CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

—Iron King—

Form ISH. 645H (48) 10M 6-62

THE CLEVELAND-CLIFFS IRON COMPANY

INTER-OFFICE LETTER

MINING DEPARTMENT

May 31, 1967

SUBJECT:

REFERENCE:

Dear Bob,

Attached is a copy of the metallurgical results on the iron sample that we picked up that day at the Iron King Mine. Results are quite good as you can see, however, this was evidently a sample of high grade. Never the less the liberation and concentration characteristics are quite good.

Jim Villar has initiated a study with ALLIS-CHALMERS concerning the best systems and capital costs. I recommended that either Hugh Leach or someone from the ore sales department visit Arizona and evaluate the market potential.

I will keep you informed of any developments. I'm also expecting some word on the Mexican project very soon.

Sincerely,

John D Ortman

JDO/re

REFERRED TO........................

NOTED........................

Davis Magnetic Tube Test Results
Sample – L.O. 3952
May 25, 1967

Mn. Grind	-Crude Head-				- Concentrate -						Tail	%	%
	% Fe	% SiO_2	% Sul.	% TiO_2	% wt.	% Fe	% SiO_2	% Sul.	% TiO_2	% Fe Rec	% Fe	-325M	-400M
15	59.00	6.62	.003	.065	85.60	67.90	1.61	.004	.074	98.51	6.10	32.27	27.09

Send to Ford

INVENTORY OF CLAIMS PROTECTED

9-1-61 14 Claims	9-1-62 12 Claims	9-1-63 9 Claims
Iron King No. 1	Iron King No. 1	Iron King No. 1
Iron King No. 3	Iron King No. 3	Iron King No. 3
Iron King No. 4	Iron King " 4	Iron King No. 4
Iron King No. 5	Iron King No. 5	Iron King No. 5
Iron King No. 6	Iron King No. 6	Iron King No. 6
Iron King No. 7	Iron King No. 7	-
Iron King No. 8	-	-
Iron King No. 9	Iron King No. 9	-
Iron King No. 10	Iron King No. 10	Iron King No. 10
Iron King No. 11	-	-
Iron King No. 12	Iron King No. 12	Iron King No. 12
Iron King No. 13	Iron King No. 13	Iron King No. 13
Ferro No. 3	Ferro No. 3	Ferro No. 3
Ferro No. 12	Ferro No. 13	-
14 - CLAIMS	12 - CLAIMS	9 - CLAIMS

March 9, 1967

Mr. John D. Ortman
The Cleveland-Cliffs Iron Company
Ore Mining Department
Ishpeming, Michigan 49849

Re: Iron King Mine
Gila Co., Arizona

Dear John:

In answer to your letter of March 2, it seems your plans will fit mine very well. I intend to leave for Mexico on Friday and be back the latter part of the month.

So far as the iron property is concerned, I expect to have all plan geology maps, cross sections and other data prepared and available. There are many trenches and 14 drill holes from which data is available to support our section and outcrop data.

I doubt if it will be necessary to do much field work on the Iron King Mine; however, there are some other prospects that would be subsidiary to a direct reduction plant in the Globe area. I am also checking on a small coal field thirty miles south of Globe where the U.S.G.S. estimates thirty million tons recoverable anthracite coal by underground mining. You might advise Jim Villar of this because it may make a difference in the method of reduction used.

You are welcome to use my Jalander but perhaps it would be wise to bring some batteries or order some to be sent here. I would appreciate your sending the address of the battery manufacturer. We will be looking forward to you and Jerry coming to Prescott and I hope we can work out something mutually advantageous on this and the uranium venture.

Sincerely,

RF/pc

The Cleveland-Cliffs Iron Company

Ore Mining Department

[illegible] Johnson, Manager
[illegible], Manager [illegible]
[illegible], Ass't. Manager [illegible] and Ore Development

ISHPEMING, MICHIGAN [illegible]

March 3, [illegible]

Mr. Robert B. [illegible]
Box [illegible]
Prescott, Arizona

Dear Bob:

In checking with Jerry Anderson, I find that he will be tied up on business in [illegible] the latter part of March. We are tentatively planning on a trip to [illegible] examine your iron deposit immediately after the 1st of April. Please advise if this fits in with your schedule.

I am considering doing a [illegible] field work on the property if it appears justified and wonder if your [illegible] would be available for this. Let me know your thoughts on this.

Best personal regards to you and your family.

Sincerely,

John D. [illegible]

JDC:[illegible]

The Cleveland-Cliffs Iron Company

Ore Mining Department

E. B. JOHNSON, MANAGER, MICHIGAN MINES
S. W. SUNDEEN, MANAGER, RESEARCH & ORE DEVELOPMENT
J. W. VILLAR, ASS'T. MANAGER, RESEARCH AND ORE DEVELOPMENT

ISHPEMING, MICHIGAN 49849

March 2, 1967

Mr. Robert B. Ford
Box 2337
Prescott, Arizona

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Best personal regards to you and your family.

Sincerely,

John D Ortman

John D. Ortman
Geologist

JDO:kmh

xxxxxxxxxxxx
550 W. Fort StreetDetroit, Michigan
Coolidge, Arizona
March 1, 1967

file Iron King

Mr. Herb Miller
2871 Sky Harbor Boulevard
Suite 1 A
Phoenix, Arizona, 85034

Dear Herb:

I just talked with two Ford Motor Company executives who are old friends of mine and acquainted with our process.

Robert L. Bodor, director of Mining Properties and his assistant Jim McNelis, were in Longviw when plant runs were made for several steel companies and also at Coolidge. McNelis is now manager of New Developments, an im½ortant job, of course.

As you know, Cleveland Cliffs and Ford Motor Company have several joint ventures in developing ore bodies, concentrating and pelletizing plants; Fprd for its own use and Cleveland Cliffs for the market. At one plant alone Ford is making pellets at the rate of 2 million tons a year (yesterday they made 6,000 tons). He has wide aaquaibtance with steel and mining people in the U. S. and abroad and makes frequent trips to Europe, Asis, Australia, Japan or what have you. On Ford's part he heads the joint ventures with Cleve;and Cliffs. R. FORD

As I also knew from other sources, he said that Cleveland Cliffs is eagerly and anxiously looking fir a practical process to turn the hot pellete concentrates into well reduced sponge iron. This is most urgent, he said. "But so are we (that is Ford) and so are all other steel and mining companies who make pellets". Very soon pellets will be amed at the rate of 50 million tons a year.

He urged me to see them and also Cleveland Cliffs. He gave me names of officials of C. E. I should talk with and said he would arrange for a meeting. He, with friends at Fords and with others of steel companies often speak of me and my process. He wants to seem me.

He and the others are now convinced that all direct ~~method~~ reduction processes are failures. "except Madaras" and that the fluidized bed is just about the worst. In general he was the most frank and wants to be helpful.

Mr. Herb Miller

page 2

As to which engineering company they would prefer, he says they are a dime a dozen, any of them can be good if we choose right. He commented that the engineering company would need to carry out the design under my supervision and of course, at their own responsibility. The design is always sent out to builders for construction on a turn key basis. It is done on a 100% guaranty bais.

Sincerely

Julius D. Madaras

copy for Mr. Ford

33-34
110-111

PRELIMINARY REPORT

IRON KING MINE

Gila County, Arizona

and

NOTES ON REDUCED IRON FOR COPPER PRECIPITATION

By

Robert Ford, Mining Geologist
Prescott, Arizona

May 9, 1967

Including Separate Folder of:

General Property and Topographic Map, 1" = 300'
Geologic Plan Map, 1"= 100', "South Ore Body"
Geologic Plan Map, 1"= 100', "North Ore Body"
Cross Sections, 1"= 100', "South Ore Body"
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Preliminary Report

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Many of these replacement deposits have been investigated by the writer. From the standpoint of reserves, availability, and access, the Iron King Mine is considered the most important. That mine, consisting of thirty-eight unpatented claims is under option.

LOCATION

The Iron King Mine is located between Zimmerman and Asbestos Points in the Sierra Ancha Mountains of Gila County, Arizona. Sections 16, 20, 21, and 29 of Township 5 North, Range 14 East center the property. The relationship of the outcrops at or near the 5,500 foot contour can be noted on the McFadden Peak 15' USGS Quadrangle Map.

The mine is reached by driving four miles northwest from Globe on U.S. Highway 60-70 to its junction with the Apache Trail (Arizona Highway 88), then fifteen miles northwest on the Apache Trail to its junction with the Young Road (Arizona Highway 288), then north 15.7 miles on Arizona Highway 288 to

the junction with access roads leading northeast to the property which is visible from the Highway and about two miles distant.

GEOLOGY

Magnetite occurs in irregular contact-metamorphic replacements of serpentinized, chloritized and silicified Mescal limestone that is 100 to 300 feet thick. The altered limestone and magnetite iron is sandwiched between two large diabase sills. The upper sill is probably 500 feet thick and lower about 1000 feet thick. The iron is entirely magnetic and occurs as massive high-grade bodies separated by disseminated and low-grade areas. The magnetite forms two or more beds as much as 100 feet thick. The outcrops can be traced intermittently more than two miles. For purposes of map reference the outcrop zone has been separated into the "South" and the "North" ore bodies. (See accompanying geology maps and cross sections.)

METALLURGY

Magnetic separation beneficiation tests indicate optimum concentrate at -35 +65 mesh grind. Samples submitted to the Pickands Mather Hibbing Laboratory by the W.S. Moore Mining Company when ground to -100 mesh gave an average 63.39% magnetic concentrate. These magnetic tube tests averaged 6.26% SiO_2 with a weight recovery of the total contained iron of 96.01 %. (See attached summary of tests.)

The samples sent to the Hibbing Laboratory were from the number four trench on the "North" ore body and probably metallurgically representative of the entire property. The higher grade natural ores at a one inch to six inch break should average about forty percent iron. A magnetic concentration ratio of 2 to 2½: 1 should be representative of the mine's ore. Certainly the magnetic concentrates from the Iron King Mine, as well as from other similar contact deposits would make an ideal direct-reduction plant feed.

HISTORY AND PREVIOUS WORK

The claims which make up the Iron King Mine were originally located by Mr. Charles H. Jonas, Mining Engineer, in 1957. Shortly thereafter they were optioned to the Cerro de Pasco Copper Company. Cerro spent about $80,000.00

in building roads, trenching, and drilling. The results of their drilling are shown on the accompanying geology maps and sections. The contour representation is that of USGS Quadrangle Map, enlarged.

It is reported that the highest estimate ever expressed by Cerro for the Iron King Mine was eight million tons of plus sixty percent (60%) concentrates. Apparently this was not a sufficient reserve for their plans. Cerro made one semi-annual payment of $7,000.00 and then canceled the lease in 1961. W.S. Moore Mining Company and others subsequently investigated the property. However, the iron market, except for the proposed direct reduction plant product, does not warrent development of the Iron King Mine.

REGIONAL RESERVES

The Iron King Mine is perhaps the best of many contact replacement deposits in the district. By virtue of access and exploration drilling alone it is probably the most important. Several geologically similar high-grade replacement deposits of magnetite have been examined by the writer. Many of these are available for location by staking. Ground or airborne magnetic surveys may well establish an additional potential on the Iron King Mine and other known deposits.

In addition to the contact replacement deposits of the Globe-Miami area, reserves are available from the magnetic sand deposits of adjacent Maricopa and Pinal Counties. The Cuprious magnetites of the Christmas Mine offer a large potential reserve. Iron reserves immediately available and the considearble potential future reserves certainly justify consideration of a small, two hundred to five hundred ton per day direct-reduction plant for purposes of furnishing sponge iron as a substitute for tin cans used in copper precipitation. The cans are increasingly difficult to obtain even at ever higher prices.

NOTES ON THE IRON POWDER PRODUCT

The precipitation of copper on iron is one of the earliest known chemical reactions (6). The iron is usually in the form of shredded and detinned cans, plate, or sponge iron. This form of precipitation is called cementation and the copper precipitate is called cement copper. The copper bearing solution is won by leaching oxide copper ores with dilute sulfuric acid or ferric sulfate. The leach solution is collected and piped over iron

to effect precipitation. Of the many precipitation agents tested, tin cans are considered the most suitable available (4).

Copper is also produced in the same general manner by leach-precipitation-float (LPF). In this process the oxide copper minerals combined with sulfide minerals are selectively and effectively sulfated in solution, precipitated on sponge iron and recovered with the sulfide minerals in floration. Copper produced in the United States from oxide minerals, amounting to 150,000 tons annually, is about ten percent of the total United States output (8). This percentage is steadily increasing. By far the greatest part of the copper produced, from oxides is precipitated on iron at a consumption of about one and one-half tons of iron for each ton of copper recovered.

Arizona provides over fifty percent of the United States' primary copper production. Most of this is centered in Southeastern Arizona, subsidiary to the contemplated direct-reduction plant near Globe-Miami, Arizona. In 1965 that part of Arizona produced 50,000 tons of copper by precipitation from leach solution. By 1970 it is estimated that the production will be 90,000 tons (9). Sponge-iron is produced from pyrite obtained from flotation concentrates at Phelps Dodge Corporation in Douglas, Arizona and from Kennecott's Ray Mines at Ray, Arizona. However, this production is inadequate for their own needs and the low iron content of the calcined pyrites makes an inferior cement copper. In fact, Kennecott, on the first of May of this year, closed its pyrite-sponge-iron plant at Ray and is attempting to purchase fine grained magnetite for reduction and use in the LPF circuit. Expanded facilities at Kennecott's Ray Division will treat an additional 10,000 tons of oxide copper ores daily. The fifty tons per day of copper so produced will require about seventy-five tons of iron per day. That sponge-iron from direct-reduction processes will play an important part in this simple reaction is well established and justified. Kennecott (1) and Phelps Dodge (3) have each developed precipitation vessels or launders to handle sponge iron.

Increased production by precipitation on tin cans combined with the decreased availability of cans due to the substitution in packaging of aluminum, plastic, glass, and waxed containers has already made it difficult to obtain sufficient quanities and quality of iron from the scrap market; the situation is steadily becoming worse. The cost of cans delivered to the Arizona copper mining districts is quoted at $55.00 to $57.00 per ton. Demand is not satisfied and standby substitutes such as shredded auto bodies, wire, chains, and assorted scrap metal are being used. The contaminates present in these substitutes and their relative

inefficiency as precipitating agents result in higher cost and less pure cement copper. Reduced iron pellets were tried and found unsatisfactory (10).

Sponge-iron precipitates copper sulfate in one-third the time with about eighty percent of the iron used compared to cans. Labor savings are also considerable. Sponge iron is certainly perferable to other types for precipitating iron and should sell for $60.00 to $65.00 per ton.

Respectfully Submitted

Robert Ford, Mining Geologist

May 9, 1967

REGISTERED GEOLOGIST
CERTIFICATE NO. 5451
ROBERT FORD
Signed 5-9-67
ARIZONA, U.S.A.

BIBLIOGRAPHY

1. Black, A.E.: Use of Particle Iron in Precipitation of Copper from Dilute Solutions. Presented 95th Annual Meeting of AIME, New York, New York.

2. Harrer, C.M.: Reconnaissance of Iron Resources in Arizona. U.S. Bureau of Mines Information Circular. 8236, 1964, 204pp.

*3. Hogue, W.G.: Use of Sponge Iron in the V-Trough Precipitator. Mining Congress Journal, Vol 53, January, 1967, pp. 17-20.

4. Hon, C.Li.: Chemical Processing: Copper. Mining Engineering, Vol 19, February, 1967, pp. 122-123.

5. Julihm, C.E., and Moon, L.B.: Summary of Bureau of Mines Exploration Projects on Deposits of Raw Materials Resources for Steel Production. U. S. Bureau of Mines Report of Investigation 3801, 1945, 35pp.

***6. Monninger, Frank M.: Precipitation of Copper on Iron. Mining Congress Journal, Vol 49, October, 1963.

**7. Spedden, H. R., Malouf, E.E. and Prater, J.D.: Cone-Type Precipitators for Improved Copper Recovery. Mining Engineering, Vol 18, April, 1966, pp. 57-62.

8. Wideman, F. L.: Copper: Mineral Facts and Problems, 1965 Edition. U.S. Bureau of Mines Bulletin 630, 1965, pp. 276-278.

9. The Wide World of Hydrometallurgy: Dump Leaching; LPF; Copper Precipitation Tank. Engineering and Mining Journal, Vol 167, September, 1966, pp. 175-177.

***10. Precipitation of Copper from Dilute Solutions: A Digest. Engineering and Mining Journal, vol 18, June, 1966, pp. 70-74.

* Papers on mechanics of using sponge-iron for copper precipitation

** Excellent paper on increased copper production comparison of other precipitation methods with precipitation of copper on iron.

*** Apt description of present and future [illegible] of iron for precipitation of copper from dilute solutions.

ARIZONA IRON MINES, INC.

(Iron King Group)

Pickands Mather
Hibbing Laboratory
W. S. Moore Mining Co.

3-23-61

MAGNETIC TUBE TESTS

SAMPLE	SIZE	PRODUCT	% WT.	ASSAY % IRON	ASSAY % SILICA	% TOTAL IRON
1.	-100M	Mag.Conct.	79.06	66.23		98.11
		NonMag.tails	20.94	4.82		1.89
		TOTAL	100.00	53,37	9.57	100.00
2.	-100M	Mag.Conct.	22.12	54.55		92.32
		NonMag.Tail	77.88	1.29		7.68
		TOTAL	100.00	13,02	5.36	100.00
3.	-100M	Mag.Conct.	82.69	69.60		97.60
		NonMag.tail	17.31	8.32		2.40
		TOTAL	100.00	58.99	3.84	[illegible]

CRUDE ANALYSIS

SAMPLE	Fe	SiO2	P	S	TiO2
1.- South Outcrop -	53.37	9.57	.072	.007	.04
2.- South-Low Grade-	13.02	5.37	.343	(High in CaCO3)	
3.- North trenches-	58.99	5.84	.021	.003	.11

Explanatory Notes:

Above samples taken by Irving Moore, Geologist of Duluth, Minn.

Special attention is called to the # 3 sample, where at 100 M grind, the iron content is 69.60.

At 325 M, which was not tried, the grade would be 70. % Fe. This is probably as high grade concentrate as can be found in a [illegible] side of Brazil.

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ROBERT FORD & ASSOCIATES
GEOLOGISTS

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Robert Ford

Robert Ford, Mining Geologist

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REGISTERED GEOLOGIST
CERTIFICATE NO. 5451
ROBERT FORD
Signed 5-9-67
ARIZONA, U.S.A.

BIBLIOGRAPHY

1. Black, A.E.: Use of Particle Iron in Precipitation of Copper from Dilute Solutions. Presented 95th Annual Meeting of AIME, New York, New York.

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* Papers on mechanics of using sponge-iron for copper precipitation

** Excellent paper on increased copper product[illegible] comparison of other precipitation methods with precipitation of copper on iron.

*** Apt description of present and futu[illegible] of iron for precipitation of copper from dilute solutions.

ARIZONA IRON MINES, INC.

(Iron King Group)

Pickands Mather
Hibbing Laboratory
W. S. Moore Mining Co.

3-23-61

MAGNETIC TUBE TESTS

SAMPLE	SIZE	PRODUCT	% WT.	ASSAY % IRON	ASSAY % SILICA	% TOTAL IRON
1.	-100M	Mag.Conct.	79.06	66.23		98.11
		NonMag.tails	20.94	4.82		1.89
		TOTAL	100.00	53,37	9.57	100.00
2.	-100M	Mag.Conct.	22.12	54.55		92.32
		NonMag.Tail	77.88	1.29		7.68
		TOTAL	100.00	13.02	5.56	100.00
3.	-100M	Mag.Conct.	82.69	69.60		97.60
		NonMag.tail	17.31	8.52		2.40
		TOTAL	100.00	58.99	3.84	[illegible]

CRUDE ANALYSIS

SAMPLE	Fe	SiO2	P	S	TiO2
1.- South Outcrop -	53.37	9.57	.072	.007	.04
2.- South-Low Grade-	13.02	5.57	.348	(High in CaCO3)	
3.- North trenches-	58.99	5.84	.021	.003	.11

Explanatory Notes:

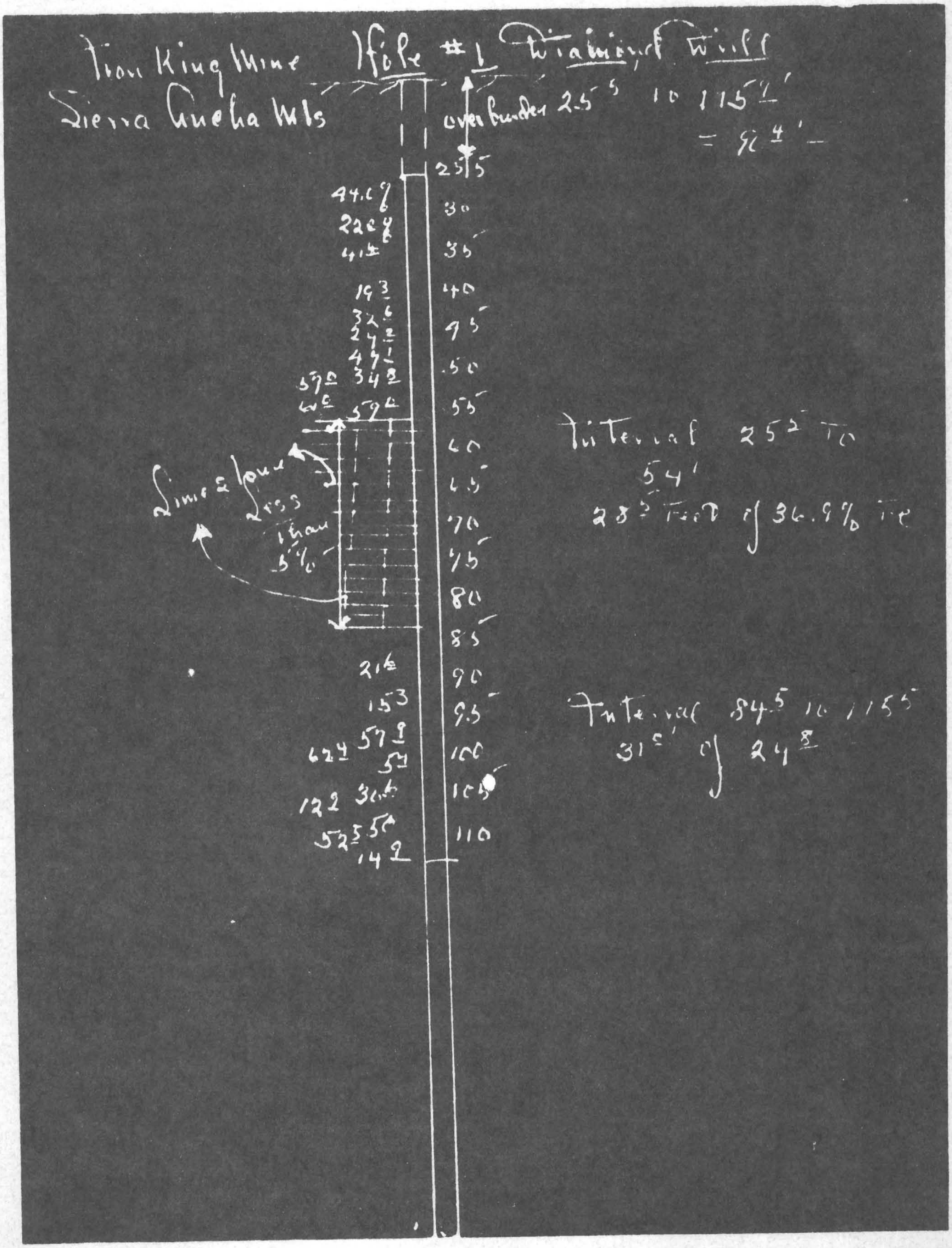
Above samples taken by Irving Moore, Geologist of Duluth, Minn.

Special attention is called to the # 3 sample, where at 100 M grind, the iron content is 69.60.

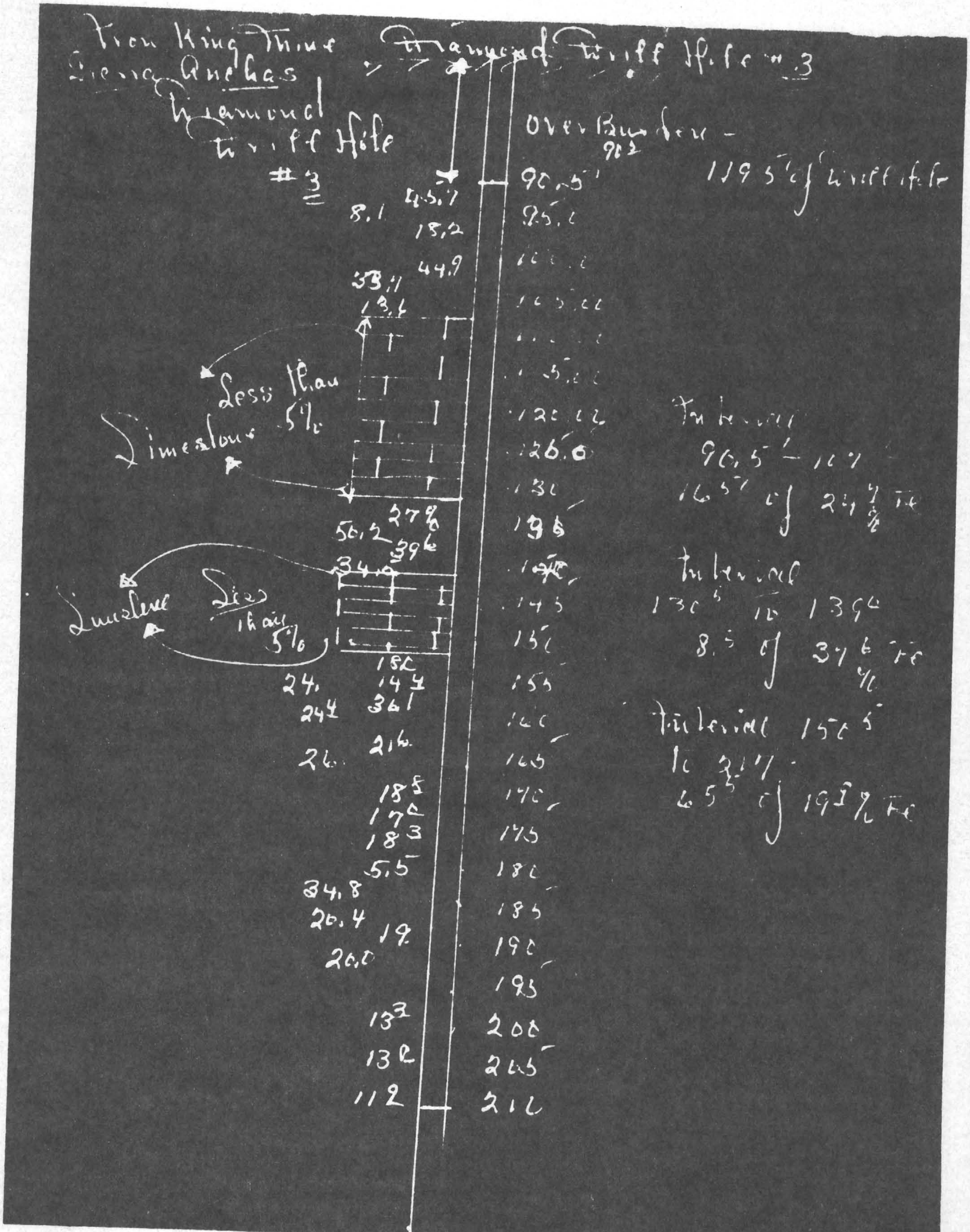
At 325 M, which was not tried, the grade would be 70. % Fe. This is probably as high grade concentrate as can be found in a [illegible] side of Brazil.

