and manganese samples were found to contain magnetic material. However, a rough magnetic separation of Sample No.3 showed that the less magnetic material assayed higher in silver than did the more magnetic portion (3). These results are the reverse of those obtained on the previous Hardshell sample.

These tests demonstrated that with the high silver-manganese Hardshell sample it was possible to concentrate the silver and manganese by magnetic or electrostatic separation. However, magnetic separation did not concentrate the silver with the low silver-manganese samples.

SAMPLE

A 93-lb sample of Hardshell ore (MR-10) was received at the Mineral Research Laboratory. It is a portion of the 500-lb composite sample from approximately 20 drill holes shipped to the El Paso Ore Testing Laboratory (5,6). The assay of the sample follows:

	oz/T							
	Ag	Au	Mn	Pb	Zn	Fe	Insol.	CaO
MR-10 Hardshell	5.85	0.005	11.2	1.8	1.0	2.0	71.2	1.0

Although the assay of this sample did not differ appreciably in most respects from the previous high silver ore tested at El Paso, the manganese content of 11.2% is considerably higher than the 6.45% Mn in the original.

Mineralogical Investigation

Mr. R.B. Haagensen examined the Hardshell ore sample and the following is his report:

> Preliminary studies involved handpicking, microscopic examination, X-ray diffraction, and spectrographic analyses of the head sample as well as various fractions from magnetic, high tension, and heavy liquid separations.
>
> Handpicked phases identified by X-ray diffraction were quartz, orthoclase ($KAlSi_3O_8$), goethite [$Fe(OH)$], and probable cryptomelane (KMn_8O_{16}). The X-ray diffraction identification of cryptomelane is based on data by McMurdie and Golvato (7). The cards in the ASTM Powder Diffraction File for cryptomelane differed somewhat from the pattern produced by the "cryptomelane" handpicked from Hardshell. Spectrographic results on very small handpicked samples indicated a slight enrichment in silver in particles similar to those yielding an X-ray diffraction pattern of cryptomelane. An enrichment of Pb, Zn, Ba, Cu, Na, Sn, Ni, Mo and Tl was also detected in these particles.

> The literature generally gives cryptomelane as $R\ Mn_8O_{16}$ where R is Na, K, or Ba and the manganese is chiefly Mn^{4+} with substitutions of Mn^{2+}, Zn^{2+}, Al^{3+}, Cu^{2+}, Co^{2+}, and Fe^{3+} to maintain electrostatic balance (8).

Samples of some of the handpicked particles were run on the Perkin-Elmer thermobalance. The particles tentatively identified as cryptomelane gave a weight-loss temperature curve similar to that reported in the literature for cryptomelane (8). The presence of calcium carbonate in a predominantly quartz sample was detected by the thermal balance as well as by infrared spectrophotometry.

A previous study had shown that cryptomelane is weakly magnetic and can be concentrated in a strong magnetic field (9). The mineral is dark in color and this was the only guide that could be used in the concentration tests. In setting the variables in either the magnetic or high tension separator an attempt was made to obtain a dark colored concentrate.

Silver-Manganese Association

The concentration tests discussed below confirmed the strong association of silver and manganese. It was found that the original ore and the fractions containing high silver and manganese values generally had approximately the same ratio of silver to manganese. Dividing the silver assay in oz. per ton by the manganese assay in percent gave a value of approximately 0.5 in the silver-manganese concentrates and ore. The test results indicate the largest portion of the silver in Hardshell is associated with the manganese mineral.

An exception to the above was in a highly magnetic concentrate from the magnetic tube test which contained 69.9 oz. per ton of silver but only 3.08% Mn, giving a silver-manganese ratio of 22.7. The silver present in this form is probably less than 5% of the total silver in the Hardshell sample under investigation.

The low silver-manganese fractions found in the tailings from the various tests had a much higher ratio of silver to manganese than did the concentrates or the original ore. It is believed that a large portion of this silver is associated with quartz or silicates and cannot be concentrated by magnetic, high tension, or gravity separators. It is estimated that possibly 8 to 10 percent of the silver in the original ore may be in this form. The estimate is based on calculations made on some of the separated fractions.

It should be noted that the sample tested at El Paso (1,2), in which it was possible to concentrate the silver and manganese by magnetic or high tension separation, had a silver-manganese ratio of 0.81 compared to 0.52 in the present one. The ratios for the concentrates from this original sample obtained at El Paso were approximately 0.6 to 0.7.

The low silver-manganese samples tested at El Paso, in which magnetic separation was not effective, had silver-manganese ratios of 12.6 to 19.2.

The ratio of silver to manganese in the Hardshell ore is not just of academic interest. Assuming the ore contains 5 to 6 oz. per ton of silver, a relatively low manganese assay, or high silver-manganese ratio, should make it possible to produce higher grade silver concentrates with a relatively high ratio of concentration. If the manganese content is high, giving a low silver-manganese ratio, the silver assays of the concentrates will tend to be depressed and the ratio of concentration decreased. An extremely high ratio may indicate that magnetic or high tension separation will not be effective in concentrating the silver.

To date, two Hardshell samples have been tested in which the silver can be concentrated by physical separations. However, the silver-manganese ratios have been quite different for the two samples. Therefore, it is important that any future tests be run on a sample that is known to be representative of the bulk of the ore in the Hardshell deposit prior to making any final judgements on the grade of concentrate, recovery or ratio of concentration to be expected from a given flowsheet.

TEST RESULTS AND DISCUSSION

In view of the results of magnetic separation on Hardshell samples obtained at El Paso, the initial tests were run to determine the association of silver in the ore and whether magnetic, high tension, and gravity separations would concentrate the silver.

Size Analysis

Representative samples were split and crushed to minus 10 mesh. A screen analysis with assays of silver, manganese, and iron is given in Table I. The minus 200 mesh fraction was run in the Infrasizer and the results included in Table I.

A slight enrichment of silver and manganese is found in the finer sizes, and there is a similarity in the distribution of silver and manganese in the sized fractions. Iron shows a pronounced increase with a decrease in particle size.

Gravity Separation

A sample 100 x 200 mesh was submitted to heavy liquid separation at a specific gravity of 2.73. The results are given in Table II. A good recovery of silver (83.8%) and manganese (92.2%) was obtained in the sink fraction. Note that approximately 35% of the sample reported to the sink which would indicate a ratio of concentration (number of tons of feed to produce one ton of concentrate) of only 3.

No reference could be found that gave the specific gravity of cryptomelane. Assuming a specific gravity of 4.5 for cryptomelane and 2.65 for quartz, the following are the concentration criteria in water and in air:

Water

$$\text{Conc. Crit.} = \frac{4.5-1}{2.65-1}$$

or 2.1

Air

$$\text{Conc. Crit.} = \frac{4.5}{2.65}$$

or 1.7

The concentration criterion is a rough measure of the promise of obtaining a gravity separation. The higher the number, the easier the separation. Taggart (10) states that when the concentration criterion is greater than 2.5, separation will be easy at all sizes down to the finest sands; at 1.75, commercial separation is readily possible down to 65 or 100 mesh; at 1.5, separation becomes difficult and the lower limit is about 10 mesh.

Thus, there is a definite possibility that a gravity concentration may be a method for concentrating the silver if the true specific gravity for cryptomelane is about 4.5. The use of wet gravity concentration, if water were available at the deposit, would be more attractive than a dry separation. However, the use of pneumatic tables for gravity separation should be kept in mind as a possible supplement or alternative to magnetic and high tension separation.

Magnetic Separation

Two sized fractions, -30+100 mesh and -100+200 mesh, were run on the Carpco induced roll magnetic separator. The results are shown in Table III. There was a definite concentration of the silver and the manganese in the magnetic fractions demonstrating that the Hardshell ore being tested was similar to the original ore run at El Paso (1,2).

Two samples of Hardshell, one ground to -10 mesh and the other to -65 mesh, were sent to the Magnetic Equipment Division of the Indiana General Corporation. The samples were run in their IGC Phelan Magnetic Tube Tester (Davis Tube) to remove the highly magnetic fraction and then dried prior to passing through an induced roll separator. The results are given in Table IV.

The "Tube Test Magnetic" fractions returned from Indiana General were very small. Therefore, the assays on these samples could not be checked. But the silver assay of 69.9 oz. per ton from the -65 mesh sample was the highest silver content obtained in all the tests. This highly magnetic fraction contained only 3.08% Mn, indicating that a small portion of the silver in Hardshell may not be associated with the cryptomelane or silica.

High Tension Separation

Sized fractions of a deslimed -10 mesh Hardshell sample were run in the Carpco Model HP16-114 High Tension Laboratory Separator. Various operating conditions were tried for each sized fraction in an effort to obtain a dark concentrate. It was found that the dark particles, which contained the highest silver content, tended to be lifted from the drum. The light colored particles, principally quartz, tended to be pinned to the drum. The results of the separations on each sized fraction are given in Table V. In addition, a composite of the overall results is included.

The data indicate that the silver and manganese can be concentrated by high tension separation. Although an overall recovery of only 33% was obtained, a better separation is undoubtedly possible with further testing of the operating variables.

Magnetic-High Tension Separation

Two tests were run using a combination of magnetic and high tension separation. In running the samples through either the magnetic or high tension separator, it was found that an adjustment in one of the variables, such as splitter setting or voltage, could result in an appreciable change in the distribution of the products. Therefore, the results obtained are only preliminary and should not be considered as optimum.

A sample of approximately 1200 grams was crushed to minus 10 mesh and dry sieved. The 10 x 30 mesh, 30 x 100 mesh, and 100 x 200 mesh fractions were run on the high tension separator and the minus 200 mesh size was not treated. The sample was separated into three fractions: lifted, middlings, and pinned. The middlings were passed through the separator one time. The voltage was 32 kv and it was found that the drum speed had to be increased as the particle size decreased. The coarse size was run at 50 rpm, the 30 x 100 mesh at 90 rpm, and the 100 x 200 mesh at 130 rpm.

The results of the high tension separation are given in Table VI. Concentrations of the silver and manganese were obtained in the lifted particles. The pinned fractions were predominantly quartz and were low in silver and manganese.

The middlings and pinned portions from each size fraction were combined and run on the magnetic separator. The material was passed through the separator once and the non-magnetic passed two more times with all the magnetic portions being combined. A current of 1.2 amperes was used for the 10 x 30 mesh size and 1.0 amperes for the finer fractions.

Additional silver and manganese were concentrated magnetically (Table VI). The composite of the data shows that a silver recovery of 53.2% was obtained in a concentrate, consisting of the lifted and magnetic fractions, that was 23.4% of the whole sample. Over 15% of the silver was present in the untreated minus 200 mesh fraction.

To determine whether the silver-manganese particles lifted in the high tension separator would respond magnetically, the 10 x 30 mesh lifted fraction was passed through the magnetic separator set at 1.2 amperes using the same procedure described above. Approximately one third of the sample reported to the magnetic hopper. This indicates that some of the manganese-silver particles that were lifted are very weakly magnetic and might not be recovered if only magnetic separation is used.

A second sample was crushed to minus 10 mesh and dry sieved. Sized fractions down to 325 mesh were run first on the magnetic separator and the non-magnetic fractions passed through the high tension unit. The results are shown in Table VII.

An attempt was made in this test to decrease the weight of concentrate, i.e. increase the ratio of concentration. The magnetic flowsheet involved passing the sample through once at approximately 1.2 amperes and recycling the magnetic fraction once. The non-magnetic portions were combined and run through the high tension separator one time. The tailings consisted of the pinned and middlings from the high tension unit.

The settings and flowsheet changes resulted in a considerable decrease in recovery in the coarser sizes compared to the previous test. A recovery of 26.9% of the silver in the 10 x 30 mesh size was obtained compared to 66.0% in the first test. Therefore, the overall recovery of silver is only 44.6%, as shown in the composite data in Table VII. However, had a recovery of 66% been obtained in the 10 x 30 mesh size, which was 40.9% by weight of the total sample, the overall silver recovery would have been increased to approximately 60%.

The test demonstrated that it may be possible to obtain an effective concentration of the silver by magnetic-high tension separation down to the 325 mesh size.

The combination of magnetic and high tension separation should recover over 60% of the silver without the minus 200 or 325 mesh fractions being treated. If the silver and manganese values in the ore are similar to the sample tested, the concentrate will be approximately 25% by weight of the total ore and contain 16 to 18 oz. per ton of silver.

As discussed previously, the silver being recovered by physical separation is predominantly associated with the manganese mineral cryptomelane. The silver associated with the quartz or silicates is not being recovered. Note that in every test the recovery of manganese is greater than that of silver. Future tests should involve the investigation of other methods, such as cyanidation, to determine whether the silver in the tailings and in the untreated fines may be recoverable.

CONCLUSIONS

The silver in the Hardshell sample under investigation was present in three forms:

a. associated with the manganese mineral cryptomelane

b. associated with a highly magnetic phase

c. associated with quartz or silicates.

The silver in the first two can be recovered by magnetic, high tension, and gravity separation. These methods will not recover the silver associated with the quartz or silicates.

Cryptomelane is weakly magnetic and is lifted in a high tension separator. A combination of magnetic and high tension separation should recover over 60% of the silver without treating the minus 200 or 325 mesh fraction.