INVENTORY OF CLAIMS [illegible]

9-1-61 14 Claims	9-1-62 12 Claims	9-1-63 9 Claims
Iron King No. 1	Iron King No. 1	Iron King No. 1
Iron King No. 3	Iron King No. 3	Iron King No. 3
Iron King No. 4	Iron King " 4	Iron King No. 4
Iron King No. 5	Iron King No. 5	Iron King No. 5
Iron King No. 6	Iron King No. 6	Iron King No. 6
Iron King No. 7	Iron King No. 7	-
Iron King No. 8	-	-
Iron King No. 9	Iron King No. 9	-
Iron King No. 10	Iron King No. 10	Iron King No. 10
Iron King No. 11	-	-
Iron King No. 12	Iron King No. 12	Iron King No. 12
Iron King No. 13	Iron King No. 13	Iron King No. 13
Ferro No. 3	Ferro No. 3	Ferro No. 3
Ferro No. 12	Ferro No. 15	-
14 - CLAIMS	**12 - CLAIMS**	**9 - CLAIMS**



Iron King Mine
Sierra Ancha Mts
Hole #1 Diamond Drill
overburden
25.5
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
44.0%
22.0%
19.3
Lime & gouge less than 5%
Interval 25.2 to 54'
Interval 84.5 to 115.5


Iron King Mine
Diamond Drill Hole #3
Diamond Drill Hole #3
OverBurden - 90.5'
119.5' of Drill Hole
90.5'
95.0
45.7
8.1
18.2
44.9
33.4
13.4
Less than 5%
Limestone
126.0
130
135
27%
56.2
39%
34.0
Limestone Less than 5%
145
150
155
160
165
170
175
180
185
190
195
200
205
210
18.0
24.
14.4
24.4
36.1
26.
21.6
18.5
17.0
18.3
5.5
34.8
20.4
19.
20.0
13.3
13.0
11.2
Interval
90.5' - 107
16.5' of 24.7% Fe
Interval
130.5 to 139.0
8.5 of 37.6% Fe
Interval 150.5
to 216
65.5 of 19.7% Fe

Core Drill Hole # 4 100' To 330'

Iron King Mine
Sierra Anchas Mts
Gila County
Arizona
Limestone
Less than 5% Fe

Over Burden 104'

11.3%
1.5%
17.2%
20.9 18.6
17.2
23.5
21.7
43
32.2
.40
37.4
14.5
29.6
41.3
27.2
26
21.2
18.1
20.6
17.1
12.2
14.8
19.6
13.8
13.0
15.5
12.0
12.8
14.2
0
0
22.2
29.8 22.1
25.2
16.5 19.5
17.2

100'
110'
120'
130'
140'
150'
160'
170'
180'
190'
200'
210'
220'
230'
240'
250'
260'
270'
280'
290'
300'
310'
320'
330'

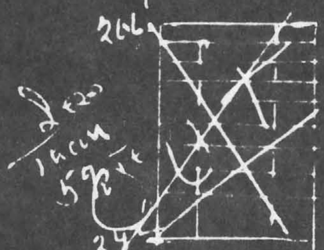
Interval
140' - 330'
190' of 18.5% Fe

Interval 140 - 175'
35' of 19.3% Fe

Interval 175 - 220'
45' of 31.7% Fe

Interval 175 - 285'
110' of 17.2% Fe

Interval 295 - 330'
35' of 2.-% Fe



Diamond Drill Hole #5

Iron King Mine
Sierra Ancha Mts
Gila - County
Arizona

136.5' overburden

41'%

136.5		
140'	41.1% Fe	
	15.2%	
145'	16.6%	
150'	29.4%	
	25.3%	
155'	24.6%	
160'	7.7%	
165'	37.2%	
	34.2	28.2
170'	47.5	45.9
175'	48.0	55.6
180'	33.8	48.6
185'	19.7	34.2
190'	36.3	29.4
	26.8	24.8
195'	44.2	51.5
200'	33.6	
205'	43.2	
210'	46.5	
215'	18.8	
220'		

Ore -
136.5' To 218'
81.5'

Interval
136.5 - 226
89.5 of 30.7% Fe

Interval
158' - 218'
60' of 35.9% Fe

Interval
158' - 180'
22' of 41.8% Fe

Interval
201 - 218'
17' of 34.5%

Diamond Drill Hole #6

Iron King Mine
Sierra Ancha Mt
Gila County
Arizona

overburden
104'

4⁰% 36.9%
19⁶% 67%
31⁸ 36

104	
113	
125	
135	
145	
155	
165	
175	
185	
195	
205	
215	
225	
235	
245	
255	
265	
275	
285	
295	

37⁶
13⁶ 32⁷
27³
34⁶ 47⁵
23⁶
26² 38²
37⁰
35¹ 27⁵ 7²
7² 5²
21⁸
16⁵ 5⁶ 48²
12⁴ 22⁰
8⁰ 24⁸ 17⁰
6² 17⁴

Limestone
26'

26⁴
16³
32⁷ 2'

8¹ 34⁶
28⁶
10³ 46 30²
26¹ 36
35²

Interval
104 - 206
102' of 21⁷% Fe

Interval
104 - 121'
17' - 19⁹% Fe

Interval
126 - 159⁵
33⁵' - 28⁷% Fe

Interval
139 - 148'
9' - 38'% Fe

Interval 149⁵
to 159⁵
10' - 31⁹% Fe

Interval
159⁵ to 206
46⁵' of 17⁹% Fe

Interval - 181 - 189'
8' of 28⁴% Fe

Interval
272 - 294'
22' of 22¹% Fe

Interval
272 - 279'
7' of 27⁴% Fe

Interval 288 - 294
6' of 21⁸% Fe

ASSAY LOG CDH #7 - IRON KING

Footage	Assay
115 - 120	11.1
120 - 125	10.7
125 - 130	12.7
130 - 135	5.0
135 - 140	3.4
140 - 145	3.0
145 - 150	3.4
150 - 155	4.5
155 - 160	6.0

Interval 115 - 160
No plus 20% Iron

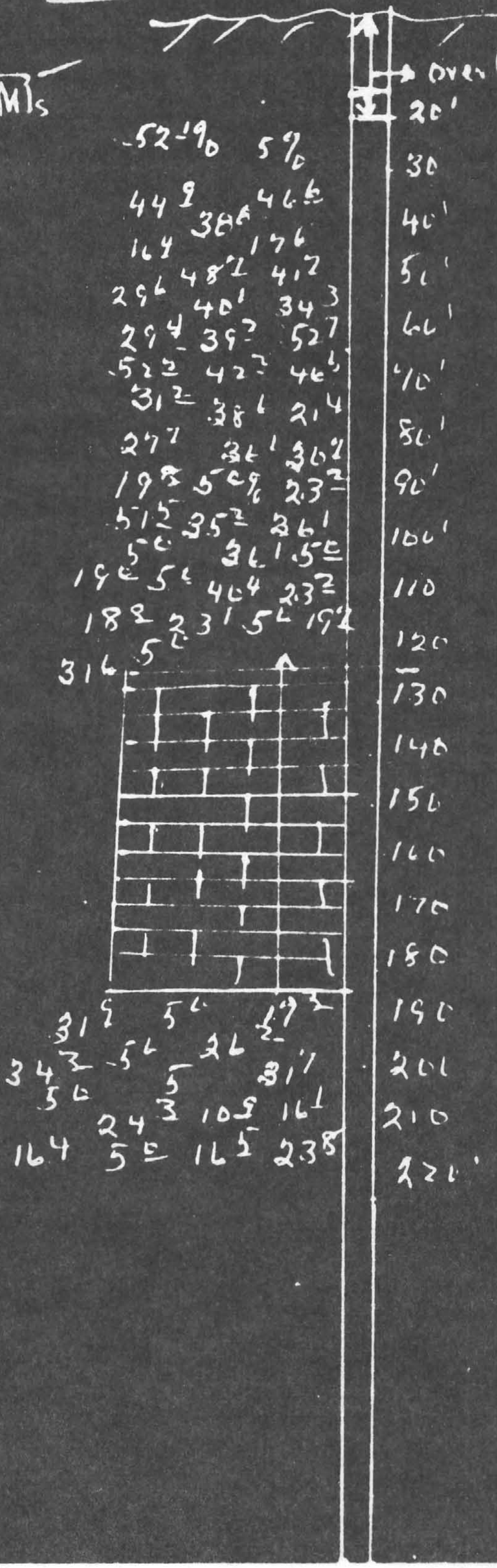
ASSAY LOG DDH #8 - IRON KING

Footage	Assay
50 - 55	10.6
55 - 60	7.6
60 - 65	7.8
65 - 70	7.4
70 - 75	14.9
75 - 80	6.4
80 - 84	5.5
84 - 88	11.3

Interval 50' - 88'
No plus 20% Fe

Diamond Drill Hole #9

Iron King Mine
Sierra Ancha Mts
Gila County
Arizona –



Interval
20' – 220'
200' 16.9 Fe

Interval
20 – 72'
52' of 31.0 Fe

Interval
72' – 121'
49' of 23.0 Fe

Interval
187 – 202
15' of 22.8% Fe

ASSAY LOG DDH #9 - IRON KING

Footage			Assay
20	-	24	52.1
24	-	34	5.0*
34	-	36	46.6
36	-	38	44.9
38	-	40	38.8
40	-	42	16.4
42	-	44	17.6
44	-	46	48.7
46	-	48	41.7
48	-	50	29.6
50	-	52	40.1
52	-	54	34.3
54	-	56	29.4
56	-	58	39.2
58	-	60	52.7
60	-	62	52.5
62	-	64.8	42.2
64.8	-	70	46.5
70	-	72	31.2
72	-	74	38.6
74	-	76	21.4
76	-	78	27.7
78	-	80	36.1
80	-	82	19.8
82	-	85	5.0*
85	-	87	30.7
87	-	89	23.2
89	-	91	31.5
91	-	93	35.2
93	-	95	36.1
95	-	97	5.0*
97	-	99	36.1
99	-	100	5.0*
100	-	102	19.0
102	-	105	5.0*
105	-	107	40.4
107	-	109	23.2
109	-	111	18.8
111		113	23.1
113	-	116	5.0*
116	-	118	19.7
118	-	119	5.0*
119	-	121	31.6
121	-	184	0.0*
184	-	186	17.3
186	-	187	5.0
187	-	189	31.9
189	-	191	26.2
191	-	192	5.0*
192	-	194	31.7
194		196	5.0*

Interval 20' - 220'
200' of 16.9% Fe

Interval 20' - 72'
52' of 31.0% Fe

Interval 72' - 121'
49' of 23.0% Fe

Interval 187' - 202'
15' of 22.8% Fe

ASSAY LOG DDH #2 - (Cont'd.)

Footage	Assay
196 - 198	34.3
198 - 199	5.0*
199 - 202	24.3
202 - 206	10.9
206 - 211	16.1
211 - 213	16.4
213 - 216	5.0*
216 - 218	16.5
218 - 220	23.8

Estimated grade for intervals too low to assay.

ASSAY LOG DDH #10 - IRON KING

Footage	Assay
0 - 210	None
210 - 211	Med.
211 - 262	None
262 - 263	Med.
263 - 332	None

No assays because there is essentially no iron to assay.

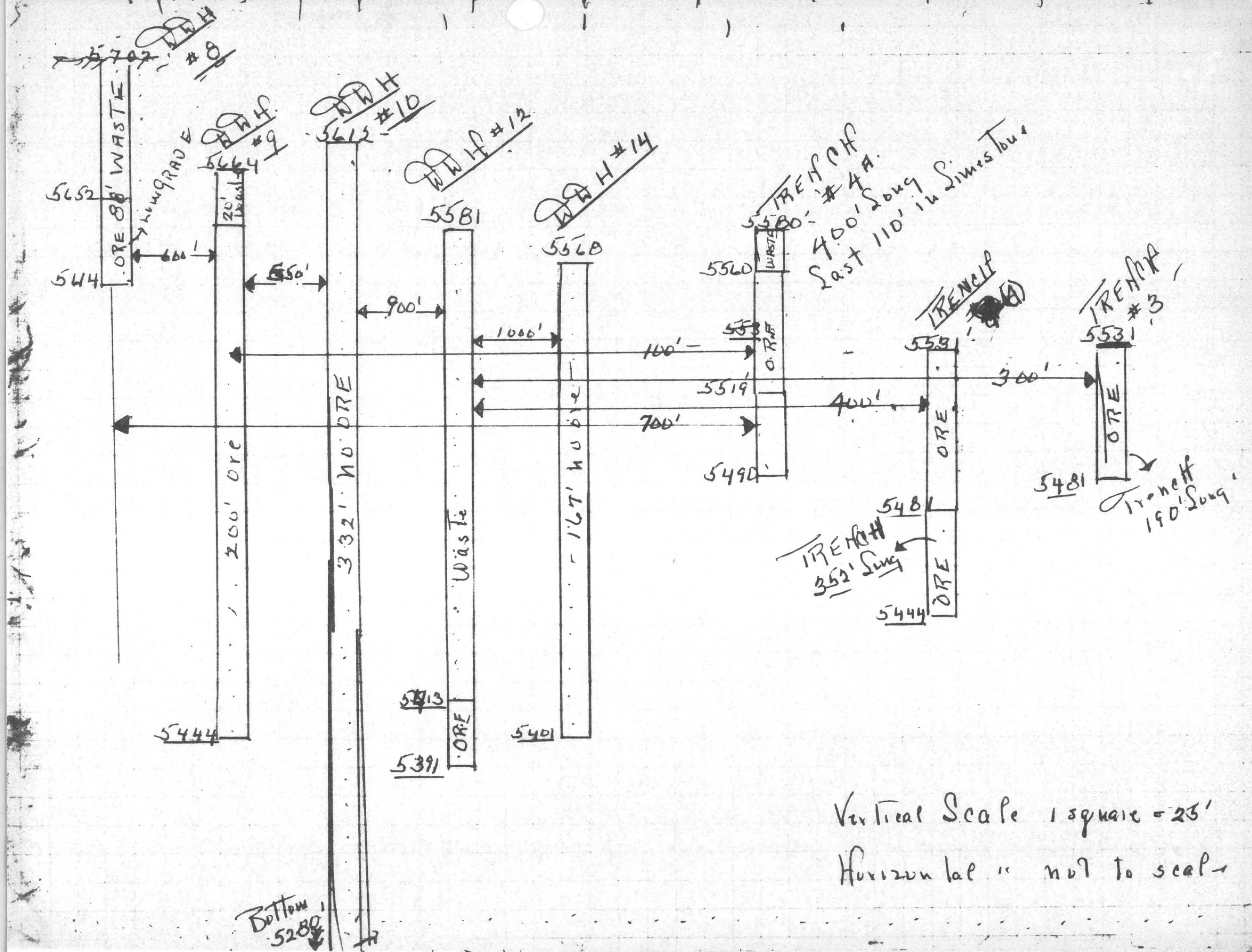
ASSAY LOG DDH #14 - IRON KING

Footage	Assay
0 - 167	None

(1)

Elevation of Collar of	Depth	Elevation of Bottom of Ore	Elevation of Top of Ore	Assays at Bottom
DH #9 - 5664	220'	5444	5644	200-211- 16.1% 211-213 16.4% 213-216- 5.0% 216-218 16.5% 218-220- 23.8%
TRENCH 4A 100' along strike from Drill Hole #9 - 5580' Elevation Top of Trench ~~5500~~ ~~5520'~~	Length 400'	5664 3580 84 5502'	5564'	Last 180' from 290 to 408' in Altered Limestone Low grade 4.5% to 8% Fe -
TRENCH #3 - 3 1500' along strike from DH #9 - 5520 Elevation of TRENCH	Length 230' Last 40' Covered & no samples (190 net.)	5470	5520' ~~5470~~	140-160 45.0% 160-170 48.8% 170-180 39.3% 180-190 - 29.2% Covered to 280'
TRENCH #4 - 1600' along strike from DH #9 - Elevation Top of Trench 5526	Length 352'	5435 ~~5470~~ ~~5435~~	~~5526~~ 86 ~~5434~~ 5520	~~77 8~~ 309-319- 25.8% 319 to 329- 17.4% 329 to ~~349~~ 352 - 18.7%

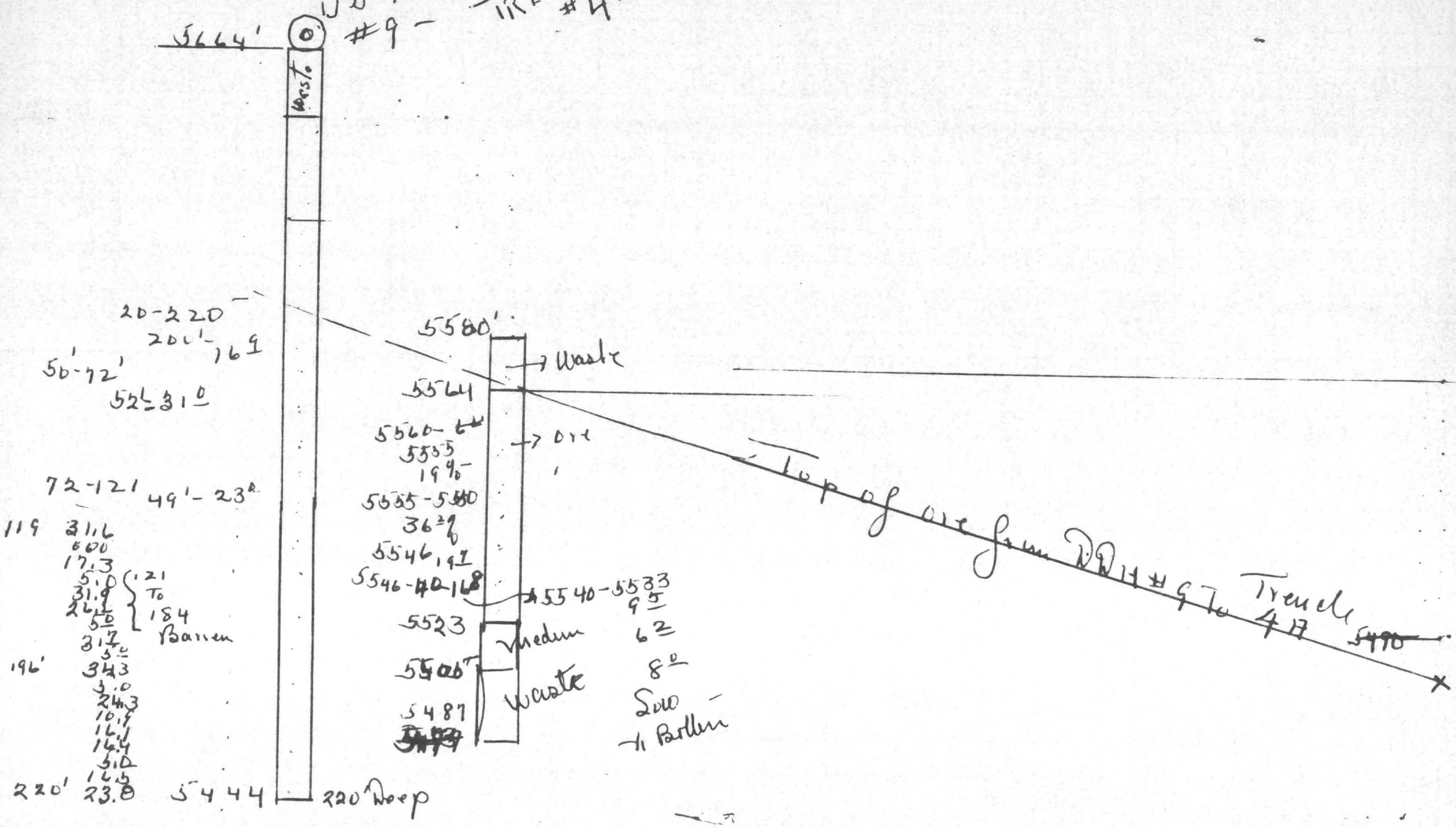
Thickness of ORE Beds		DH #9 -	200'	Average of TRENCHES
TRENCH 4A			62'	
TRENCH #3			50'	3) 198 66'
TRENCH 4			86' -	

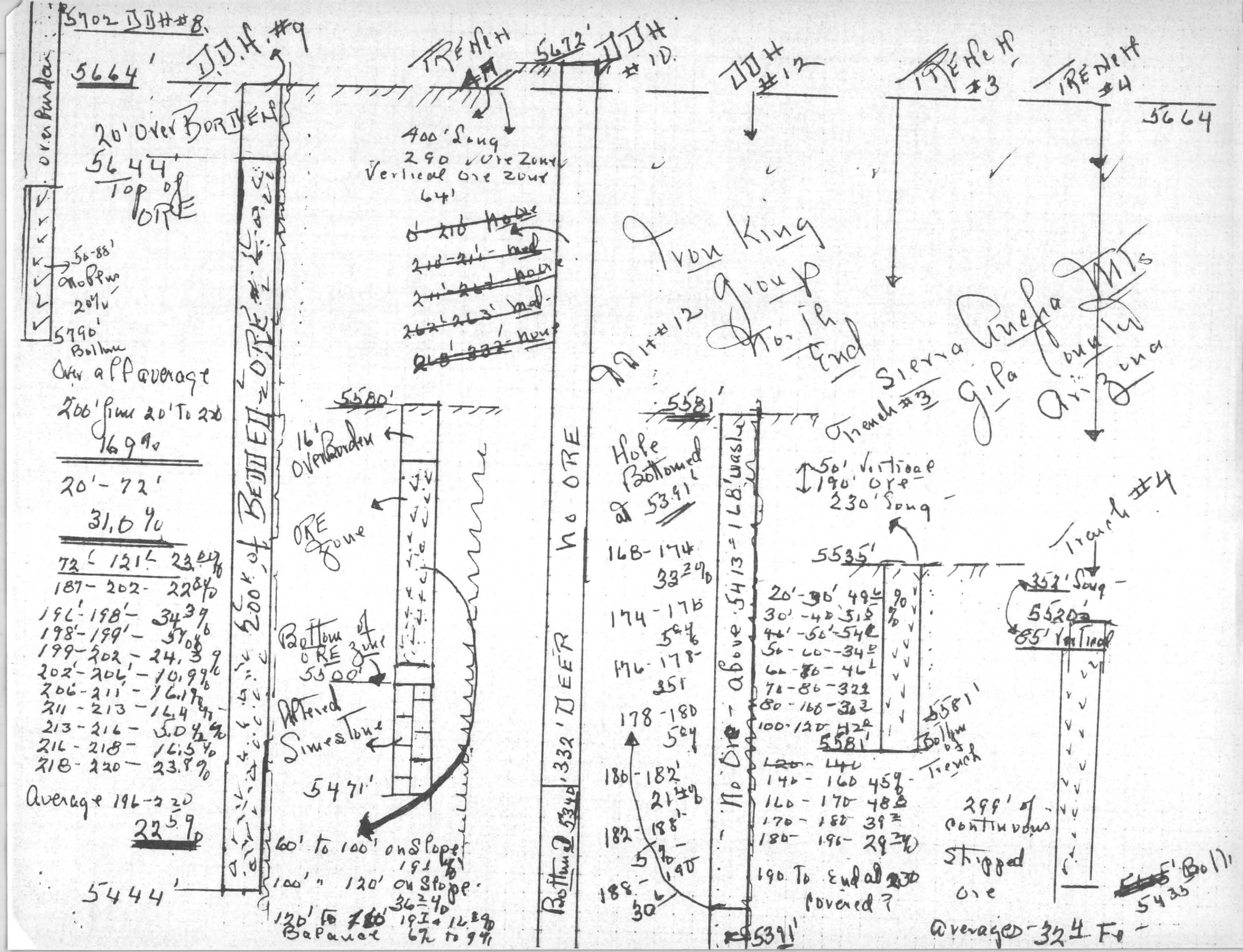


Vertical Scale 1 square = 25'

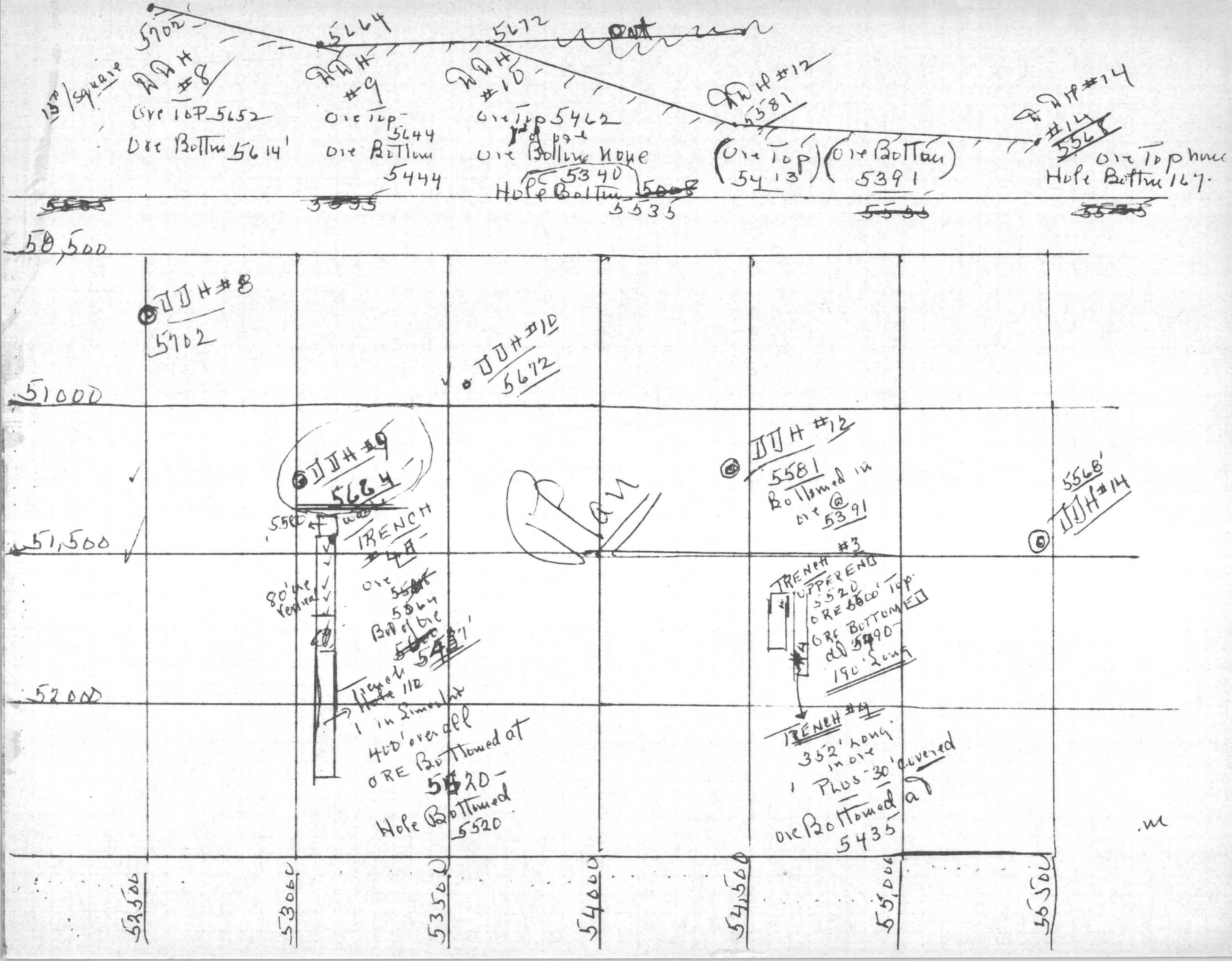
Horizontal " not to scale

JII #9 - TRENCH #4A





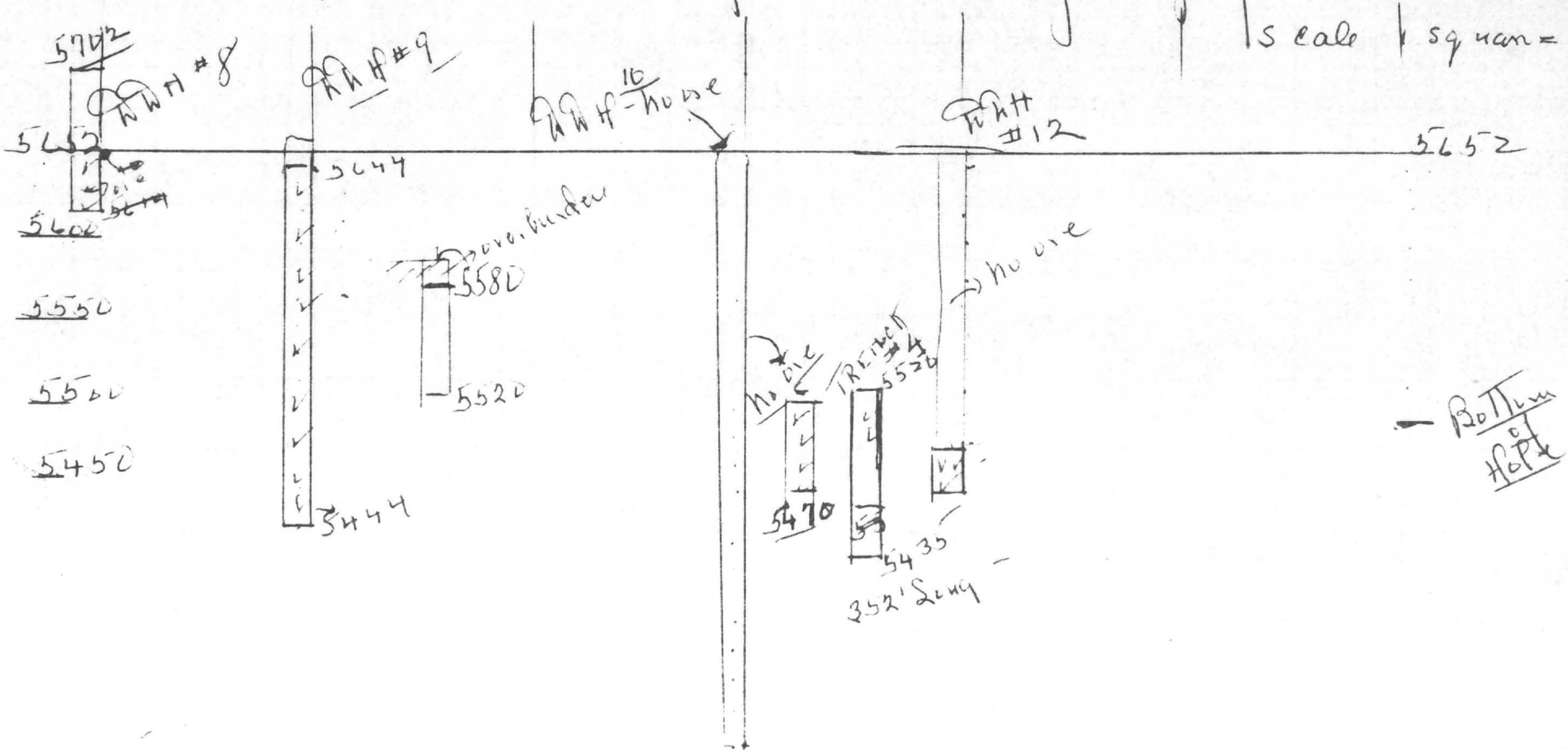
5702 DDH #8
overburden
5664'
DDH #9
20' Over Burden
5644'
Top of ORE
56-88'
20%
5790'
Bottom
Over all average
200' from 20' To 220
16.9%
20'-72'
31.0%
72'-121' 23.8%
187-202- 22.8%
196'-198'- 34.3%
198'-199'- 37.0%
199-202- 24.3%
202'-206'- 10.9%
206-211- 16.1%
211-213- 16.4%
213-216- 15.04%
216-218- 16.5%
218-220- 23.8%
Average 196-220
22.5%
5444'
200' of BEDDED ORE #2
TRENCH #A
400' Long
290 Ore Zone
Vertical Ore zone
64'
0-210 none
210-211- med
211-262 none
262-263' med
263'-332' none
5580'
16' OverBurden
ORE Zone
Bottom of ORE zone
5500'
Altered Limestone
5471'
60' to 100' on Slope 19.1%
100' " 120' on Slope 36.4%
120' to 180' 19.1 + 12.8%
Balance 6% to 9%
5672'
DDH #10
No ORE
332' DEER
Bottom 5340
DDH #12
Iron King Group
North End
Hole Bottomed at 5391'
5581'
168-174 33.2%
174-176 5.4%
176-178- 35%
178-180 5.4%
180-182' 21.4%
182-188' 5%
188-190 30%
5391'
No Ore - above 5413 = 168' wash
DDH #12
TRENCH #3
Trench #3
Sierra Ancha Mts
Gila County
Arizona
50' Vertical
190' Ore
230' Long
5535'
20'-30' 49.6%
30'-40' 51.5
40'-50'-54.0
50-60-34.0
60-70-46.1
70-80-32.1
80-100-30.2
100-120 42.5
5581'
120-140
140-160 45%
160-170 48%
170-180 39%
180-190- 29.3%
190 To End at 230
covered?
5581'
Bottom of Trench
TRENCH #4
Trench #4
5664
352' Long
5520'
85' Vertical
299' of continuous Stripped ore
Averaged - 32.4 Fe -
5435' Bottom



5702
5644
5672
DDH #8
Ore Top 5652
Ore Bottom 5614'
DDH #9
Ore Top 5644
Ore Bottom 5444
DDH #10
Ore Top 5462
Ore Bottom None
5340
Hole Bottom
5535
DDH #12
5581
(Ore Top) 5413
(Ore Bottom) 5391
DDH #14
5568
Ore Top None
Hole Bottom 167.
50,500
51000
51,500
52000
52500
53000
53500
54000
54,500
55,000
55500
DDH #8
5702
DDH #10
5672
DDH #9
5664
TRENCH
80' ore
400' over all
ORE Bottomed at
5520
Hole Bottomed
5520
DDH #12
5581
Bottomed in ore @ 5391
5568'
DDH #14
#3
TRENCH
UPPER END
5520
ORE 5500' Top
ORE BOTTOMED
190' Long
TRENCH #4
352' Long
in ore
Plus 30' covered
Ore Bottomed at
5435

Chart Showing Contour of Top of Ore Bodies Elevation

Scale 1 square = 15'



FROM SURFACE TO HOLE

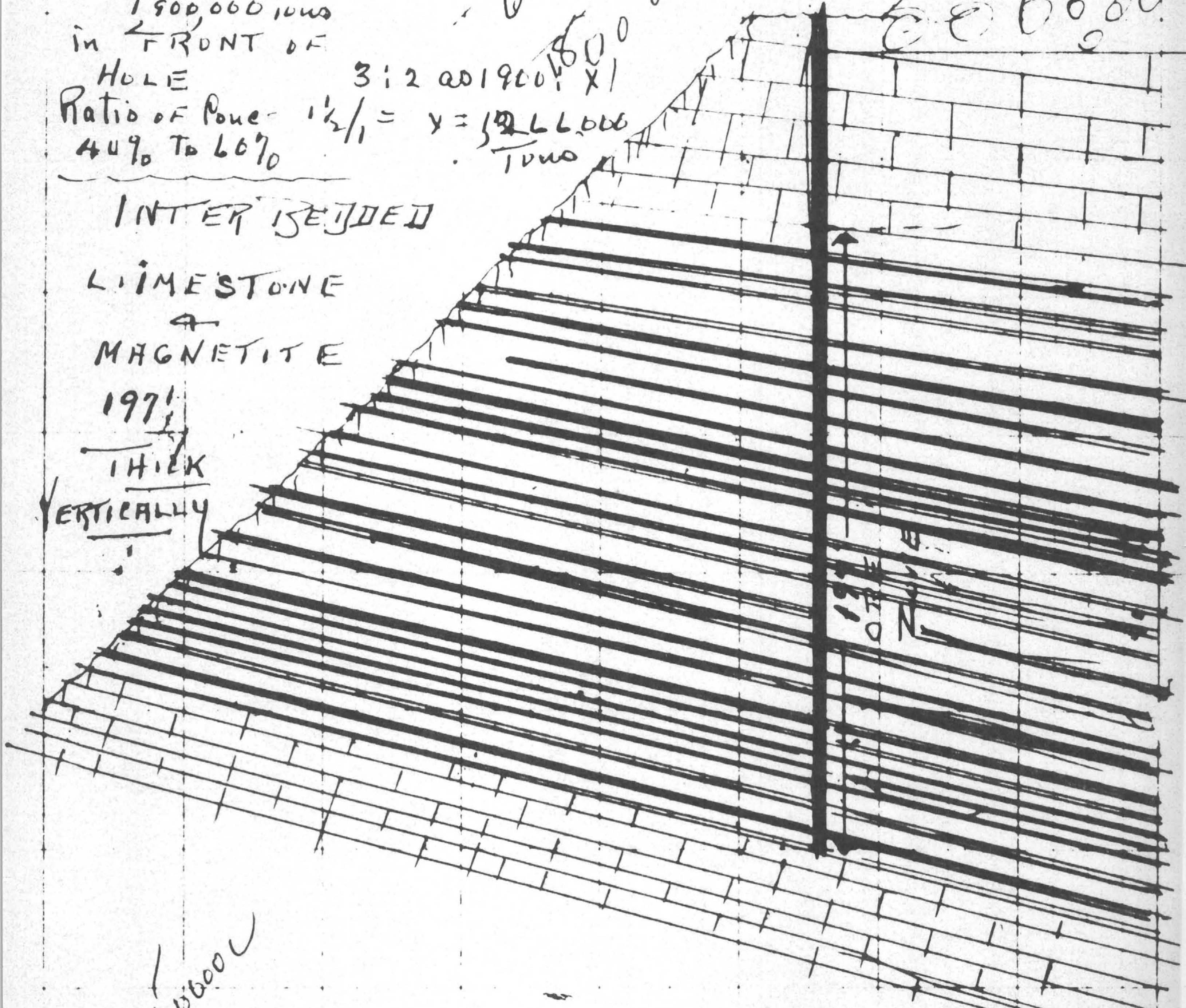
T = 190'
L = 500'
W = 200

500
200
100000
190
19000000
10 cu ft/Ton
1900000 Tons
in FRONT OF HOLE

3:2 as 1900:X
Ratio of Pone 1½/1 = X = 1266000 Tons
40% To 60%

3000 200 16 | 18000000 | 1125000
600000 300 14 200
80000000 16/40

Via Pass
Alluvial



INTERBEDDED
LIMESTONE
&
MAGNETITE
197'
THICK
VERTICALLY

1160000

December 9, 1966

Mr. Jerry Mills
2222 South 27th Street
Phoenix, Arizona

My dear Jerry:

The people in Globe who know the roads up the hill and who know the property are:

1) Rusty Moore - everyone in Globe know him as Rusty.

2) Wayne Hamman

3) R. F. (Red) Henderson.

The property is 34 miles from Globe and about four miles from the Highway to Young (paved)

You cross the bridge at the Intersection of the Gila and the Roosevelt Lake, then 11 miles to the mine road turn-off.

I will send a map but going up there alone would be a waste of time.

A helicopter would be my choice for efficiency.

You could land on the outcrop at the south end and then land at the North end cabin and walk a half mile up a badly washed road or have a power wagon meet you.

Sincerely,

C. A. Johas

There was one thing left out of my report because I did not want to exploit a name. But when I met Donald J. Fresch, Manager of Solid State Materials at Motorola, the first morning (cold) he made an appointment for lunch (and he paid for it). After that we had breakfast together about ten times in the next two or three weeks.

It finally got to the point where he wanted to continue the testing on a basis of 50-50 - with ______________, a consultant, and myself as the financing part of the deal.

Also, when I got to the C. K. Williams Co. (now absorbed by Pheizer Pharmaceutical), they shifted me up until I was with the head guy in the Emeryville plant.

I was with him several times. He finally dismissed me with the statement, "I believe that we can make ferrites more cheaply synthetically." He never questioned my different approach, and I am repeating what is said in my report - amplified.

My theory was and is based on the theory or theories as follows:

It was not until iron oxides were made into an absolutely pure state and then rebuilt - molecularly into ferrites - that the potential television image was increased from 8" to 16".

It was my theory that in certain forms of iron oxides, old Mother Nature had inculcated certain inherent characteristics and phenomena that were perpetual as long as the overall structure was not altered from Mother Nature's original form through treatment of pyrometallurgy or chemical dissolution.

I pointed out that what was involved was a change in the geometric pattern, the lattice structure, the x-ray diffraction characteristics, and surface transfiguration. I wanted to find an iron ore that was amenable to removal of lime, silica, alumina, titanium, vanadium, sulfur and phosphorous, without attacking the iron molecule.

The Iron King ore starts so high, in grade, has such common impurities, that I regard it as a perfect trial ore for experiments.

I would prefer to come over to Phoenix and meet with your people, and if they furnish the power wagon - go up the hill.

As far as showing the property is concerned, the following people in Globe have done assessment work on the property and know when the outcrops start and finish, where the holes were drilled and where the trenches are shown.

* * * * * * * * * * * * * * *

Jerry and Jim - I know that I have dug up a unique, possibly nutty, idea, but it has been discussed by me, with learned technical brains, and so far it has not been laughed at. It might be a patentable breakthrough. Old Mother Nature still has secrets.

But the guys you have in tow know more in a minute than I will ever know. (Maybe I am a second Dave McConnell.)

CHJ

I shall forward maps, assays, road maps, drill records, etc.

THE IRON KING GROUP OF MINING CLAIMS

COON CREEK, ARIZONA

My connection with this group of mining claims started with a casual inspection, on the recommendation of an experienced prospector from Miami, Arizona.

In my sixty years of poking around the mining camps of the Southwest and Mexico, I have seen probably a hundred iron and iron manganese properties without, in most cases, taking a second look.

In the case of the Iron King, I spent enough time to conclude that it was unusual and worthy of a drilling program.

Legal Title:

An investigation showed that the property (at that time 10 claims) had been held by doing <u>no annual labor</u> and merely filing an Affidavit of Labor.

Proper locations were then made and a Quiet Title Suit was filed and won by me.

The legal fees in this unpleasant suit amounted to three thousand dollars.

* * * * * * * * * * * * * * * *

When the judgement was handed down, I immediately contacted the Western Unit office of Cerro de Pasco Corporation at Tucson, Arizona (now the Cerro Corporation - Tucson office now closed.)

The Cerro Corporation took an option at a price of $437,500 - a 14-year contract with a balloon payment in 14 years and $14,000 per year after one year.

They spent many months on the property with their geological staff and followed up with a program of road building, trenching and core drilling that, I was told, cost close to $100,000.

Six months after completion of the drilling program, Cerro made one semi-annual payment under their option (of $7,000) and I figured that I was going to receive it for fourteen years. However, five months later they cancelled out.

By this time, an Arizona corporation composed of three stockholders had acquired title and the present ownership is in a position to deliver good valid mining claim title by quit claim, and eventual patent title.

Cerro de Pasco's reason for their interest in the Iron King group was that Cerro proposed to construct in the area between the Iron King group and Globe, a sponge iron plant to produce iron powder as a substitute for tin cans and in copper precipitation.

The idea was sound then and is <u>more than ever sound today</u>.

The invasion of aluminum as a substitute for iron in the manufacture of tin cans has cut the iron tin-can product in half.

In order to compete, the tin can industry has met part of the competition by reducing the gauge of their cans 50%.

This means that the new cans require twice the bulk in order to furnish the same tonnage for copper replacement.

This has resulted in more bulk in the original laundries and/or tumbling equipment.

* * * * * * * * * * * * * * *

Cerro started out on the assumption that they would be justified in assuming an economical basis of amortization on a tonnage of 21,000,000 tons ore reserve 65% concentrate. Later, after they had drilled out an estimated 8,000,000 tons of 65% concentrates on the Iron King groups, they told me that they had cut their requirement to 13,000,000 tons of 65% ore concentrate content, and suggested that I find them the extra 5,000,000 tons.

A short time later I offered them three high-grade small properties - "The Big Pig," "The Fern," and the "Kennedy," which overall I figured would make up the 5,000,000 tons. Because these three properties were non-contiguous, they abandoned our entire contract.

The sponge iron idea is more than ever a sound one today.

HISTORY OF DEVELOPMENT AFTER CANCELLATION:

The drill-hold records of the Cerro campaign, I was told (and the logs of the drill holes confirm the story) that the zone of iron (magnetite) was from 200' to 300' in thickness - made up of interbedded "mescal" limestone and magnetite.

The iron was entirely in the form of magnetite.

The crystallization was such that due to the absence of half-breeds and twining of crystals, an iron concentrate of 65% iron plus/obtained with relatively coarse crushing and grinding.

is

However, the interbedded formation and the amount of overburden does not, at the present level of iron prices, allow for shipping from the south end of the property, where the major iron deposit is located, to the iron or steel industry at a profit.

* * * * * * * * * * * * * * * *

THE IDEA FOSTERED BY CERRO FOR A SPONGE IRON PLANT IS DEFINITELY A SOUND FIELD FOR SCIENTIFIC INVESTIGATION.

* * * * * * * * * * * * * * * *

However, in my opinion the north end of the property containing from 1,000,000 to 2,000,000 tons is an area of very promising possibilities.

The drill hole records on this end of the property show two drill holes having a mineralized zone of ____________ to ____________.

On the surface in front of one of these holds, there is a surface trench 310' long on the hill slope, with the iron outcrop throughout the entire distance.

After the cancellation of the Cerro Corporation option, I was contacted by the W. S. Moore Co., through the son of W. S. Moore, Irving Moore, their geologist.

The Moore Company is one of the old companies of the Mesabi Range in Minnesota and they are only interested in marketing bulk lump iron ores.

After an investigation they decided that distance from the coast foreign shipping docks made the operation non-profitable, and I agree as of this time, but not for the future.

However, Mr. Moore took a series of surface samples and took one careful iron type sample from the 310' trench on the north end.

A copy of his assay report from the Pickens and Mathers Laboratory at Hibbings, Minnesota is attached, and I call your attention to Sample #3 - "The Iron Concentrate Value of 69.60%" (whereas pure magnetite is 72.4%).

I also call attention to the voluntary statement made by Pickens & Mathers, and I quote:

> "This is probably as high grade a concentrate as can be found in a natural state this side of Brazil."

CONCLUSION AND RECOMMENDATIONS:

The north end of the Iron King property could, with proper equipment, turn out a grade of magnetite iron concentrate of extreme purity - probably 71.5% to 72%.

Such a grade of iron concentrate would retain its internal geometric pattern, its lattice structure, its x-ray diffraction characteristics, and its surface transfiguration.

Five years or more ago, I worked in conjunction with Dr. Donald J. Fresch - who was in charge of Solid State Materials at Motorola in Phoenix. Dr. Fresch was interested in my idea which involved making a ferrite by magnetic and chemical means, but no fusion of the iron itself, because he thought that I was on the track of purifying the iron oxide mechanically and chemically, but not by heat, to a point where it would be pure enough to enter the magnetic core field of ferrites.

He had me write to Professor M. L. Gandin, a world authority on silica of the Massachusetts Institute of Technology in Cambridge, Mass., and Dr. Gaudin asked questions in an exchange of letters.

I am attaching to this report a magazine article "Pageant" describing ferrites and their value in scientific developments.

Dr. Fresch was interested in my approach from the first time I contacted him as an engineer - sent to him by top engineers in Hughes Aircraft and Jetrodyne of Los Angeles, who said that Dr. Fresch was, in their opinion, "<u>the</u> USA authority on solid state materials."

Dr. Fresch was curious when I argued that all solid state materials, employed in the microwave field, were manufactured from iron oxides by synthetic methods and that these synthetic processes <u>might</u> have destroyed certain inherent phases involving lattice structures, geometric patterns, x-ray diffraction, surface transfiguration potentialities, etc. that might have had unknown natural solid state material end points not achieved by the <u>synthetic</u> type of treatment.

I was sent by Dr. Fresch to the C. K. Williams Co. in Emeryville, California, who spent considerable time with me. They are one of the lasgest producers of synthetic ferrites in the country.

I went to Shell Chemical in Pittsburg, California and they listened and set me off into iron oxide <u>catalysts</u>, another branch of potential research.

Along the same line of thought, I went to John T. Long of the Arizona Research Consultants in Phoenix, and he carried on a series of tests chemically on another iron ore which did not change the iron content physical structure - but with chemicals such as hydrofluoric acid, acetic acid and other chemicals to remove the silica, the aluminum and the lime, etc. and raise the iron grade or purity thereby to 71.4%.

* * * * * * * * * * * * * * *

About this time, Dr. Fresch left Motorola and took a similar position with Martin Marietta in Ohio, and our working partnership agreement was abandoned.

As far as I know, the idea has never been exploded or tested.

* * * * * * * * * * * * * * *

In closing this report, I will summarize my conclusions:

(1) The Cerro Corporation idea of a sponge iron plant is today more needed than five years ago.

(2) The idea of ferrites is an interesting scientific and potentially practical profitable operation and research.

(3) The Iron King iron deposit as a source of lump iron ore is not feasible under present marketing conditions, but is an assured profitable operation of the future.

(4) Patenting the property would require commercial production almost certainly.

(5) This commercial production could be brought into existence with a very small investment with a portable or semi-portable magnetic separator plant to produce a 65% to 68% magnetic concentrate for sale to plants such as Ray Consolidated or Hayden in their mill concentration circuits.

* * * * * * * * * * * * * * *

On the north end of the property there is an open trench 310 feet long from which the 70% ± concentrate was picked for concentration in Minnesota, and a small operations start would be simple and inexpensive.

Charles H. Jonas

December 9, 1966

PIT

↓

Drag Line

↓

Trommel → ~~+12" Rejected~~

↓

Magnets → ~~+ 3/4" Rejected~~

↓ → Non-magnetic Rejected
By stacker or trucks

Magnetics

↓

Trucks or Conveyors

Rough Concentrate
Stockpile (at water supply)

↓

Feeder

↓ (Water added)

Belt Scale

↓

De Magnetizer

↓

Hopper Bin

↓

Syntron Feeder

↓

Wet Scrubber

(Also screening to get + 1/4" for media market if advantageous)

↓ → -150 Mesh to tailings pond ?

↓

Low Intensity Magnets

Magnetics | Non-Magnetics → To tailings pond ok

→ +20 Mesh to tailings pond ?

-20 Mesh

↓

Ball Mill

→ -325 Mesh

Flotation | Direct oxide Market | Chemical Plant | To Micron Grind

↓

To Ferrites

TECHNICAL

Older-

PRELIMINARY STUDY FLOW SHEET

PIT

Haulage Devices

Drag Line

LeTourneau

Conveyors

Rough Screening Devices

Grizzlies

Trommels → + ~~12" Tailings~~

Screens → + ~~3/4" Tailings~~

→ _3/4 + 1/4 Tailings

Magnets

→ Non magnetic tailings

Magnetic

+1/4 _1/4

Heavy Media Product

Ball Mill - 325

_20 +20 Mesh → Tailings

To Magnetite Market

To calcining plant kilns for change to Hematite

Portion to chemical plant → Ferrite tapes, powders, etc.

Pigments Animal Feeds

Paige—

this is what I want for use in our direct reduction Fe deal for production figures — put with profit file.—

R B Ford.
from McAl.

Preprint from the 1965

BUREAU OF MINES MINERALS YEARBOOK

The Mineral Industry of Arizona

By Leonard P. Larson and William C. Henkes

UNITED STATES DEPARTMENT OF THE INTERIOR

UNITED STATES DEPARTMENT OF THE INTERIOR • Stewart L. Udall, Secretary

BUREAU OF MINES • Walter R. Hibbard, Jr., Director

This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals, (Except Fuels); Volume II, Mineral Fuels; Volume III, Area Reports: Domestic; and Volume IV, Area Reports: International.* Individual chapters from all four volumes and the separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 – Price 15 cents

The Mineral Industry of Arizona

This chapter has been prepared under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the Arizona Bureau of Mines for collecting information on all minerals except fuels.

By Leonard P. Larson [1] and William C. Henkes [2]

The value of the mineral industry of Arizona rose to $580.2 million, the highest on record, 9 percent greater than in 1964. Responding to high demand, the copper industry increased the output of primary copper 12,389 short tons (2 percent) and $47.5 million (11 percent) in value. The average price received for electrolytic copper at the refinery rose from 32.6 cents per pound in 1964 to 35.4 cents per pound in 1965.

The high demand for copper resulted in the increased output of silver and molybdenum, byproducts of milling and smelting copper ores, and stimulated that section of the economy which provided raw materials and services to the industry. Crushed limestone, sandstone, and pyrite were all consumed in greater quantities.

Activity in the Arizona nonmetal industry declined in value. Output of sand and gravel, portland and masonry cements, and stone was less because of reduced construction, primarily because of overbuilding in residential, commercial, and other types of construction. A 3-month summer shutdown of nearly all construction in the State caused by a strike of most construction trade unions also contributed to the lower demand for cement.

Prospecting and development increased over that in 1964. Newmont Development Co. drilled exploratory holes in a ¾-mile area east of the Vekol Mountains, 32 miles south and west of Casa Grande; West Range Co. explored for molybdenum-copper ores at the Ventura mine in the Palmetto district of Santa cruz County; exploration work was continued by Hecla Mining Co. & Newmont Exploration, Ltd., at the Big Bird Development Co. Copper Flats claims in the Lone Star district of Graham County; Arkla Exploration Co. filed on an additional 46 mining claims in the San Francisco mining district, T 17 N, R 19 and 20 W, Mohave County; and the Apache and Big Monument gold and silver mines 12 miles south of Arivaca were diamond drilled and trenched for George Audish of Tucson.

Arizona mine evaluations increased $9.9 million over those of 1964. The largest increase was placed on the Duval Corp. new Mineral Park operation near Kingman, assessed at $6.4 million. The remaining increases were spread among the Inspiration, Kennecott, Magma, and Phelps Dodge holdings in the State.

Kerr-McGee Corp. began exploratory diamond drilling on a large group of claims in Gila, Pinal, and Santa Cruz Counties.

Employment and Injuries.—Final statistics for 1964 of employment and injuries in the mineral industries, excluding the petroleum and natural gas industries, and preliminary data for 1965, compiled by the Federal Bureau of Mines, are given in table 3.

Arkansas Louisiana Gas Co. conducted an extensive core-drilling program for various minerals on the Holbrook tract in Navajo County.

[1] Mining engineer, Bureau of Mines, Denver, Colo.
[2] Petroleum engineer, Bureau of Mines, Denver, Colo.

Table 1.—Mineral production in Arizona[1]

Mineral	1964 Quantity	1964 Value (thousands)	1965 Quantity	1965 Value (thousands)
Asbestos short tons	W	W	3,469	$441
Clays thousand short tons	[2] 168	[2] $213	[3] 129	[3] 164
Copper (recoverable content of ores, etc.) short tons	690,988	450,524	703,377	497,991
Diatomite do	450	16	295	8
Gem stones	NA	120	NA	120
Gold (recoverable content of ores, etc.) troy ounces	153,676	5,379	150,431	5,265
Gypsum thousand short tons	147	770	103	540
Iron ore (usable) thousand long tons, gross weight	4	32	8	51
Lead (recoverable content of ores, etc.) short tons	6,147	1,611	5,913	1,845
Lime thousand short tons	177	2,920	204	3,543
Mercury 76-pound flasks	77	24	158	90
Molybdenum (content of concentrate) thousand pounds	6,296	9,532	9,399	15,880
Natural gas (marketed) million cubic feet	[r] 2,014	241	3,106	376
Petroleum (crude) thousand 42-gallon barrels	64	W	97	W
Pumice thousand short tons	880	1,635	1,273	1,605
Sand and gravel do	18,116	20,868	14,918	16,621
Silver (recoverable content of ores, etc.) thousand troy ounces	5,811	7,513	6,095	7,881
Stone thousand short tons	3,759	6,283	2,474	4,171
Tungsten concentrate (60-percent WO_3 basis) short tons	16	17	3	5
Uranium ore do	102,258	3,253	117,898	3,918
Vanadium do	W	575	W	381
Zinc (recoverable content of ores, etc.) do	24,690	6,716	21,757	6,353
Value of items that cannot be disclosed: Asbestos (1964), cement, clays (bentonite, fire clay 1964), feldspar, helium, mica (scrap), perlite, pyrites, and values indicated by symbol W	XX	[r,4] 16,111	XX	[5] 12,933
Total	XX	[r] 534,353	XX	580,182

NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable. [r] Revised.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes bentonite and fire clay; included with "Value of items that cannot be disclosed."

[3] Excludes bentonite; included with "Value of items that cannot be disclosed."

[4] Value of mineral fuels, $1,785,000; value of nonmentals, $14,326,000.

[5] Value of mineral fuels, $2,307,000; value of nonmetals, $10,626,000.

Table 2.—Value of mineral production in constant 1957-59 dollars

(Millions)

Year	Value
1956	$359
1957	359
1958	339
1959	317
1960	380
1961	414
1962	450
1963	[r] 454
1964	[r] 473
1965	471

[r] Revised.

Duval Corp. reported that exploratory drilling in the Supai salt basin in Apache County had disclosed the presence of potash mineralization. Potash was reportedly found in the Permian bed 1,000 feet below the surface.

Legislation and Government Programs.—The United States Government played an increasingly important role in the copper market in 1965 with the release of copper from the Government stockpiles and the request to producers to maintain the 36 cents per pound price of copper. Other steps taken included introduction of legislation to suspend the 1.7-cents-per-pound import tax on copper, effective February 8, 1966 and restriction of copper exports.

Construction projects financed by Federal, State, and municipal funds accounted for much of the production of cement, sand and gravel, and stone. State highway construction contracts awarded during the year totaled $69.9 million. Seventy-three percent ($50.8 million) was for constructing roads in the National System of Interstate and Defense Highways.[3] Of the 1,166.5 designated miles in this system in Arizona,

[3] Engineering News-Record. State Highway Contracting Plans: 1966 Will be a Record Breaker. V. 176, No. 14, Apr. 7, 1966, pp. 74–76.

Bagdad Copper Corp. obtained an option on a mica property at Buckeye. At the time of acquisition, the property was yielding a low-grade ground mica used chiefly as roofing material. During the option period, the company was to study feasibility of adapting new processes which would produce a much higher grade product. During the same period, the company was to evaluate markets for this higher grade product.

Phoenix Cement Co. produced portland and masonry cements at its cement plant near Clarkdale. Limestone, clays, and shale used in manufacturing these cements were obtained from the company-owned Redwall limestone quarry and Lakebed clay deposits. Slag, gypsum, and resin for manufacturing cements were purchased by the company.

Arizona Gypsum Corp. operated gypsum and clay deposits near Camp Verde. Bentonitic clays dug by the company were sold for use in pelletizing ores and for reservoir pond or ditch lining. Crude gypsum ores mined by the company were sold for use as a portland cement retarder and in treating alkali soils. Yavapai Block Co. produced a small quantity of scoria for use as a lightweight aggregate in manufacturing lightweight building block.

U.S. Lime Products produced quicklime and hydrated lime at the lime plant from limestone quarried and crushed by the company at the Nelson quarry. The quicklime was sold for use by the coke, gas, magnesium, and steel industries and in the concentration of copper ores. Hydrated lime was sold for construction purposes, for use in the concentration of copper ores, and for other chemical and industrial uses.

Iron ore obtained from the Cowden and Iron Chancellor hematite deposits, 19 miles south of Seligman, was sold by G. A. Swartz and Arizona Gypsum Corp. for use in manufacturing sponge iron. Ore from the Cowden deposit was hauled by trucks to Seligman, ground to minus 8 mesh, and shipped by rail to Ray Mines for use as sponge iron in the LPF plant at Hayden. Ore from these deposits was high grade, red to black hematite, containing about 61 percent iron, low silica, and moisture.

Contractors for the Arizona Highway Department produced a small quantity of miscellaneous stone used as riprap. Additional quantities of stone were produced by commercial operators: Miscellaneous stone for concrete and road stone and dimension sandstone for building stone.

Sand and gravel was produced by commercial producers, contractors for the Arizona Highway Department, and crews of the Yavapai County Highway Department. Most of the product was paving sand and gravel produced by the Arizona Highway Department; small quantities of building sand and gravel and fill sand were produced by commercial operators.

Yuma.—Sand and gravel and stone—the principal mineral commodities produced in the county—accounted for 97 percent of the value of mineral output. Contractors for the Arizona Highway Department and contractors and crews of the Federal Bureau of Reclamation produced 627,000 tons of paving sand and gravel, valued at $557,000. Commercial operators—Arrow Transit Mix Concrete Co., Inc., Janney Sand and Gravel, Tanner Paving & Materials, Valley Sand and Gravel Co., and Yuma Builders Supply, collectively—produced 241,000 tons of building and paving sand and gravel valued at $293,000. Granite, limestone, and miscellaneous stone produced and crushed by contractors and crews of the Federal Bureau of Reclammation were used for riprap and as a concrete and roadmetal. Dimension sandstone produced by Western States Stone Co. and Apache Building Stone from the Scott-Weaver and Quartzite quarries was sold to the construction industry as rough construction and rough architectural building stone. Agricultural gypsum produced by the Harquahala Gypsum Co. at the Harquahala underground gypsum mine near Salome was sold and used uncalcined as a soil conditioner. Principle markets for the product were in the Aguila, Parker, Yuma, and Blythe, Calif., farming areas.

Gold, silver, copper, lead, and zinc were recovered from small lots of ore produced at five lode and two placer mines; gold, silver, and lead were recovered from lead tailings at the Ruby Nos. 1 and 2 dumps. E. F. Peterson and Associates shipped copper ore from their lease on the Black Mesa copper claims located about 6 miles from Brenda. The ore was trucked 32 miles to McVay for rail shipment to the Asarco smelter at Hayden.

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the trench shaft and trucked to the mill. Dewatering of the January and Trench mines was started in November 1964; mining began the following April. Arivaca Mining Co., operator of the Glove mine in the Tyndall district, prepared to sink the main vertical shaft at the mine from the 360-foot to the 460-foot level, crosscut to the main ore zone, and raise an additional shaft to the surface. Lead-zinc ore from the mine was trucked to Amado for rail shipment to the Asarco smelter at El Paso. Ore mined by the company at the Arizona mine in the Oro Blanco district was trucked 20 miles to the Cerro Colorado mill northwest of Arivaca for processing. A bulk concentrate containing lead, copper, and zinc was produced and stockpiled for future shipment. Both mine and mill were operated by Arivaca Mining Corp. West Range Co. explored for molybdenum-copper ores at the Ventura mine in the Palmetto district.

Mineral rights to 8,656 acres in the Salero mining camp, located between Patagonia and Tubac, were purchased by Salero International Mining & Milling Co. of California. The camp, first developed in 1895, had been idle nearly 50 years. The property, a high-grade copper, silver, and lead-zinc source, was worked for low-grade ores during World War I.

Yavapai.—Gold, silver, copper, lead, and zinc comprised 78 percent of the total value of mineral production. Except for molybdenum and iron ore, nonmetals production, led by cement, accounted for most of the remainder. The Iron King mine at Humboldt, operated by Iron King Branch of Shattuck Denn Mining Corp., was the leading producer of gold, silver, lead, and zinc in the county. According to the company annual report to shareholders, 44,855 tons of concentrates was recovered at the company mill from the milling of 333,743 tons of ore; the ore contained 15,677 ounces of gold, 589,377 ounces of silver, 71,570 pounds of cadmium, 9,176,020 pounds of lead, 543,451 pounds of copper, and 27,247,330 pounds of zinc. The 333,743 tons of ore mined and processed during the year constituted an alltime high for the Iron King mine. Approximately 92 percent of this production came from the 2,300- and 2,400-foot levels; the remaining 8 percent was produced from the upper levels at the southern end of the ore body. A modified system of sublevel stoping facilitated mining of the lower one-half of the stopes by normal shrinkage methods and the upper one-half by vertical long-hole stoping. This system has resulted in reduced cost and better grade control.

The grade of ore at the Iron King mine had decreased as deeper levels were developed. The company reported that the decrease in grade was offset by lower operating costs and increased metal prices. Overall operating costs were reduced by 2.8 percent.

Exploration was conducted within the mine to evaluate known areas and to search for new ore bodies. Drilling on the north end of the ore zone did not reveal minable widths. Strong mineralization was present and deeper drilling was planned to explore the possibility of greater widths at depths. South of the main ore body, the grade of ore appeared to increase with depth. A program of deeper drilling was planned in this area.

The Bagdad mine, Bagdad Copper Corp., was the principal producer of copper in the county and the tenth largest producer in the State. As reported to shareholders in the annual report, the company produced 20,275 tons of copper. Recovery of copper from sulfide ores was 24.7 million pounds, an increase of 4 percent over the 23.8 million pounds in 1964. Average ore grade during 1965 was 0.83 percent, compared with 0.77 in 1964. The increase in grade accounted for the increased production. Recovery of copper by leaching ores in place increased about 2 percent: 15.5 million pounds in 1964 compared with 15.8 million pounds in 1965. Molybdenum shipments during 1965 were 453,364 pounds, compared with 276,624 pounds in 1964. The sharp increase resulted from changes made in the molybdenum recovery circuit. Stripping was continued at a high rate during the year and was well ahead of mining operations. By the end of 1966, the present ore body was expected to be sufficiently developed to reduce the rate of stripping.

Construction at the refinery, a joint venture between Bagdad Copper Corp. and Chemetals Corp., was being scheduled; the plant was to be completed in May 1966. The primary product of the refinery was to be pure copper powder; the refinery also would be capable of producing high-purity copper briquets suitable for melt stocks.

Table 3.—Employment and injury experience in the mineral industries

Year and industry	Average men working daily	Days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1964:								
Coal	3	---	(1)	3	--	---	---	---
Metal	10,632	302	3,210	25,633	8	785	30.94	3,199
Nonmetal	378	222	85	676	--	10	14.80	536
Sand and gravel	1,115	234	261	2,102	--	53	25.21	562
Stone	681	242	165	1,309	--	13	9.93	199
Total	12,809	290	3,721	29,723	8	861	29.24	2,820
1965:p								
Coal	5	---	(1)	3	--	---	---	---
Metal	11,575	304	3,519	28,102	11	658	23.81	3,715
Nonmetal	285	221	63	508	1	19	39.37	12,232
Sand and gravel	1,150	204	234	1,883	--	27	14.34	660
Stone	655	237	155	1,223	2	18	16.35	10,277
Total	13,670	290	3,971	31,719	14	722	23.20	3,923

pPreliminary.
[1]Less than 1/2 unit.

645.2 miles was opened to traffic at year-end; 481.2 miles was in the construction, engineering, or right-of-way phase; and 40.1 miles had not been started.[4]

A comprehensive review[5] of the geology of the U.S. Highway from Douglas on the Mexican border to Lupton on the New Mexico border was published by the Arizona Bureau of Mines. The 68-page guide was illustrated with maps, pictures of past and current mining operations, and geological reports correlated to each section of the highway. A geologic log identified the rocks, according to the type and age, seen along the highway. An appended glossary defined the types of rocks.

REVIEW BY MINERAL COMMODITIES

METALS

Copper.—Production from mines in the State was at a record high of 703,400 short tons; most mines were worked at or near capacity. Shipments exceeded production, and stocks declined.

Mines in Arizona yielded more than 52 percent of the domestic primary production and about 18 percent of the free world output. Production from the 12 large open pit and 4 principal underground properties accounted for 97 percent (684,000 tons) of the State total output of 703,377 tons of primary copper; 78 percent was derived from open pit ores, and 22 percent was derived from underground ore. In 1964, the 11 open pit and 5 underground mines accounted for 98 percent of the State total output. The remaining 2 percent was supplied by 72 small operations.

Copper was mined throughout a large area of Arizona and was a significant factor in the economy of 7 of the 14 counties in the State. Rapidly expanding operations in the Tucson area, since 1962, has pushed Pima County ahead of Pinal County in the production of copper. Greenlee and Gila Counties also were substantial producers, followed by Cochise, Yavapai, and Mohave.

Four mines owned by Phelps Dodge Corp. accounted for about 38 percent of the State production. Magma Copper Co. accounted for 16 percent of the total output from its two underground properties. American Smelting and Refining Co. (Asarco), with two open pits that accounted for about 11 percent, was third. Ray Mines Division, Kennecott Copper Corp., accounted for 10 percent followed by Inspiration Consolidated Copper Co. with 9 percent. Duval Corp. and Miami Copper

[4] Bureau of Public Roads. Quarterly Report on the Federal-Aid Highway Program, Dec. 31, 1965. Press Release BPR 66-5, Feb. 9, 1966.
[5] Wilson, Eldred D. Guidebook 1—Highways of Arizona, U.S. Highway 666. Arizona Bureau of Mines Bull. 174, 1965, 68 pp.