The two Hardshell samples tested at the El Paso Ore Testing Laboratory and the Mineral Research Laboratory had approximately the same silver contents but differed considerably in the manganese assays. The ratio of the silver to manganese in the deposit will have an effect on the grade of concentrate, recovery of silver, and ratio of concentration that will be obtained. Therefore, any future tests should be run on a sample that is believed to be most representative of the ore in the Hardshell deposit.

RECOMMENDATIONS

Dry methods of concentrating the silver should be investigated further. Large scale magnetic and high tension separation tests should be run on a representative Hardshell sample to determine:

a. optimum recovery, grade of concentrates, etc.

b. capacities of magnetic and high tension units

c. develop a preliminary flowsheet and costs.

Gravity concentration should be further investigated. Tests on pneumatic tables should be run, particularly on the coarse sizes.

The cyanidation of the tailings and fine sizes from the above separations should be investigated. It may be possible to stockpile the untreated fines and tailings for possible recovery of the silver at some future time.

E. Martinez

EM:jf

REFERENCES

1. F.L. Bazzanella: Preliminary Testing of the Hardshell Project Ore, October 1967

2. F.L. Bazzanella: Testing of the Hardshell Project Ore - Part II, December 1967

3. H.F. Keeler: Raw Cyanidation of Low Manganese Hardshell Project Drill Core Samples, April 1968

4. G.W. Bossard: letter to J.H. Courtwright dated December 7, 1967

5. G.W. Bossard: letter to V. Kudryk dated June 26, 1968

6. J.R. Wojcik: letter to T.D. Henderson dated July 9, 1968

7. H.F. McMurdie and E. Golvato, Study of the Modifications of Manganese Dioxide, Research Paper 1941, Vol.41, U.S. Dept. of Commerce, Natl. Bur. of Stnds., Dec. 1948, 589-600

8. G.M. Faulring, W.K. Zwicker, and W.D. Forgeng: Thermal Transformations and Properties of Cryptomelane, Am. Mineral., Vol.45, Sept.-Oct. 1960, 946-959

9. E. Martinez: The Concentration of Weakly Magnetic Minerals, Penn. State Univ. 1953

10. A.F. Taggart: Handbook of Mineral Dressing, Wiley, 1945

REPORT NO. 4299

TABLE I

Size Analysis

Mesh	%Wt.	Silver oz./T	Silver Dist.	Manganese %	Manganese Dist.	Iron %	Iron Dist.
-10 +30	37.4	4.95	31.3	9.15	29.8	1.5	26.1
-30 +100	29.5	6.00	29.9	11.8	30.7	1.95	26.1
-100+200	16.9	6.48	18.4	13.6	20.2	3.2	21.7
-200	16.2	7.46	20.4	13.6	19.3	3.9	26.1
	100.0		100.0		100.0		100.0
Composite		5.85		11.4		2.3	

Infrasizing of -200 Mesh

Product	Approx. Size μ	% Wt.	Ag Oz./T.	% Mn	% Fe
Cones 1-3	-74 +28	8.0	8.40	14.4	4.2
Cones 4-6	-28 +10	5.3	6.68	10.6	4.45
Dust	-10	2.9	7.40	9.4	6.6
		16.2			

TABLE II

Gravity Separation - Heavy Liquid

Sample: -100 +200 Mesh

Specific Gravity: 2.73

	% Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.	Iron %	Iron Dist.
Float	65.2	2.0	16.2	1.39	7.8	1.9	36.4
Sink	34.8	19.4	83.8	33.7	92.2	6.1	63.6
	100.0		100.0		100.0		100.0
Calc. Assay		8.05		11.6		3.3	

REPORT NO. 4299

TABLE III

Magnetic Separation of Sized Fractions

Sample: -30 +100 Mesh

Product	%Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.	Iron %	Iron Dist.
Magnetic 1.0a.	27.8	14.68	64.3	28.3	71.6	2.8	41.5
" 3.0a.	20.4	7.40	23.8	14.0	25.9	2.3	24.1
Non-magnetic	51.8	1.44	11.9	0.53	2.5	1.3	34.4
	100.0		100.0		100.0		100.0
Calculated Head		6.33		11.0		1.9	

Sample: -100 +200 Mesh

Product	%Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.	Iron %	Iron Dist.
Magnetic 1.0a.	37.1	11.36	57.1	22.4	62.1	4.4	54.2
" 3.0a.	33.9	7.60	35.0	14.3	36.3	2.7	30.5
Non-Magnetic	29.0	2.0	7.9	0.74	1.6	1.6	15.3
	100.0		100.0		100.0		100.0
Calculated Head		7.37		13.4		3.0	

Carpco Super High Intensity Separator

Speed of drum: 25 RPM

Flowsheet: Sample passed 1 time at 1.0 amps. Non-magnetic passed 2 times at 3.0 amps.

REPORT NO. 4299

TABLE IV

Magnetic Separation

Indiana General Tests

Procedure: Samples were run on Phelan Magnetic Tube Separator. The non-magnetic portion was dried and run on laboratory induced roll separator.

Sample: -10 Mesh Hardshell

Product	% Wt.	Silver Oz./T	Silver Dist.	Manganese %	Manganese Dist.
Tube Test Magnetic	0.7	23.73	3.1	6.58	0.6
Weakly Magnetic	11.3	13.50	27.9	25.3	35.4
Non-magnetic	88.3	4.28	69.0	5.85	64.0
	100.0		100.0		100.0

Sample: -65 Mesh Hardshell

Tube Test Magnetic	0.5	69.9	5.0	3.08	0.2
Weakly Magnetic	8.6	11.40	13.9	17.5	13.3
Non-magnetic	90.9	6.32	81.1	10.9	86.5
	100.0		100.0		100.0

REPORT NO. 4299

TABLE V

High Tension Separation

Deslimed Hardshell Ore

Desliming and Screening

Procedure: Stirred 389g. sample of -10 Mesh ore in 1 liter beaker filled with water. Allowed solids to settle for 2 minutes, decanted approximately half of water. Repeated several times. A screen analysis was run on settled solids.

Mesh	% Wt.
-10 +30	46.1
-30 +60	16.0
-60	26.3
slimes	11.6
	100.0

High Tension Separation

	Silver								
	-10 +30 Mesh			-30 +60 Mesh			-60 Mesh		
	% Wt.	Ag oz./T	Dist.	% Wt.	Ag oz./T	Dist.	% Wt.	Ag oz./T	Dist.
Lifted	16.4	10.32	34.7	10.9	16.4	28.2	20.6	17.3	48.6
Middlings	56.1	4.90	56.5	72.0	5.7	64.6	36.7	7.28	36.4
Pinned	27.5	1.56	8.8	17.1	2.7	7.2	42.7	2.58	15.0
	100.0		100.0	100.0		100.0	100.0		100.0

	Manganese								
	% Wt.	% Mn	Dist.	% Wt.	% Mn	Dist.	% Wt.	%Mn	Dist.
Lifted	16.4	23.0	40.7	10.9	33.0	29.7	20.6	27.8	50.0
Middlings	56.1	9.5	57.5	72.0	10.0	66.6	36.7	11.8	37.7
Pinned	27.5	0.61	1.8	17.1	2.2	3.7	42.7	3.2	12.3
	100.0		100.0	100.0		100.0	100.0		100.0

Composite of Data

	% Wt.	Ag Oz./T.	Dist.	Mn,%	Dist.
Lifted	14.6	13.6*	33.3	26.1*	36.8
Middlings	47.2	5.6*	44.3	10.2*	46.6
Pinned	26.6	2.1*	9.4	1.9*	4.9
Slimes	11.6	6.62	13.0	10.4	11.7
	100.0		100.0		100.0

* Calculated assay.

REPORT NO. 4299

TABLE VI

HIGH TENSION - MAGNETIC SEPARATION

High Tension Separation

Magnetic Separation of HTS Middlings and Pinned

-10 +30 Mesh (42.3% of total)

	% Wt.	Silver oz./T	Silver Dist.	Manganese %	Manganese Dist.		% Wt.	Silver oz./T	Silver Dist.	Manganese %	Manganese Dist.
Lifted	16.4	14.32	39.4	29.3	44.2	Lifted	16.4	14.32	44.3	29.3	[illegible].6
Middlings	21.8	6.16	22.4	12.0	24.0	Magnetic	7.7	15.80	21.7	34.7	[illegible].6
Pinned	61.8	3.68	38.2	5.59	31.8	Tailings	75.9	2.37	34.0	1.71	14.8
	100.0		100.0		100.0		100.0		100.0		100.0

-30 +100 Mesh (27.7% of total)

Lifted	20.5	11.12	34.8	24.0	38.7	Lifted	20.5	11.12	35.8	24.0	43.7
Middlings	14.4	12.28	26.8	26.2	29.6	Magnetic	4.9	18.00	13.8	30.5	13.4
Pinned	65.1	3.88	38.4	6.20	31.7	Tailings	74.6	4.30	50.4	6.40	42.9
	100.0		100.0		100.0		100.0		100.0		100.0

-100 +200 Mesh (15.6% of total)

Lifted	17.7	11.20	24.9	21.6	27.2	Lifted	17.7	11.20	27.0	21.6	28.6
Middlings	16.3	11.60	23.8	21.6	25.0	Magnetic	21.7	16.88	49.8	34.7	[illegible].3
Pinned	66.0	6.16	51.3	10.2	47.8	Tailings	60.6	2.80	23.2	3.30	[illegible].1
	100.0		100.0		100.0		100.0		100.0		100.0

Composite of Data

	% Wt.		Silver oz./T	Silver Dist.		Manganese %	Manganese Dist.	
Lifted	15.4	23.4	12.5*	31.5	53.2	25.8*	38.8	65.0
Magnetic	8.0		16.6*	21.7		33.7*	26.2	
Tailings	62.2		3.1*	31.1		3.1*	18.5	
-200 Mesh	14.4		6.68	15.7		12.1	16.5	
	100.0			100.0			100.0	

* Calc. Assay

REPORT NO. 4299

TABLE VII

Magnetic - High Tension Separation

		% Wt.	Silver oz./T	Silver Dist.	Manganese %	Manganese Dist.
-10 +30 Mesh(40.9% of Total)						
	Magnetic	5.9	18.0	21.6	36.6	27.2
	Lifted	2.0	12.9	5.3	27.3	7.4
	Tails	92.1	3.90	73.1	5.75	65.4
		100.0		100.0		100.0
-30 +100 Mesh(28.0% ofTotal)						
	Magnetic	14.5	18.88	45.4	30.5	44.0
	Lifted	5.0	10.96	9.2	22.5	11.0
	Tails	80.5	3.40	45.4	5.65	45.0
		100.0		100.0		100.0
-100 +200 Mesh(16.2% of Total)						
	Magnetic	23.8	18.08	59.1	34.7	65.9
	Lifted	9.8	11.48	15.5	17.7	13.5
	Tails	66.4	2.78	25.4	3.92	20.6
		100.0		100.0		100.0
-200 +325 Mesh(7.1% of Total)						
	Magnetic	22.9	16.08	49.0	29.3	53.6
	Lifted	1.5	16.88	3.3	18.96	2.4
	Tails	75.6	4.76	47.7	7.32	44.0
		100.0		100.0		100.0

Composite of Data

	% Wt.		Silver oz./T	Silver Dist.		Manganese %	Manganese Dist.	
Magnetic	12.0	15.9	18.1*	36.9	44.6	33.3*	41.2	47.5
Lifted	3.9		11.5*	7.7		15.4*	6.3	
Tailings	76.3		3.7*	47.4		5.6*	44.3	
-325 Mesh	7.8		6.06	8.0		10.9	8.2	
	100.0			100.0			100.0	

* Calculated Assay

CC: TASnedden 7/8/68
JHCourtright

Misc 11-4

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N.J., 07080

J. H. C.
JUL 8 1968

July 3, 1968
M102-247

Mr. T. D. Henderson
El Paso Assay & Ore Dressing Laboratory
El Paso, Texas

HARDSHELL PROJECT - SILVER-MANGANESE ORE

With reference to Mr. Bossard's letter of June 26, a 500-lb. sample from Hardshell should arrive in El Paso the latter part of July. This sample should be more representative than the sample shipped out last September. Therefore, all test work should be postponed until this new sample arrives.

After the sample arrives and has been thoroughly mixed and sampled for analysis, I would like you to send approximately 50 lbs. to the South Plainfield laboratory. This will be used for mineralogical evaluation and for the magnetic and possibly electrostatic separation tests to try and concentrate the silver.

In view of the factors we had discussed in El Paso and outlined in Mr. Bossard's letter with respect to the isolated area and unavailable power and natural gas at this time and furthermore the doubtful supply of water, the immediate effort will be on trying to upgrade the ore to produce a concentrate that could be absorbed by the smelters. However, to get as complete a picture as possible, reduction tests should be carried out on the new sample to see how the results compare with your past tests. We expect a report from Lurgi very shortly on chloride volatilization of the Waterloo ore. If the results look promising, we will also consider this as a possible means for concentrating the silver.

V. Kudryk

VK/lk
cc: CENelson
EHScheick
GWBossard
GCartwright
JSSmart, Jr.