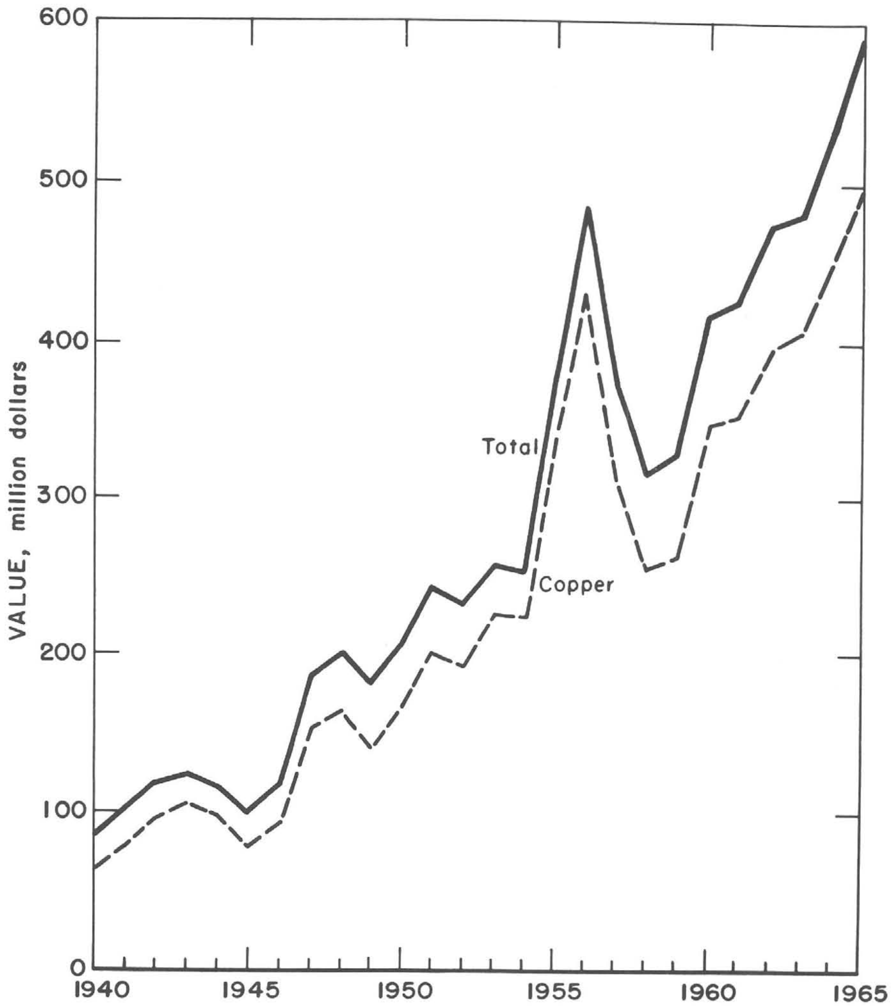


Figure 1.—Value of mine production of copper, and total value of mineral production in Arizona.

Co. yielded about 6 percent and 4 percent, respectively. Operations of Bagdad Copper Corp. and Pima Mining Co. accounted for about 3 percent and 2 percent, respectively. Several smaller firms provided the remaining 1 percent.

Eight primary smelters operated in the State during the year, primarily on ores produced by the company operating the smelter. Phelps Dodge Corp. smelter at Douglas, Inspiration Consolidated Copper Co. smelter at Inspiration, and Asarco at Hayden also smelted ores on a custom or toll basis. Phelps Dodge Corp. controlled about 55 percent of the smelting capacity in the State; Magma Copper Co., Asarco, and Kennecott Copper Corp. each about 13 percent; and Inspiration Consolidated Copper Co. about 6 percent.

Approximately 89 percent of the recoverable copper produced at mines in Arizona was smelted locally. About 9 percent was shipped to copper, lead, and zinc smelters operated by Asarco at Amarillo and El Pa-

cent sulfide copper, compared with 12.4 million tons assaying 0.828 percent sulfide copper in 1964. Tons of ore mined per operating day increased from 34,756 tons in 1964 to 37,791 tons in the current year. With completion of a $10 million expansion program, plant capacity was increased 12 percent in July. The San Manuel concentrator treated 13.4 million tons of ore at an average of 37,591 tons per operating day. Approximately 88 percent of the total copper and 92 percent of the sulfide copper were recovered. Copper per ton of ore mined in 1965 was 13.89 pounds compared with 14.88 pounds in 1964. A total of 314,750 tons of copper concentrates assaying 30.24 percent copper was processed at the smelter, compared with 316,547 tons assaying 29.91 percent in 1964. Tons smelted per operating day averaged about 880 tons in 1965. Metal production at San Manuel was 93,767 tons of copper, 5.7 million pounds of molybdenum sulfide, 21,550 ounces of gold, and 273,610 ounces of silver.

From quarries operated by the company, San Manuel furnished 58,765 tons of limestone and 14,532 tons of quartzite for metallurgical purposes.

Copper production at the Magma mine increased about 14 percent during the year. The mine yielded 439,911 tons of ore assaying 4.65 percent copper, 0.031 ounce of gold, and 0.99 ounce of silver, compared with 377,575 tons of ore assaying 4.78 percent copper, 0.030 ounce of gold, and 0.85 ounce of silver in 1964. Metal production was 19,452 tons of copper, 12,748 ounces of gold, and 408,366 ounces of silver.

A replacement ore body in a limestone strata lying some 410 feet stratigraphically above the area being developed and mined was discovered by diamond drilling during the last half of the year. Indications were that the new ore body, outlined between the 3,600- and 3,300-foot levels, may contain 2 million tons of ore containing approximately 6 percent copper. Underground workings did not provide access to obtain information regarding the extent of mineralization below the 3,600-foot level. The determination and evaluation of the economic possibilities of the ore body were expected to influence the life of this property.

Americana Investments, Inc., Phoenix, stockpiled gold ore obtained from the Golden Beauty vein at the White Chief mine. Development work, including shaft sinking, was continued to evaluate known mineralized areas at the property. The White Chief mine, owned by Triumph Mines Co., Inc., was held by Americana under a 5-year lease.

Phelps Dodge Corp. received daily shipments of siliceous flux ore from an open pit at the Pico Nos. 1 and 2 mine operated by A. W. Robart.

McFarland & Hullinger shipped open pit copper silica ores from the Del Oro mine and gold-silver tailings from the Mammoth and Tiger tailings dumps to the Asarco smelter at Hayden. Little Hill Mines shipped additional quantities of copper and silver fluxing ores to the smelter from the Canyon Pit, Copper Rose, Gold Hill, and Hilltop open pit mines in the Old Hat mining district.

Nonmetals accounted for 2 percent of the total value of mineral output. Crude gypsum, mined by Arizona Gypsum Co. and National Gypsum Co. near Winkelman and by Garcia Gypsum Co. near Mammoth, was shipped to wallboard and cement plants; some was used locally for agricultural purposes. Arizona Gypsum also produced a small quantity of diatomite from the White Cliffs mine near Mammoth for use as a filler. Lime was produced by San Manuel for use at the San Manuel concentrator. Crude vermiculite from Montana was exfoliated by Ari-Zonolite at a plant in Phoenix; the product was sold for use in acoustical and thermal insulation, as an aggregate in plaster and concrete, and as a soil conditioner. Perlite produced by Arizona Perlite Roofs, Inc., and Harborlite Corp. was expanded at Tucson and out-of-State expanding plants for use in building plasters and other construction applications and as filter aids. Contractors for the Arizona Highway Department and crews and contractors for the Pinal County Highway Department produced most of the sand and gravel in the county.

Santa Cruz.—Gold, silver, copper, lead, and zinc were recovered from five lode mines, collectively, and cleanup at the Trench mill. The Trench mill, located in the Harshaw district, was reopened in the middle of May by Nash-McFarland, Inc. Lead, zinc, and silver ores from the January mine, owned by Asarco and operated by Nash-McFarland, Inc., were hoisted up was the largest source of gold and the second largest of silver. The Mission mine ranked first in the production of silver and zinc. The small quantity of lead produced came from the Mission mine and two small lode mines. A small quantity of tungsten concentrates—recovered from ores obtained, mined, and milled at the Carbaloy mine by Fernstrom Mining Co.—were sold to Kennametals, Inc., Fallon, Nev.

Cement (portland and masonry) was the major nonmetal mineral commodity produced in the county in terms of value of mineral output, followed by sand and gravel and stone.

Arizona Portland Cement Co. manufactured portland and masonry cements by the dry process at its plant near Rillito from crushed limestone produced at the company quarry and from purchased slag, gypsum, and iron ore. Cement produced by the company was shipped to consumers in and out of the State. Grabe Brick Co., Inc., Phoenix Brick Yard, and Tucson Pressed Brick Corp. mined miscellaneous clay for use in manufacturing building brick.

Twelve commercial operators produced a total of 867,000 tons of sand and gravel valued at $1 million from 14 operations. The sand and gravel, processed in 10 stationary and 4 portable plants, was used principally for construction. A small amount was not processed. Contractors and crews of the Arizona Highway Department and the Pima County Highway Department, respectively, used the remainder. A small quantity of marble was mined and crushed at the Andrada quarry by Andrada Marble Co. and sold for use as roofing granules, landscaping, and animal feed. Sandstone produced and crushed by San Antonio Mine Co. near Ajo was sold to the copper producers as a smelter flux. The company also sold a small quantity of dimension sandstone from the San Antonio mine for use in building. Miscellaneous stone quarried by contractors for the Arizona State Highway Department was used as riprap.

Pinal.—Output of copper was 10 percent higher than that of the previous year, principally because of increased output at Ray Mines and the Magma mine. Gold and silver recovered principally as byproducts from copper refining in the county accounted for 2 percent of the total value of mineral production.

Kennecott Copper Corp., in its annual report, stated that Ray Mines Division near Hayden mined and milled 8.6 million tons of ore, compared with 6.9 million tons in 1964. Copper production from all sources totaled 72,153 tons, a 24-percent increase. The average grade of ore mined in 1965 contained 0.86 percent copper compared with 0.87 percent in 1964. Installation of a concentrate dryer permitted higher throughput in the reverberatory furnace and increased copper output. Site preparation and excavation were begun for a new primary crushing facility at the property. The new facility was to include a 54-inch gyratory crusher, a 54-inch conveyor belt, a 60-ton overhead crane, and a loading tunnel. When the new plant is completed, the existing crusher was to be dismantled to make way for planned pit expansion. Completion was scheduled for late 1966.

Pyrite recovered from the mill tailings and purchased from Magma Copper Co. was roasted in a fluidizing reactor as one step in producing sponge iron and sulfur dioxide for manufacturing sulfuric acid. The final reduction to sponge iron was accomplished in two parallel Bruckner furnaces which were directly fed by hot calcines from the fluidizing reactor. Sulfuric acid was used as a solvent for recovering nonsulfide copper in the ore. The sponge iron was used as precipitant for the dissolved nonsulfide copper. Copper from two underground and one open pit mines accounted for $130.4 million (92 percent) of the total value of mineral production in the county.

Magma Copper Co. operated the San Manuel and Magma underground mines. The San Manuel mine was developed by large-scale block-caving system; the Magma mine by square set and retreat-caving but more recently by sandfill. At the San Manuel Division, according to the company annual report, production of all metals, except silver, increased during the year. The sulfide content of the ore mined in 1965 was less than in the previous year; the increased tonnage of ore mined, however, more than compensated for the lower grade. The drop in grade resulted from lower grades of ore being mined in order to maintain the normal sequence of operations. During the year, the company mined 13.5 million tons of ore assaying 0.773 per-

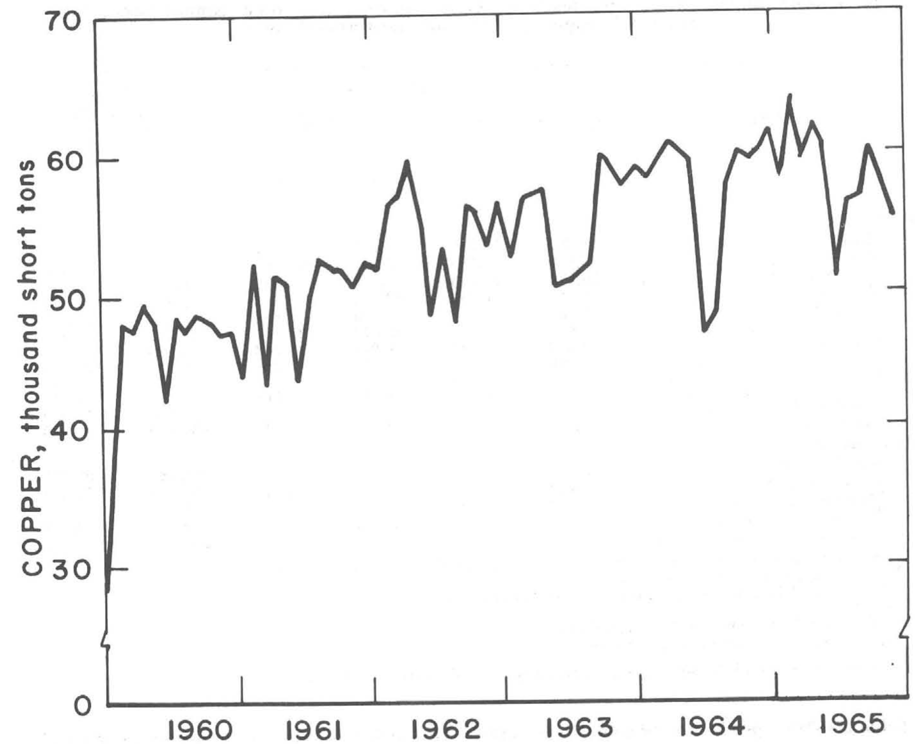


Figure 2.—Mine production of copper in Arizona, 1955–65, by months, in terms of recoverable metal.

Table 4.—Fifteen leading copper-producing mines in 1965, in order of output

Rank in 1965	Rank in 1964	Mine	District	County	Operator	Source of copper in 1965
1	1	Morenci	Copper Mountain	Greenlee	Phelps Dodge Corp.	Copper ore, copper precipitates, gold-silver ore.
2	2	San Manuel	Old Hat	Pinal	Magma Copper Co.	Copper ore.
3	5	Ray	Mineral Creek	do	Kennecott Copper Corp.	Copper ore, copper precipitates.
4	4	New Cornelia	Ajo	Pima	Phelps Dodge Corp.	Copper ore, gold-silver ore.
5	3	Copper Queen, Lavender Pit	Warren	Cochise	do	Copper ore, copper precipitates, silver ore.
6	6	Mission	Pima	Pima	American Smelting and Refining Co.	Copper ore.
7	7	Inspiration	Globe-Miami	Gila	Inspiration Consolidated Copper Co.	Copper ore, copper precipitates.
8	10	Esperanza	Pima	Pima	Duval Corp	Do.
9	8	Silver Bell	Silver Bell	do	American Smelting and Refining Co.	Do.
10	12	Bagdad	Eureka	Yavapai	Bagdad Copper Corp.	Do.
11	11	Copper Cities	Globe-Miami	Gila	Miami Copper Co.	Do.
12	13	Magma	Pioneer	Pinal	Magma Copper Co.	Copper ore, gold-silver ore.
13	--	Mineral Park	Wallapai	Mohave	Duval Corp	Copper ore, copper precipitates.
14	9	Pima	Pima	Pima	Pima Mining Co.	Copper ore.
15	15	Miami	Globe-Miami	Gila	Miami Copper Co.	Copper precipitates.

Table 5.—Ore mined, waste and leach material removed, and total copper production at principal copper open-pit and underground mines

Mine	Ore mined (thousand short tons)		Waste and leach material removed (thousand short tons)		Total copper produced from all sources [1] (short tons)	
	1964	1965	1964	1965	1964	1965
Open pit:						
Morenci	18,632	19,089	30,068	29,601	129,406	127,566
Ray	6,890	8,595	13,330	22,061	58,235	72,153
New Cornelia	10,371	10,655	18,973	15,889	70,818	70,905
Mission	7,561	6,646	27,961	29,282	[2] 53,810	[2] 56,237
Inspiration	5,837	5,799	9,293	9,491	48,908	53,436
Lavender	6,001	5,661	19,017	21,886	41,508	35,687
Esperanza	4,292	4,232	6,071	8,253	[3] 22,550	[3] 21,691
Silver Bell	3,033	3,185	6,974	6,951	[3] 24,142	[3] 21,479
Bagdad	2,063	2,091	12,063	10,568	[3] 19,632	[3] 20,376
Copper Cities	3,164	3,200	6,266	11,668	[3] 21,453	[3] 20,184
Mineral Park	387	4,914	10,238	4,822	[2] 1,350	[3] 19,039
Daisy-Pima	2,850	2,646	[4] 4,718	[4] 9,243	[2] 30,000	[2] 18,000
Underground:						
San Manuel	12,443	13,504	-----	-----	92,588	93,767
Copper Queen	749	766	-----	-----	32,525	30,948
Magma	378	440	-----	-----	17,064	19,452
Miami	(5)	(5)	-----	-----	[6] 9,037	[6] 9,111

[1] Includes copper recovered from leaching of material in place and in dumps.
[2] Gross metal in concentrate shipped.
[3] Gross metal in concentrate and precipitates shipped.
[4] Cubic yards.
[5] All production from in-place leaching.
[6] Gross metal in precipitates shipped.

Source: Bureau of Mines data or company-published annual reports.

Table 6.—Mine production of gold, silver, copper, lead, and zinc, in terms of recoverable metals [1]

Year	Mines producing: Lode	Mines producing: Placer	Material sold or treated [2] (thousand short tons)	Gold (lode and placer): Troy ounces	Gold: Value (thousands)	Silver (lode and placer): Troy ounces (thousands)	Silver: Value (thousands)
1956–60 (average)	128	5	59,703	141,846	$4,965	4,763	$4,311
1961	96	4	72,537	145,959	5,109	5,120	4,733
1962	83	5	79,583	137,207	4,802	5,454	5,917
1963	90	4	81,214	140,030	4,901	5,373	6,873
1964	85	1	86,742	153,676	5,379	5,811	7,513
1965	92	2	93,466	150,431	5,265	6,095	7,881
1890–1965	NA	NA	NA	13,321,041	353,732	387,166	310,482

Year	Copper: Short tons	Copper: Value (thousands)	Lead: Short tons	Lead: Value (thousands)	Zinc: Short tons	Zinc: Value (thousands)	Total value (thousands)
1956–60 (average)	495,301	$321,221	10,965	$2,879	32,231	$7,704	$341,080
1961	587,053	352,232	5,937	1,223	29,585	6,804	370,101
1962	644,242	396,853	6,966	1,282	32,888	7,564	416,418
1963	660,977	407,162	5,815	1,256	25,419	5,846	426,038
1964	690,988	450,524	6,147	1,611	24,690	6,716	471,743
1965	703,377	497,991	5,913	1,845	21,757	6,353	519,335
1890–1965	20,482,028	8,826,411	639,619	125,666	985,039	239,083	9,855,374

NA Not available.

[1] Includes recoverable metal content of gravel washed (placer operations), ore milled, old tailings or slimes retreated, and ore, old tailings, or copper precipitates shipped to smelters during the calendar year indicated.

[2] Does not include gravel washed or tonnage of precipitates shipped.

contractor (Isbell Construction Co.) at Esperanza and Mineral Park in Mohave County and commenced mining operations at these properties. The company completed plans for centralizing exploration, research, and planning at Tucson. Construction of a new office-laboratory building neared completion at the end of the year. The centralization of the exploration, research, and planning groups was to improve coordination of personnel and facilitate investigation and evaluation of new projects.

The 1965 annual report issued by Cyprus Mines Corp. stated that Pima Mining Co. (50 percent owned by Cyprus Mines Corp.) mined and milled 2.6 million tons of ore averaging 0.76 percent copper and produced 18,000 tons of contained copper. In 1964, production totaled 2.9 million tons of ore containing 1.17 percent copper and 30,000 tons of contained copper. Copper concentrates produced from ore from open pit mines milled in the company mill were shipped to Asarco for smelting and refining. In April, the company approved plans to expand daily plant capacity to 18,000 tons of ore. By yearend, this expansion was about 70 percent completed and was scheduled to go on stream in April 1966. The larger mill was to lower unit costs and make it profitable to process lower grade ores from areas adjoining the present pit, extending the life of the mine into the 1980's.

Banner Mining Co. reported that proceeds from the mining of Daisy ore by Pima Mining Co. under a custom mining and milling agreement between the two companies increased 80 percent, from $694,623 to $1,247,975. This increase was due, primarily, to increased copper prices.

According to the Phelps Dodge Corp. annual report, production of copper from the New Cornelia Branch, Ajo mine, increased slightly. The ratio of waste to ore mined in the Ajo open pit was 1.49:1, compared with 1.83:1 in 1964. Major developments at the property included the use of a new type of explosive, high-density hot ammonium nitrate, and the installation of remote controls on most of the locomotives used in the mine. The use of the new explosive, although more expensive than other ammonium nitrate explosives, permitted wider spacing between blast holes and a reduction in drilling requirements. The installation of remote controls in the locomotives permitted the trains to be operated by one-man instead of two-man crews. The remaining locomotives were to be similarly equipped in 1966. Automatic control of grinding in ball mills was studied.

In its annual report Asarco stated that production from the Mission copper mine totaled 35.9 million tons; 6.6 million tons was ore. Concentrates produced at the company mill contained 56,237 tons of recoverable copper. Although harder ore reduced grinding capacity at the mill, this reduction was more than offset by higher grade ore mined during the first half of the year. Construction was begun to expand mill capacity 50 percent by early 1967. The molybdenum byproduct plant was operated satisfactorily throughout the year.

At the Silver Bell mine, 40 miles northwest of Tucson, Asarco mined and milled 3.2 million tons of ore from the El Tiro and Oxide pits, recovering 19,167 tons of copper in concentrate form. Leaching of waste dumps provided an additional 2,312 tons of copper as precipitates. Leaching operations were expanded during the year. Molybdenum production was down slightly. Expansion of the company mill to increase capacity by one-sixth was to be completed by mid–1966.

According to its annual report, The Anaconda Company continued plans to expand copper production in Arizona. Exploratory drilling at the Twin Buttes area near Tucson disclosed a large low-grade sulfide copper ore body with appreciable molybdenum. Stripping of 600 feet of overburden was begun in September; plans for a concentrator were being made. Operations were scheduled to begin early in 1969. When complete, the mine and plant were to handle about 30,000 tons of ore per day. A shaft and underground workings at Twin Buttes provided access for investigation of the large zone of copper mineralization. Ore was tested metallurgically through a 200-ton-per-day pilot plant. Additional drilling supplied information concerning the characteristics of the ore and its commercial limitations. Drilling was continued at nearby Helvetia with favorable results.

Most of the gold and silver produced in the county was recovered as byproducts of copper mining. The New Cornelia mine

Marble was quarried and dressed at the Harquahala quarry by Agnes D. Mick for decorative use in building construction. Dimension sandstone for rough architectural use was quarried by Apache Building Stone at the Drum, Lemons, and Sunflower quarries. Contractors for the Arizona Highway Department quarried miscellaneous stone for riprap. Scrap mica produced at the Buckeye mine by Buckeye Mica Co. was ground at the company mill near Buckeye for use in manufacturing paint.

More than 75 percent of the output of mercury in the State was recovered by furnacing ores from the Big Sam and Pine Mountain mines north of Sunflower.

Output of crude ore totaled 8,119 short tons, averaging 0.062 and ranging from 0.04 to 0.8 percent mercury. Most of the ore was furnaced, approximately half the ore being treated in 50-ton Gould rotary furnaces, the other half treated in a 100-ton Shutte furnace.

Miscellaneous clay for manufacturing building brick was mined by Phoenix Brick Yard and Wallapai Brick & Clay Products, Inc., at deposits near Phoenix. Small quantities of gold, silver, and copper were recovered from ores mined by several small producers in the county.

Mohave.—The value of mineral production in Mohave County increased eightfold ($2 million in 1964 to $19.6 million in 1965) because of the first full year of production at the Mineral Park copper-molybdenum mine near Kingman, owned and operated by Duval Corp. The corporation produced all of the molybdenum and most of the gold, silver, copper, and zinc output in the county. A small quantity of gold, silver, copper, lead, and zinc, collectively, was obtained from seven lode operations in the Cedar Valley, McConnico, and Wallapai mining districts and in the Hualpai Indian Reservation.

Contractors for the Arizona Highway Department and crews of the Federal Bureau of Reclamation furnished 1 million tons of paving sand and gravel used on highway construction. Commercial production valued at $1.1 million was mainly sand and gravel for buildings and roads. Three commercial operators reported production at four operations. Basalt quarried by Peter Kiewit Sons' Co. was used as concrete and road material. Crushed quartz from the Taylor mine near Kingman, operated by a contractor for IMC, and from the White Spar quarry, operated by C. F. Weeks, was used in manufacturing abrasives. Feldspar, also from the Taylor mine, was ground by IMC and shipped to consumers in California, Ohio, Texas, Washington, Wisconsin, and the Philippines. Miscellaneous stone, quarried by contractors for the Arizona Highway Department, was crushed and used for road construction.

Navajo.—Sand and gravel was the principal mineral commodity, accounting for 82 percent of the total value of mineral output. Contractors for the Federal Bureau of Public Roads, Federal Forest Service, Arizona Highway Department, and the city of Winslow produced 605,000 tons of paving sand and gravel.

Uranium ore production supplied $202,143 of the $1.5 million value of mineral production. The major producer was Industrial Uranium Co., operator of the Moonlight and South Sunlight mines. Properties of the A & B Mining Co., Atlas Minerals Division, Atlas Corp., Robert Shriver, and Grant L. Shumway were operated during the year. A small quantity of vanadium was recovered from uranium ores produced by A & B Mining Co. and Robert Shriver from the Monument No. 1 and Mitchell Mesa mines.

Pima.—Five mines—New Cornelia, Mission, Esperanza, Silver Bell, and Pima—were the source of 99 percent of the copper produced in the county and 26 percent of that produced in the State. Production of copper from the county was 12,845 tons below 1964 output, reflecting principally a lower output at Pima, Daisy, Silver Bell, and Esperanza mines. Output of molybdenum rose 34 percent in quantity and 61 percent in value. Nonmetals—cement, clays, sand and gravel, and stone—production was lower.

The 1965 annual report for Duval Corp. reported total production from the Esperanza open pit mine (33 miles southwest of Tucson) about 21,600 tons of copper and 1.4 million pounds of molybdenum. Production of copper from leach dumps supplemented the output of copper from the 12,000-ton-per-day concentrator operated by the company. On August 1 the company acquired the open pit equipment and employed most of the personnel of the mining

Table 7.—Mine production of gold, silver, copper, lead, and zinc in 1965, by counties, in terms of recoverable metals

County	Mines producing [1]: Lode	Mines producing [1]: Placer	Material sold or treated [2] (short tons)	Gold (lode and placer): Troy ounces	Gold (lode and placer): Value	Silver (lode and placer): Troy ounces	Silver (lode and placer): Value
Cochise	8	---	6,453,127	44,046	$1,541,610	962,077	$1,243,966
Coconino	1	---	[3] 100,000	---	---	23,248	30,060
Gila	12	---	10,734,696	3,706	129,710	206,025	266,390
Greenlee	3	---	19,090,733	10,968	383,880	512,873	663,145
Maricopa	3	---	536	9	315	6,843	8,848
Mohave	8	---	4,660,607	50	1,750	524,787	678,550
Pima	12	---	27,218,009	39,552	1,384,320	2,145,008	2,773,495
Pinal	17	---	22,636,639	36,279	1,269,765	930,363	1,202,959
Santa Cruz	5	---	5,646	36	1,260	21,795	28,181
Yavapai	17	---	2,553,745	15,771	551,985	759,559	982,110
Yuma	6	2	12,343	14	490	2,670	3,452
Total:							
1965	92	2	93,466,081	150,431	5,265,085	6,095,248	7,881,156
1964	85	1	86,742,262	153,676	5,378,660	5,810,510	7,512,989

County	Copper: Short tons	Copper: Value	Lead: Short tons	Lead: Value	Zinc: Short tons	Zinc: Value	Total value
Cochise	67,021	$47,450,585	6	$1,794	86	$24,981	$50,262,936
Coconino	810	573,268	---	---	---	---	603,328
Gila	95,320	67,486,772	---	---	---	---	67,882,872
Greenlee	127,586	90,330,640	---	---	---	---	91,377,665
Maricopa	12	8,602	---	---	---	---	17,765
Mohave	18,483	13,085,858	([4])	78	28	8,088	13,774,324
Pima	185,727	131,494,963	11	3,323	1,077	314,470	135,970,571
Pinal	184,677	130,751,776	---	---	---	---	133,224,500
Santa Cruz	63	44,392	359	111,914	653	190,807	376,554
Yavapai	23,678	16,763,989	5,465	1,705,236	19,907	5,813,034	25,816,354
Yuma	([4])	71	72	22,511	6	1,664	28,188
Total:							
1965	703,377	497,990,916	5,913	1,844,856	21,757	6,353,044	519,335,057
1964	690,988	450,524,176	6,147	1,610,514	24,690	6,715,680	471,742,019

[1] Operations at miscellaneous cleanups not counted as producing mines; various uranium mines from which copper was recovered as a byproduct not included as they were in the mine count of uranium.
[2] Does not include gravel washed or tonnage of precipitates shipped.
[3] Excludes tonnage of uranium ore milled.
[4] Less than ½ unit.

so, Tex.; 1 percent to the Asarco copper smelter at Tacoma, Wash.; and 1 percent to The National Zinc Co. zinc smelter, Bartlesville, Okla.

Production in the State was 2 percent (12,000 tons) higher than in 1964. In the United States, production increased 8.4 percent (105,000 tons); output from mines in Arizona accounted for 12 percent of this increase.

Porphyry copper ores were mined at open pits in Cochise, Gila, Greenlee, Pima, and Pinal Counties. Copper recovered from the ores ranged from 0.381 to 0.855 percent copper, averaging about 0.651 percent. In 1964, copper recovered from ores from open pit mines had ranged from 0.339 percent to 1 percent recoverable copper, averaging 0.682 percent. In 1965 ore from the underground mines contained from 0.698 to 4.52 percent copper; the lower analysis represents the copper content of the ore block caved at San Manuel and the higher analysis the copper content of the ore at the Magma mine where sandfill methods were used. Companies operating the 12 large open pit mines moved about 76.3 million tons of ore to recover 496,772 tons of copper.

Production of 429,794 tons of copper from five of the largest mines represented 61 percent of the State total; the first 10 major copper-producing mines accounted for 600,304 tons, or 85 percent; and the first 15 accounted for 682,962 tons, or 97 percent of the total. The production of 497,000 tons of copper required the removal of 190.1 million tons of waste and leach material. The ratio of waste and leach material to that of ore at the 12 principal producers was 2.48:1.

Table 8.—Mine production of gold, silver, copper, lead, and zinc in 1965, by classes of ore or other source materials, in terms of recoverable metals

Source	Number of mines [1]	Material sold or treated (short tons)	Gold (troy ounces)	Silver (troy ounces)	Copper (pounds)	Lead (pounds)	Zinc (pounds)
Lode ore:							
Dry gold	3	96	39	85	100	---	---
Dry gold-silver	6	114,793	428	9,519	1,795,300	---	---
Dry silver	17	23,847	24	31,348	194,300	1,900	900
Total	26	138,736	491	40,952	1,989,700	1,900	900
Copper	40	92,859,535	133,830	5,352,850	1,308,809,700	13,200	2,212,200
Copper-zinc	4	85,172	87	21,602	4,332,700	22,500	9,398,000
Lead	7	1,403	30	2,812	2,900	109,300	8,900
Lead-zinc	4	336,557	15,402	624,807	650,000	11,463,900	30,865,100
Zinc	1	2,763	---	8,828	114,400	112,200	995,400
Total	56	93,285,430	149,349	6,010,899	1,313,909,700	11,721,100	43,479,600
Other "lode" material:							
Gold tailings	1	19	8	2	---	---	---
Gold-silver and silver tailings [2]	4	29,815	529	15,213	97,400	---	---
Copper cleanup and copper smelter cleanup [2]	([3])	807	43	1,061	176,900	---	---
Copper precipitates	19	63,159	---	---	89,282,500	---	---
Lead cleanup	([3])	2	---	---	---	1,500	---
Lead tailings	2	11,200	1	946	---	60,900	3,400
Lead-zinc mill cleanup	([3])	[4] 72	[4] 2	[4] 26,174	[4] 1,297,800	[4] 40,600	[4] 30,100
Zinc mill cleanup	([3])	([4])	([4])	([4])	([4])	([4])	([4])
Uranium ore	---	---	---	([4])	([4])	---	---
Total	26	105,074	583	43,396	90,854,600	103,000	33,500
Total "lode" material	92	93,529,240	150,423	6,095,247	1,406,754,000	11,826,000	43,514,000
Placer	2	---	8	1	---	---	---
Total, all sources	94	93,529,240	150,431	6,095,248	1,406,754,000	11,826,000	43,514,000

[1] Detail will not necessarily add to totals because some mines produce more than one class of material.
[2] Combined to avoid disclosing individual company confidential data.
[3] From properties not classed as mines.
[4] Lead-zinc mill cleanup, zinc mill cleanup, and uranium ore combined to avoid diclosing individual company confidential data.