G.W.B.
JUL 5 1968

J.H.Courtright

J. H. C.

EL PASO ORE TESTING AND ASSAY LABORATORY AUG 19 1968

W.E.S.
AUG 8 1968

El Paso, Texas
July 22, 1968

Dr. V. Kudryk
Central Research Laboratories
South Plainfield, N. J. 07080

I am sending to you today by prepaid Air Freight (Airbill No. 001-251-1681) one can containing eighty-five pounds of a composite sample of Hardshell Project silver ore, which I have designated as Hardshell Composite A. This composite was made by mixing together all of the nine cans of ore samples sent to us by Mr. Wojcik in Tucson. The five-hundred pound composite thus represents a total of 1329 feet in 21 drill holes as described in the tabulation attached to Mr. Wojcik's letter of July 9th. The silver grade of Hardshell Composite A which we will be using for test work here in El Paso and at South Plainfield will be approximately 6.0 oz Ag/T. Complete assays on the composite will be reported when they are completed.

T. D. HENDERSON, JR.

TDH/cb
cc: CENelson
EScheick
JSSmart,Jr.
TASnedden
GWBossard
JHCourtright
JRWojcik

AMERICAN SMELTING AND REFINING COMPANY

ASARCO

CENTRAL RESEARCH LABORATORIES

SOUTH PLAINFIELD, N.J. 07080

J.H.C
AUG 19 1968

W.E.S.
AUG '8 1968

J.R.W
AUG 19 1968

VAL KUDRYK
MANAGER, MINERALS RESEARCH

MR. T.D.H.
READ AND RETURN
PREPARE ANSWERS ..... HANDLE
FILE ✓ INITIALS

July 12, 1968
M103-247

Mr. T. D. Henderson
El Paso, Texas

Hardshell Project - Silver-Manganese Ore

With reference to Mr. Wojcik's letter of July 9 indicating that the nine cans of composite samples from Hardshell have been shipped, I believe that we should blend this into one master composite sample. This should then provide a single large sample which should be adequate for most of the test work contemplated in the near future. There might be a problem of thoroughly mixing a sample this size in any of the equipment we have at El Paso. However, if it is necessary, the material could be spread out on a clean concrete floor or one of the pads that was poured for the Waterloo project.

As soon as the material is blended and sampled for analysis, would you please ship 50 lbs. to the South Plainfield laboratory for preliminary evaluation and magnetic separation tests.

V. Kudryk

VK/lk

cc: CENelson (Attach.)
EScheick "
JCourtright ✓
GWBossard
JSSmart, Jr. (Attach.)

pl. copy for JRW - ES
6-26-68 lm

AMERICAN SMELTING AND REFINING COMPANY
CENTRAL RESEARCH LABORATORIES
SOUTH PLAINFIELD, N. J., 07080

J. H. C.

JUN 26 1968

June 24, 1968
M103-247

Mr. J. S. Smart, Jr.
BUILDING

HARDSHELL PROJECT - SILVER-MANGANESE ORE

Mr. E. H. Scheick asked that priority be given to the Hardshell Project in developing an acceptable process for the recovery of silver from this ore.

Preliminary Tests

Some preliminary tests have been carried out at the El Paso laboratory which indicated that -

1) Due to the association with manganese, the ore is very refractory and less than 50% of the silver can be recovered by a direct cyanidation.

2) Chloridizing roasts followed by cyanidation indicates a recovery of more than 80% of the silver.

3) The silver was concentrated magnetically up to about 15 oz. per ton with a 65% recovery.

4) Concentration by flotation yielded a 17.3 oz. per ton concentrate with a 46% recovery of silver.

5) Leaching the ore with sulfur dioxide and then followed by cyanidation resulted in an 80% recovery of silver.

6) A reduction roast followed by cyaniding gave a recovery of over 70% silver.

Ore Sample

Approximately 80 pounds of ore are available at El Paso for testing; however, consideration should be given to obtaining a more representative sample if cores are available from more recent exploration work.

Proposed Investigation

1) Mineralogical Examination.

The ore will be examined to evaluate the mineral composition and association which will help to correlate with previous work and act as a guide for test work.

2) Physical Concentration.

A systematic series of tests will be carried out to determine optimum concentration which can be achieved by magnetic separation. Some additional flotation work will also be carried out to see if the recovery by this method can be improved. If the silver can be concentrated sufficiently, it would be possible to ship this concentrate to the smelters, thus eliminating other processing steps.

3) Chloridizing Roasts.

Confirmatory tests will be run using a small rotary kiln at South Plainfield to determine optimum conditions for salt roasting followed by cyanidation. If the report from Lurgi on Waterloo ore is favorable, consideration will be given to some volatilization tests on the Hardshell ore.

4) Reduction Roasts.

The lower temperature reduction roasts will be continued to determine the optimum conditions for reduction followed by cyanidation.

It is planned to carry out the mineralogical examination, magnetic separation and chloridizing tests at South Plainfield and the flotation and reduction roasts at El Paso. The results of the initial phases of this work should be available by the latter part of August.

V. Kudryk

VK/lk

cc: EHScheick
TASnedden
JHCourtright
GWBossard
TDHenderson

Mr. J. H. Courtright

Please copy for WES, JRW, NPW
6-27-68

AMERICAN SMELTING AND REFINING COMPANY
UNITED STATES MINING DEPARTMENT
P. O. BOX 5795, TUCSON, ARIZONA 85703

J. H. C.

JUN 26 1968

June 26, ~~1965~~ 1968

G. W. BOSSARD
MILLING ENGINEER

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

Mr. Val Kudryk, Manager
Mineral Research
Central Research Laboratories
American Smelting and Refining Company
South Plainfield, New Jersey 07080

HARDSHELL PROJECT

Dear Sir:

During a discussion held this morning with Mr. Courtright and Mr. Snedden it was decided that a new composite for metallurgical testing should be prepared and forwarded to the El Paso Laboratory. The first Hardshell composite received at El Paso on September 21 was made up from hammer drill cuttings from only five drill holes, therefore it represents only a small portion of the total ore body. This new sample, which will be composited from approximately 20 drill holes and weighing 500 lbs, should arrive in El Paso within 2-3 weeks.

To date the best results have been obtained by chloridizing the ore with six percent by weight sodium chloride and roasting under oxidizing conditions at 850°C. Silver recoveries from test work using other procedures have been much lower as pointed out in your letter to Mr. Smart, dated June 24. Silver recovery by cyanidation would be less than 25 percent and not less than 50 percent as given in your letter.

In developing a flow sheet to treat the Hardshell ore it should be kept in mind that the orebody is located in a relatively isolated area in which power and natural gas are not readily available. Also, all supplies and final product or concentrate would have to be hauled by truck approximately 30 miles by secondary roads to a railhead in Nogales. Finally, the establishment of a water supply of sufficient capacity for a cyanidation or a brine leach circuit, both requiring in the neighborhood of 250 gallons/ton milled, would be difficult.

In view of the above difficulties it is apparent that our efforts should be devoted toward developing a flow sheet which requires a minimum of water and power and which would produce a small-tonnage final

Ore – 1000 Tpd = 250 tpd magnetic conc.
250 × 250 gal water = 62,500 gal per day
or 40 gpm

product for shipment to an Asarco plant for further processing or refining. Magnetic separation procedures might produce a fair recovery of silver but even at a ratio of concentration of 6 or 7:1, the amount of concentrate would be 350 to 400 tons per day for a 2500 tpd operation.

A considerable amount of work has been done recently in the field of chloride volatilization. Assuming that such a process could be applied to Hardshell ore it might be possible to recover the bulk of the silver, lead, zinc and possibly the manganese in a low-weight fraction for retreatment to recover the silver. As mentioned in your letter to Mr. Smart, Lurgi is apparently doing test work on the Waterloo sample and could also undertake evaluation of the Hardshell sample. Since our dealings with Lurgi have proceeded so slowly, I would like to suggest that a portion of the second composite be sent to the Dorr-Oliver Company for their evaluation. If such an action is taken it should be possible to have an idea within a month or less whether-or-not chloride volatilization of the Hardshell ore for silver recovery is feasible.

Yours truly,

G. W. Bossard

G. W. BOSSARD
Milling Engineer

GWB/mg

cc: CENelson
JSSmart
EHScheick
TASnedden
JHCourtright
TDHenderson

J.H.C.
JUN 14 1968
J.R.W
JUN 25 1968

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

W.E.S.
JUN 18 1968

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 14, 1968

Mr. T. D. Henderson
El Paso Ore Testing Laboratory

HARDSHELL PROJECT

Dear Sir:

In view of the fact that the recent drilling program for this project has indicated moderate reserves of five ounce silver ore, Mr. Courtright has requested that metallurgical testing be resumed in an attempt to develop an acceptable flow sheet for this material. The sample to be used for this test work is the one described in my letter of September 15, 1967.

Since the previous test work has indicated that this ore does not respond to standard cyanidation, then particular attention should be paid to the pyrometallurgical approaches. Mr. Bazzanella's report of October, 1967, indicated good cyanidation silver recoveries with the chloridizing roast under oxidizing conditions. The reducing roast (Caron Process) should also be investigated.

Yours truly,

ORIGINAL SIGNED BY
G. W. BOSSARD

G. W. BOSSARD
Milling Engineer

GWB/mg

cc: JHCourtright
VKudryk

AMERICAN SMELTING AND REFINING COMPANY
UNITED STATES MINING DEPARTMENT
P. O. BOX 5795, TUCSON, ARIZONA 85703

J. H. C.
APR 17 1968

April 17, 1968

G. W. BOSSARD
MILLING ENGINEER

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

J. R. W.
MAY 8 1968

MR. [illegible]
READ AND RETURN
PREPARE ANSWERS ____ HANDLE ____
FILE ✓ INITIALS ____

Mr. J. H. Courtright
Building

HARDSHELL PROJECT

I am attaching three copies of Project Report No. M103 covering the cyanidation tests on the low-manganese Hardshell Project drill core samples forwarded to El Paso by Mr. Wojcik. As Mr. Henderson has pointed out in his cover letter dated April 16 the results of raw cyanidation on all three samples were poor and ranged from 9 to 55 percent silver recovery when using a normal cyanidation procedure for material ground to 70 percent minus 200 mesh. Sulfurous acid leaching to remove the manganese previous to cyanidation resulted in a small improvement in silver recoveries. Magnetic separation results were negative as the non-magnetic tailing assayed higher in silver than the magnetic fraction.

Yours truly,

G. W. Bossard

G. W. BOSSARD
Milling Engineer

GWB/mg
Enclosures (3)

cc: VKudryk - w/o copy report
TDHenderson - " " "

AMERICAN SMELTING AND REFINING COMPANY

EL PASO ORE TESTING LABORATORY

A

REPORT

OF

PROJECT NO. M103

RAW CYANIDATION OF LOW MANGANESE HARDSHELL PROJECT DRILL CORE SAMPLES

- APRIL 1968 -

HARDSHELL PROJECT ORES

Received March 15, 1968, sent by Mr. J. R. Wojcik, were three composite samples of 21 to 27 pounds each, representing 410 feet of drill hole intercepts in three areas of the Hardshell prospect. These three samples were of low silver content and were sent for cyanidation testing. The samples were of low manganese content and it was thought that they would respond better to cyanidation than the previous Hardshell ore samples.

The assays of the samples were as follows:

	ASSAYS								
	Ounces	Percent							
	Ag	Pb	Cu	Zn	Fe	Mn	SiO_2	CaO	Al_2O_3
Sample No. 1	2.32	0.21	.021	0	3.35	.14	69.8	0.1	1.29
Sample No. 2	2.26	0.18	.017	0	3.15	.18	68.4	0.1	1.19
Sample No. 3	3.27	0.34	.01	0	2.60	.17	70.0	0.1	1.47

All three samples carry a magnetic material. A rough magnetic separation showed that the less magnetic material assayed higher in silver than does the more magnetic portion. Also, sand fraction separated in grinding tests is higher in silver than is the material passing a 200 mesh sieve.

OBJECT OF TESTS

To determine the response of the three Hardshell samples to the raw cyanidation process of treatment.

CONCLUSIONS

In general, raw cyanide extraction of silver is poor. The ore represented by Sample No. 3 gave the best indicated extraction, and that of sample No. 2 the poorest.

1. Variations in lime alkalinity from 0.10 lb per ton of solution to saturation did not affect silver extraction.

2. Variations in cyanide strength from one to five pounds of sodium cyanide per ton of solution showed no difference in the extraction of silver.

3. No improvement in extraction of silver was indicated by increasing the agitation period from 24 to 72 hours.

4. The degree of grinding has some effect upon the amount of silver extracted by cyanidation, the extraction being lowest at coarse grinds and improvement is indicated by fine grinding.

5. Apparently some of the silver is associated with manganese and not liberated by raw cyanidation. Preliminary 17 hour treatments with sulfurous acid, followed by filtering and washing before cyanidation removed the greater part of the manganese and improved the silver extraction by cyanidation.

   The same preliminary treatment with sulfurous acid followed by neutralization with lime, without filtering, also improved silver extraction by cyanidation.

6. The Hardshell ores exhibit poor settling and filtering characteristics, which would complicate its treatment by the raw cyanidation process. Ore represented by Sample No. 2 is especially offensive in regard to settling and filtering.