Table 9.—Mine production of gold, silver, copper, lead, and zinc in 1965, by types of material processed and methods of recovery, in terms of recoverable metals

Type of material processed and method of recovery	Gold (troy ounces)	Silver (troy ounces)	Copper (pounds)	Lead (pounds)	Zinc (pounds)
Lode:					
Amalgamation:					
Ore	20	1	---	---	---
Tailings	8	2	---	---	---
Total	28	3	---	---	---
Concentration and smelting of concentrates:					
Ore [1]	135,681	5,622,805	[2] 1,282,293,300	11,185,500	43,246,700
Direct-smelting:					
Ore	14,140	453,239	29,439,800	598,400	237,200
Cleanings	45	3,987	177,500	42,100	30,100
Precipitates	---	---	89,282,500	---	---
Old tailings	529	15,213	97,400	---	---
Total	14,714	472,439	118,997,200	640,500	267,300
Other:					
Leaching of copper ore	---	---	5,463,500	---	---
Placer	8	1	---	---	---
Grand total	150,431	6,095,248	1,406,754,000	11,826,000	43,514,000

[1] Includes uranium ore concentrate.
[2] Includes copper recovered from leaching of ore at operations that employ "dual-process" treatment of leaching followed by flotation concentration.

Greenlee.—Morenci Branch, Phelps Dodge Corp., the largest producer of copper in the State, was ranked second in the Nation. According to the company annual report, production of copper was 127,566 tons, compared with 129,406 tons in 1964. The open pit mine at Morenci was operated on the equivalent of 6.5 days per week. Operations were continual throughout the year, except for regular 2-week vacation shutdowns. Ratio of waste and leach material to ore was 1.55:1 compared with 1.61:1 in 1964.

Installation of the leach-precipitation-flotation system for recovering part of the nonsulfide copper content of the Morenci ores was completed and was partly in operation at the end of the year. The plant was to reach its designed capacity during the first half of 1966. Built at a cost of $18.7 million, the new system when operating at designed rate was to add 10,000 tons of copper to the annual output of the mine.

Work was continued on the application of X-ray analysis to the continuous analysis of feed, concentrate, and tailing streams in the concentrator and ore-dressing pilot plant. The mechanical tuyere puncher developed by the Morenci staff was installed at the Morenci smelter.

The Blue Ridge Dam project on East Clear Creek, a tributary of the Little Colorado River in central Arizona, begun in May 1963, was completed in November at a total cost of $6.9 million. The project provided additional water for the Morenci operation.

With increased quantities of water available, production of copper from leaching waste dumps was increased. Construction of a new precipitation plant, begun during the year, was to be operated in the second quarter of 1966. The new facilities, when operated on a full-year basis, were to increase copper production at Morenci an additional 15,000 tons per year.

Expansion of the Morenci pit was to require the relocation of a part of the town of Morenci over the next several years. This project was begun in 1965 with the relocation of the industrial railroad, some site preparation and design, and start of construction of the first new buildings, including the administration building and shopping center. Thirty-seven new houses also were under construction.

The Morenci mine yielded significant quantities of gold, silver, and molybdenum as byproducts from treatment of copper ores. Limestone mined by the company at the Morenci quarry was used as a flux and in manufacturing quicklime used for metallurgical purposes. The company also produced crushed sandstone from a quarry near Morenci for use as a flux in smelting copper ores.

Charles E. Stevens reported production of a small quantity of copper ore from the Molinar-Alaska mine in Copper Mountain mining district. The mine was recently reopened following the repairing, retimbering, and laying new track in 1,400-foot adit.

High-grade silica rock from the Harmony claims was quarried and shipped by O. Brice Willis to Phelps Dodge Corp. smelter at Morenci for use as a flux in the reverberatory furnaces.

Nonmetals accounted for about 2 percent of the total value of mineral production in the county. Sand and gravel was produced and most of it prepared in portable plants by contractors for the State highway department and crews of the county highway department for use in road construction and maintenance. A small quantity of miscellaneous crushed stone was produced by contractors for the Arizona Highway Department.

Maricopa.—Maricopa County was the leading producer of sand and gravel, producing 32 percent of the State's entire output. Nonmetals comprised 99 percent of the total value of mineral production of which 97 percent was sand and gravel. Thirteen commercial operators, utilizing 12 stationary and 4 portable plants, produced 4.4 million tons of sand and gravel valued at $5.4 million. More than 4.3 million tons of sand and gravel was produced for the construction industry. Much of the output came from pits in Buckeye, Mesa, Phoenix, and Tempe. United Materials, Inc., supplied most of the blast sand produced in the State. American Sand and Rock Co., a subsidiary of California Portland Cement Co., began producing precast, prestressed, hollow-cored, machine-extruded concrete slabs at its new Phoenix plant on April 6. The company produced sand and gravel for aggregate from pits near Phoenix.

miles north of Hayden. Early in the year, underground mining was curtailed because of ground movement on the 1,300-foot level. Extensive repairs required caused a decrease in production. With ground support a major problem, the ore body was mined in limited segments and back-filled as soon as possible. A new area in the mine was developed for mining by smaller stoping areas, a method permitting earlier back filling. The older areas in the mine were to be more extensively back filled at an earlier date than before. Course mill tailing, obtained from the treatment of open pit and underground ores, together with dump material, was used as back fill.

Concentrates produced from underground ores at the Christmas mine were trucked 36 miles north to Miami and discharged into railroad cars for transportation over the Inspiration railroad, a short distance up the hill to the company smelter for extraction of blister copper. Blister copper for producing refined cathodes was moved to the nearby Inspiration electrolytic refinery.

Miami Copper Co. Division, Tennessee Corp. (a subsidiary of Cities Service Co.) recovered copper from low-grade copper ores obtained from the Copper Cities open pit mine, from leaching low-grade dumps at the Castle Dome property, and from inplace leaching of ore at the Miami mine. The Miami mine, closed in 1959, had been operated by block caving. Copper concentrates produced at the Copper Cities mill were shipped to the smelter operated by Inspiration Consolidated Copper Co. at Inspiration. Copper precipitates from Copper Cities and Miami were trucked to the Phelps Dodge Corp. smelter at Douglas.

Ten other properties yielded ore from which gold, silver, and copper, collectively, were recovered. Ranchers Exploration and Development Corp. increased the output of copper precipitate at the Blue Bird mine near Miami and prepared to expand mining-leaching plant operations to produce 20,000 pounds of cement copper per day. Production was reported to have been limited by shortages of water. Asarco recovered silver and copper from silver tailing contained in dump material from the Christmas tailing dump. Copper ore, shipped from the Copper Hill mine by E. M. Moores, Jr., was used at Inspiration in smelting copper ore.

Nonmetals production accounted for 2 percent of the value of mineral production. Asbestos and lime were the main nonmetallic minerals produced. Jacquays Mining Corp. (Regal and Chrysotile mines), Metate Asbestos Corp. (Lucky Seven mine), and Asbestos Manufacturing Co. (Phillips mine) produced asbestos fiber, dust, and tails from ores obtained from deposits in the Salt River Valley. Crushed limestone produced at quarries operated by Hoopes & Co. near Miami and Ray Mines near Hayden was used in producing quicklime and as a flux in smelting copper ores. A small quantity of noncommercial granite and miscellaneous stone was obtained from deposits on the San Carlos Indian Reservation for use as rip-rap. George O. Gould shipped dimension sandstone from the Yellow Stone quarry near Pine for use as a decorative stone in fireplace (hearth) construction; a small quantity also was sold as rubble. McKusick Mosaic Co. mined fire clay from the Weary Lode No. 2 for use in manufacturing pottery and floor and wall tile.

Five properties yielded ore from which mercury was recovered. Output of crude ore totaled 3,132 tons containing 0.049 percent mercury, ranging from 0.02 to 0.25 percent. Most of the ore was retorted; only 4 percent was furnaced. Gordon K. Grimes, operator of the Rattlesnake mine, was the largest producer. A small quantity of magnetite ore was mined and shipped by H. M. Seitz from the Margaret-Howard mine for use as a processing agent. The deposit, located about 38 miles north of Miami, was as a contact metamorphic or pyrometosomatic replacement of Mescal limestone associated with diabase intrusives.

Graham.—The value of mineral production in Graham County declined. More than half of the value of mineral production was derived from crushed limestone at a stationary plant near Safford. Accounting for the remainder, volcanic cinders produced by Gila Valley Block Co. from the Pumice, Blue Bird, and Triangle claims were used as aggregate in manufacturing lightweight building blocks.

Exploration was conducted at the Copper Flat claims in accord with the terms of a lease with purchase option held by Newmont Exploration, Ltd., & Hecla Mining Co.

Production of copper during the first 6 months averaged about 61,000 tons per month. During the second 6 months, production dropped to 56,000 tons per month.

Cement copper, recovered by precipitation from leach solutions obtained from dump leaching, contained 44,600 tons of recoverable copper, slightly less than the 45,400 tons recovered the previous year. In addition, 2,732 tons was recovered by heap leaching in 1965 compared with 1,044 tons in 1964. Output was to be increased approximately 50 percent with completion of plants currently under construction.

The price of copper increased from 34 to 36 cents per pound in May. Early in November almost all major producers increased their price to 38 cents; a few days later at the urging of the Government, domestic producers returned to the 36-cent level. Copper prices remained at the 36-cent level for the balance of the year. The weighted average domestic price for 1965, calculated from sales of electrolytic copper at producer plants as reported to the Federal Bureau of Mines, was 35.4 cents per pound.

Gold.—Output of gold totaled 150,431 ounces, 2 percent less than in 1964. Eighty-nine percent was recovered as a byproduct in the refining of copper, 10 percent recovered from lead-zinc ores, and 1 percent from other ores. The major mines, listed in order of output, were Copper Queen-Lavender Pit, New Cornelia, San Manuel, Iron King, Magma, Morenci, Christmas, and Ray. The eight leading producers accounted for 148,000 ounces, 98 percent of the total. Two percent of the production came from 43 smaller operations throughout the State.

In its annual report to the shareholders, Phelps Dodge Corp. stated that the combined output of gold recovered as a by-product of copper mining at Morenci, New Cornelia, and Copper Queen branches totaled 96,000 ounces, 64 percent of the State total.

Magma Copper Co. reported to its shareholders that production of gold at the San Manuel Division was 21,550 ounces. Output at the Superior Division, Magma mine, was 12,748 ounces. Combined output from the two properties was 8 percent above that of 1964, resulting from a slightly higher gold content in the ore and the higher tonnage of ore milled.

Cochise was the leading gold-producing county, followed in close order by Pima and Pinal Counties. Other counties reporting production were Yavapai, Greenlee, Gila, Mohave, Santa Cruz, Yuma, and Maricopa.

Shattuck Denn Mining Corp., third leading producer in the State, recovered gold from lead-zinc ores obtained from the Iron King mine in Yavapai County. According to the company annual report, 1965 production totaled 15,677 ounces compared with 18,749 ounces in 1964.

Iron Ore.—Arkota Steel Corp., the largest producer of iron ore in the State in 1964, was idle. Production of small quantities of hematite ore was reported by Arizona Gypsum Corp. from the Iron Chancellor mine and by G. A. Swartz from the Cowden mine near Seligman, Yavapai County. Magnetite ore produced by H. M. Seitz from the Margaret-Howard mine in Gila County was used as a processing agent. Sponge iron was produced from iron oxides obtained in the smelting process at the Phelps Dodge Corp. smelter at Douglas and from pyrite at Ray Mines.

Lead.—Production of lead declined 4 percent in 1965. Ore produced at the Iron King mine and concentrated in the company mill accounted for most of the output. Concentrates from the company mill were shipped to the Asarco smelter at El Paso for processing. Arivaca Mining Corp., the second largest producer of lead in the State, mined lead-zinc ores from the Arizona, Idiho, and Glove mines in Santa Cruz County. Indiana Mining Corp. operated the Indiana mine near Nogales. Yavapai County with six operators led the State with the production of 5,465 short tons, representing 92 percent of the total output. Santa Cruz County with five operators was second, accounting for 6 percent. The remaining 2 percent came from operations in Cochise, Mohave, Pima, and Yuma Counties.

Mercury.—Output of mercury from seven mines in the Mazatzal Mountains in Gila and Maricopa Counties, principal producing area in the State, reflected the high demand for this commodity in domestic and world markets. Production and value of mine shipments more than doubled with the price of mercury rising from $475 per flask to $740 per flask between January and May. Since May, prices ranged from $525 to $550 per flask.

Mercury content of ore mined in the State averaged 0.059 percent and ranged from 0.02 to 0.25 percent. Seventy-three percent was furnaced; the balance was retorted. The Pine Mountain mine, Maricopa County, operated by United Nuclear Corp. and Bacon & Brunson, was the largest mercury-producing mine, followed in descending order by National mine, Maricopa County, operated by V. D. Bradley and Dr. Duane Brown; Valley Assay mine, Gila County, operator unknown; Rattlesnake mine, Gila County, operated by Gordon K. Grimes; Mercuria mine, Gila County, operated by Five Points Mining Co.; and an unnamed deposit in Gila County, operated by Associated International Mineral and Mountain State Electric. Sales of mercury totaled 158 flasks valued at $90,000. Buyers of mercury in order of purchases were Chemical Manufacturing Co., Piggott Projects, and Braun Corp.

Molybdenum.—Arizona accounted for 12 percent of the total U.S. molybdenum production.

Molybdenum concentrate produced in the State as a byproduct in the processing of copper ores increased 49 percent. The molybdenum content of the concentrate ranged from 38 to 60.1 percent molybdenum, averaging about 54 percent for 9.4 million pounds produced. The large increase in output resulted primarily from the first full year of operation at the Mineral Park plant operated by Duval Corp. near Kingman, Mohave County, and of the zinc-recovery unit at the Mission mine in Pima County operated by Asarco. The modification of the molybdenum circuit at the San Manuel concentrator, operated by Magma Copper Co., was a contributing factor. Inspiration Consolidated Copper Co. reported a decline in production because of lower grade ores being mined. Asarco reported lower production from the Silver Bell property. Approximately 50.3 million tons of ore was processed in the recovery of 8,782 tons of molybdenite concentrates, containing 4,750 tons of molybdenum.

Shipments of molybdenum concentrates from nine mines in six counties contained 9.4 million pounds of molybdenum valued at $15.9 million. The average price reported for molybdenum in concentrate form was $1.69 per pound. In 1964, the average price per pound of molybdenum in concentrate form was $1.51. Exports of molybdenum concentrates from mines in Arizona contained 2.1 million pounds of molybdenum, 23 percent of the total shipments. Stocks increased.

Listed in order of decreasing production, the mines and operators were San Manuel, Magma Copper Co.; Mineral Park, Duval Corp.; Esperanza, Duval Corp.; Mission, Asarco; Silver Bell, Asarco; Bagdad, Bagdad Copper Corp.; Morenci, Phelps Dodge Corp.; Inspiration, Inspiration Consolidated Copper Co.; and Childs-Aldwinkle, Burney Mines, Inc.

The new molybdenite extraction process installed at San Manuel concentrator, operated by Magma Copper Co., was reported[6] to have increased flotation capacity of the existing plant by at least 25 percent. The change from the sodium hypochlorite-ferrocyanide process to the new process included a conditioning step with hydrogen peroxide, sulfuric acid, sodium cyanide, and zinc sulfate; a two-stage rougher-flotation step with stove oil and sodium ferrocyanide; one-step cleaning with ferrocyanide; one-step cleaning with sodium hypochlorite and potassium ferrocyanide used to treat the pulp; and four cleaning steps with anti-foam Exfoam 636 and potassium ferrocyanide. The high rate of corrosion and the high maintenance cost experienced with the hypochlorite process formerly used was to be greatly reduced.

Following completion in 1966, the $1 million molybdenum recovery unit, Ray Mines was to become the 10th Arizona porphyry copper mine to recover molybdenite as a byproduct of copper mining. The decision to build the plant followed several years of testing and design.

Silver.—Production of silver was only slightly higher than that of the previous year. Copper ores, primarily porphyry, from 16 mines yielded 5,352,850 ounces of silver, 88 percent of the State output. Lead-zinc ores was the source of 10 percent, and other ores 2 percent. In 1965, the ratio of silver to copper was 8.2 ounces of silver for each ton of copper produced

[6] Burke, Harry K., and Shirley, Joseph F. San Manuel's New Process for Molybdenite Recovery. Min. Eng. v. 17, No. 3, March 1965, pp. 79–84.

About 89 percent of the total production was gravel; the balance was sand. Pumice and pumicite material produced at quarries in the Flagstaff-Winona area was sold for use as concrete aggregate, as railroad ballast, and in road construction. Paul Zanzucchi and Roberta Forehand produced volcanic cinders (pumice) from deposits near Flagstaff which was sold to Harenberg Block Co., Inc., in Flagstaff for manufacturing building block. Peter Kiewit Sons' Co. quarried and crushed sandstone and miscellaneous stone for use in road construction. Companies operating quarries in the Williams-Ash Fork-Drake area quarried and prepared dimension sandstone for use as a building stone and flagging.

Gila.—Output of copper and associated metals from mines in the Globe-Miami and Christmas areas furnished 98 percent of the total value of mineral production in the county. Nonmetallic minerals and mineral products, together with iron ore and mercury, accounted for the remainder.

Inspiration Consolidated Copper Co., operator of the Live Oak and Thornton open pit mines and Christmas underground mine, was the largest producer. According to the company annual report, the Live Oak and Thornton open pit mines were operated continually throughout the year, except for seven holidays and two 1-day wildcat strikes. Mine operations were routine, except for the month of December when heavy rains disrupted surface operations. The high rate of waste stripping was maintained, particularly on the Thornton West extension, established in 1963 and 1964. The division mined and treated 5.8 million tons at an average rate of 16,521 tons per day. The ore contained 0.894 percent total copper (0.416 percent oxide copper and 0.478 percent sulfide copper), indicating that the ore was slightly lower in grade than in the previous year. The ratio of waste to ore was higher (1.64:1 in 1965 and 1.59:1 in 1964); the higher ratio resulted from development work at the Thornton West extension.

The Inspiration Division used several processes for producing copper. Leaching-in-place was employed on waste dumps or mined-out areas. Copper was dissolved and subsequently precipitated as cement copper on scrap iron. In 1965, 7.19 percent of the total output by the Inspiration Division was obtained by this method. Vat leaching, a similar process involving the treatment of ore-grade material (part is acid soluble and part is not), accounted for 40.67 percent of the 1965 production. Leach solutions in this process were stripped of their copper content by electrowinning which produced a refined copper cathode and by precipitation in the form of cement copper. The leached ores were retreated by grinding and flotation concentration to liberate and recover the sulfide copper. This process recovered 40.18 percent of the total copper produced during the year. The remaining 12.8 million pounds representing 11.96 percent of the total production was recovered by separately treating ore particles too small for vat leaching, first by flotation concentration and then by agitation-leaching; the process produced a concentrate and a copper precipitate. Copper concentrates and precipitates obtained from the above processes were further treated by smelting and electrorefining to produce cathodes. A small quantity of copper precipitate was upgraded and sold for powdered metallurgy and chemical operations. Overall recovery through the refinery was 87.05 percent, compared with 85.33 percent in 1964.

Molybdenum content of the concentrate produced by retreating copper concentrates totaled 355,503 pounds, compared with 587,014 pounds in 1964. The smelter treated 176,112 tons of concentrates, precipitates, and other materials; 108,031 tons was company material, 68,081 tons was custom or toll intake. During the year one of the old reverberatories at the smelter was dismantled to permit construction of a large furnace. Design began in February 1965; completion was expected in the second quarter of 1966. The remaining reverberatory was operated at capacity; some material was shipped elsewhere for treatment to avoid accumulation of inventory. The new furnace was to handle normal smelter intake, and the remaining old furnace was to be held on standby.

Operations at the refinery were conducted at or near capacity during most of the year. Extensive repairs were made on the old section of the refinery principally to refining tanks, solution heating equipment, and facilities for byproduct recovery.

The company continued to have difficulty in mining the O'Carroll ore body of the Christmas underground mine, 10

Table 16.—Value of mineral production in Arizona, by counties

County	1964	1965	Minerals produced in 1965 in order of value
Apache	$5,483,255	$4,347,106	Helium, uranium ore, natural gas, sand and gravel, vanadium, petroleum, pumice, clays, stone.
Cochise	53,727,756	W	Copper, gold, silver, stone, lime, sand and gravel, zinc, lead.
Coconino	7,367,976	W	Uranium ore, pumice, sand and gravel, copper, stone, silver.
Gila	64,278,510	70,389,453	Copper, lime, molybdenum, asbestos, silver, stone, sand and gravel, gold, mercury, iron ore, clays.
Graham	W	W	Stone, pumice.
Greenlee	87,325,743	93,809,251	Copper, lime, molybdenum, silver, stone, gold, sand and gravel.
Maricopa	9,088,660	6,004,733	Sand and gravel, mercury, mica (scrap), clays, stone, silver, copper, gold.
Mohave	2,092,263	19,586,739	Copper, molybdenum, sand and gravel, silver, stone, feldspar, zinc, gold, lead.
Navajo	1,004,117	1,468,466	Sand and gravel, uranium ore, stone, vanadium.
Pima	148,899,356	149,153,395	Copper, cement, molybdenum, silver, sand and gravel, gold, stone, zinc, clays, tungsten concentrate, lead.
Pinal	119,452,151	141,730,125	Copper, molybdenum, sand and gravel, gold, silver, gypsum, lime, pyrites, perlite, stone, diatomite.
Santa Cruz	356,623	377,323	Zinc, lead, copper, silver, gold, stone.
Yavapai	32,570,543	33,054,812	Copper, zinc, cement, lead, silver, molybdenum, sand and gravel, gold, stone, lime, gypsum, clays, iron ore, pumice.
Yuma	2,428,721	1,290,738	Sand and gravel, stone, lead, gypsum, silver, zinc, gold, copper.
Undistributed [1]	[r] 277,271	58,969,629	
Total	[r] 534,353,000	580,182,000	

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes gem stones that cannot be assigned to specific counties and values indicated by symbol W.

Sandstone quarried by Andrew J. Gilbert Construction Co. at the Gilbert Silica pit near Courtland was used as a smelter flux by Phelps Dodge Corp. at Douglas. A small quantity of miscellaneous stone was quarried for use as riprap by contractors for the Arizona Highway Department.

Sales and shipments of quicklime by Paul Lime Plant, Inc., near Paul Spur, were less than those of the previous year; sales of hydrated lime increased. The company operated four natural-gas-fired rotary kilns. The lime was sold primarily for industrial and chemical uses; smaller quantities were sold for use by the building and agricultural industries.

Limestone—used in producing its lime, as a flux by the copper industry, an aggregate in road construction, as a mineral food, and for other uses—was quarried by Paul Lime Plant, Inc., near Paul Spur.

Coconino.—The county was the leading producer of uranium ore in the State. All of the ore was produced by Western Equities, Inc., at its mine on the south rim of the Grand Canyon. Silver and copper were recovered as byproducts in the processing of uranium ores produced by Western Equities, Inc., at the El Paso Natural Gas Co. Tuba City Mill. Zontelli Western Mining Co. operated its precipitation plant at the Mardun copper sandstone mine in the White Mesa district, Navajo Indian Reservation, for producing cement copper.

Construction materials—pumice, sand and gravel, and stone—comprised 43 percent of the total value of mineral output in the county. Sand and gravel was produced from 14 pits; 80 percent was produced by crews and contractors for the Federal Bureau of Indian Affairs and by contractors for the Federal Forest Service and the Arizona State Highway Department. All of the sand and gravel sold by commercial operators and 83 percent of that used by Government-and-contractor operators was proccessed in portable plants.

from copper ores, compared with 7.7 ounces of silver for each ton in 1964. The four leading silver producers in the State—Phelps Dodge Corp., Asarco, Duval Corp., and Shattuck Denn Mining Corp.—accounted for 74 percent of the total State output; in 1964, the same companies furnished 71 percent. Counties in which production was reported, listed in descending order of output, were Pima, Cochise, Pinal, Yavapai, Mohave, Greenlee, Gila, Coconino, Santa Cruz, Maricopa, and Yuma.

Tungsten.—A small quantity of tungsten concentrate (65.51 percent WO_3) was produced from ore mined at the Carboloy mine in Pima County in 1964 and shipped to Kennametals, Inc., Fallon, Nev., by Fernstrom Mining Co.

Uranium Ore.—Shipments of crude ore from 26 operations to processing plants at Tuba City; Grand Junction, Colo.; Shiprock, N. Mex.; and Mexican Hat and Moab, Utah, totaled 117,898 short tons, valued at $3.9 million, an increase of 15 percent in quantity and 20 percent in value. The f.o.b. mine value of the ore produced ranged from $1.96 for crude ore containing 0.07 percent uranium oxide (U_3O_8) to $145.50 per ton for crude ore containing 1.51 percent U_3O_8. The average grade of ore shipped from mines during the year was 0.38 percent U_3O_8, comparable with that shipped in 1964. The average value of the mine shipments was $33.24 per ton. The Orphan Lode mine, owned by Western Equities, Inc., on the south rim of the Grand Canyon, was the principal source.

Vanadium.—Uranium ores in Apache County, and to a lesser extent in Navajo County, contained sufficient quantities of vanadium to warrant recovery.

Zinc.—Ores from four lode mines, three in Yavapai and one in Pima County, yielded 96 percent of the recoverable zinc produced in the State. Output declined 12 percent in quantity and 5 percent in value because of lower grade ore mined at the Iron King mine operated by Shattuck Denn Mining Corp. and because of a decline in ore production at Old Dick Division mines operated by Cyprus Mines Corp. According to the company annual report, reserves of developed ore at the Old Dick and Copper Queen mines were essentially exhausted at yearend.

NONMETALS

Asbestos.—Output of asbestos—dust, sands, and fiber—from three underground mines in the Salt River Valley of south central Arizona totaled 3,500 short tons valued at $441,000. The leading producer, Jacquays Mining Corp., selectively mined and hand-sorted chrysotile asbestos ore at the Regal and Chrysotile mines for shipment to the company mill at Globe. Production also was reported by Asbestos Manufacturing Co. from the Phillips mine and by Metate Asbestos Corp. from the Lucky Seven mine. Prices ranged from $6 per ton for chrysotile sand (tails) to $460 per ton for filter-grade material.

The Fort Apache Indian Agency at Whiteriver issued a call for bids for leasing two tracts of tribal lands in Gila County. The tracts have had a history of commercial production.

Cement.—Activity in the Arizona cement industry declined in 1965. Arizona Portland Cement Co., a division of California Portland Cement Co., and Phoenix Cement Co., a division of American Cement Corp., produced portland and masonry cements at plants in Pima and Yavapai Counties, respectively. Shipments of cement were 24 percent below those of 1964. Average price per barrel for portland and masonry cements remained aprpoximately the same; the downward trend in shipments reflected the decline in construction.

Portland-cement capacity was 5.3 million barrels, the same as in 1964. The entire output was by the dry process. All electrical energy used by the cement industry was purchased. Cement stocks at the end of the year were more than those at yearend 1964. Of the total shipments, 75 percent was shipped by truck and 25 percent by rail. Most of the shipments were in bulk form (83 percent); 17 percent was in containers.

Clays.—The quantity of bentonite and miscellaneous clays produced at mines in the State declined; that of fire clay increased slightly. The lower output of miscellaneous clay was attributed to reduced construction activity. Increased demand for clay products manufactured by McKusick Mosaic Co. accounted for a larger production of fire clay. Miscellaneous clay and shale used in manufacturing building brick and portland cement comprised most of the total output.

Bentonite clays were mined from two deposits, one each in Apache and Yavapai Counties; miscellaneous clay came from three deposits in Pima County, two in Maricopa County, and one in Yavapai County; and fire clay came from a deposit in Gila County. Most of the clays were mined at captive operations.

Diatomite.—A small quantity of crude diatomite—prepared and sold for use as a filler—was mined by Arizona Gypsum Corp. from its White Cliffs property near Mammoth, Pinal County.

Feldspar.—Industrial Minerals Division, International Minerals & Chemical Corp. (IMC), was the only producer of crude and ground feldspar in the State. All of the crude potash feldspar produced by a contractor for IMC from the pegmatite deposits at the Taylor mine was ground in the company mill near Kingman and used in manufacturing glass, pottery, and soaps and abrasives.

Gypsum.—The gypsum industry in Arizona in 1965 consisted of five mining operations; three in Pinal County and one each in Yavapai and Yuma Counties. Output was lower than in the previous year. National Gypsum Co. calcined crude gypsum obtained from the company open pit mine near Winkelman (Pinal County) at the company plant at Phoenix for use in manufacturing wallboard, lath, and other plaster products. Gypsum mined by Arizona Gypsum Co. from deposits near Winkelman and Camp Verde in Pinal and Yavapai Counties was sold uncalcined for use as a cement retarder and as a soil conditioner. Garcia Gypsum Co. sold crude gypsum from an open pit deposit near Mammoth; Harquahala Gypsum Co. sold the product from an underground deposit near Salome for use as a soil supplement.

Lime.—Marketed quicklime (calcium oxide) and hydrated lime (calcium hydroxide) increased 15 percent because of a greater demand for quicklime by the copper industry. Of the quantity sold or used, 94 percent was quicklime and 6 percent was hydrated lime. Chemical and industrial uses consumed most of the output; included were 178,000 tons used by the copper industry. Sales for use by the construction industry, principally for soil stabilization, were higher. A small quantity was consumed in refining magnesium, in manufacturing open-hearth steel, and in gas purification.

Most of the lime was used within the State; a small quantity was shipped to consumers in California, New Mexico, and Mexico. About 48 percent was used by a captive market. Morenci, Ray Mines, and San Manuel used their entire output for concentrating copper ore. Lime was produced and sold by Paul Lime Plant, Inc., in Cochise County; Hoopes & Co. in Gila County; and U.S. Lime Division, The Flintkote Co., in Yavapai County.

Six companies operated six plants in five counties—one each in Cochise, Greenlee, Pinal, and Yavapai, and two in Gila. Greenlee County replaced Cochise County as the leading producer in the State. Cochise County, the second largest producing county, was followed in order by Gila, Yavapai, and Pinal Counties.

Approximately 392,000 tons of limestone was used in producing the lime. Natural gas was used as fuel for one Ellernan, seven rotary, and five shaft kilns used in the State; fuel oil was used for one rotary kiln.

Mica.—A small quantity of scrap mica produced by Buckeye Mica Co., at its mine near Buckeye in Maricopa County, was dry-ground in the company mill in Buckeye. The ground mica was sold for use in manufacturing paint.

Perlite.—Output of crude perlite from three mines in Pinal County increased 4 percent in quantity but declined 11 percent in value. Most of the crude was shipped to processing plants outside the State. Arizona Perlite Roofs, Inc., operated the Adams and Iberri mines near Superior in Pinal County and shipped crude perlite to the Supreme Perlite, Inc., expanding plant in Maricopa County and to an expanding plant outside the State. Expanded perlite produced by Supreme Perlite, Inc., at Phoenix was used as a concrete aggregate, as an aggregate replacing sand in plaster, as loose-fill insulation, and as a soil conditioner. Harborlite Corp. operated the Harborlite perlite mine in Pinal County and shipped crude perlite to company-owned and other expanding plants outside the State.

Pumice.—Output of pumice and pumicite materials from 11 mines—12 operations, collectively, in Apache, Coconino,

REVIEW BY COUNTIES

Apache.—Mineral fuels accounted for 63 percent of the total value of mineral output in the county. All of the helium, the most valuable mineral commodity, petroleum, and natural gas produced in the State came from fields in Apache County. Fifty-five percent of the wildcat drilling in the State was in the county.