DESCRIPTION OF TESTS

All tests were made using 300 grams of -10 mesh ore charges, each being ground separately with lime before cyanidation. No lime was used in grinding in the tests given the preliminary treatment with sulphur dioxide. Cyanidation was performed in closed 2 1/2 liter bottles, the pulp occupying about 1/3 of the bottle volume. To compare the closed bottle tests with mechanical stirring in open air, Tests No. 3 were made, shown on page 11. The results are nearly identical to those of the closed bottle tests.

SUPPORTING DATA

Page 10. Tabulation of the results of cyanidation of Hard-shell ores after preliminary treatment with sulphur dioxide.

Page 11. Tabulation giving the results of cyanidation tests performed in open beakers with mechanical stirring.

H. F. KEELER

RAW CYANIDATION OF HARDSHELL ORES
VARIATIONS IN LIME

24 Hours Agitation. Grind: Approximately 70% through 200 Mesh.

SAMPLE NO. 1				SAMPLE NO. 2				SAMPLE NO. 3			
Test No.	Lbs CaO/Ton Solution	Assay Oz Ag Feed	Recovery % Silver	Test No.	Lbs CaO/Ton Solution	Assay Oz Ag Feed	Recovery % Silver	Test No.	Lbs CaO/Ton Solution	Assay Oz Ag Feed	Recovery % Silver
1-1		2.32	100.0	1-2		2.26	100.0	1-3		3.27	100.0
		Tailing				Tailing				Tailing	
1-1-1	0.10(1)	1.54	33.6	1-2-1	0.10(1)	2.04	9.7	1-3-1	0.10(1)	1.48	54.7
1-1-2	0.15(2)	1.59	31.5	1-2-2	0.20(2)	1.97	12.8	1-3-2	0.20(2)	1.51	53.8
1-1-3	0.25	1.57	32.3	1-2-3	0.40	1.97	12.8	1-3-3	0.25	1.60	51.1
1-1-4	0.55	1.60	31.0	1-2-4	0.85	2.06	8.8	1-3-4	0.5	1.56	52.3
1-1-5	0.90	1.61	30.6	1-2-5	1.45	2.13	5.8	1-3-5	0.85	1.57	52.0
1-1-6	1.40	1.65	28.9	1-2-7	1.75	1.99	11.9	1-3-6	1.35	1.57	52.0
1-1-7	1.70	1.54	33.6	1-2-8	1.95	2.00	11.5	1-3-7	1.8	1.48	54.7
1-1-8	1.85	1.50	35.3	1-2-9	2.05	2.05	9.3	1-3-8	2.0	1.46	55.4
1-1-9	1.95	1.55	33.2	1-2-10	2.05	2.02	10.6	1-3-9	2.0	1.47	55.0

	OFF Lbs/Ton Solution		Consumption Per Ton of Ore		Ratio Soln to		OFF Lbs/Ton Solution		Consumption Per Ton of Ore		Ratio Soln to		OFF Lbs/Ton Solution		Consumption Per Ton of Ore		Ratio Soln to
Test No.	NaCN	CaO	NaCN	CaO	Solids	Test No.	NaCN	CaO	NaCN	CaO	Solids	Test No.	NaCN	CaO	NaCN	CaO	Solids
1-1-1	2.65	.10	2.35	1.5	3.79	1-2-1	2.95	.10	1.55	1.4	4.99	1-3-1	2.9	.10	1.47	1.4	4.19
1-1-2	2.8	.15	0.94	3.0	4.27	1-2-2	3.05	.20	1.06	2.7	4.82	1-3-2	3.1	.20	0.76	2.8	4.20
1-1-3	2.95	.25	1.32	4.4	4.27	1-2-3	3.1	.40	0.74	3.8	4.35	1-3-3	3.2	.25	0.34	4.4	4.29
1-1-4	2.7	.55	0.77	7.7	2.67	1-2-4	2.7	.85	0.85	6.9	2.65	1-3-4	2.85	.5	0.52	7.8	2.60
1-1-5	2.65	.9	0.93	10.4	2.66	1-2-5	2.65	1.45	0.93	8.9	2.66	1-3-5	2.65	.85	0.94	10.5	2.62
1-1-6	2.65	1.4	0.94	12.6	2.69	1-2-7	2.5	1.75	1.11	10.9	2.31	1-3-6	2.6	1.35	1.10	12.9	2.62
1-1-7	2.5	1.7	0.91	14.2	2.38	1-2-8	2.55	1.95	1.03	13.6	2.35	1-3-7	2.4	1 8	1 33	14.0	2.33
1-1-8	2.65	1.85	1.05	17.2	2.27	1-2-9	2.5	2.05	1.16	16.4	2.41	1-3-8	2.45	2.0	1.20	16.8	2.27
1-1-9	2.45	1.95	1.23	20.1	2.32	1-2-10	2.5	2.05	1.08	19.7	2.41	1-3-9	2.4	2.0	1.40	19.9	2.37

Note: (1) No settlement of fines.
(2) Poor settlement of fines.

RAW CYANIDATION OF HARDSHELL ORES
VARIATIONS IN CYANIDE STRENGTH

24 Hours Agitation. Grind: Approximately 70% through 200 Mesh

SAMPLE NO. 1				SAMPLE NO. 2				SAMPLE NO. 3			
Test No.	Lbs NaCN/Ton Solution	Assay Oz Ag Feed	Recovery % Silver	Test No.	Lbs NaCN/Ton Solution	Assay Oz Ag Feed	Recovery % Silver	Test No.	Lbs NaCN/Ton Solution	Assay Oz Ag Feed	Recovery % Silver
4-1		2.32		4-2		2.26		4-3		3.27	
		Tailing				Tailing				Tailing	
4-1-1	1.00	1.62	30.2	4-2-1	1.05	2.04	9.7	4-3-1	0.90	1.54	52.9
4-1-2	2.75	1.60	31.0	4-2-2	2.95	2.00	11.5	4-3-2	2.75	1.53	53.2
4-1-3	4.6	1.59	31.5	4-2-3	4.65	2.02	10.6	4-3-3	4.6	1.55	52.6

DETAIL OF CYANIDATION

Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids	Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids	Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids
4-1-1	1.00	1.9	0.07	16.9	2.37	4-2-1	1.05	1.9	0.12	17.1	2.34	4-3-1	0.9	1.8	0.21	17.3	2.39
4-1-2	2.75	1.95	0.56	16.7	2.41	4-2-2	2.95	2.2	0.30	15.9	2.53	4-3-2	2.75	2.0	0.62	16.4	2.48
4-1-3	4.6	2.05	0.74	16.6	2.39	4-2-3	4.65	2.3	0.55	16.0	2.38	4-3-3	4.6	2.0	0.87	16.9	2.29

RAW CYANIDATION OF HARDSHELL ORES
VARIATION IN CYANIDE AGITATION TIME

Grind: Approximately 70% through 200 mesh

SAMPLE NO. 1				SAMPLE NO. 2				SAMPLE NO. 3			
Test No.	Hours Cyanide Agitation	Assay Ounces Ag	Recovery % Silver	Test No.	Hours Cyanide Agitation	Assay Ounces Ag	Recovery % Silver	Test No.	Hours Cyanide Agitation	Assay Ounces Ag	Recovery % Silver
Feed		2.32	100.0	Feed		2.26	100.0	Feed		3.27	100.0
		Tailing				Tailing				Tailing	
5-1-1	24	1.53	34.1	1-2-9	24	2.05	9.3	1-3-9	24	1.46	55.4
5-1-2	48	1.56	32.8	5-2-1	48	2.08	8.0	5-3-1	48	1.53	53.2
5-1-3	72	1.63	29.7	5-2-2	72	2.10	7.1	5-3-2	72	1.55	52.6

DETAIL OF CYANIDATION

Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids	Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids	Test No.	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Soln to Solids
5-1-1	2.7	2.0	0.39	17.1	2.16	1-2-9	2.5	2.05	1.16	16.4	2.41	1-3-9	2.45	2.0	1.20	16.8	2.27
5-1-2	2.65	1.9	0.56	17.3	2.16	5-2-1	2.75	2.25	0.35	16.6	2.18	5-3-1	2.65	2.05	0.52	17.0	2.16
5-1-3	2.6	1.7	0.70	16.8	2.26	5-2-2	2.25	1.9	1.44	17.2	2.22	5-3-2	2.2	1.85	1.62	17.0	2.30

RAW CYANIDATION OF HARDSHELL ORES

VARIATION IN GRINDING

48 HOURS AGITATION IN CYANIDE

SAMPLE NO. 1

Test#	Grind Minutes	Assays Feed Oz Ag	Assays Tailing Oz Ag	Recovery % Silver	Mesh of Grind Percent Weight on Sieve 35	48	65	100	150	200	-200	Total
6-1-1	2	2.32	1.85	20.3	9.8	7.8	9.8	10.6	10.2	6.7	45.1	100.0
6-1-2	4	2.32	1.72	25.9	2.8	2.2	4.8	9.5	13.2	9.9	57.6	100.0
6-1-3	6	2.32	1.52	34.4	0.5	0.3	1.4	4.6	10.5	10.9	71.8	100.0
6-1-4	8	2.32	1.44	37.9	Tr	0.1	0.1	1.2	4.8	8.1	85.7	100.0

DETAIL OF CYANIDATION

Test No.	ON Lbs/Ton of Solution NaCN	ON Lbs/Ton of Solution CaO	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Solution to Solids
6-1-1	2.89	8.48	2.3	1.95	1.49	16.5	2.531
6-1-2	2.88	8.44	2.3	2.0	1.46	16.3	2.525
6-1-3	2.90	8.48	2.35	1.85	1.39	16.7	2.520
6-1-4	2.93	8.57	2.55	1.85	0.95	16.7	2.493

RAW CYANIDATION OF HARDSHELL ORES
VARIATION IN GRINDING
48 HOURS AGITATION IN CYANIDE

SAMPLE NO. 2

Test No.	Grind Minutes	Assays Feed Oz Ag	Assays Tailing Oz Ag	Recovery % Silver	Mesh of Grind Percent Weight on Sieve 35	48	65	100	150	200	-200	Total
6-2-1	2	2.26	2.05	9.3	6.1	4.6	7.5	10.1	10.8	7.2	53.7	100.0
6-2-2	4	2.26	2.02	10.6	0.3	0.5	2.3	5.8	10.9	9.9	70.3	100.0
6-2-3	6	2.26	2.01	11.1			0.2	1.7	5.9	8.8	83.4	100.0
6-2-4	8	2.26	1.92	15.0			0.2	1.2	3.9	6.4	88.3	100.0

DETAIL OF CYANIDATION

Test No.	ON Lbs/Ton of Solution NaCN	ON Lbs/Ton of Solution CaO	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Solution to Solids
6-2-1	2.95	8.65	2.75	2.15	0.50	16.2	2.490
6-2-2	2.88	8.33	2.8	2.15	0.21	15.9	2.574
6-2-3	2.90	8.57	2.7	2.15	0.50	16.0	2.493
6-2-4	2.92	8.61	2.65	2.1	0.67	16.2	2.484

RAW CYANIDATION OF HARDSHELL ORES

VARIATION IN GRINDING

48 HOURS AGITATION IN CYANIDE

SAMPLE NO. 3

Test No.	Grind Minutes	Assays Feed Oz Ag	Assays Tailing Oz Ag	Recovery % Silver	Mesh of Grind Percent Weight on Sieve 35	48	65	100	150	200	-200	Total
6-3-1	2	3.27	1.70	48.0	13.4	7.0	9.1	10.7	10.8	7.0	42.0	100.0
6-3-2	4	3.27	1.62	50.5	0.1	0.8	4.3	10.5	15.5	10.9	57.9	100.0
6-3-3	6	3.27	1.53	53.2	0.7	0.4	1.7	4.5	9.9	10.5	72.3	100.0
6-3-4	8	3.27	1.46	55.4		0.1	0.3	1.7	5.3	8.7	83.9	100.0

DETAIL OF CYANIDATION

Test No.	ON Lbs/Ton of Solution NaCN	ON Lbs/Ton of Solution CaO	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Solution to Solids
6-3-1	3.03	8.52	2.75	1.95	0.71	16.5	2.518
6-3-2	3.01	8.57	2.65	2.0	0.90	16.4	2.497
6-3-3	2.89	9.95	2.65	2.05	0.52	17.0	2.155
6-3-4	3.03	8.53	2.65	1.9	0.95	16.6	2.498

CYANIDATION OF HARDSHELL ORES

PRELIMINARY TREATMENT WITH SULPHUR DIOXIDE FOLLOWED BY FILTRATION, WASHING AND 48 HOUR CYANIDATION

	Test No.	Preliminary Sulfurous Acid Treatment pH	Hours	Assays Feed Percent Fe	Mn	Oz Ag	Cy'n Tails Percent Fe	Mn	Oz Ag	Indicated Recovery % Silver	Cyanidation OFF Lbs/Ton of Solution NaCN	CaO	Consumption Lbs/Ton of Ore NaCN	CaO	Ratio Solution to Solids
Sample No.1	2-1-1	1.2	17	3.35	.14	2.32	2.4	.01	1.47	36.6	2.45	2.1	1.46	20.8	2.80
Sample No.2	2-2-1	1.6	17	3.15	.18	2.26	2.4	.02	1.58	30.1	2.5	2.2	1.51	20.4	2.85
Sample No.3	2-3-1	1.9	17	2.60	.17	3.27	1.8	.01	1.24	62.0	2.6	2.1	1.21	21.1	2.63