Uranium ore was mined at 18 operations —mostly from the Carrizo and Lukachukai Mountains in the northern part of the county. Principal producers were Vanadium Corporation of America; Pioneer Drilling Co.; Climax Uranium Co., a unit of Climax Division, American Metal Climax, Inc. Vanadium was recovered from Apache County uranium ores at the Grand Junction, Colo., and Shiprock, N. Mex., mills which were equipped with vanadium-recovery units.

The sharp decline in the output of sand and gravel and stone reflected a reduction in road construction in the county. Filtrol Corp. mined and processed nonswelling bentonitic clays from the Cheto mine near Sanders for use as a filter in refining mineral and vegetable or animal oils and fats. Pumice mined near Springerville by the Apache County Highway Department was prepared and used in road construction.

Cochise.—Copper mining in Cochise County, principally in the Douglas-Bisbee area, accounted for $50.3 million of the total value of mineral output. Construction materials—lime, sand and gravel, and stone —accounted for the remainder. Cochise County, the leading producer of gold in the State, ranked second in the output of silver and fifth in copper.

Phelps Dodge Corp., Copper Queen Branch, produced most of the gold, silver, and copper at the Copper Queen underground mine and at the Lavender open pit mine in the Warren district at Bisbee. The Copper Queen Branch, the oldest of the three big active branches, was the cradle of mining by Phelps Dodge in Arizona. According to the company annual report, production from this property was less than in 1964. The ratio of waste and leach material to ore mined at the Lavender Pit increased from 3.17:1 reported in 1964 to 3.87:1 in 1965. Part of the ore from the underground mine was shipped to the company smelter at Douglas; part was treated at the Lavender Pit concentrator. All of the concentrate produced at the concentrator was smelted at Douglas.

In November the company announced plans for a minor westward expansion of the Lavender open pit. The enlargement of the mine was expected to extend the life of the pit about 2 years.

Underground exploration continued during the year; the tonnage of ore developed was less than the tonnage mined. The system for pumping sand tailing into mined-out areas as waste fill, introduced into some parts of the mine in 1964, was extended throughout the mines in 1965. The system of waste fill has materially reduced expenses and speeded up mining operations. Metallurgical testing of mixed oxide-sulfide copper-bearing material was carried out at Bisbee. The application of automatic control of grinding in ball mills was studied.

The Douglas smelter, 40 miles east of the Copper Queen Branch operations at Bisbee, treated ores from the underground mines at Bisbee, concentrates from the Lavender Pit concentrator, and copper precipitates from leach material obtained from the Lavender Pit. The smelter also treated a small tonnage of other materials on a custom or toll basis. The tonnage of copper scrap treated at the smelter in 1965 was considerably higher than that of the previous year. During the year, improvements were made in facilities and methods for handling the increased flow of this material. At the Douglas smelter, adaptation of a mechanical tuyere-puncher, developed by the staff, was studied.

Small quantities of gold, silver, copper, lead, and zinc were recovered from ores mined at seven small properties collectively. Siliceous copper ore produced at the Burro claims by Ira L. Moseley & Sons was trucked to Dragoon for rail shipment to the Asarco smelter at El Paso.

Interstate Accounting & Office Service continued work at the Mame mine of Hope Mining and Milling Co. in the Turquoise mining district. Pipelines installed between the Mame shaft and the Musso shaft provided an adequate supply of water for leaching. Cement copper was produced from the leaching of underground stopes.

Table 14.—Stone sold or used by producers, by uses

Use	1964		1965	
	Quantity	Value	Quantity	Value
Dimension stone:				
Rough construction____short tons__	2,355	$23,957	3,037	$22,428
Rubble ________________________do__	380	1,634	496	11,293
Rough architectural __cubic feet__	23,935	14,192	31,822	26,419
Dressed architectural _________do__	34,962	57,226	13,252	27,174
Curbing and flagging _________do__	106,211	122,612	52,744	52,542
Total (approximate, in short tons) ______________________	15,300	219,621	10,900	139,856
Crushed and broken stone:				
Riprap _______________short tons__	977,720	1,618,123	286,073	413,228
Metallurgical _________________do__	526,962	1,147,114	530,658	1,138,903
Concrete and roadstone ______do__	676,340	925,825	362,684	731,568
Lime _________________________do__	316,871	746,246	391,835	717,420
Other ________________________do__	[1]1,246,026	1,626,018	[2]891,890	[2]1,030,200
Total _______________________do__	3,743,919	6,063,326	2,463,140	4,031,319
Total stone (approximate, in short tons) _________________	3,759,200	6,282,947	2,474,000	4,171,175

[1] Includes stone used in abrasives, agriculture, animal feed, cement, ceramics, cleansers, exposed aggregates, gunite, landscaping, marble fines, mineral food, porcelain, pottery, roofing granules, terrazzo, and tile.
[2] Includes stone used in abrasives, animal feed, cement, landscaping, mineral food, roofing granules; in making book ends, clocks, etc.; and for unspecified use.

Table 15.—Drilling for petroleum in 1965, by counties

County	Dry	Total	Footage
Exploratory completions:			
Apache ________________________________	16	16	88,936
Coconino ______________________________	1	1	6,998
Graham ________________________________	1	1	5,321
Navajo ________________________________	7	7	37,852
Yavapai _______________________________	4	4	5,519
Total _________________________________	29	29	144,626
Development completions:			
Apache ________________________________	4	4	10,186
Total all drilling ______________________	33	33	154,812

Source: Oil and Gas Journal.

Graham, and Yavapai Counties—increased 45 percent in quantity but declined 2 percent in total value. An increased demand for pumice and pumicite material as railroad ballast was the principal reason for the higher output. Pumice produced for use as road base and surfacing material in Apache and Coconino Counties increased, partly offsetting the decline in pumice and pumicite materials used as concrete aggregate. Accounting for 37 percent of the Nation's requirements, Arizona led all other States in the output of pumice and pumicite materials.

Pyrites.—Ray Mines recovered pyrites as a byproduct in milling copper ores. The pyrite was used in manufacturing sulfuric acid and sponge iron. The company also purchased a quantity of pyrite from the Magma mine as a supplemental feed for its sulfuric acid and sponge iron plant. Sulfuric acid was used in leaching copper from waste dumps and with sponge iron in leaching and precipitating oxide copper by the leach-precipitation-flotation process. Production of pyrites increased 29 percent in quantity and in value over that of the preceding year.

Sand and Gravel.—Sand and gravel ranked second in value of mineral output. Of the 14.9 million tons produced, 7.4 million tons was Government-and-contractor output used for highway construction; 7.6 million tons was classified commercial. Production was reported from 59 commercial and 84 Government-and-contractor operations. Approximately 90 percent of 7.3 million tons shipped by commercial carrier was by truck and 10 percent by rail.

Table 10.—Sand and gravel production in 1965, by counties

(Thousand short tons and thousand dollars)

County	Quantity	Value
Apache ____________________	277	$367
Cochise ___________________	341	350
Coconino __________________	1,016	903
Gila ______________________	93	132
Greenlee __________________	104	113
Maricopa __________________	4,737	5,829
Mohave ____________________	1,981	2,008
Navajo ____________________	1,186	1,201
Pima ______________________	1,811	2,173
Pinal _____________________	1,824	1,947
Yavapai ___________________	680	748
Yuma ______________________	868	850
Total ___________________	14,918	16,621

Stone.—Production of stone in Arizona declined 34 percent in quantity and value. Lower construction activity, resulting from overbuilding and a 3-month construction strike that occurred during the summer were the primary reasons for the decline. Stone produced by or for the use of Government agencies used in highway construction declined 74 percent in quantity and 72 percent in value below figures for the previous year. Large quantities of limestone were used in manufacturing cement and lime and as a flux in the smelting of copper ores.

MINERAL FUELS

Coal.—Coal owned by the Navajo and Hopi Indians was to be used for generating 1.5 megawatts of power at an electric generating plant to be constructed in Clark County, Nev., by Western Energy Supply & Transmission Associates (WEST), a group of public and private utilities. Under an agreement between Southern California Edison Co. and Peabody Coal Co., Navajo and Hopi coal reserves in the Black Mesa area were to be transported by pipeline or rail to the plant site in Nevada. The generating plant, to be known as the Mohave Steam Station, was to be constructed as a part of the regional power plan developed by WEST. The agreement called for an expected consumption of 140 million tons of coal to be delivered over a 35-year period.

Helium.—Helium was extracted from helium-bearing, naturally occurring gas produced from the Pinta Dome and Navajo Springs fields, Apache County, at the Kerr-McGee Corp., Navajo plant. Based on Arizona Oil and Gas Conservation Commission reports of gas production, helium content of about 8.5 percent, and on assumed helium recovery of 97 to 98 percent, the plant produced an estimated 58 million cubic feet of grade A helium during the year. This output would be an increase of more than 17 percent over the 1964 indicated production of 46 million cubic feet. At $35 per 1,000 cubic feet, the price established by the Federal Bureau of Mines for sale of Government-produced helium to Government and industrial consumers, the Navajo plant output was valued at $2 million.

Kerr-McGee marketed the helium production from the Navajo plant to private customers, principally on the West coast.

Nine wells in the Pinta Dome and two

Table 11.—Sand and gravel sold or used by producers, by classes of operations and uses
(Thousand short tons and thousand dollars)

Class of operation and use	1964		1965	
	Quantity	Value	Quantity	Value
Commercial operations:				
Sand:				
Construction:				
Building	1,782	$2,346	1,207	$1,601
Paving	782	912	491	591
Fill	[1] 202	[1] 101	153	105
Other	(1)	(1)	11	9
Industrial:				
Blast	[2] 161	[2] 348	[3] 51	[3] 76
Engine	---	---	(3)	(3)
Oil (hydrafrac)	(2)	(2)	18	196
Other	---	---	12	16
Total	2,927	3,707	1,943	2,594
Gravel:				
Construction:				
Building	2,484	3,149	1,553	2,056
Paving	4,117	4,881	3,409	3,945
Railroad ballast	[4] 698	[4] 373	[5] 54	[5] 36
Fill	(4)	(4)	548	535
Other	---	---	(5)	(5)
Miscellaneous	18	28	47	63
Total	7,317	8,431	5,611	6,635
Total sand and gravel	10,244	12,138	7,554	9,229
Goverment-and-contractor operations:				
Sand:				
Paving	1,167	1,373	1,274	1,429
Fill	64	49	92	84
Total	1,231	1,422	1,366	1,513
Gravel:				
Building	16	16	---	---
Paving	6,625	7,292	5,924	5,827
Fill	---	---	66	48
Other	---	---	8	4
Total	6,641	7,308	5,998	5,879
Total sand and gravel	7,872	8,730	7,364	7,392
All operations:				
Sand	4,158	5,129	3,309	4,107
Gravel	13,958	15,739	11,609	12,514
Total	18,116	20,868	14,918	16,621

[1] Fill and "other (construction)" sand combined to avoid disclosing individual company confidential data.
[2] Blast and oil (hydrafrac) sand combined to avoid disclosing individual company confidential data.
[3] Blast and engine sand combined to avoid disclosing individual company confidential data.
[4] Railroad ballast and fill gravel combined to avoid disclosing individual company confidential data.
[5] Railroad ballast and other gravel combined to avoid disclosing individual company confidential data.

Table 12.—Stone production in 1965, by counties

County	Short tons	Value
Apache	16	$24
Cochise	437,984	1,031,808
Coconino	149,981	390,118
Gila	159,649	240,706
Graham	W	W
Greenlee	W	W
Maricopa	2,772	15,176
Mohave	142,737	338,214
Navajo	W	W
Pima	553,882	621,008
Pinal	74,091	153,582
Santa Cruz	513	769
Yavapai	370,756	478,654
Yuma	274,088	397,938
Undistributed	307,572	503,178
Total	2,474,041	4,171,175

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

in the Navajo Springs fields yielded helium-bearing gas.

At yearend, Apache Drilling Co., Phoenix, and La Fleur Corp., Los Angeles, Calif., announced that construction was to begin on a new helium plant at Navajo. The new plant, to be near the Kerr-McGee plant, was expected to be in operation by January 1, 1967; planned output was 1 million cubic feet per month. Apache was to be the operator; La Fleur, owned by Douglas Aircraft Co., was to market the product.

Natural Gas.—Marketed natural gas increased 54 percent over that of 1964. Production was from the Bita Peak, East Boundary Butte, North Toh Atin, and Twin Falls Creek fields. With the exception of output from the one gas well at Bita Peak, all of the gas was associated with crude oil.

Petroleum.—Output of crude petroleum increased 52 percent, to 97,000 barrels. East Boundary Butte had the greatest production, 43,600 barrels; followed by Dry Mesa, 27,600; and Walker Creek, 19,400 barrels.

Thirty-three unsuccessful wells were drilled in the State: 29 exploratory and 4 development wells. Five of the exploratory wells marked the first drilling on lands in the Hopi Reservation—lands first available for leasing in 1964.

Leasing in the State was at a much lower level than in 1964 when the Hopi Reservation was opened for leasing. Total acreage leased in 1965 was 13,280 acres for a bonus of $227,284, an average of slightly more than $17 per acre.

Table 13.—Stone sold or used by producers, by kinds

Year	Basalt and related rocks (traprock)		Granite		Limestone		Marble	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1961	285,371	$285,850	7,155	$7,155	1,099,455	$2,458,371	4,513	$60,732
1962	586,323	879,482	113,274	117,424	1,986,091	2,430,203	12,528	104,929
1963	80,816	208,716	20,705	32,738	1,771,114	2,307,107	22,713	287,042
1964	40,814	36,370	W	W	1,800,623	2,483,623	[1] 22,476	[1] 275,787
1965	W	W	236,735	362,186	1,601,867	2,146,626	W	W

Year	Sandstone		Slate		Other stone		Total	
	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1961	334,557	$942,155	------	------	851,276	$872,217	3,582,327	$4,626,480
1962	601,532	1,486,902	84	$837	1,033,310	1,596,130	4,333,142	6,615,907
1963	714,897	1,574,782	------	------	646,370	658,765	3,256,615	5,969,150
1964	788,171	1,675,194	------	------	1,107,096	1,811,973	3,759,180	6,282,947
1965	460,152	1,233,788	------	------	175,287	428,575	2,474,041	4,171,175

W Withheld to avoid disclosing individual company confidential data; included with "Other stone."
[1] Excludes dimension marble; included with "Other stone."

McALESTER FUEL COMPANY
McALESTER, OKLAHOMA

May 4, 1967

Mr. George F. Fry,
3000 Phyllis Lane,
Dallas, Texas 75234

Dear Mr. Fry:

I am returning to you herewith the copy of the iron ore reserves of certain claims made August 23, 1965 by Gifford A. Dieterle, with our thanks.

We have reviewed your discussion of this matter and must say that we regret we cannot go any further with it at this time.

With all thanks, I am,

Very truly yours,

T. E. GARRARD,
President.

TEG:BF
Encl.

bcc: Robert B. Ford -- Are you interested in his mercury?

T.E.G.

May 3, 1967

Mr. Tom Garrard
McAlester Fuel Company
Box 907
McAlester, Oklahoma

Re: Reduced Iron

Dear Tom:

In regards to your letter of April 21, concerning Mr. George Fry of Dallas, Texas who stopped into your office to promote several ventures, let me add something to your understanding of the reduced iron project. The Archean Corporation of Phoenix was statted as a $300,000.00 pubslic stock offering. The promoters of the Company are also the authors of the report which accompanied your letter. The ore reserves at the Archean Property were developed on three or four drill holes. Be that as it may, they do have some considerable iron ore reserves in a very inaccessible area. My personal opinion is that Archean Corporation will never make any reduced iron and we should neither rely on them for any production nor consider them any type of competition for any proposals that we may be considering.

Very truly yours,

RF/pc

with Lady Bug Report?

McALESTER FUEL COMPANY

TOM E. GARRARD
PRESIDENT

McALESTER, OKLAHOMA

April 21, 1967

MR. ROBERT B. FORD:

Today one George F. Fry, 3000 Phyllis Lane, Dallas, Texas 75234, Phone: Chapel 7-6232, a nice little man - a broker or promoter - was in to see me about several things, and particularly he was pushing some 300 iron ore claims near the Indian Reservation wherein C. F. & I. are mining iron ore. This is about 30 miles from Young, Arizona. These claims are owned by one Rex Ricks, whom one gets in contact with through the attorney John Goodson of Goodson & Rose, located in Phoenix.

Fry says that Rex Ricks owns a considerable amount of the Archean Corporation of Phoenix, which is installing a 100 tons per day plant at Young to process this iron ore, using a cost of about $4.50 per ton of iron as the ore cost. He left with me a report on the Archean Corporation, whose claims join the Rex Ricks' 300 in this vicinity.

It is not at all certain what Fry's real objective in talking to me was. He wanted to buy out McAlester Fuel Company for the Leidtke Brothers who have taken over control of United Gas and Pennzoil, he said; he wanted to interest us in 3,000,000 tons or more of 3-lb. per ton mercury in Nevada near the Arizona line; he told of the great sulphur potential near Thermopolis. I believe he figured that if he could get us to agree that the Fuel Company is for sale he could find a buyer and the other was just to keep his hand in. Probably the Archean people and Ricks would welcome some money either to make their affairs go or to buy them out.

In view of your interest in iron ore in this part of the world, and the process and the use in particular of powdered iron in copper production (which Fry emphasized very strongly and it is mentioned in the report), I talked to him somewhat at length and have had copied and am sending you herewith copy of his report.

T. E. GARRARD.

TEG:BF
Encl.

200

REPORT

I IRON ORE RESERVES OF THE LADY BUG AND ZEROX CLAIMS Gila County, Arizona

II THE MANUFACTURING OF SPONGE IRON FROM CONTAINED ORES

III THE MARKET FOR SPONGE IRON IN THE COPPER MINING INDUSTRY

ARCHEAN EXPLORATION CORP.
Phoenix, Ariz.

By; Gifford A. Dieterle
Consultant Geologist
52 Wall Street
New York, N.Y.

Dated: August 23, 1965

TABLE OF CONTENTS

INTRODUCTION

A geological investigation was carried out on the iron ore claims of Archean Exploration Company, located near the town of Young, Gila County, Arizona, for the purpose of developing sufficient ore reserves to commence a small sponge iron operation.

Technical aspects regarding the reduction of this ore to sponge iron were discussed with Dr. Greene and Mr. Allison, both familiar with the process involved. A preliminary cost estimate of producing sponge iron was provided by Archean Exploration Company.

A market study was made for the possible sale of sponge iron to the copper mining industry in Arizona. Information was obtained by interviewing purchasing agents with the major copper companies, suppliers to the copper industry, and various other informed persons.

SUMMARY

A geological investigation was carried out on the iron ore claims of Archean Exploration Company, near Young, Gila County, Arizona, to determine sufficient iron ore reserves to establish a commercial sponge iron plant, capable of providing a reliable supply of good quality sponge iron to the copper mining industry.

The field investigation which I personally carried out was supplemented by important drilling information, surface sampling, assays, surveys, and other pertinant data, provided by Archean Exploration Co., O.M.E., and other knowledgeable geologists and engineers.

The results of this investigation proved 14,487,000 tons of iron ore grading 55% Fe. on the Lady Bug Claims, and a possible 85,937,000 tons on the Zerox Claims.

The technical feasability of the reduction process was discussed in detail with Dr. Greene, Mr. Allison, and Mr. Hartman, and a preliminary cost estimate of delivering sponge iron to the copper companies was established. The production cost was estimated at $27.50/ton.

The process was termed absolutely feasable and competetive, with a delivery price of $55.00 to $65.00/ton at the copper plants.

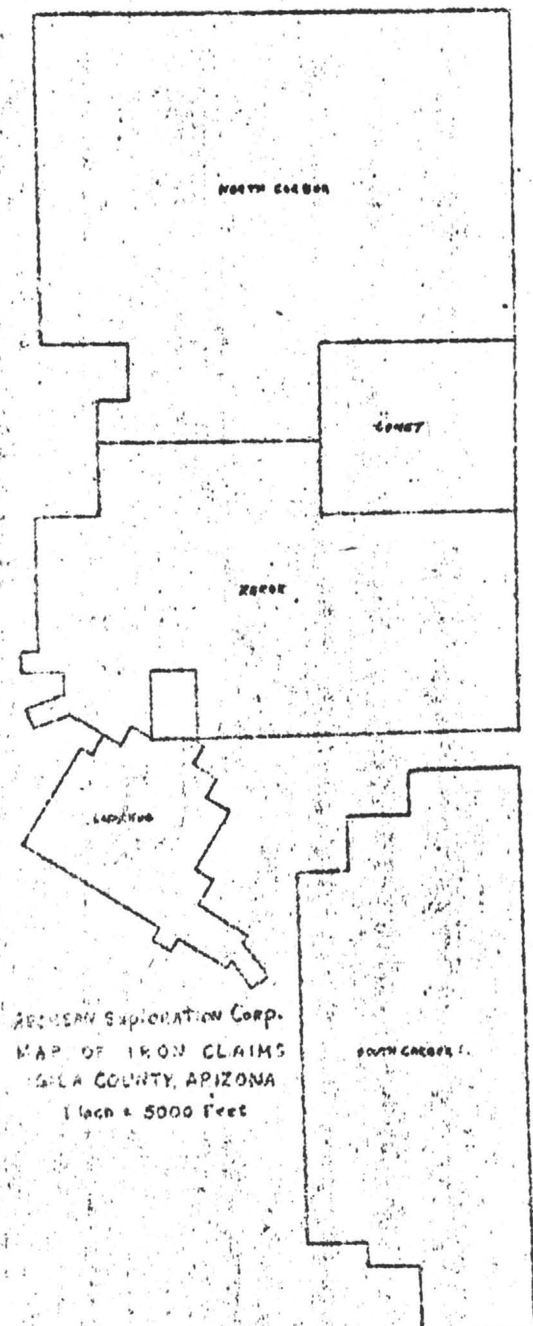
A market study was conducted, geared at selling iron sponge to the copper mining industry in Arizona. This resulted in favorable responses from all sources contacted, and it was determined beyond doubt that sponge iron had a real and growing place in the industry. It was further aknowledged that the time would soon be over for the tin can and scrap iron in the precipitation of copper cement.

I

THE CLAIMS

Owned or partially owned by Archean Exploration Company in Gila County, Arizona.

	ownership:	no.claims	size
Lady Bug Claims	100%	18	371 acres
North Carbox Claims	10%	132	2720 "
South Carbox Claims	10%	100	2060 "
Zerox Claims	100%	119	2451 "
Comet Claims	100%	27	556 "


COMET
MAP OF IRON CLAIMS
GILA COUNTY, ARIZONA
1 Inch = 5000 Feet

LOCATION

The Claims are located in Gila County, Arizona; 9 degrees North, 15 degrees East, Salt River meridian; sections 8, 9, 16, 17. The site of proposed sponge iron plant is located near highway 160, and about 38 miles northeast of claim groups.

ACCESS AND TRANSPORTATION

The Claims can be reached by truck and auto via highway 160, and thence 11 miles south on county road 288 towards Young. The plant site can be reached both by auto, truck, and railroad.

Excellent transportation conditions exist.

TOPOGRAPHY AND WEATHER

The Claims are situated on Lost Tank Ridge Mesa, and constitute a portion of Sierra Ancha Mountains. The ore is a stratigraphic unit, horizontally disposed within the mesa and extending southward along an irregularly projecting arm. The mesa is bordered by fairly steep canyons on all sides and elevations vary from 6400 to 6800 feet. The top of the mesa is relatively flat and covered with Ponderosa pine.

The weather is mild and pleasant throughout the summer, with plenty of rain. The winter months are moderate, with fair amounts of snow which does not last long, and with temperatures rarely dipping below zero.

GEOLOGY

The geology consists of a series of predominantly flat-laying formations of Pre-Cambrian Age, consisting of the Martin Limestone, the Troy Quartzite, the Chediski Sandstone, the Mescal Limestone, and the Dripping Spring Quartzite; the last overlaying igneous basement.

These formations have been subjected to a series of northeast-southwest and northeast-southwest striking faults, wherein the movement apears to have been one mainly of vertical displacement or rotation in blocks. Vertical displacements in excess of 700 feet have been determined.

The iron ore bed is situated near the basal member of the Mescal Formation. It forms an irregular, basically horizontal sheet, varying in thickness from 8 to 37 feet, but averaging 11 feet, and is considered to be a hematite replacement of limey chert. Overlaying the iron ore bed is a similar sheet of ferruginous chert, varying in thickness from 3 to 30 feet, but averaging 8 feet. At times, this section may also be classsified as ore. The iron ore bed has been traced for many miles throughout the area.

Within the Lady Bug Claims, which cover the irregular southward projection of the mesa, the iron ore bed and it's associated cherty member lie to a great extent exposed on the surface. Extending northward however, a slight dip creates an increasing thickness of overburden, which near the Zerox property line amounts to 50-60 feet.

Two known faults exist on the Lady Bug Claims. One, aparently striking northeast-southwest, of large vertical displacement, and located near the juncture of the Lady Bug and Zerox Claims. The second fault, striking northwest-southeast, a minor rotational type, and located across the center of the Group.

Little is known about the nature and behavior of the iron bed within the Zerox, North and South Carbox, and Comet Claims. However, it's existance throughout these Groups is assured, based on outcroppings low on the canyon walls. The iron ore bed is exceptionally well exposed in the Zerox Claims along the west side of the canyon, and at a place called

Iron Springs.

Throughout this area, the Martin Formation is generally well intruded by diabase dikes and sills. Howeber, few if any of these intrusives cross the Mescal Formation, and only occasionally do they contact the iron member.

EXPLORATION

Exploration programs on the Lady Bug and Zerox Claims have been carried out in several stages. In 1943, the O.M.E. conducted a drilling program of 4 holes on the Zerox Claims. This program seems to have been conducted in a sloppy and haphazzard manner, with little or no engineering supervision, and resulting in little or no knowledge about the nature and depth of the iron member. What was discovered however, was a thick diabase sill and the fact the iron ore must lie at a depth greater than 700 feet.

Several years ago, Archean Exploration Company conducted a drilling and sampling program on the Lady Bug Claims. The results of this program are as follows:

Hole No.	Location	Drill Depth	Intersects	Assay Fe
1	2050' N20W of SE corner sec.8	147"	91-120'	broken hematite ?
2	1200' N20W of SE corner sec.8	157'	141.5-152.5'	50.3%
3	1250' N37E of SW corner sec.9	235'	251 - 231'	51.2%
4	825' S37E of NW corner sec.17	?	26 - 37'	40.45%

Sample No.	Location	Thickness	Assay Fe
1	1800' S58E of NW corner sec.17	15'	57.9%
2	700' N72W of SW corner sec.8	18'	55.8%
3	1750' N59E of SW corner sec 9	12'	56.1%

4	2100' N45W of SE corner of sec.8	16'	59.9%
LB 1	Top of creek, 800' S of Frog Pond	12'	60.8%
LB 6	225' SE of LB 1 (see map)	14'	61.8%
LB 12	200' SE of LB 6 (see map)	12'	62.2%

A surface geological map of the Mescal Formation with iron bed was prepared by Archean Exploration Company, and susequent studies made by Dr. Greene, Mr. Hammond, Dr. Ridland, and myself, tend to agree with the reliability of it's contents.

The unfortunate situation still remains however, that little is presently known about the nature and condition of the iron bed in the Zerox, North and South Carbox, and Comet Claims.

THE ORE

The iron ore consists of hematite and specualr hematite, and sometimes includes the feruginous chert.

The average iron content of the hematite on the Lady Bug Claims is about 55% Fe. The chert varies in iron tentent from 20 to 50% Fe, but is generally not considered to be ore.

ORE RESERVES

Lady Bug Claims::

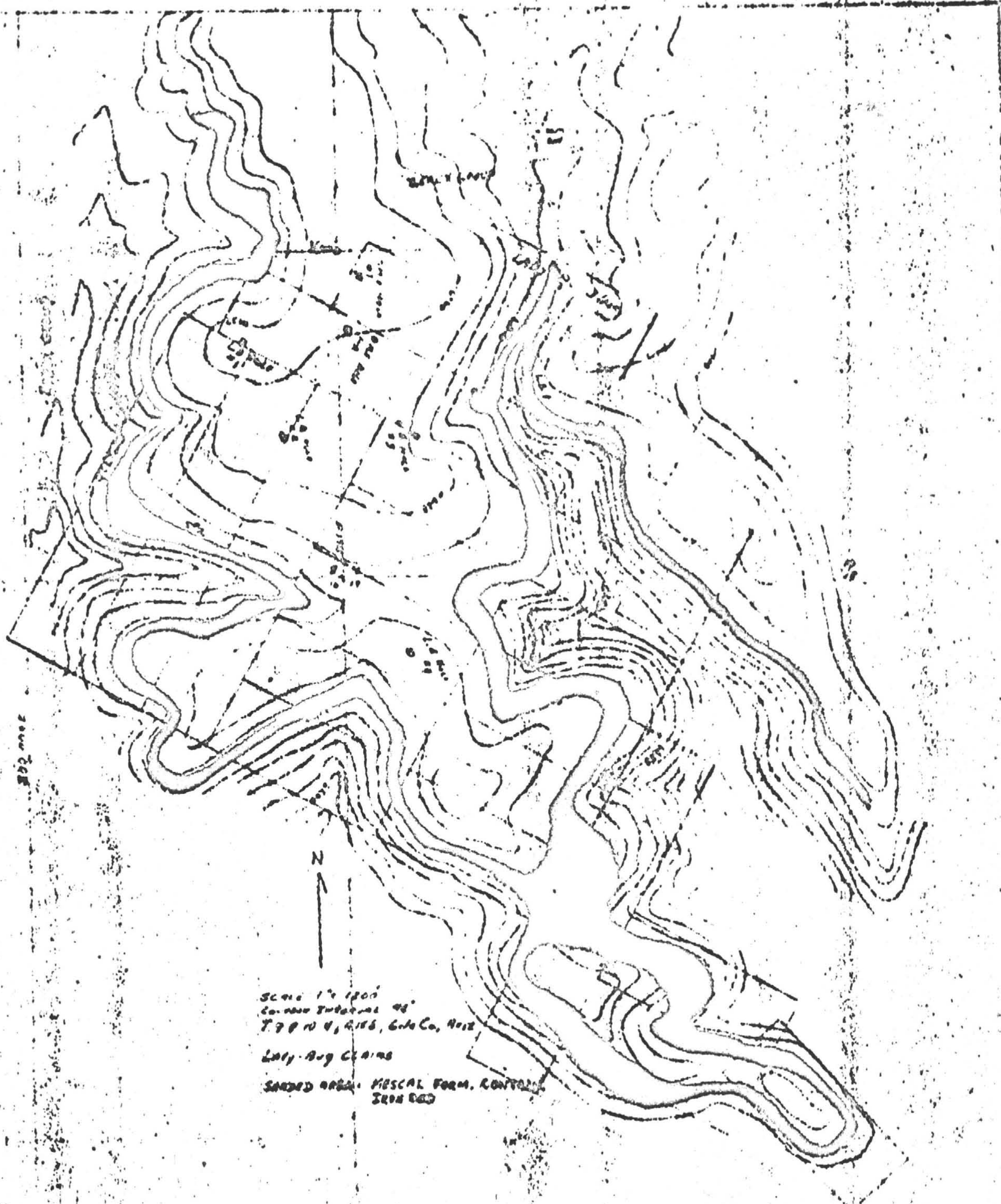
Calculations based on iron shows along the rim and top of mesa, and 4 drill hole intersections in NE section.

Proven Ore .... $\frac{13,171,000 \text{ ft}^2 \times 11 \text{ ft(av. thickness)}}{10 \text{ ft}^3/\text{ton}}$

.... 14,487,600 tons

Zerox Claims:

Calculations based on iron shows on west side of canyon and at Iron Springs, and assuming that the same conditions exist here as throughout


N
Lady-Bug Claims
MESCAL FORM.

the Lady Bug Claims.

Possible Ore .... $\frac{78,125,000\ ft^2 \times 11\ ft}{10\ ft^3/ton}$(av. thickness)

.... 85,937,000 tons

II

THE SPONGE IRON PROCESS

Sponge iron is a metalic product reduced from iron ore at such low temperatures that melting of the iron or gangue constituents has not taken place.

The process of making sponge iron is a simple one, consisting basically of heating a mixture of finely crushed iron ore and coal in an oxygen-free furnace at temperatures of 14-1700 degrees Fahrenheit for a period of 90 to 120 minutes. The result is a more or less porous substance, with a metalic iron content of 85 to 95 %, depending on the degree of reduction.

A more detailed description of the process is available from Dr. Greene and Mr. Allison.

FUEL, POWER, REAGENT, AND ORE

Fuel to fire the reduction process is available near the proposed plant site from a large gas transmission line. Electrical power is also available. Bituminous coal(reagent) is found on the Federal Reserve, 10 miles away, and can be mined by anyone for a fee of $.10/ton. Iron ore is located on the claims near Young, and requires trucking 38 miles.

TRANSPORTATION TO MARKET

The railroad runs directly adjacent to the proposed plant site. Only a short rail-spur and loading platform need be constructed.

Sponge iron can thus easily be shipped to all consuming centers.

PRODUCTION COSTS

The cost of producing and delivering sponge iron, based on a 50 ton/day operation, using a modified form of the Southern Iron Ltd. Process, has been itemized by Dr.Ridland and Mr. Allison as follows:

Mining and hauling iron ore($.05/mile/ton)	4.50
Mining and hauling coal(2 tons of coal per ton of iron)..	5.00
Gas consumption	2.00
Electrical power consumption	.60
Labor(3 shifts/day)	6.50
Supervision	.65
Office staff, office, insurance & tel(12% of above)	2.25
Freight cost per ton	6.00
Cost of production	27.50/ton

Various economies indicated by Mr. Allison and Dr. Greene, such as pre-heating the iron-coal mixture with the excess heat from the furnace, and re-using part of the charged coal, may cause to bring the cost of production down to $21.00/ton

QUALITY OF THE FINAL PRODUCT

All those concerned at the copper companies, and at the Arizona Bureau of Mines Division in Tuszon, having received samples of sponge iron from the Company's pilot plant in Phoenix, had high regard for it's quality.

III

THE COPPER INDUSTRY - COPPER LEACHING

The major copper companies in Arizona today are mining two forms of copper; copper sulfides and copper oxides.

The oxide form of copper is generally found in great volume associated with primary sulfides in the copper porphyries of the Arizona copper belt. Metalic copper is recovered from the oxide form by a process known as "leach-precipitation" Sulfides are recovered by conventional crushing, milling, and floatation.

The "leach-precipitation" process is briefly described at follows: The surface oxide ores are mined, crushed, then placed in great piles under conditions of controlled drainage and draw. Weak sulphuric acid (1 part per 100)is then poured on the pile and permitted to perculate through, oxidizing sulfides, becoming more acid, reducing copper oxides and taking copper into solution. The resulting solution is called is called a "hot liquer" and is drawn off the bottom of the pile and piped into the precipitation vats.

PRODUCING COPPER CEMENT

The resulting "hot liquer" consisting of concentrated sulphuric acid and ions of copper and sulphate are brought into contact with metalic iron, and the common ion effect takes place, whereby ferric iron goes into solution and the copper precipitates out. The resulting precipitate is known as copper cement.

The ferric iron used to precipitate copper from solution has classically consisted of "tin" cans. Lately, standby substitutes such as automobile bodies, engine blocks, chains, scrap metal, etc., isbeeng used. The newest and most favorably accepted precipitant is sponge iron.

CONSUMPTION OF TIN CANS & OTHER FERRIC WASTES

The amount of "tin" cans and other ferric wastes consumed by the copper industry is reported by Mr. Allison and Mr. Hartman to be about 18,350 tons per month.

AVAILABILITY AND COST OF "TIN" CANS

"Tin" cans in sufficient quantities are difficult to get, and the situation is getting worse. Changes from iron to aluminum, plastic, glass, and vaxed containers, is driving the "tin" can off the market. Also, high cost of collection, preparation, shipping, and new ordinances forbidding burning of garbage within city limits, is causing the price of cans to rise every year.

The cost of burnt "tin" cans delivered in the Arizona copper mining district is quoted around $55.00/ton, with demand not beeng satisfied.

EFFICIENCY AND PRICE OF SPONGE IRON

The efficiency of sponge iron in the precipitation of cement copper has been indicated as follows:

Mr. E. J. Stebbins; "sponge iron works 20% better than "tin" cans" (purchasing agent, Kennecott Copper Co., Ray, Ariz.)

Mr. Bill Hoag; " sponge iron does in 20 seconds what "tin" cans do in one hour"
(purchasing agent, Phelps Dodge, Bizbee, Ariz.)

The price of sponge iron has been tentatively set by Archean Exploration Company at $55.00/ton, based on the present price of "tin" cans. However, with a metalic iron content of 90% Fe, one ton of sponge iron has a far greater metalic content than one ton of burnt cans, which after burning oxidizes rapidly, thus reducing the Fe content, and indirectly much of it's intended efficiency.

On this basic knowledge, Archean Exploration Company believes that sponge iron can be competitively sold to the copper mining industry for up to $65.00/ton.

TRENDS IN THE COPPER MINING INDUSTRY

The trend in the copper industry is to convert from the present use of "tin" cans and other ferric wastes to a more reliable and efficient substitute. Sponge iron has qualities idially suited to take this place.

With a reliable source of supply of inexpensive sponge iron at hand it apears very likely that the copper mining industry would rapidly convert to this product.

Based on what I have seen, I believe that Archean Exploration Company has all the basic materials to supply such a product.

OPINION IN INDUSTRY

Throughout the copper industry, and those associated with it, the opinion is that the age of the "tin" can is over, and that sponge iron wheather produced from pyritic slag or virgin ore, will be taking it's place. If locally produced sponge iron can be made available, reliably, and in sufficient quantities, a strong new industry will be developed in Arizona.

OPINION

The iron ore deposit owned by Archean Exploration Company, in Gila County, Arizona, is of considerable economic importance, and measuring approximately 14,487,600 tons of proven ore, and a possible 85,937,000 of other ore, assaying 55% Fe.

This ore can easily be mined and treated to form sponge iron, and sold to the copper industry as precipitation stock at a competitive price.

Sponge iron will be an excellent substitute for the inefficient and dwindling supply of "tin" cans. The copper industry is in a critical stage as it departs from the classical "tin" can, and Archean Exploration Company should not delay in preparing to meet this new demand, or risk the chance of loosing this golden oportunity.

SUMMARY

On the basis of this investigation it is clearly evident that the the iron ore deposit owned by Archean Exploration Company, in Gila County, Arizona, is of important economic significance, with proven reserves of 14,487,600 tons and possible reserves of 85,937,000 tons of iron ore grading 55% Fe.

This ore can successfully be mined and used in the manufacture of sponge iron, employing a standard reduction process, and be competitively sold to the copper companies as precipitation stock in their leach operations.

"Tin" cans, the classical precipitating agent in the manufacture of copper cement, is in a short and dwindling supply, and that a conversion to a more efficient and reliable substitute is at hand.

Ton for ton, the metalic iron content of sponge iron is considerably greater than that of burnt cans, and the efficiency is likewise much greater. The sales price of sponge iron will range from $55.00 to $65.00 per ton. The estimated cost of production is about $27.00 per ton.

Archean Exploration Company can have a very promising future in the manufacturing of sponge iron for the copper mining industry, but in order for it to accomplish this, a minimum of $400,000 willbe required to build a furnace and commence operations.

Gifford A. Dieterle
Consulting Geologist

Dated: August 23, 1965

Dr. Gerald U. Greene
CONSULTANT
P. O. Box 631 -:- Phone (505) 835-1233
SOCORRO, NEW MEXICO 87801

September 9, 1965

Mr. R. Jay Allison, President,
Archean Exploration Corporation,
1416 East Thomas Road,
Phoenix, Arizona.

Dear Sir:

REPORT ON THE FEASIBILITY OF CONSTRUCTING A SPONGE IRON PLANT IN ARIZONA

INTRODUCTION

The writer spent four days in June of 1965 examining mineral deposits and visiting plants which use some form of metallic iron to precipitate copper from solution. While time did not permit examining all the properties of the Archean Exploration Corporation enough was seen to assure one that there is sufficient iron ore for many years operation on even a larger scale than is presently anticipated. The reaction of the officials of the copper companies to the proposed plant was even more favorable than was anticipated. In the writer's opinion, the time is now ''ripe'' for the production of sponge iron on a commercial scale in Arizona.

IRON ORE DEPOSIT - The property consists of several groups of claims, some of which have out-crops showing. The present report considers only the ''Lady Bug'' group of claims. This group of claims lie in Gila County, Arizona, in Township 9 and 10 North and Range 15 East.

This deposit lies in low hills and shallow valleys and has exposures in numerous places. The presence of the ore body under the hills has been proven by drilling in the areas between the surface exposures.

The deposit has apparently been formed by replacement of a linestone bed by hematite and chert. The hematite is a very good grade of ferric oxide. Chert is a crypto-crystalline variety of chalcedonic silica. Because the deposit is a replacement of a sedimentary rock, it is safe to assume that the ore is continuous under the hills which have exposures on both sides.

The area covered by the body of iron ore in the ''Lady Bug'' group was calculated from a topographic map. A total area of 14.590×10^6 square feet was found. The thickness of the bed may be calculated from the thickness of the exposed areas and from the drill hole cores. An average of 11 feet was found as a fair but conservative figure for the third dimension. The specific gravity of the ore is such that the figure of 10 cubic feet of ore equals one ton is again a fair but conservative figure.

The approximate total tonnage may be calculated:

$(14.590 \times 10^6) \times 11$ divided by 10 equals (16.049×10^6) tons.

The percentage of iron in the deposit varies but an average may be obtained from the analyses made on the out-cropping and from the drill holes. The drill holes show thin, low grade beds in some instances. These have not been included and they have no effect upon the mining operation as the cost of mining has been

Calculated to include these variations in the deposit.

Drill hole No. 1 --	15.0 feet thick	@ 57.90 % Fe	
" " No. 2 --	18.0 " "	@ 55.80 % Fe	
" " No. 3 --	12.0 " "	@ 56.10 % Fe	
" " No. 4 --	22.0 " "	@ 46.70 % Fe	
	16.0 " "	@ 51.20 % Fe	
	3.5 " "	@ 46.50 % Fe	
	5.0 " "	@ 44.20 % Fe	
" " No. 5 --	11.0 " "	@ 50.30 % Fe	

For No. 4 drill hole an average of 48.06 % Fe was found. The samples taken from the side exposures run higher, in the upper 50 per cents and the lower 60 per cents so an average of 55% was used. This, again, is quite conservative but it is well known that in sampling surface material analyses tend to run high. Considering all factors, an average iron content for the entire deposit of 52.0 per cent is accepted with the certain knowledge that this is a safe value to use.

The amount of iron present is: $(16.048 \times 10^{6}) \times .52$ equals 8.345×10^{6} tons and the amount of hematite is $(8.345 \times 10^{6}) \times 160/112$ is 11.896×10^{6} tons. Assuming that the ore consists of hematite and chert, the amount of chert in the deposit is then 4.153×10^{6} tons. One ton of ore contains 1485 pounds of hematite and 515 pounds of chert.

<u>COAL</u> - The writer did not visit the coal deposit but from reports from others there appears to be a huge tonnage available. This is on Government land and a royalty of 10 cents per ton is written into the lease held by the Corporation.

<u>UTILITIES</u> - Water, power and natural gas are all available within reasonable distances of the proposed plant site. Most of the distance from the ore deposit to the plant is paved. Roads from the plant to the markets are all paved. The plant site has been well selected from a standpoint of raw supplies and utilities.

<u>MARKET FOR SPONGE IRON</u> - The discovery of new deposits of oxide copper ores which respond to a leaching process and which necessitates an increasing quanitiy of iron in some form to precipitate the copper from solution makes a contemplated sponge iron plant appear very attractive at the present time. The following data were obtained on the Arizona tour: Inspiration Con at Globe uses about 1800 tons of tin cans per month; Miami Copper requires about 2500 tons per month; Silver Bell about 1200 tons per month; Kennecott, Ray Division, uses 1800 tons per month; Phelps-Dodge at Warren requires 2500 tons per month and so it goes. Smaller companies use a smaller tonnage of cans and there are other properties coming into production in the next few years that will require iron to precititate the copper.

So far the precipitation has been made by buying tin cans and tin can scrap. The market has grown so large that the majority of old sources of supply have been exhausted and the production

Of new cans has not kept up with the demand. Also more and more material is being canned in plastics and other than iron containers so that the actual supply is decreasing while the demand is increasing.

Some of the companies have already started producing sponge iron, more will have to do the same unless a new source of supply of iron is soon found. While the producing companies have a talking point on the price of sponge iron, it seems evident that they would welcome an adequate source of supply and welcome a chance to stop producing their own sponge. No figures were mentioned but their method of production is rather costly and the writer believes that their costs are above the price of tin cans but that they have to produce the sponge regardless of cost. In most cases they stated that they would try out any new product and some went so far to state that while it would necessitate some changes in the plant flow sheet, they would not hesitate to change. The big factor, however, is that the source of supply must be adequate so that no lost time would be encountered because of lack of supply. This must be thoroughly understood and any plant producing sponge iron must have surplus stock so that shipments can be made even is the plant is closed for a few days.

<u>MANUFACTURE OF SPONGE IRON</u> - Several different processes have been invented for the production of sponge iron. Some are based entirely upon gaseous reactions while other, similar to the present flow-sheet, are based upon a combination of the gaseous and the

solid reductants for the iron oxide. The essential reactions are:

$$Fe_2O_3 + 3C = 2Fe + 3CO$$

$$Fe_2O_3 + 3CO = 2Fe + 3CO_2$$

$$CO_2 + C = 2CO$$

$$Fe_2O_3 + 3H_2 = 2Fe + 3H_2O$$

$$Fe + CO_2 = CO + FeO$$

All of these reactions may be calculated thermodynamically and for the first reaction, the free energy value is positive at 1800°F. This means that the reaction will not proceed as written at any appreciable rate. The second reaction which produces CO_2 will proceed more readily but there is the danger that some of the reduced iron will be re-oxidized to form FeO. At the reactant temperature, CO_2 is rapidly reduced to CO by the C in the coal so it is doubtful if any remains to oxidize the iron. When the amount of coal is increased beyond the stoichiometric amount, it tends to force the reaction in the direction of iron production. Since the reduction of ferric oxide by carbon is endothermic, heat must be supplied from some other source and in this case natural gas is used. The constants are not available for the calculations of the reaction rates. Therefore it is not possible to state just how long it will take to reduce X pounds of hematite.

The time must be determined experimentally. It has been stated that the reaction rate is doubled for each 10 degrees Centigrade increase in temperature.

<u>THE IRON-CARBON EQUILIBRIUM DIAGRAM</u> - The pertinent areas of this diagram are given on page 6A. In the area marked alpha the reaction rate is very slow because alpha iron is the low temperature form of the element iron. Alpha iron is a body-centered cube and is one of the allotropic modifications of iron. It dissolves only a few hundreths of one per cent of iron. In the area marked alpha and gamma, gamma iron which is a face-centered cube and which dissoves up to about 2% of carbon is also present. In the upper area marked gamma, only the face-centered cubic form is present. It will be noted from the diagram that if a temperature of 1800°F is used, all of the iron will be in the form of the face-centered cubic structure. This is immaterial since the amount ofcarbon dissolved at this temperature and in the time in the furnace will be negligible. It should be furthermore remembered that a small amount of carbon dissolved in the iron has no effect on its use as a precipitant of copper.

The tin cans used at the present time are of steel and contain more carbon than will the sponge iron made by this process at a temperature even in excess of 1800°F. These facts may be used to argue that an even higher temperature would be beneficial to the process but there is considerable danger that a higher temperature would cause the mass to become sticky and this would make it difficult to handle. To maintain the best conditions of operation the temperature should never be high enough to cause the charge to stick to the furnace or to itself. The temperature that causes stickiness will vary with the particle size and again must be determined experimentally.

<u>HEAT REQUIRED TO RAISE THE REACTANTS TO THE TEMPERATURE OF 1800°F</u>

Assume one ton of iron ore. It has been shown that one ton contains 1,485 pounds of hematite and 515 pounds of silica.

The specific heat of hematite may be represented by the equation:

$C_p = 24.72 + 16.04 \times 10^{-3} T - 4.234 \times 10^{5} T^{-2}$. Now $\Delta H = \int \Delta C_p \, dt$,

and $\Delta H = \int_{298}^{1255} (24.72 + 16.04 \times 10^{-3} T - 4.234 \times 10^{5} T^{-2}) \, dt$.

Integrating this expression between the limits shown, there is obtained a value of 34,462 gram calories per gram mole required to raise the temperature from room temperature to one of 1800°F. In the expression, the temperatures for the limits must be in absolute and the units are either in gram-calories per gram mole or in kilogram-calories per kilogram mole. For simplicity, the gram-calorie per gram mole unit will be used in all calculations involving the Centigrade temperature scale. H represents the heat contents of the material under discussion. Now the molecular weight of Fe_2O_3 is 160 units and the number of grams per pound avoirdupois may be rounded off to 454,454/160 x 34,462 = 97,345 gram-calories required to raise one pound of hematite to 1800°F, (982°C). There are 1485 pounds of hematite in a ton of ore and 1485 x 97,345 = 144,437325 gram calories. This is equivalent to 573,495 B.T.U. For the silica in one ton of the ore, the specific heat equation is:

$C_p = 11.22 + 8.20 \times 10^{-3} T - 2.70 \times 10^{5} T^{-2}$ and $\Delta H = \int \Delta C_p \, dt$ as before,

$\Delta H = \int_{298}^{1255} (11.22 + 8.20 \times 10^{-3} T - 2.70 \times 10^{5} T^{-2}) \, dt$ and upon

intergation it is found that it requires 16,156 gram-calories per gram-mole to raise the temperature to 1800°F. Then 454/60 x 16,156 = 122,140 gram-calories are required for one pound of silica. For one ton of iron ore, 122,140 x 515 = 62,902,100 x (3.968 x 10^{-3}) = 249,721 B.T.U. and the total B.T.U. required for one ton of iron ore is 823,216.

<u>COAL</u> - The mean specific heat for coal between room temperature and 1800°F may be taken as 0.36 B.T.U. per pound per degree F. Then 0.36 x 1732 = 623.52 B.T.U. are required to raise the temperature of one pound of coal to the reacting temperature.

<u>HEAT AVAILABLE FOR RAISING THE TEMPERATURE</u> - The heat of combustion of this coal has been determined as 10,300 B.T.U. per pound. It should be kept in mind that this value is for complete combustion, i.e., for oxidation of the carbon to carbon dioxide. In this process this is not true, the carbon dioxide will be unstable

at the temperature of operation and carbon monoxide will form. The analysis of the coal is unknown and an approximation should be made. The hydrogen in the coal will burn to H_2O and it will be assumed that 25% of the heat of combustion comes from this element. The free energy of formation of carbon dioxide is about 94,000 gram calories while that of carbon momoxide is only about 32,00 gram calories. On the assumption that 75% of the heat of combustion comes from the carbon, a correction must be made and on this basis the heat evolved from one pound of coal is only 5175 B.T.U.

There are 800 pounds of coal per ton of iron ore added to the furnace charge. The total heat requirement for this amount and for the hematite and silica in one ton of ore is 1,322,032 B.T.U. to raise the temperature the desired amount.

The 800 pounds of coal burning to CO and H_2O will produce about 4,140,000 B.T.U. The composition of the exit gases is not known but from the reduction of the hematite and the gases of combustion of the natural gas, about 2,000 cubic feet per ton of ore, it appears that about 1,600,000 B.T.U. are carried out of the furnace by these gases. The combustion of this amount of Natural gas will furnish about 1,800,000 B.T.U. Some heat will be lost through the furnace walls, the amount is unknown. Until the composition of the exit gases are known it is not possible to calculate the value of the endothermic reaction,

$CO_2 + C = 2CO$. However, there are sufficient B.T.U. present to permit the reaction.

These calculations indicate that the relative amounts of materials used in the experimental furnace should be satisfactory in the production furnace.

COST

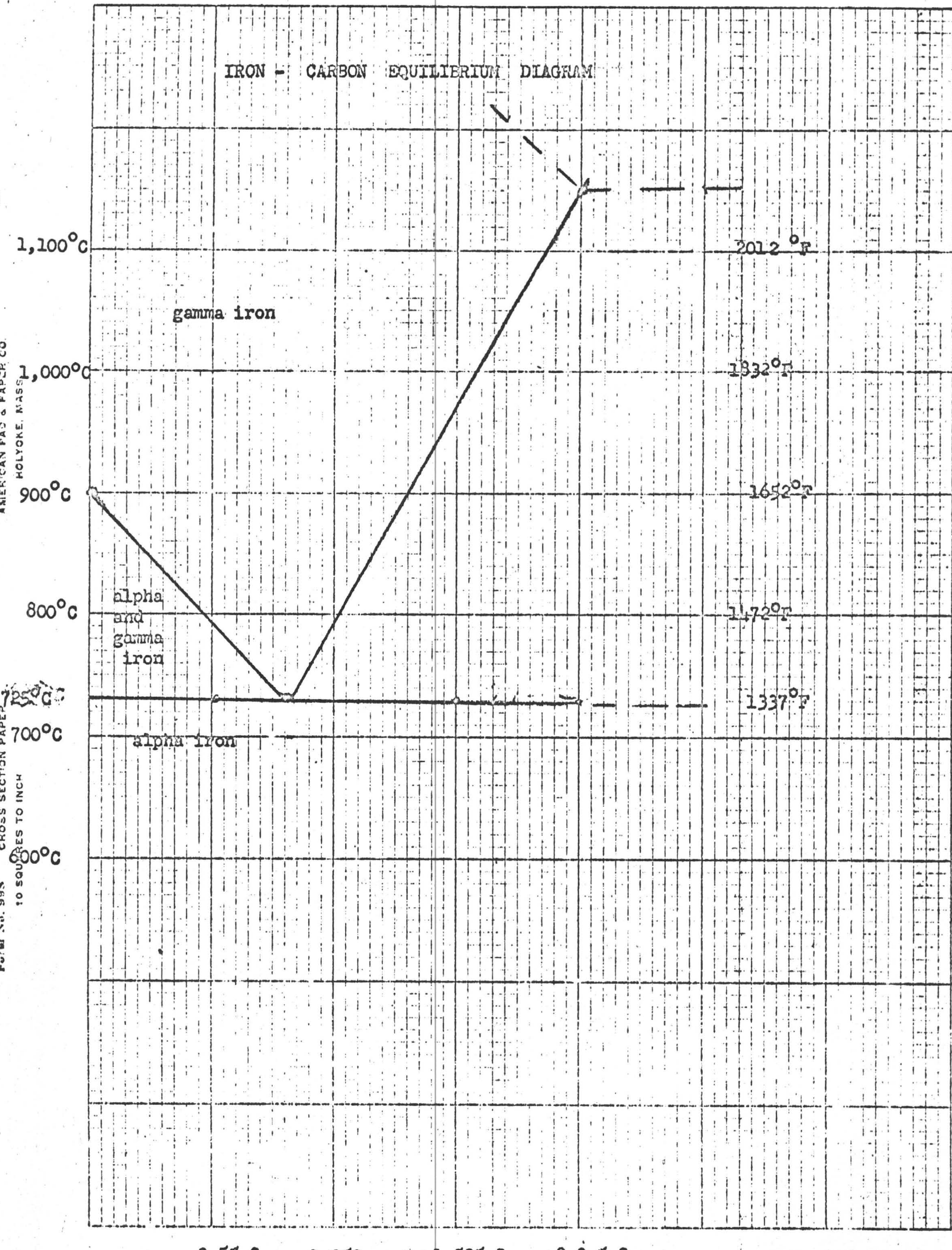
Labor	Men/Shift	Shifts/Day	Pay rate/Hour	Cost/Day
Furnace Operator	1	3	$3.25	$ 78.00
Helper	1	3	2.75	66.00
Crushing	2	1	2.75	44.00
Finishing*	1	1	2.75	22.00
				$210.00
Supervision				35.00
			Total	$245.00

*It may be found necessary to add another helper with two furnaces.

COST OF MATERIAL LAID DOWN AT PLANT

Iron ore per ton	$ 4.50
Coal per ton	2.75
Wood chips (if used)	3.00
	10.25

Natural gas - @ 50¢ per 1000 cubic feet decreasing to 36¢ per 1,000 cubic feet depending upon quantity used.



AMERICAN PAD & PAPER CO. HOLYOKE, MASS.
Form No. 995 CROSS SECTION PAPER 10 SQUARES TO INCH

TONNAGE TREATED PER DAY - It is not definitely known what time is required to finish a heat in the furnaces which are to be installed. It is assumed that by proper operation and proper mechaincal installation that a heat can be finished in two hours if the temperature is maintained at about 1700 to 1800 degrees F. If the temperature drops too much while discharging the heat, more natural gas should be used to raise the temperature rapidly. After the plant is in operation consideration should be given to using the waste heat in the exit gases for preheating the incoming charge. This has been mentioned by Mr. Allison and this will lead to economy in operation. The exit gases should be analyzed and if the CO/CO_2 ratio is high enough, the gases could be burned to give even more thermal saving and greater efficiency. It is not necessary to try for 100 per cent reduction of the ferric oxide because as the reduction proceeds, the reaction rate decreases and the labor cost per pound of iron jumps up. It will probably be found that about 75 per cent reduction is the most economical point. This can be checked in actual production.

Assume that 12 heats are finished in each furnace per 24 hours. Assume also that five tons of iron ore are treated in each heat, then a total of 120 tons of ore are treated daily. At 52% iron in the ore, 2,00 x .52 = 1,040 pounds of iron per ton, 1,040 x 120/2,000 = 62.4 tons. This will vary some as all of the hematite is not reduced; there will be some inert material that will not be removed and against this there will be some loss in handling so the daily production should approximate this tonnage.

COST PER TON OF IRON PROCUCED

Labor	$ 3.93
Material	13.91
Power	0.80
Overhead @ 15%	3.30
	Total$21.94

This figure does not include amortization charges.

SELLING PRICE OF SPONGE IRON

No definite price can be stated until the product has been tried in plant operation. The price of tin cans was stated to be $53.00 per ton of the material available today. On this basis, the minimum price on should expect is $50.00 per ton. The differance between the selling price and the cost (without capital retirement) is then $28.06.

COST OF PLANT.

The figures furnished by Mr. Allison, which are list prices, show that a plant can be built for about $150,000.00. To allow for exigencies and for a fund to tide over the period between the start of the operation and the return of sales, another $100,000,00 should be allowed.

RECOMMENDATIONS

It is recommended, after a study of the process and the market conditions, and the costs, that a minimum of $250,000.00, and preferably more, be allotted to build and operate a plant for the production of sponge iron in Arizona at the site selected by Mr. Allison.

Respectfully submitted,

G. Greene

Gerald U. Greene

Reg. Prof. Eng.
No. 11,242, Ohio

GUG/bj

Iron Finds Stir Town Of Young

By RALPH A. FISHER SR.
Gazette Correspondent

[redacted]

Apache Tribe Grants Mining Lease

By WADE CAVANAUGH
Eastern Arizona Bureau

[redacted]

The Phoenix Gazette

Tuesday Sept 29, 1964

CHESTERFIELD REALTY

LARRY CHANTLER, Broker

Ranch, Farm and Mining Specialists

119 North Montezuma Phone 445-3070

PRESCOTT, ARIZONA 86301

file

INFORMATION IRON KING MINE

OCTOBER 3,1968

Assessment work on the IRON KING CLAIMS namely 1-3-4-5-6-10-12-13, and FERRO #3 has been recorded in the County Court House in Globe Arizona. Gila County, in the Sierra Ancha. Original claims dated as Docket 82, Pages 62,63,64, Docket 83, Pages 43, & 44, Docket 86, Pages 12 & 73.

Between the 1st of August 1968 and the 31st of August 1968 there was expended at least $900.00 by Charlie Moore, R. Keith Hazen & William M. Curtis. They claim they cleared off all roads with Cat and Dozer and made exploratory Cuts. Recorded at the request of Charlie Moore on the 28th day of August 1968.

* Notation (((Mail to IRON KING MINES INC. % W.T. Elsing, Arizona Bank Building Phoenix Arizona 85003.)))

I noted that the assessment work was all in order for the previous years. Upon an inspection of the property I noted that as claimed they had dozed a new road to the property and that all roads had been cleaned off with a dozer. I attempted to drive up to the claims but it was impossible because of the bad rain while I was on the property. I also decided against walking upon the property as it was clearly evident that the work had been done as claimed.

Also I noted that the Uranium claims in front and West of the Iron King Claims had drill holes. I counted 15 holes.

Submitted

Laurence G. Chantler

Lawrence G. Chantler

* Kelsey -?

ROBERT FORD & ASSOCIATES, INC.
Consulting Geologists
P. O. BOX 2337 110 UNION STREET PHONE (602) 445-0050
PRESCOTT, ARIZONA 86301

October 10, 1968

Mr. Chuck Arms, Vice President
Pickands Mather & Co.
2000 Union Commerce Building
Cleveland, Ohio 44115

Dear Chuck:

Trying to promote an iron property is anything but exciting; however, this is a special purpose property with a guaranteed market for production. The attached report is short and covers the situation.

You may find the first part of the report "Notes on Reduced Iron for Copper Precipitation" interesting. What we are proposing is a small direct-reduction plant to produce sponge-iron or particulate iron for precipitation of copper. There are a number of methods by which copper can be recovered from copper sulfate solutions, but the use of metallic iron to produce cement copper precipitate is the best known and most used.

The use of sponge-iron offers considerable advantage in faster precipitation and lends itself to automation. The price of scrap for this purpose has reached $55.00 per ton. What we are suggesting is a small, 200 ton per day, facility on rail near the center of existing markets; ample ore reserves exist. This facility would probably be what the steel industry would consider a "pilot plant", with the product salable at $60.00 per ton; with mines in which I own interests taking 70 tons per day and the remaining market almost assured, this situation could not only make a nice profit but also lay the groundwork to make Pickands Mather a leader in direct-reduction.

We control the iron reserves and would be glad to go over all reports and maps concerning the property with you.

With kind regards,

Sincerely,

Robert Ford

Robert Ford

RF/pc
Enc.

NOTES ON REDUCED IRON FOR COPPER PRECIPITATION

and

PRELIMINARY REPORT

IRON KING MINE

Gila County, Arizona

By

Robert Ford, Mining Geologist
Prescott, Arizona

October 1, 1968

Including Separate Folder of:

General Property and Topographic Map, 1" = 300'
Geologic Plan Map, 1" = 100', "South Ore Body"
Geologic Plan Map, 1" = 100', "North Ore Body"
Cross Sections, 1" = 100', "South Ore Body"
Cross Secitons, 1" = 100', "North Ore Body"

REGISTERED GEOLOGIST
CERTIFICATE NO.
5451
ROBERT
FORD
Date Signed 10-9-68
ARIZONA, U.S.A.

Notes on Reduced Iron for Copper Precipitation

The precipitation of copper on iron is one of the earliest known chemical reactions (6). The iron is usually in the form of shredded and detinned cans, plate, or sponge iron. This form of precipitation is called cementation and the copper preciptiate is called cement copper. The copper bearing solution is won by leaching oxide copper ores with dilute sulfuric acid or ferric sulfate. The leach solution is collected and piped over iron to effect precipitation. Of the many precipitation agents tested, tin cans are considered the most suitable available (4).

Copper is also produced in the same general manner by leach-precipitation-float (LPF) (7). In this process the oxide copper minerals combined with sulfide minerals are selectively and effectively sulfated in solution, precipitated on sponge iron and recovered with the sulfide minerals in flotation. Copper produced in the United States from oxide minerals, amounting to 150,000 tons annually, is about ten percent of the total United States output (9). This percentage is steadily increasing. By far the greatest part of the copper produced from oxides is precipitated on iron at a consumption of about two tons of iron for each ton of copper recovered.

Arizona provides over fifty percent of the United States' primary copper production. Most of this is centered in Southeastern Arizona, subsidiary to the contemplated direct-reduction plant near Globe-Miami, Gila County, Arizona. In 1965 that part of Arizona produced 50,000 tons of copper by precipitation from leach solution. By 1970 it is estimated that the production will be 90,000 tons (10). Sponge-iron is produced from pyrite obtained from flotation concentrates at Phelps Dodge Corporation in Douglas, Arizona and from Kennecott's Ray Mines at Ray, Arizona. However, this production is inadequate for their own needs and the low iron content of the calcined pyrites makes an inferior cement copper. In fact, Kennecott, on the first of May, 1967, closed its pyrite-sponge-iron plant at Ray and is attempting to purchase fine grained magnetite for reduction and use in the LPF circuit. Expanded facilities at Kennecott's Ray Division will treat an additional 10,000 tons of oxide copper ores daily. The fifty tons per day of copper so produced will require about one hundred tons of iron per day. That sponge-iron from direct-reduction processes will play an important part in this simple reaction is well established and justified. Kennecott (1) and Phelps Dodge (3) have each developed precipitation vessels or launders to handle sponge-iron.