PRELIMINARY TREATMENT WITH SULPHUR DIOXIDE FOLLOWED BY NEUTRALIZATION WITH LIME AND 48 HOURS CYANIDATION

	Test No.	Preliminary Sulfurous Acid Treatment pH	Hours	Assays Feed Ounces Ag	Cyanide Tailing Ounces Ag	Indicated Recovery % Silver	Cyanidation OFF Lbs/Ton of Solution NaCN	CaO	Consumption Lbs/Ton of Ore NaCN	CaO	Ratio Solution to Solids
Sample No.1	2-1-2	4.1	17	2.32	1.39	40.1	2.4	1.8	1.81	36.5	2.79
Sample No.2	2-2-2	1.8	17	2.26	1.47	35.0	2.5	1.6	2.12	40.3	3.60
Sample No.3	2-3-2	2.4	17	3.27	1.17	64.2	2.6	1.7	1.52	44.9	3.03

Note: All pulps aerated before cyanidation and at 24 hours cyanidation

Note No.2: All grinding was to approximately 70% through 200 mesh

RAW CYANIDATION OF HARDSHELL ORES
AGITATED BY MECHANICAL STIRRING IN OPEN BEAKERS

48 Hours Agitation. Grind: Approximately 70% through 200 Mesh

	Test No.	Assays Feed Oz Ag	Assays Tailings Oz Ag	Indicated Recovery % Silver	ON Lbs/Ton of Solution NaCN	ON Lbs/Ton of Solution CaO	OFF Lbs/Ton of Solution NaCN	OFF Lbs/Ton of Solution CaO	Consumption Lbs/Ton of Ore NaCN	Consumption Lbs/Ton of Ore CaO	Ratio Solution to Solids
Sample No.1	3-1-1	2.32	1.53	34.1	2.93	7.22	2.4	1.35	1.59	17.6	2.99
Sample No.2	3-2-1	2.26	1.93	14.6	3.27	8.05	2.8	1.9	1.25	16.4	2.67
Sample No.3	3-3-1	3.27	1.48	54.7	3.24	7.98	2.7	1.2	1.45	18.2	2.68

J.H.C.

APR 17 1968

EL PASO ORE TESTING AND ASSAY LABORATORY

El Paso, Texas
April 16, 1968

Hardshell

Mr. G. W. Bossard
Milling Engineer
Tucson Office

Dear Sir:

Enclosed herewith are five copies of a Report of Project No. M103, Raw Cyanidation of Low Manganese Hardshell Project Drill Core Samples, by Mr. H. F. Keeler. This report summarizes the results of cyanidation tests of three low manganese content composite samples from the Hardshell prospect. The cyanide leaches of the raw ore employed variations in lime content of the solution, cyanide strength of the solution, agitation time, and degree of grinding for the three samples. Tests also included (1) cyanidation of the ore after a preliminary leach with sulfur dioxide for removal of manganese, and (2) comparison of raw cyanidation leaches by open stirred agitation with cyanidation done in sealed bottles.

The results of raw cyanidation of all three samples were generally poor, the best silver recoveries being from Sample No. 3(50-55%). Preliminary sulfur dioxide leaching of the ore before cyanidation improved the silver recoveries somewhat on all three samples, but the silver recoveries were not greatly improved on any of the samples by this treatment, indicating that only part of the silver refractory to cyanidation is associated with manganese. The results of open stirred cyanidation leaches were almost identical to those done in sealed bottles in a bottle agitator. This comparison was made to ensure that sufficient oxygen is present in the sealed bottle agitation tests for effective cyanidation, and the results confirm that there is enough oxygen.

Mr. Keeler performed one magnetic separation test on Sample No. 3. An assay of the products indicated that the less magnetic fraction of this ore assayed higher in silver than the more magnetic fraction, which is opposite to magnetic separation test results on previous samples of Hardshell ore.

Yours very truly,

ORIGINAL SIGNED BY

T. D. Henderson, Jr.

TDH/cb
cc: VKudryk/with 2 copies of report
TASnedden/no enc.
RBMeen/ "
JHCourtright/ "
JWojcik/ "

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

Aa-19.8.8

March 18, 1968

Mr. Steve Von Fay
ASARCO
2640 Broadway, N.E.
Knoxville, Tennessee

Dear Steve:

Enclosed herewith are maps and sections on the Hardshell deposit.

Drilling was recently suspended, pending further metallurgical work and a further evaluation of the geology. A very rough open pit estimate shows around 6½ million tons of 5 oz. silver ore with a 7:1 waste ore stripping ratio.

As you will see, the silver-manganese mineralization continued updip and then nosed over much in the manner as depicted on your original North-South section. To the East we went over a "cliff" along what appears to be a near vertical fault.

Currently, El Paso is running tests on the high line silver mineralization encountered on the Hermosa claim. The first tests run on the principal ore zone showed very poor (25%) recovery by cyanidization. They have not yet run any roasting tests on the Hardshell ore as the Waterloo problem is occupying all their time. A salt roast plant has been constructed at El Paso and will soon be operating on Waterloo rock.

Best regards.

Yours very truly,

JHC:lmi
attachment

J. H. Courtright

Aa-.19.8.8

File Memorandum

Hardshell Mine
Santa Cruz County, Arizona

INTRODUCTION:

A blanket-like deposit of low grade silver ore, about 70 miles southeast of Tucson at Hardshell was suggested by diamond drill holes completed in the period from 1947 to 1954. Early in 1965, claims were staked to cover the area of potential silver mineralization as indicated by manganese staining on the outcrops. An option was negotiated on three claims, which could contain the outcrop of the mineralized horizon and additional drilling was started in 1967.

SUMMARY AND CONCLUSIONS:

A total of 15,912 feet of down the hole percussion drilling and 1656 feet of diamond coring were completed in 1967 and 1968 on the Hardshell property. Results of the drilling indicate a possible 6.5 million tons of silver manganese "ore," averaging 5.0 oz Ag/ton recoverable in an open pit with a w/o ratio of about 7 to 1. Possible extensions to the north and northwest were not outlined since the projection of the "ore" was below the water table and could not be prospected satisfactorily with the DTH drill. Shallow low grade "ore" (2-3 oz/ton), containing 1% or less manganese was intersected in about 1/3 of the holes, but is not included in the reported "ore." A possible 1 to 2 million tons of this "ore" might be developed in addition to any mineable extensions of the main ore zone. The overall potential "ore" appears at this time to be on the order of 10 million tons at about 5 oz Ag/ton. More drilling is needed to determine the significance of the "shallow ore" and to test the possible extensions of the main ore zone.

GEOLOGY AND MINERALIZATION:

According to VonFay (1965) the rock column in the immediate Hardshell area, consists of Paleozoic limestones overlain by Tertiary (?) fine grained sediments and Tertiary (?) Chief conglomerate. Thickness of the fine grained sediments varies as it intertongues with the Chief conglomerate. These rocks are intruded by dikes and sill like masses of granodiorite and diabase both apparently pre-ore in age and the entire sequence is overlain by various andesites. To the east, the Gila conglomerate, dipping gently eastward, overlaps all of the older rocks.

Results of the 1967 drilling suggest that the silver occurs in two distinct modes. First and most significant in terms of tonnage and grade, is the manto type occurrence near the unconformity between the Paleozoic limestones and the Tertiary (?) fine grained beds or the Chief conglomerate. This "ore" averages about 6 oz Ag/ton and 15% Mn and generally lies immediately adjacent to the limestone or within a few feet above the unconformity. Some manganese silver mineralization is present in the limestone but information compiled to date suggests it is of limited extent. Thicknesses in the main horizon range up to 180' and individual 5' assay intercepts have run

over 50 oz Ag/ton.

The unconformity is dome shaped in that it dips 25° - 30° in all directions from the vicinity of hole 15A. A fault about along the line of section 10,600E drops the area to the east 300' to 400', thus removing the potential zone from open pit mining range. To the south and west, drilling has pretty well defined the limits of mineralization along the unconformity. The strongest mineralization lies on the north and west flanks of the dome. To the east and south, the mineralization seems to diverge from the unconformity and diminish in strength. Any possible extensions to the southwest would be very deep since the ridge rises steeply west of Hardshell canyon. Additional tonnage might be developed to the north and northwest where the last holes drilled were still in "ore" but drilling difficulties prevented further exploration at this time. At least part of the extensions to the northwest would probably be mineable because the ridges and the canyon slope down in that direction. If the "ore" extends to the north, it might be recoverable to a reasonable depth, again, because the ridge slopes off quite steeply to the north.

The second occurrence of silver is in the Chief conglomerate in what are probably lenticular bodies elongated in a direction parallel to the dip of the unconformity (along bedding?). Four holes in the central part of the area returned silver assays of 2-3 oz/ton beginning at the surface and extending from 20' to 50' in depth. Six other holes contained intercepts from 10' to 60' depths from 20' to 230'. Composites of these samples showed less than 1% manganese. Assuming an area of influence of 100' each way from these holes, they represent + 900,000 tons of 2.66 oz Ag/ton "ore" that lie in the "waste" that would need to be stripped in an open pit. Two other holes to the east, 7A and 32, have intercepts of 20' to 60' assaying 3-4 oz Ag/ton in what probably represents the Hermosa and North veins from which the old Hermosa Mining Company recovered all of their ore in the 1880's. Schrader reported (USGS Bulletin 582) that the Hermosa ore was silver chloride and recoveries of 87-90% were realized by amalgamation in the old stamp mill at Harshaw. He further stated that the Salvadore ores were "more easily milled" than the Hermosa. It is possible that the shallow mineralization present in the central part of the zone represents the low grade expression of the Salvadore ore bodies. Metallurgical testing of composites of this "shallow ore" is being conducted at this time.

DRILLING:

As already indicated, the largest part of the drilling was done with a down-the-hole hammerdrill. Direct cost of the hammerdrilling was $4.47/ft. as compared to $16.42/ft. for diamond core drilling. The cost of transporting water for the core drill was over $3.00/ft. Mud and cement came to almost $3.00/ft., making the cost of mud and water together, $5.96/ft. Cost of drilling all inclusive was $9.13/ft.

Diamond core drilling is unsatisfactory for sampling the manganiferous silver "ore" because of the nature of the occurrence. The ore occurs mostly as a sooty or gougy manganese veinlet or filling in vugs or between the brecciated jasperoid(?). Total recovery of the manganese in cores has not been possible except in some of the gougy zones. The vuggy, fractured nature of the formation allows extreme loss of circulation. In addition,

washing of the manganese filling from the jasperoid (?) causes the siliceous breccia to cave into the hole. Lost time for cementing, drilling cement, drilling cave, waiting for water, casing, reaming and all the other operations that are necessary when this type formation is drilled, raise the per foot cost beyond a reasonable point for the information obtained. It should be mentioned here that while the manganiferous ore zone can not be sampled satisfactorily with the core drill, none of the 5 holes cored in the most recent program intersected the zone. Consequently, the information obtained from the cored holes is completely reliable.

Percussion drilling is the most effective method tried to date for sampling this deposit above the water table. Slight loss of air circulation can be recovered by the Lo-Loss injection method as developed at Waterloo and 200' per day advance is not unusual. Vuggy ground did eventually stop three holes. Holes 15 and 41 were shallow and were redrilled as offsets. Hole 23 passed through an 18" cavity at about 370' and 30 sacks of Portland cement with $CaCl_2$ accelerator were not sufficient to stop the loss. The hole was abandoned at that depth. Percussion drilling below the water table has been unsatisfactory because the water-detergent foam erodes particles from the walls of the hole as it rises in the annulus and by so doing, contaminates the sample and encourages caving. Besides the wall erosion problem, below a certain head of water, the air pressure required to lift the foam becomes greater than the pressure that the formation will sustain and the hole must be cemented in order to be advanced. For the purposes of the program just completed, it was not felt necessary to develop a technique for sampling beneath water, although some experimental work will be required in the future, in order to trace the northern and northwestern extensions.

RECOMMENDATIONS:

A program of detailed surface geologic mapping should be completed, using the triangulation network established on the new photographically compiled topographic map as a base. Sampling of outcrops should be completed in the vicinity of the "shallow ore" to determine if there is significant areal extent to these lenses.

If the cyanidation tests on the "shallow ore" prove favorable, a drilling program to explore the extent of this type ore should be undertaken. It is suggested that for a large part of this drilling, since the holes would be less than about 100' deep, an independent rotation Air-Trac such as the Gardner-Denver PR123 could be used to drill holes of 3" or 3½" diameter at a cost much less than that realized with the DTH. A significant part of the savings would be in the less elaborate system of roads that would be required to move the Air-Trac.

An experimental drilling project should be completed to develop a technique or device to sample the manganiferous "ore" under water. Finally, the extensions should be explored, using the new method to outline the limits of the deposit.

J. R. Wojcik

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

Aa 19.8.8
JHC File

March 12, 1968

Mr. T. D. Henderson
American Smelting and Refining Company
Post Office Box 1111
El Paso, Texas 79999

Dear Mr. Henderson:

Today, I shipped via Braswell Motor Freight, two pails containing the metallurgical samples from our Hardshell Project for cyanidation tests. The composites are in 5 cloth bags marked as follows:

Composite #1, Bag 1 of 1	Weight 21.9 lbs.
Composite #2, Bag 1 of 2	
Composite #2, Bag 2 of 2	Weight 27.2 lbs.
Composite #3, Bag 1 of 2	
Composite #3, Bag 2 of 2	Weight 24.9 lbs.

These composites represent 410' of drill hole intercepts in three areas of the prospect. The two bags of composite #2 should be combined for testing as should the two bags of composite #3.

I await your results anxiously.

Very truly yours,

J. R. Wojcik

JRW:bls
cc: JHCourtright
GWBossard
NPWhaley
File

J. H. C.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

MAR 4 1968

March 4, 1968

Mr. T. D. Henderson, Sr. Metallurgist
El Paso Assay Laboratory
American Smelting and Refining Company
P. O. Box 895
El Paso, Texas 79999

Hardshell Project

Dear Sir:

Mr. Wojcik informed me this morning that during the next week he will ship to the El Paso Laboratory, Via Braswell Freight Lines, three drill hole composites from the above project for cyanidation testing. These samples, weighing 25 pounds each approximately, are siliceous material with low manganese content, assaying two to four ounces of silver and should respond to cyanidation better than the previous Hardshell samples. The tests that you perform should investigate the effects of grinding, cyanide solution strengths and alkalinity. It will be impossible to obtain more of this material for additional testing.

Yours truly,

G. W. Bossard

G. W. BOSSARD
Milling Engineer

GWB/mg

cc: JHCourtright ✓
JRWojcik

Misc - 11A

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

January 15, 1968

J. H. C. Copy
JAN 15 1968

Mr. J. H. Courtright, Supervisor
Exploration Department
Southwestern Division
Tucson Office

HARDSHELL PROJECT

Dear Sir:

On December 14 I wrote to Mr. M. E. Volin, Director, Institute of Mineral Research, Michigan Technological University, requesting that they undertake a wet magnetic separation test on the minus 325 mesh fraction of the Hardshell Project. I did not receive an acknowledgment of my letter until January 4 at which time Mr. Henderson forwarded from El Paso 500 grams of minus 325 mesh fraction. For your reference I am enclosing copies of all correspondence between Mr. Henderson and myself with Michigan Technological University personnel.

The preliminary results forwarded to us indicate that the magnetic results on this fraction are very poor with wet recovery less than one percent. On January 10 Mr. Henderson forwarded a sample of minus 100 plus 325 mesh fraction of the same material for a wet magnetic separation test. These tests were requested for comparison with our own dry separation test results with the Carpco Separator. I will inform you of the results as soon as they are available.

Yours truly,

G. W. Bossard

G. W. BOSSARD
Milling Engineer

GWB/mg
Enclosures (5)

cc: TDHenderson wo/enclosures

Misc 11A

JAN 15 1968

MICHIGAN TECHNOLOGICAL UNIVERSITY
HOUGHTON, MICHIGAN 49931
Area Code 906, 482-1600

Institute of
Mineral Research

January 11, 1968

Mr. T. D. Henderson
Senior Metallurgist
American Smelting and Refining Co.
El Paso Assay & Ore Dressing Laboratory
P.O. Box 895,
El Paso, Texas 79999

Dear Mr. Henderson:

We have processed your 500 gram sample of minus 325 mesh low grade silver/manganese ore on our Davis Magnetic Tube Tester. The test was performed using 40 gram charges as Davis Tube feed and operating the tube for ten minutes. The magnetics were combined and dried; the non-magnetics were also combined and dried. The following is a presentation of the data:

	Wt. (gms)	% Wt.
Total weight fed to Davis Tube	519.38	100.00
Magnetics Produced	0.41	0.08
Non-Magnetics Produced	518.97	99.92

The magnetics and non-magnetics are being sent to you under separate cover. An invoice covering the work will be sent and should be about $105.00. This is well within our estimate of $250.00 arranged with Mr. Bossard by telephone on January 5. If you require additional information please feel free to contact us.

Sincerely yours,

A. William Carlson

A. William Carlson
Research Engineer
Institute of Mineral Research

cc: G. W. Bossard

G.W.B.

JAN 15 1968

JAN 12 1968

Misc 11-4
Handsell

Jan. 10, 1968

Mr. Robert Campbell
Institute of Mineral Research
Michigan Technological University
Houghton, Michigan 49931

Dear Sir:

I am sending you today by airmail approximately 95 g. of the minus 200 plus 325-mesh fraction of the same sample of low grade silver-manganese ore on which you made wet magnetic separation tests on the minus 325-mesh size. As you advised Mr. Bossard on the telephone yesterday, you recovered only about one percent of the minus 325-mesh fraction as a wet magnetic concentrate.

A magnetic separation test of a dry minus 100 plus 325-mesh fraction of the same ore was made here at the El Paso Ore Testing Lab on a Carpco Magnetic Separator. The drum speed used was 35 rpm and the current was 1 1/2 amp. Thirty-nine percent of this fraction was recovered as a magnetic concentrate.

It does not seem reasonable to me that the proportion of magnetic material in the minus 325-mesh fraction should differ so drastically from that in the minus 100 plus 325-mesh size. I would suggest that a wet magnetic separation test be made on the sample of minus 200 plus 325-mesh fraction that I am sending you for comparison with our dry separation tests with the Carpco Separator. Please advise me of the results of these tests as soon as they are available.

Yours very truly,

ORIGINAL SIGNED BY

T. D. Henderson, Jr.
Senior Metallurgist

TDH/cb
cc:GWBossard

G.W.B.

JAN 15 1968

January 10, 1968

Mr. Robert Campbell
Institute of Mineral Research
Michigan Technological University
Houghton, Michigan 49931

Hardshell Project

Dear Sir:

Reference is made to our telephone conversation of January 9 concerning the magnetic separation test work on the sample sent to you from our El Paso Laboratory. Mr. Henderson will forward to you a portion of the minus 200 plus 325 mesh material from which the sample that you received was prepared. Please evaluate this sample by the same Dings procedure used for the minus 325 mesh material. Mr. Henderson will send also information concerning how our original magnetic separation test work was conducted on this material.

Yours truly,

G. W. BOSSARD
Milling Engineer

GWB/mg
cc: TDHenderson

Misc 11A

Misc 114

January 4, 1968

Mr. Robert Campbell
Institute of Mineral Research
Michigan Technological University
Houghton, Michigan 49931

Dear Sir:

I am sending you today by airmail at the request of Mr. G. W. Bossard a 500-gram sample of the minus 325-mesh fraction of a low-grade silver/manganese ore for wet magnetic separation tests. The two envelopes of material in the package being sent represent one sample.

Yours truly,

T. D. Henderson Jr.
Senior Metallurgist

cc GW Bossard

Misc 11-A

ASARCO PO 1
REVISED 1/1/66

PURCHASE ORDER

AMERICAN SMELTING & REFINING CO.
Tucson Office 1150 North 7th Avenue
P. O. Box 5795 Tucson, Arizona 85703

DATE: January 4, 1968
ORDER NO.: T-7007
REQUISITION NO.:
PLANT JOB NO.:
APPROPRIATION NO.:

TO:
Institute of Mineral Research
Michigan Technological University
Houghton, Michigan 49931

FINAL DESTINATION — PLEASE NOTE CONSIGNMENT BELOW

DATE REQUIRED AT DESTINATION:

CONSIGNMENT — SELLER WILL SHIP TO

SHIPPING INTERVAL PROMISED | SELLER WILL SHIP BEFORE:

POINT OF SHIPMENT | TERMS

— RENDER BILLS AS PER ATTACHED SHIPPING INSTRUCTIONS —

F. O. B. POINT

SHIP VIA

QUANTITY	UNIT	SPECIFICATIONS	ITEM NO.	UNIT PRICE
		Magnetic separation test work in accordance with telephone conversation, 1/4/68, between our Mr. Bossard and your Mr. Robert Campbell, on samples sent to you this date from our El Paso Ore Testing Laboratory. Estimated cost not to exceed . . .		$250.00
		Do not incur additional expenses without clearance from this office.		
		Orig: Inst. of Min. Research cc: GWBossard KvdSteinen File		

IMPORTANT

Attached Acknowledgment Card must be completed and returned promptly.

PLEASE ENTER OUR ORDER FOR THE ITEMS SPECIFIED ABOVE, SUBJECT TO ALL INSTRUCTIONS AND PROVISIONS ON REVERSE SIDE.

D. E. C.
JAN 5 1968

/s/ G. W. Bossard
Milling Engineer

Aa 19.8.8

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

December 11, 1967

W.E.S.
DEC 20 1967

Mr. J. J. Collins, Chief Geologist
ASARCO - New York Office

Hardshell Project
Santa Cruz County, Arizona

Dear Sir:

Enclosed is the El Paso metallurgical report, Part II, with Mr. Bossard's covering letter, Part I was sent to you under my letter of October 16, 1967.

Although results from segregation tests at Silver Bell are not yet available, the best procedure still appears to be pre-concentration by magnetic separation and then treatment of this concentrate (representing 20% of the crude ore) by salt roast/cyanidation.

The concentrate containing 19 oz. silver represents a recovery of 80% for the material treated; however, the minus 325 mesh fraction amounting to 18% of the head sample was not treated due to lack of the necessary equipment. By his copy of this letter, Mr. Bossard is asked to submit a sample to an outside laboratory where the required equipment is available.

insert A

Yours very truly,

JHC:lmi
encl.

J. H. Courtright

cc: TASnedden, w/encl.
RBMoen "
GWBossard
JRWojcik "

Route file copy to WESaegart

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

December 7, 1967

J. H. C.
DEC 7 - 1967

W.E.S.
DEC 20 1967

Mr. J. H. Courtright, Supervisor
Exploration Department
Southwestern Division
Tucson Office

Hardshell Project

Dear Sir:

I am enclosing four copies of Serial Report 808, Part II, covering the remainder of the preliminary El Paso Laboratory results from tests on the Hardshell Project composite forwarded to El Paso on September 15. Part I of the same serial report was forwarded to you on October 16. Our delay in forwarding this second part has been due to vacations and our involvement with the Waterloo Project test work.

The natural impression formed from reviewing both parts of Serial Report 808 is that the metallurgy will of necessity be quite involved. The ore does not respond to a normal cyanide leach, and silver recovery by cyanidation following a salt roast approaches 85 percent. Likewise, neutral or acid brine leaching of the same salt-roasted material produces good silver recovery. Leaching the ore with sulfur dioxide gas followed by cyanidation also has shown good promise, but the cost of sulfur eliminates this process from consideration.

The most attractive flow sheet for this ore would be one using magnetic separation as a pre-concentration step and then either disposing of the magnetic concentrate if a market could be found or treating this smaller tonnage by salt roasting/cyanidation to recover a final silver product. With this latter type of flowsheet I would estimate that at least 85 percent of the silver would have to be recovered in the magnetic concentrate for re-processing to make this flow sheet attractive. Results to date indicate that approximately 80 percent of the silver in the +325 mesh fraction can be recovered in a magnetic concentrate but 20 percent of the silver is discarded with the -325 mesh slime fraction. Wet magnetic methods might recover some of the silver lost in this fraction, but El Paso does not have a Dings magnetic tube tester required for testing fine material to determine what percentage is recoverable.

The only pending work not yet reported are the results from segregation tests being performed at Silver Bell. This information will be forwarded in approximately 10 days. By copy of this letter I am instructing Mr. Henderson to defer any further test work unless such work is requested by you.

Yours truly,

G. W. Bossard

G. W. Bossard
Milling Engineer

GWB/mg
Enclosures (4)
cc: TDHenderson w/o enclosures

AMERICAN SMELTING AND REFINING COMPANY

EL PASO ORE TESTING LABORATORY

A

REPORT

OF

SERIAL 808

PART II

TESTING OF

THE HARDSHELL PROJECT ORE

- DECEMBER 1967 -

TESTING OF THE HARDSHELL PROJECT ORE

INTRODUCTION

Further testing of the Hardshell Project Ore has included sulfur dioxide leaching of the manganese followed by cyanidation of the residue, hydrochloric acid leaching of the raw ore, additional tests on the magnetic separator and flotation of the raw ore with a fatty acid.

CONCLUSIONS

(1) Cyanidation of the raw ore does not give satisfactory extraction even at very fine grinds. The best recovery obtained with raw cyanidation was 21 percent.

(2) Cyanidation of the ore following a chloridizing roast gave favorable recovery of 84.3 percent of the silver. Brine and acid brine leaching also extract a large percentage of the silver after roasting. The brine and acid brine gave recoveries of 81.8 and 83.3 percent of the silver respectively.

(3) Magnetic separation of sized fractions of the ore gave very good results with recoveries of 80 percent of the silver in the material passed through the separator.

(4) Silver recovery in excess of 80 percent can be obtained by leaching the manganese with sulfur dioxide followed by cyanidation of the silver. Sulfur dioxide consumption ranged from 200 to 300 pounds per ton of ore. This would cost about $3.75 per ton of ore based on $60.00 per ton for sulfur. In tests where the sulfur dioxide was neutralized with lime and the manganese precipitated at the same time, the silver recovery by cyanidation fell to 57 percent on one sample and 20 percent on a ground sample indicating that the manganese must be removed to prevent the reformation of refractory silver-manganese compounds. Lime consumption was approximately 170 pounds per ton of ore.

(5) Silver recovery with hydrochloric acid in strengths of 20, 30, 40 grams per liter was only 4 percent with acid consumption going as high as 125 pounds per ton of ore.

(6) Recovery of the silver by flotation of a deslimed sample was 46 percent with the concentrate assaying 17.3 oz/T silver. When the weight of the slimes is neglected, the silver recovery is 66 percent.

DESCRIPTION OF TEST WORK

Tests performed using sulfur dioxide were carried out by bubbling the gas through the pulp for one hour, then followed by filtering, washing, repulping and filtering. The residue was then cyanided for 24 hours. In later tests a sulfur dioxide solution was made up and standardized and the off solutions were then analyzed for sulfur dioxide to determine consumption.

Other tests carried out using sulfur dioxide involved neutralizing the sulfur dioxide with lime while precipitating the manganese at the same time. The lime was added until a free lime titration of about 3 pounds per ton of solution was attained. Silver recovery was lowered to 20 percent with this method.

The magnetic test performed was done by splitting the minus 10 mesh material into a plus 35 mesh fraction; a minus 35 mesh, plus 100 mesh fraction; a minus 100 mesh, plus 325 mesh fraction; and a minus 325 mesh fraction. Each fraction except the minus 325 mesh fraction was run through the magnetic separator. Complete data are shown in Table No. II.

Flotation test data are shown in Table No. III.

RECOMMENDATIONS FOR FURTHER TEST WORK

Additional test work should include more salt roasting tests followed by brine leaching and cyanidation and also additional work on the magnetic separator with additional treatment of the concentrate and slime fraction. This could include salt roasting followed by cyanidation or sulfur dioxide leaching followed by washing and cyanidation. It may also be desirable to attempt to produce some type of manganese concentrate, possibly by the dithionate process.

F. L. BAZZANELLA

FLB/cb

TABLE I

HARDSHELL PROJECT
Leaching and Precipitation Data

Test No.	Treatment		Tail Assay oz/T Ag	Tail Assay % Mn	In Soln Recovery Ag	In Soln Recovery Mn	Consumption #/Ton Soln NaCN	CaO	SO_2	HCl	Consumption #/Ton Solids NaCN	CaO	SO_2	HCl
8-1	SO_2 Leach, Filter, Wash. Cy'n24hrs		2.27	1.69	61.1	76.6	.18	2.8			.504	7.9		
8-2	SO_2 Leach, Filter, Wash. Grind 1' Cy'n 24 hrs		1.19	.36	80.3	95.2	.29	2.0			1.23	8.54		
8-3	SO_2 Leach, Filter, Wash. Grind 2' Cy'n 24 hrs		1.08	.26	82.0	96.4	.60	1.85			3.13	9.66		
8-4	SO_2 Leach, Filter, Wash. Grind 3' Cy'n 24 hrs		.82	.10	86.4	98.6	.38	2.40			1.58	9.98		
8-5	SO_2 Leach, Filter, Wash. Grind 4' Cy'n 24 hrs		.89	.07	86.4	99.1	.51	3.82			1.37	10.28		
9-1	1 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs		2.68	2.5	52.7	64.3	.17	1.90			.77	8.59		
9-2	2 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs		2.42	2.2	57.5	68.7	.30	3.17			.93	9.61		
9-3	3 hr SO_2 Leach @ 25.3 gpl SO_2.Filter, Wash. Cy'n 24 hrs	Off	2.43	2.2	57.5	68.8	.24	1.66			1.34	9.80		
10-1	24hr HCl Leach @ 20gpl.Filtered, Washed	5.6 gpl HCl	5.16	6.0	2.9	8.7				2.60				72.8
10-2	24hrHCl Leach@30gpl.Filter,Wash	10.5	5.11	6.0	4.0	8.7				2.63				103
10-3	24hrHCl Leach@40gpl.Filter,Wash	15.0	5.13	6.1	4.2	7.9				2.64				125.7
11-1	1 hrSO_2Leach. Filter, Wash assay		5.49	1.2	6.7	83.6			59.0				341	
11-2	1 hrSO_2Leach.Filter,Wash.Cy'n24hrs		2.00	1.0	65.3	85.9	1.45	2.76	57.2		5.8	11.0	228	
11-3	1 hrSO_2Leach.Filter,Wash,Grind.Cy'n24hrs		1.48	1.0	74.9	86.2	.32	2.19	55.7		1.4	9.7	247	
11-4	1 hrSO_2Leach.Neutralize with40gmCaO Cy'n 24 hrs		1.96	4.7	57.1	16.9	1.31	45.0	53.7		5.1	176	209	
11-5	1hr SO2 Leach.Neutralize with 40gmCaO Grind. Cy'n 24 hrs		3.51	4.9	20.5	10.1	1.92	27.9	52.9		11.5	167	317	

TABLE II

Magnetic Separation

Sample: The sample was divided into four fractions:

+35 mesh	-	50.60% of total weight
-35 +100	-	22.26% " " "
-100 +325	-	11.44% " " "
-325	-	15.70% " " "

Procedure:

+35 mesh. Passed through separator 5 times. Speed 24 rpm, current 3 amp.
Individual recovery of Ag - 82.3

-35 +100 Passed through separator 3 times. Speed 28 rpm, current 3 amp.
Individual recovery of Ag - 86.2

-100 +325 Passed through separator 3 times. Speed 35 rpm, current 1 1/2 amp.
Individual recovery of Ag - 70.3

The -325 mesh material was not run through the separator.

Material	Assay oz/T Ag	Assay % Mn	% Wt	Recovery with Slimes Ag	Recovery without Slimes Ag	
+35 mesh conc	16.16	25.5	9.9	34.5)	42.9)	
-35 " +100 conc	14.22	22.8	6.3	19.2)65.3	23.6)	80.9
-100 +325 conc	12.25	19.0	4.4	11.6)	14.4)	
+35 mesh tail	.84	.59	40.7	7.3	9.2	
-35 +100 tail	.89	.83	16.0	3.0	3.8	
-100 +325 tail	3.29	2.3	7.0	5.0	6.1	
-325 Slime	5.75	7.3	15.7			

TABLE III

Flotation Data

Grind: 10% +65 mesh

Reagents: 28 lb/Ton Na_2CO_3
.74 lb/Ton Na_2SiO_3
1.1 lb/Ton Oleic Acid
.006 lb/Ton Pine Oil

32.3 percent of the total sample weight was removed as slimes by decantation.

		Assays		Recovery			
				With Slimes		Without Slimes	
Product	Wt %	oz/T Ag	% Mn	Ag	Mn	Ag	Mn
Slimes	32.3	4.99	6.95	30.3	33.5	-	-
Concentrate	53.6	17.27	23.3	45.8	49.3	65.9	74.1
Tailing	14.1	2.37	2.15	23.9	17.2	34.1	25.9

please copy for GWB
11-21-67
lmi

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

J. H. C

NOV 20 1967

November 20, 1967

TO: Mr. J. H. Courtright

FROM: J. R. Wojcik

El Paso Assays of
Hardshell Samples

According to Wayne Bossard, we were charged $4.25 per sample for double silver assays. Hawley & Hawley's charges are:

For single assays	$1.75 per sample	
" verified assays	2.75 " "	
" preparation	0.85 " "	(if no drying req'd)
" drying	0.25 " "	

According to this schedule, their maximum charge would be $3.85. However, most samples are dry so verified assays would be $3.60. We do not require verified assays of individual drill hole samples so our charges from Hawley & Hawley have been about $2.60 per sample. Also, we get discounts for groups over 50 samples. Disregarding discounts, freight charges and time lag, the El Paso assays are costing us about $1.65 per sample more than we were paying Hawley and Hawley.

JRW:lmi

J. R. Wojcik

Aa 19.8.8
Hardshell

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

November 1, 1967

Mr. T. D. Henderson
ASARCO
El Paso Smelting Works
P.O. Box 1111
El Paso, Texas 79999

Dear Mr. Henderson:

From the pulps of the samples from Hole 25, would you have prepared two composite samples to be assayed for Au, Ag, Pb, Zn, Mn and SiO_2. These composites are to be compiled of equal parts of the following:

Composite 25-1	Samples No.	25-190
		25-200
		25-210
		25-220
		25-230
		25-240
		25-250
Composite 25-2	Samples No.	25-405
		25-410
		25-415
		25-420
		25-425
		25-430
		25-435
		25-440
		25-445
		25-450
		25-455
		25-460
		25-465
		25-470
		25-475

In addition, could you have returned to me, in care of Braswell Truck Lines, the cloth bags in which the samples have been shipped.

Yours very truly,

JRW:lml

J. R. Wojcik

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 27, 1967

Mr. R. B. Meen
Building

HARDSHELL PROJECT

Reference is made to Mr. Henderson's letter of October 24 to Mr. Jameson concerning a segregation test at Silver Bell on a sample from the Hardshell Project. I discussed this matter with Mr. Henderson during my visit to El Paso on October 20, but due to the press of other matters I have been negligent in keeping you informed.

We would like the Silver Bell laboratory to run one or two standard segregation tests as developed for the Lampa Project. I want to emphasize that only a minimum of time should be devoted to this effort as the investigation of the segregation process is only a sm all part of the exploratory test work we are conducting on the Hardshell ore sample.

G. W. BOSSARD
Milling Engineer

GWB:cmr

cc: DRJameson
RSalter
TDHenderson,Jr.

Misc 11-A

RBMeen

MINING E

OCT 25 1967

TUCSON

EL PASO ORE TESTING AND ASSAY LABORATORY

R.B.M. OCT 26 1967

El Paso, Texas
October 24,1967

Mr. D. R. Jameson, Superintendent
Silver Bell Unit

Dear Sir:

At the request of Mr. G. W. Bossard I mailed to you yesterday a two-kilogram sample of minus 10-mesh Hardshell Project silver-manganese ore for segregation process roasting tests.

Yours very truly,

ORIGINAL SIGNED BY
T. D. Henderson,Jr.

TDH/cb

cc:RBMeen
GWBossard

Aa 19.8.8
JHC File

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 16, 1967 W.E.S.

OCT 26 1967

Mr. John J. Collins, Chief Geologist
ASARCO - New York Office

Hardshell Prospect
Santa Cruz Co., Arizona

Dear Sir:

Reference is made to my letter of October 5 recommending continuation of the exploratory work at Hardshell. Subsequently you advised me by phone that further expenditures on this project would probably be deferred pending the outcome of metallurgical studies.

I have today received the results of initial tests run at El Paso with Mr. Bossard's covering letter, both of which are enclosed herewith.

As in the case of Waterloo, straight cyanidization failed to recover an appreciable percentage of the silver; however, after salt roasting, a cyanide leach recovered 84.3% of the silver (head assay: 5.22 oz/ton). The most encouraging method appears to be magnetic separation wherein a concentrate assaying 19 oz/ton Ag and 31.5 Mn was produced. This represents a recovery of 68.7% of the silver and 92.8% of the manganese.

As noted by Mr. Bossard, the results so far are of an exploratory nature only, and that the remainder of the preliminary testing program will cover additional areas in the roasting and magnetic separation fields.

I again recommend continuation of the exploratory drilling, at least to determine the limits of the silver-manganese mineralization and gain a better assessment of the deposit's tonnage-grade potential. The minimum expenditure to attain this objective is estimated to be $100,000. The information which would be obtained could have a bearing on the extent to which the metallurgical work is carried.

Yours very truly,

J. H. Courtright

JHC:lml
encl.
cc: TASnedden, w/encl.
RBMeen, "
GWBossard

Route file copy to WES; JRW.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 16, 1967

Mr. J. H. Courtright, Supervisor
Exploration Department
Southwestern Division
Tucson Office

HARDSHELL PROJECT

Dear Sir:

I am enclosing four copies of Report A of Serial 808 covering the preliminary El Paso Laboratory results from the Hardshell Project composite sample forwarded from Tucson on September 15. These results are of an exploratory nature only and follow the program laid out in my letter of September 15 to Mr. Henderson in addition to the magnetic separation tests suggested by El Paso.

An assay-screen analysis of the material (minus 10-mesh) indicates that the majority of the silver follows the manganese. This is confirmed by the one magnetic separation test reported. We have no idea how the remainder (approximately 30 percent) of the silver is associated. There is no particular enrichment in silver content of any screen fraction.

Cyanidation of the raw ore at various grinds proved negative with a maximum recovery of only 20 percent. Screen analysis information for these tests is not yet available. Salt roasting of the total ore at 850°C for one hour with 6 percent NaCl gave good recoveries. A straight cyanide leach recovered 84.3 percent of the silver from the calcine. This recovery is based on the feed assay of 5.22 oz/ton. A neutral brine leach recovered 81.8 percent and recovery was increased to 83.3 percent with an acidified brine leach.

The most interesting results are from the magnetic separation work. A separation was made using the -65 +200 mesh fraction of the ore and yielded a magnetic concentrate assaying 31.5 percent manganese and containing 68.7 percent of the silver. Electrostatic separation results were not too encouraging.

The remainder of the preliminary testing program will cover additional areas in the roasting and magnetic separation fields. Also remaining to be evaluated are such procedures as flotation before and after magnetic separation, sulfuric acid or SO_2 leaching, etc. The next progress report summarizing the preliminary test work should be available by November 15.

Yours truly,

G. W. Bossard

G. W. BOSSARD
Milling Engineer

GWB:cmr
Encl (4)
cc: TDHenderson, no encl.

AMERICAN SMELTING AND REFINING COMPANY

EL PASO ORE TESTING LABORATORY

A

REPORT

ON

SERIAL 608

PRELIMINARY TESTING OF

THE HARDSHELL PROJECT ORE

- OCTOBER - 1967 -

PRELIMINARY TESTING OF THE HARDSHELL PROJECT ORE

INTRODUCTION

Preliminary testing of the Hardshell Project sample has pointed out several possible methods of extraction of the contained manganese and silver. No work has been done on lead and zinc recovery, but data thus far obtained indicates that the silver, manganese, lead and the zinc are combined either mechanically or chemically. Indications of this are noticeable in the results of the magnetic separator test.

CONCLUSIONS

(1) Cyanidation of the raw ore does not give sufficient extraction of the silver even at very fine grinds.

(2) Cyanidation of the ore following a chloridizing roast shows favorable recovery of 84.3 percent of the silver. Brine and acid brine leaching also extract a large percentage of the silver after roasting. The brine and acid brine gave recoveries of 81.8 and 83.3 percent of the silver respectively.

(3) Magnetic separation of a sized fraction of the ore sample gave very good results on both silver and manganese with recovery of 68.7 percent of the silver and 92.8 percent of the manganese in a concentrate.

(4) A separation performed on the electrostatic separator on a deslimed sample gave a silver extraction of 40.0 percent in a concentrate assaying 29.16 oz per ton.

DESCRIPTION OF TEST WORK

A screen analysis on the minus 10 mesh sample indicates that about one half of all metal content is in the coarse or plus 48 mesh fraction. However, about 20 percent of each metal is in the minus 325 mesh fraction while the remainder is divided quite equally among the remaining fractions. A head sample assay and the results of the sizing test are shown in Table No. 1.

The first attempt at silver extraction was by cyanidation of the raw ore at different grinds. Each sample was ground for a different period of time and then put in the bottle agitator with approximately 4 pounds per ton of solution of sodium cyanide for 24 hours. The sample was then filtered, repulped, filtered and washed. The results of this test are in Table No. 2.

A sample of the minus 10 mesh ore was roasted at 650°C with 6 percent salt, then 4 portions were leached for 24 hours

with sodium cyanide, 20 percent salt brine, 27 percent salt brine and 27 percent salt brine with 25 grams per liter of hydrochloric acid. After 24 hours the samples were filtered, repulped, filtered and washed. The results of this test are also included in Table No. 2.

Other methods of extraction investigated to date are magnetic separation of a sized sample, electrostatic separation of a deslimed sample and flotation of a deslimed sample with a fatty acid. No assays are yet available on the flotation products.

The magnetic separation test was performed on a Carpco Laboratory Magnetic Separator. The sample was sized and only the minus 65 mesh and the plus 200 mesh fractions were used. The material was passed through the machine 3 times at 110 rpm with the current on the magnet set at 3 amperes. The rougher concentrate was cleaned once and the cleaner tails recirculated once. The tails from the scavenger were combined with the rougher tails and the concentrates from the scavenger and first cleaner were combined to give two products. The results of this test are shown on Table No. 3.

The electrostatic test consisted of a single pass of a deslimed sample through the Carpco Laboratory Electrostatic Separator. The drum speed was 110 rpm at a voltage of 28 KV. The middling product was allowed to recirculate to depletion in order to give two products. Data from this test are also shown on Table No. 3.

PROPOSED WORK

Additional work to be undertaken will include sulfuric acid leaching followed by cyanidation, sulfur dioxide leaching followed by cyanidation, calcium dithionate and sulfur dioxide leaching followed by cyanidation, additional magnetic, electrostatic, and flotation testing and also some heavy media separation testing.

F. L. BAZZANELLA

9x

cb

TABLE NO.1 HARDSHELL PROJECT
RESULTS OF SCREEN ANALYSIS (1)

Head Sample	Ag oz/ton	Mn	Pb	Zn	Fe	Insol	As	Sb	Cu
	5.22	6.45	1.15	1.08	2.8	78.0	.17	.06	.10

Mesh	On	Passing	Ag	Mn	Zn	Pb
40	59.7	40.3	4.66	5.30	.58	.60
65	7.3	33.0	5.52	7.15	1.00	.90
100	5.5	27.5	5.54	7.50	1.05	1.05
150	4.7	22.8	6.17	8.10	1.12	1.20
200	3.0	19.8	6.24	8.10	1.16	1.30
325	4.5	15.3	6.50	8.45	1.05	1.30
-325	15.3		6.11	8.25	1.38	1.70

	Total Contents				Distributions - Percent			
	Ag	Mn	Zn	Pb	Ag	Mn	Zn	Pb
40	2.787	3.164	.340	.478	53.59	49.70	42.04	46.82
65	.403	.522	.073	.066	7.75	8.20	9.07	6.46
100	.305	.413	.058	.058	5.87	6.49	7.05	5.68
150	.290	.381	.053	.061	5.58	5.99	6.44	5.97
200	.187	.243	.035	.039	3.60	3.82	4.25	3.82
325	.293	.380	.047	.059	5.63	5.97	5.71	5.78
-325	.935	1.262	.211	.260	17.98	19.83	25.64	25.47
Calc.Head	5.20	6.365	.823 (2)	1.021				

(1) Sample was minus 10 mesh

(2) Assays for zinc to be repeated

TABLE NO. 2 HARDSHELL PROJECT

LEACHING DATA

Test No.	Product	Preliminary Treatment Grind	Roast °C	Reagent	Leach Solution H_2O cc	NaCN gm	CaO gm	NaCl gm	HCl cc	Time hr	Reagent Consumption lb/T soln NaCN	lb/T soln CaO	lb/T ore NaCN	lb/T ore CaO	Assay Au	Recovery Au
1	Raw Ore	-10Mesh	-	-	-	-	-	-	-	-	-	-	-	-	5.22	100.0
1-1	Cy'n Tail	-10Mesh	-	-	300	.70	1	0	0	24	.38	1.91	1.16	5.83	4.63	11.30
1-2	"	"	1 Min	-	-	941	1.98	1	0	0	24	.08	.68	.79	6.70	4.55	12.84
1-3	"	"	1 1/2"	-	-	735	1.58	1	0	0	24	Nil	.72	Nil	6.34	4.52	13.41
1-4	"	"	2	"	-	-	693	1.48	1	0	0	24	.08	.98	.58	7.06	4.51	13.60
1-5	"	"	2 1/2"	-	-	714	1.53	1	0	0	24	.10	.88	.74	6.54	4.22	19.16
1-6	"	"	3	"	-	-	750	1.60	1	0	0	24	.20	.88	1.54	6.80	4.35	16.67
1-7	"	"	4	"	-	-	662	1.43	1	0	0	24	.10	.94	.70	6.59	4.20	19.54
1-8	"	"	5	"	-	-	1018	2.54	1	0	0	24	.22	.55	2.28	5.70	4.12	21.07
5	Calcine	-10Mesh	850	6% NaCl	-	-	-	-	-	-	1	-	-	-	-	4.21		100.0
5-1	Cy'n Tail	"	"	"	300	.60	1	1/2	0	0	24	Not Determined				.82	(1)	84.5
																	(2)	80.5
5-2	BrineTail	"	"	"	200	0	0	50	6	24	"		"			1.33	(1)	74.5
																	(2)	68.4
5-3	BrineTail	"	"	"	200	0	0	74	0	24	"		"			.95	(1)	81.8
																	(2)	77.4
5-4	AcidBrineTl	"	"	"	200	0	0	74	4.5	24	"		"			.87	(1)	83.3
																	(2)	79.3

(1) Recovery calculated on basis of head assay
(2) Recovery calculated on basis of calcine assay

TABLE NO. 3 MARSHELL PROJECT
MAGNETIC AND ELECTROSTATIC SEPARATION

Magnetic Separation

Feed: -65 mesh +200 mesh
Speed of drum: 110 rpm
Current on field: 3 amperes

Electrostatic Separation

Feed: 34.4% of weight removed by decantation
Speed of drum: 110 rpm
Power: 28 kilovolts

Method	Product	Wt	% Wt	Assays				(1) Recovery			
				Ag	Mn	Zn	Pb	Ag	Mn	Mn	Pb
Magnetic	Tailing	318	81.2	2.00	.57	.3	.31	31.3	7.2	27.1	36.8
"	Conc	73.5	18.8	19.00	31.5	3.5	2.3	68.7	92.8	72.9	63.2
Electrostatic	Slimes	319	35.9	4.93	6.55	-	-	34.44	37.2		
"	Tailing	526	59.5	3.39	3.45	-	-	39.30	32.4		
	Conc	41	4.6	29.16	41.5	-	-	26.26	30.4		

NOTE: When the weight of slimes removed is neglected the recoveries of silver and manganese in the concentrate are 40.0 and 46.3 percent respectively.

(1) Calculated on basis of calculated head

Aa 19.8.8
JHC File

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 11, 1967

Mr. T. D. Henderson
American Smelting and Refining Company
El Paso Smelting Works
P.O. Box 1111
El Paso, Texas 79999

Dear Mr. Henderson:

I am sending you today 11 pulps of composite samples from the Hardshell project for check assaying. These should be essayed for gold, silver, lead, zinc manganese and SiO_2. In addition, I have sent individual samples numbered 25-10 to 25-510 for silver assay and am sending today individual samples 26-10 to 26-200 and 27-10 to 27-200 for silver essay. A list of sample numbers is attached.

Yours very truly,

J. R. Wojcik

JRW:lml
attachment

ASARCO - Tucson, Ariz.
Hardshell Project

10-11-67

Samples for El Paso:

25-10	25-395	26-160
25-20	25-400	26-170
25-30	25-405	26-180
25-40	25-410	26-190
25-50	25-415	26-200
25-60	25-420	
25-70	25-425	27-10
25-80	25-430	27-20
25-90	25-435	27-30
25-100	25-440	27-40
25-110	25-445	27-50
25-120	25-450	27-60
25-130	25-455	27-70
25-140	25-460	27-80
25-150	25-465	27-90
25-160	25-470	27-100
25-170	25-475	27-110
25-180	25-480	27-120
25-190	25-485	27-130
25-200	25-490	27-140
25-210	25-495	27-150
25-220	25-500	27-160
25-230	25-510	27-170
25-240		27-180
25-250	26-10	27-190
25-260	26-20	27-200
25-270	26-30	
25-280	26-40	
25-290	26-50	
25-300	26-60	
25-310	26-70	
25-320	26-80	
25-330	26-90	
25-340	26-100	
25-350	26-110	
25-360	26-120	
25-370	26-130	
25-380	26-140	
25-390	26-150	

Composite samples:

S-9	290-370
S-10	260-380
S-12	30-75
S-15	110-150
S-15A	100-125
S-16	120-185
S-17	10-60
S-18	160-200
S-18	235-265
S-19	120-210
S-20	325-370

Composite samples:

S-9	290-370
S-10	260-380
S-12	30-75
S-15	110-150
S-15A	100-125
S-16	120-185
S-17	10-60
S-18	160-200
S-18	235-265

MR. ERW, WES

READ AND RETURN

PREPARE ANSWERS ..... HANDLE .....

FILE ..... INITIALS .....

J.H.C

SEP 15 1967

W.E.S.

SEP 18 1967

September 15, 1967

J.R.W.

SEP 18 1967

Mr. T. D. Henderson, Senior Metallurgist
El Paso Ore Testing Laboratory
American Smelting and Refining Company
P.O. Box 895
El Paso, Texan 79999

HARDSHELL PROJECT

Dear Sir:

Within the next several days you will be receiving two bags (approximately 125 pounds total) of a composite sample made up of hammer drill cuttings, from five drill holes from the Hardshell Project. An approximate analysis of the sample is as follows:

Oz per Ton		Percent			
Au	Ag	Pb	Zn	Mn	SiO_2
<0.01	4-5	1-1.5	1-1.5	8-10	+80

The material supposedly is all minus 10 mesh.

The following exploratory tests are suggested for the preliminary testwork:

1.) A standard cyanidation test at a grind of 50-55 percent minus 200 mesh.

2.) An oxidizing chloride roast following Waterloo practice and followed by cyanidation.

3.) A reducing roast (Caron process) using a controlled atmosphere and followed by cyanidation.

I have previously forwarded to Mr. Gunther a copy of the Bureau of Mines report by Clevenger and Caron describing the treatment of manganese-silver ores. It will undoubtedly be necessary to forward a small portion of the sample to Central Research for the controlled atmosphere testing once you have decided what parameters you want to investigate.

Yours truly,

G. W. Bossard
Assistant Milling Engineer

GWB:dh
cc: TASnedden
RBMeen
JHCourtright