Increased production by precipitation on tin cans combined with the decreased availability of cans due to the substitution in packaging of aluminum, plastic, glass, and waxed containers has already made it difficult to obtain sufficient quanities and quality of iron from the scrap market; the situation is steadily becoming worse. The cost of cans delivered to the Arizona copper mining districts is quoted at $55.00 to $57.00 per ton. Demand is not satisfied and standby substitutes such as shredded auto bodies, wire, chains, and assorted scrap metal are being used. The contaminates present in these substitutes and their relative inefficiency as precipitating agents result in higher cost and less pure cement copper. Reduced iron pellets were tried and found unsatisfactory (11).

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Gila County, Arizona

INTRODUCTION AND SUMMARY

Widespread occurrences of hematite and magnetite as contact replacements of Precambrian Mescal limestone associated with diabase intrusive sills are in Navajo and Gila Counties, Arizona. These medium to high grade iron replacements have been inferred, in 1945 (5), to contain fourteen million tons, averaging forty-six percent (46%) iron. That this estimate is woefully inadequate is evidenced by the fact that the Iron King Mine alone, the subject mine, contains an estimated potential of about ten million tons of high grade concentrates. More than thirty replacement deposits are known to exist in the same general area (2) subsidiary to a contemplated direct-reduction plant in the town of Globe or of Miami, Arizona.

Many of these replacement deposits have been investigated by the writer. From the standpoint of reserves, availability, and access, the Iron King Mine is considered the most important. That mine, consisting of thirty-eight unpatented claims is under option.

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The Iron King Mine is located between Zimmerman and Asbestos Points in the Sierra Ancha Mountains of Gila County, Arizona. Sections 16, 20, 21 and 29 of Township 5 North, Range 14 East center the property. The relationship of the outcrops at or near the 5,500 foot contour can be noted on the McFadden Peak 15' USGS Quadrangle Map.

The mine is reached by driving four miles northwest from Globe on U.S. Highway 60-70 to its junction with the Apache Trail (Arizona Highway 88), then fifteen miles northwest on the Apache Trail to its junction with the Young Road (Arizona Highway 288), then 15.7 miles on Arizona Highway 288 north to the junction with access roads leading northeast to the property which is visible from the Highway and about two miles distant.

GEOLOGY

Magnetite occurs in irregular contact-metamorphic replacements of serpentinized, chloritized and silicified Mescal limestone that is 100 to 300 feet thick. The altered limestone and magnetite iron are sandwiched between two large diabase sills. The upper sill is probably 500 feet thick and the lower is about 1000 feet thick. The iron is entirely magnetic and occurs as massive high-grade bodies separated by disseminated and low-grade areas. The magnetite forms two or more beds as much as 100 feet thick. the outcrops can be traces intermittently more than two miles. For purposes of map reference, the outcrop zone has been separated into the "South" and the "North" ore bodies.

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Magnetic separation beneficiation tests indicate optimum concentrate at -35 +65 mesh grind. Samples submitted to the Pickands Mather Hibbing Laboratory by the W. S. Moore Mining Company when ground to -100 mesh gave an average 63.39% magnetic concentrate. These magnetic tube tests averaged 6.26% SiO_2 with a weight recovery of the total contained iron of 96.01%. (See the attached summary of tests.)

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The claims which make up the Iron King Mine were originally located by Mr. Charles H. Jonas, Mining Engineer, in 1957. Shortly thereafter they were optioned to the Cerro de Pasco Copper Company. Cerro spent about $80,000.00 in building roads, trenching, and drilling. The results of their drilling are shown on the geology maps and sections. The contour representation is that of USGS Quadrangle Map, enlarged.

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In addition to the contact replacement deposits of the Globe-Miami area, reserves are available from the magnetic sand deposits of adjacent Maricopa and Pinal Counties. The Cuprious magnetites of the Christmas Mine offer a large potential reserve. Iron reserves immediately available and the considerable potential future reserves certainly justify consideration of a small, two-hundred to five hundred ton per day direct-reduction plant for purposes of furnishing sponge iron as a substitute for tin cans used in copper precipitation. The cans are increasingly difficult to obtain, even at ever higher prices.

BIBLIOGRAPHY

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*** Apt description of present and future use of iron for precipitation of copper from dilute solutions.

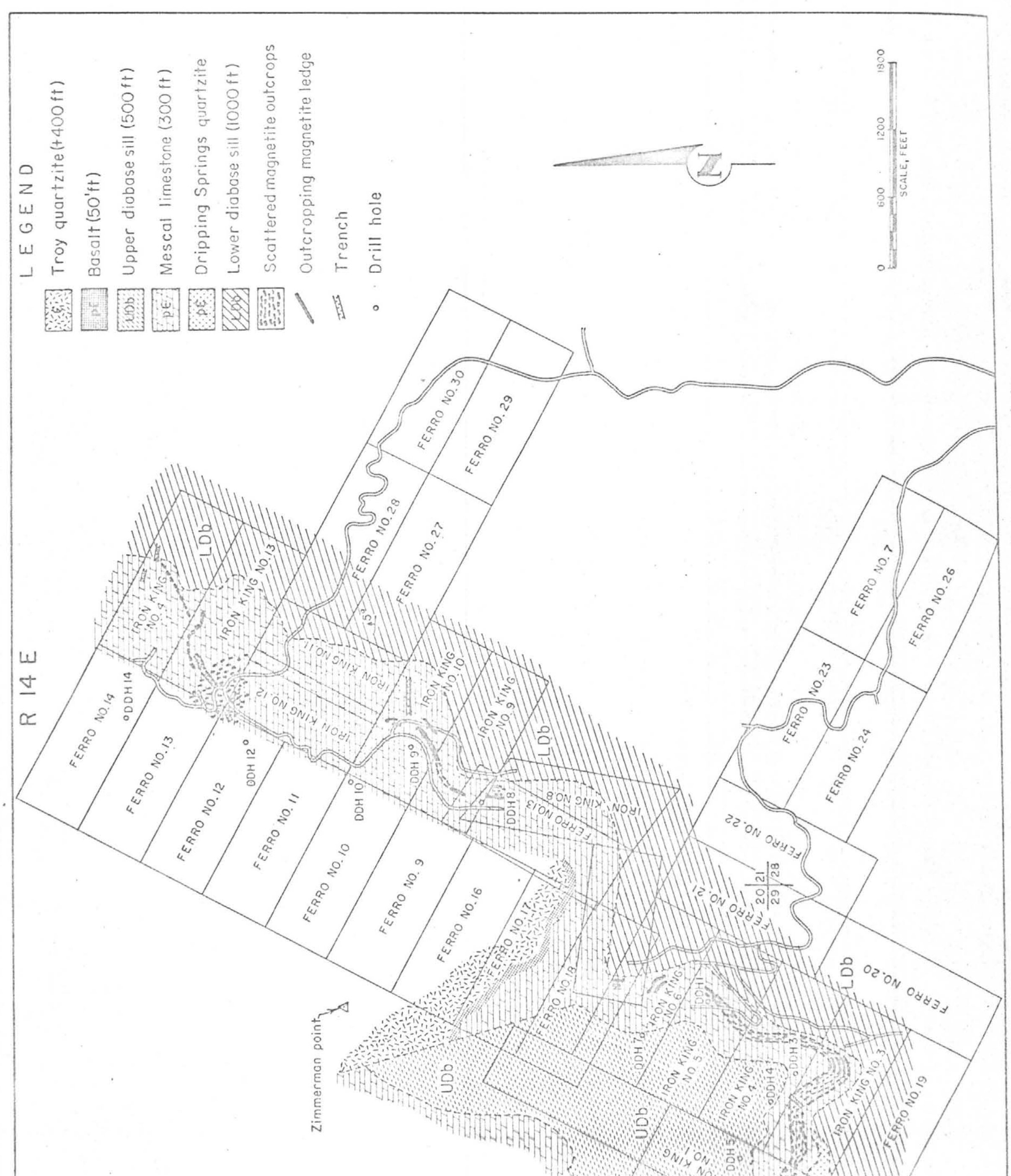


FIGURE 17. - Iron King-Ferro Magnetite Deposit, Gila County, Ariz.

CHESTERFIELD REALTY
LARRY CHANTLER, Broker
Ranch, Farm and Mining Specialists
119 North Montezuma Phone 445-3070
PRESCOTT, ARIZONA 86301

file in iron report
on Iron King

IRON KING MINE

Located in Gila County, Sierra Ancha Mining District, State of Arizona. Jack Aneas, Jesse A. Clark, Cletus Baker, and Wayne Willyerd are the locators of Record. Also James W. Fuller D. 172-99 Jan 4-65. Assesment.

Jack Aneas claims assessment work for Iron King 1 thru 8 on January 4, 1965, in Docket 172, Page 99. I also note he claimed labor on Easy Money same date and Docket but page 98.

Arizona Iron Mines Inc. claim assessment work on Iron King claims 1-~~2~~-3-4-5-6- et al Sept 7-65 in Docket 181, Page 333. Iron King 10-12-13, Sept 7,1965. Iron King 1 et al Sept 28, 1965, Docket 182, Page 262. Iron King 1-3-4-5-6-10,12,13 August 31,1966 Book 195, Page 511, Iron King 1-3-4-5-6-10-12-13- & Ferro 3 assesment work August 30,1967 in Docket 219, Page 174. I note this is the first time Ferro #3 has been claimed for assesment work in the docket.

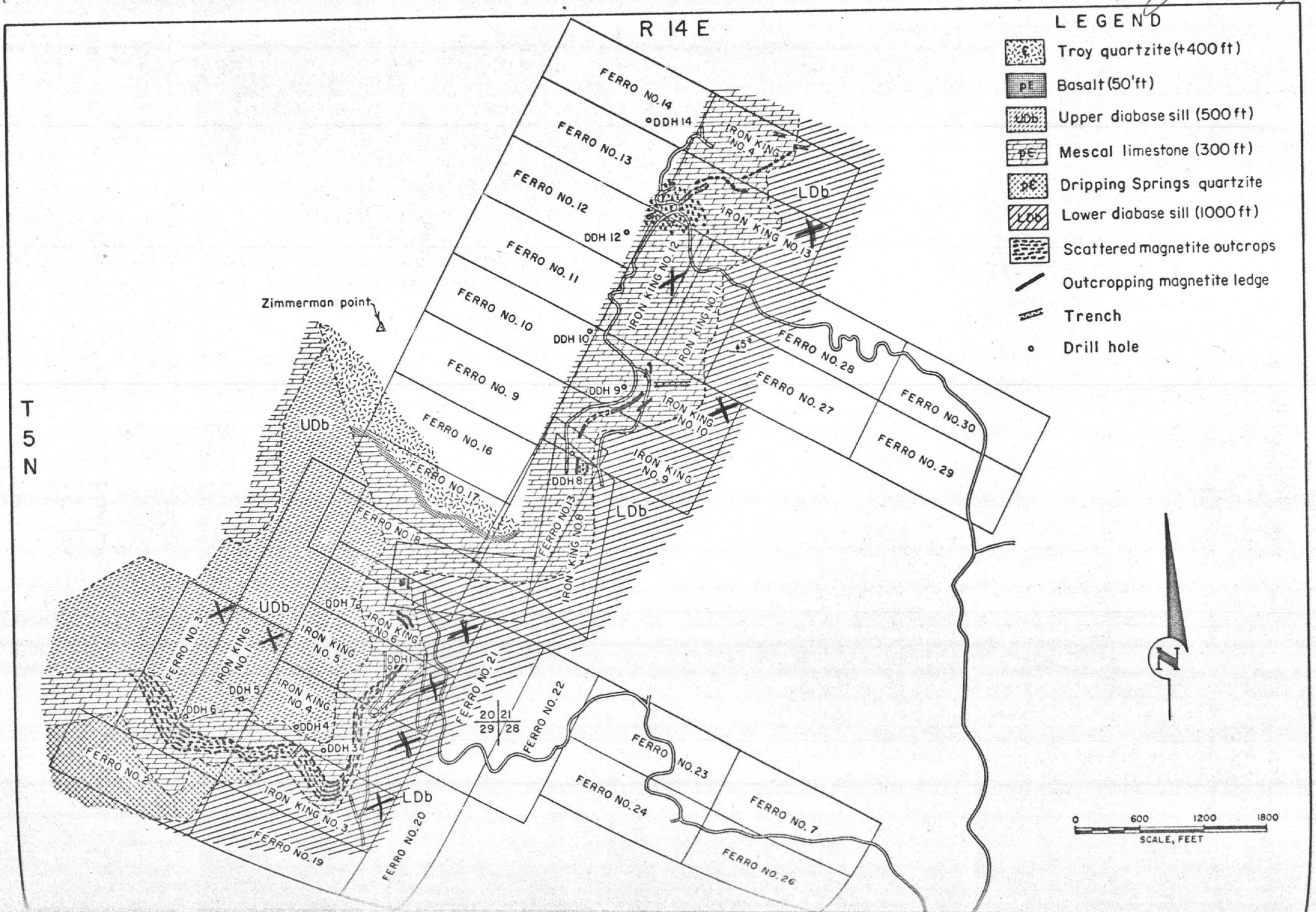
Docket 219, Page 174 Mr. Charley L. Moore claims Assesment work on Iron King 1-3-4-5-6-10-12-13- & Ferro #3 on August 26,1967. He claims $900.00 by clearing all roads, dug 9 exploration cuts 4 X 8 on all of the claims for sampling. Location: Docket 82, Pages 62,63,64,69, & 72.
1st to 16th Aug 67. Docket 83, Pages 43 & 44.
Docket 86, Pages 12 & 73

Lawrence G. Chantler
Lawrence. G. Chantler

cc. Kelsey Boltz

X assessment work August 30, 1967 Docket 219 Page 174 by Charley L. Moore

58



by L. Chantler 8-31-67

to Bob Ford

33-34 Peterson
110-111
Iron King

Docket 269 page 68 states, "Charlie Moore 'worked all roads with cat and dozer and made exploration cuts'". Was unable to get a copy of document as the Globe office is in the process of microfilming that particular docket, and their Xerox machine cannot make a copy of the photostat. This affidavit of Labor was made August 21, 1969 for the assessment year 1969-1970.

A copy of Affidavit Of Labor dated the 20th of May, 1970, by Nathan E. Ellison, is attached.

An earlier copy of an Affidavit of Labor is attached also. These were the only two copies I could get at the time.

Since mining locations are listed only by locator's name and the mining district was not noted, I was unable to find out if any relocations or new locations were made in the vicinity.

Betty Lucke
3/12/71

RECEIVED MAR 16 1971

DOCKET 286 PAGE 85

Affidavit of Labor Performed and Improvements Made

STATE OF ARIZONA, }
County of Gila } ss.

Nathan E. Ellison being duly sworn, deposes and says that he is a citizen of the United States and more than twenty-one years of age, and resides at Globe in Gila County, State of Arizona, and is personally acquainted with the mining claim known as Iron King Nos. 1,3,4,5,6,10,12, 13 and Ferro No. 3 mining claim, situate in Sierra Ancha Mining District, County of Gila, State of Arizona, the location notice of which is recorded in the office of the County Recorder of said County, in Book Docket 82, pages 62, 63,64,69,72; Docket 83, pgs 43,44; Docket 86, pgs 12 and 73 of Records of Mines, at page ; that between the 15th day of October A. D. 1969, and the 20th day of May A. D. 1970, at least $900.00 dollars worth of work and improvements were done and performed upon said claim, not including the location work of said claim. Such work and improvements were made by and at the expense of Arizona Iron Mines, Inc. owner of said claim for the purpose of complying with the laws of the United States pertaining to assessment of annual work, and Nathan E. Ellison, Mona T. Ellison, Carley L. Moore, and others were the men employed by said owner and who labored upon said claim, did said work and improvements, the same being as follows, to-wit: A clearing of roads with cat and dozer, other road work and excavations.

Nathan E. Ellison

Subscribed and sworn to before me this 18th day of June A. D. 1970

[illegible]
Notary Public.

(My commission expires [illegible])

INVENTORY OF CLAIMS PROTECTED

9-1-61 14 Claims	9-1-62 12 Claims	9-1-63 9 Claims
Iron King No. 1	Iron King No. 1	Iron King No. 1
Iron King No. 3	Iron King No. 3	Iron King No. 3
Iron King No. 4	Iron King " 4	Iron King No. 4
Iron King No. 5	Iron King No. 5	Iron King No. 5
Iron King No. 6	Iron King No. 6	Iron King No. 6
Iron King No. 7	Iron King No. 7	-
Iron King No. 8	-	-
Iron King No. 9	Iron King No. 9	-
Iron King No. 10	Iron King No. 10	Iron King No. 10
Iron King No. 11	-	-
Iron King No. 12	Iron King No. 12	Iron King No. 12
Iron King No. 13	Iron King No. 13	Iron King No. 13
Ferro No. 3	Ferro No. 3	Ferro No. 3
Ferro No. 12	Ferro No. 15	-
14 - CLAIMS	12 - CLAIMS	9 - CLAIMS

X Assessment work August 30, 1967 Docket 219 Page 174 by Charley L. Moore

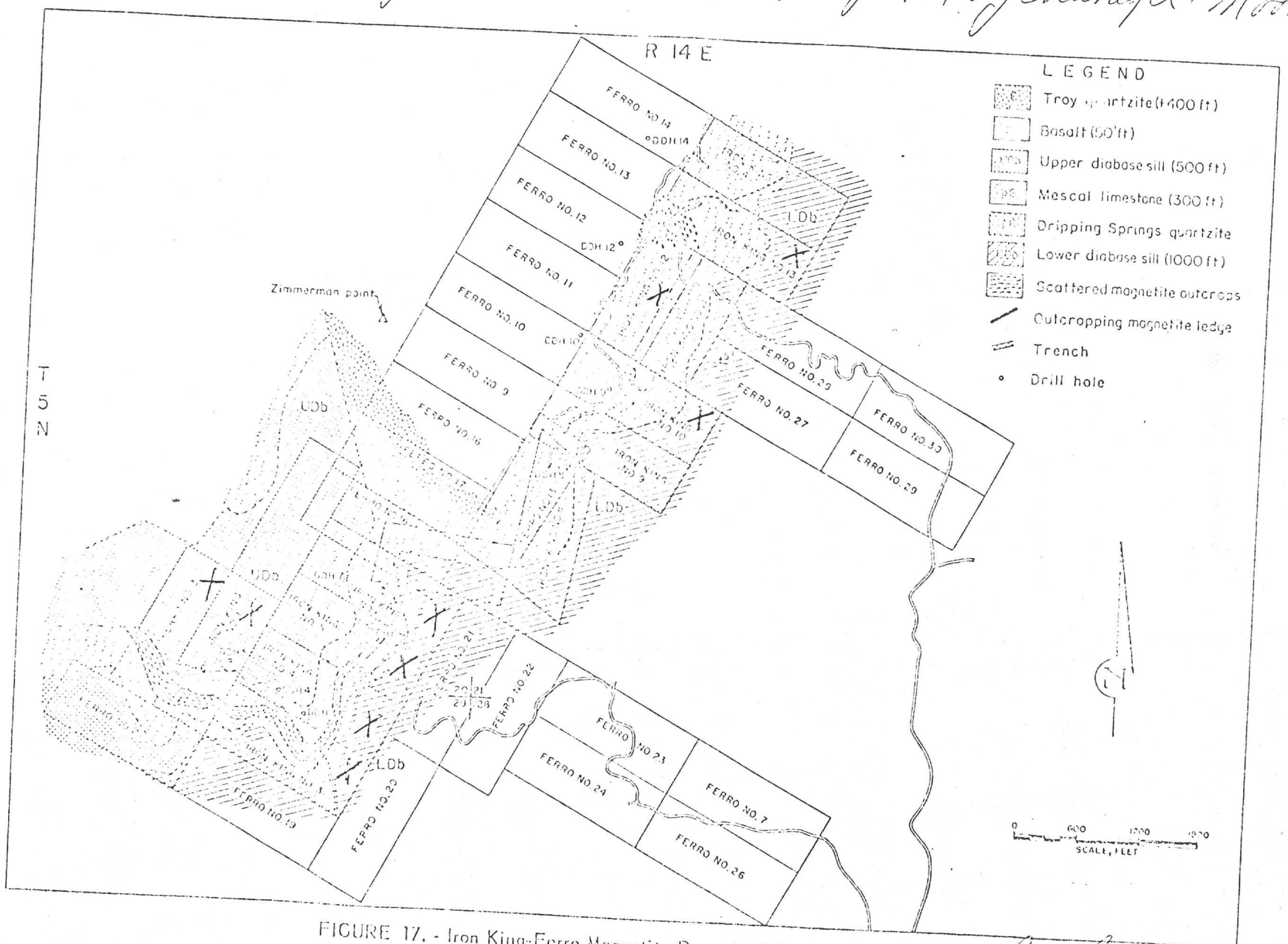


FIGURE 17. - Iron King-Ferro Magnetite Deposit, Gila County, Ariz.

by L. Chandler 8-31-67

April 14, 1971

To: Bob Ford
Herb Miller
Joe Walton

From: Kelsey Boltz

Re: Iron King Property North-East of Roosevelt Lake

The owner of the property is Mr. Charles Older of Los Angeles. His attorney is Bill Elsing of Phoenix, a good friend of Joe Walton's. Elsing has done work for us, and you may recall, he did the title examination for the Mammoth property.

Today I spoke with Bill Elsing regarding the Iron King property. He advised me as follows: Older has indeed kept up the assessment work on the Iron King group of claims. He, Older, would be very amenable to almost any type of reasonable arrangement on the claims to be made with a company who was serious about getting something done. Elsing indicated that Older is getting tired of paying for the assessment work and would be very anxious to make a deal. Elsing suggests that any offer be made through him (Elsing) as he will recommend us very highly to Older.

Incidentally, Older's son is the judge who is and has been trying the Charles Manson case.

KB

KLB/dmh

5

Sovereign Iron Ore and Steel Projects in Arizona

Mountain iron ore, local coal and

[redacted]

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Iron King No. 3	Iron King No. 3	Iron King No. 3
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Iron King No. 5	Iron King No. 5	Iron King No. 5
Iron King No. 6	Iron King No. 6	Iron King No. 6
Iron King No. 7	Iron King No. 7	-
Iron King No. 8	-	-
Iron King No. 9	Iron King No. 9	-
Iron King No. 10	Iron King No. 10	Iron King No. 10
Iron King No. 11	-	-
Iron King No. 12	Iron King No. 12	Iron King No. 12
Iron King No. 13	Iron King No. 13	Iron King No. 13
Ferro No. 3	Ferro No. 3	Ferro No. 3
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October 10, 1968

Mr. Chuck Arms, Vice President
Pickands Mather & Co.
2000 Union Commerce Building
Cleveland, Ohio 44115

Dear Chuck:

Trying to promote an iron property is anything but exciting; however, this is a special purpose property with a guaranteed market for production. The attached report is short and covers the situation.

You may find the first part of the report "Notes on Reduced Iron for Copper Precipitation" interesting. What we are proposing is a small direct-reduction plant to produce sponge-iron or particulate iron for precipitation of copper. There are a number of methods by which copper can be recovered from copper sulfate solutions, but the use of metallic iron to produce cement copper precipitate is the best known and most used.

The use of sponge-iron offers considerable advantage in faster precipitation and lends itself to automation. The price of scrap for this purpose has reached $55.00 per ton. What we are suggesting is a small, 200 ton per day, facility on rail near the center of existing markets; ample ore reserves exist. This facility would probably be what the steel industry would consider a "pilot plant", With the product salable at $60.00 per ton; with mines in which I owns interests taking 70 tons per day and the remaining market almost assured, this situation could not only make a nice profit but also lay the groundwork to make Pickands Mather a leader in direct-reduction.

We control the iron reserves and would be glad to go over all reports and maps concerning the property with you.

With kind regards,

Sincerely,

Robert Ford

RF/pc
Enc.

PRELIMINARY REPORT

IRON KING MINE

Gila County, Arizona

~~and~~

NOTES ON REDUCED IRON FOR COPPER PRECIPITATION

and

By

Robert Ford, Mining Geologist
Prescott, Arizona

October 1, 1968
~~May 9, 1967~~

Including Separate Folder of:

OK

General Property and Topographic Map, 1" = 300'
Geologic Plan Map, 1"= 100', "South Ore Body"
Geologic Plan Map, 1"= 100', "North Ore Body"
Cross Sections, 1"= 100', "South Ore Body"
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Gila County, Arizona

~~and~~

~~Notes on Reduced Iron for Copper Precipitation~~

INTRODUCTION AND SUMMARY

Widespread occurences of hematite and magnetite as contact replacements of Precambrian Mescal limestone associated with diabase intrusive sills are in Navajo and Gila Counties, Arizona. These medium to high grade iron replacements have been inferred, in 1945 (5), to contain fourteen million tons, averaging forty-six percent (46%) iron. That this estimate is woefully inadequate is evidenced by the fact that the Iron King Mine alone, the subject mine, contains an estimated potential of about ten million tons of high grade concentrates. More than thirty replacement deposits are known to exist in the same general area (2) subsidiary to a contemplated direct-reduction plant in the town of Golbe or of Miami, both in Gila County, Arizona.

Many of these replacement deposits have been investigated by the writer. From the standpoint of reserves, availability, and access, the Iron King Mine is considered the most important. That mine, consisting of thirty-eight unpatented claims is under option.

LOCATION

The Iron King Mine is located between Zimmerman and Asbestos Points in the Sierra Ancha Mountains of Gila County, Arizona. Sections 16, 20, 21, and 29 of Township 5 North, Range 14 East, center the property. The relationship of the outcrops at or near the 5,500 foot contour can be noted on the McFadden Peak 15' USGS Quadrangle Map.

The mine is reached by driving four miles northwest from Globe on U.S. Highway 60-70 to its junction with the Apache Trail (Arizona Highway 88), then fifteen miles northwest on the Apache Trail to its junction with the Young Road (Arizona Highway 288), then north 15.7 miles on Arizona Highway 288 to

the junction with access roads leading northeast to the property which is visible from the Highway and about two miles distant.

GEOLOGY

Magnetite occurs in irregular contact-metamorphic replacements of serpentinized, chloritized and silicified Mescal limestone that is 100 to 300 feet thick. The altered limestone and magnetite iron is sandwiched between two large diabase sills. The upper sill is probably 500 feet thick and lower about 1000 feet thick. The iron is entirely magnetic and occurs as massive high-grade bodies separated by disseminated and low-grade areas. The magnetite forms two or more beds as much as 100 feet thick. The outcrops can be traced intermittently more than two miles. For purposes of map reference the outcrop zone has been separated into the "South" and the "North" ore bodies. ~~(See accompanying geology maps and cross sections.)~~

METALLURGY

Magnetic separation beneficiation tests indicate optimum concentrate at -35 +65 mesh grind. Samples submitted to the Pickands Mather Hibbing Laboratory by the W.S. Moore Mining Company when ground to -100 mesh gave an average 63.39% magnetic concentrate. These magnetic tube tests averaged 6.26% SiO_2 with a weight recovery of the total contained iron of 96.01 %. (See attached summary of tests.)

The samples sent to the Hibbing Laboratory were from the number four trench on the "North" ore body and probably metallurgically representative of the entire property. The higher grade natural ores at a one inch to six inch break should average about forty percent iron. A magnetic concentration ratio of 2 to 2½: 1 should be representative of the mine's ore. Certainly the magnetic concentrates from the Iron King Mine, as well as from other similar contact deposits would make an ideal direct-reduction plant feed.

HISTORY AND PREVIOUS WORK

The claims which make up the Iron King Mine were originally located by Mr. Charles H. Jonas, Mining Engineer, in 1957. Shortly thereafter they were optioned to the Cerro de Pasco Copper Company. Cerro spent about $80,000.00

in building roads, trenching, and drilling. The results of their drilling are shown on the ~~accompanying~~ geology maps and sections. The contour representation is that of USGS Quadrangle Map, enlarged.

It is reported that the highest estimate ever expressed by Cerro for the Iron King Mine was eight million tons of plus sixty percent (60%) concentrates. Apparently this was not a sufficient reserve for their plans. Cerro made one semi-annual payment of $7,000.00 and then canceled the lease in 1961. W.S. Moore Mining Company and others subsequently investigated the property. However, the iron market, except for the proposed direct reduction plant product, does not warrent development of the Iron King Mine.

REGIONAL RESERVES

The Iron King Mine is perhaps the best of many contact replacement deposits in the district. By virtue of access and exploration drilling alone it is probably the most important. Several geologically similar high-grade replacement deposits of magnetite have been examined by the writer. Many of these are available for location by staking. Ground or airborne magnetic surveys may well establish an additional potential on the Iron King Mine and other known deposits.

In addition to the contact replacement deposits of the Globe-Miami area, reserves are available from the magnetic sand deposits of adjacent Maricopa and Pinal Counties. The Cuprious magnetites of the Christmas Mine offer a large potential reserve. Iron reserves immediately available and the considerable potential future reserves certainly justify consideration of a small, two hundred to five hundred ton per day direct-reduction plant for purposes of furnishing sponge iron as a substitute for tin cans used in copper precipitation. The cans are increasingly difficult to obtain, even at ever higher prices.

Reduced For Copper Precipitation -> Center

NOTES ON ~~THE~~ IRON ~~POWDER PRODUCT~~

The precipitation of copper on iron is one of the earliest known chemical reactions (6). The iron is usually in the form of shredded and detinned cans, plate, or sponge iron. This form of precipitation is called cementation and the copper precipitate is called cement copper. The copper bearing solution is won by leaching oxide copper ores with dilute sulfuric acid or ferric sulfate. The leach solution is collected and piped over iron

to effect precipitation. Of the many precipitation agents tested, tin cans are considered the most suitable available (4).

Copper is also produced in the same general manner by leach-precipitation-float (LPF).(7) In this process the oxide copper minerals combined with sulfide minerals are selectively and effectively sulfated in solution, precipitated on sponge iron and recovered with the sulfide minerals in flotation. Copper produced in the United States from oxide minerals, amounting to 150,000 tons annually, is about ten percent of the total United States output (9). This percentage is steadily increasing. By far the greatest part of the copper produced from oxides is precipitated on iron at a consumption of about ~~one and one-half~~ two tons of iron for each ton of copper recovered.

Arizona provides over fifty percent of the United States' primary copper production. Most of this is centered in Southeastern Arizona, subsidiary to the contemplated direct-reduction plant near Globe-Miami, Arizona. In 1965 that part of Arizona produced 50,000 tons of copper by precipitation from leach solution. By 1970 it is estimated that the production will be 90,000 tons (10). Sponge-iron is produced from pyrite obtained from flotation concentrates at Phelps Dodge Corporation in Douglas, Arizona and from Kennecott's Ray Mines at Ray, Arizona. However, this production is inadequate for their own needs and the low iron content of the calcined pyrites makes an inferior cement copper. In fact, Kennecott, on the first of May, ~~of this year~~ 1967, closed its pyrite-sponge-iron plant at Ray and is attempting to purchase fine grained magnetite for reduction and use in the LPF circuit. Expanded facilities at Kennecott's Ray Division will treat an additional 10,000 tons of oxide copper ores daily. The fifty tons per day of copper so produced will require about seventy-five tons of iron per day. That sponge-iron from direct-reduction processes will play an important part in this simple reaction is well established and justified. Kennecott (1) and Phelps Dodge (3) have each developed precipitation vessels or launders to handle sponge iron.

Increased production by precipitation on tin cans combined with the decreased availability of cans due to the substitution in packaging of aluminum, plastic, glass, and waxed containers has already made it difficult to obtain sufficient quanities and quality of iron from the scrap market; the situation is steadily becoming worse. The cost of cans delivered to the Arizona copper mining districts is quoted at $55.00 to $57.00 per ton. Demand is not satisfied and standby substitutes such as shredded auto bodies, wire, chains, and assorted scrap metal are being used. The contaminates present in these substitutes and their relative

inefficiency as precipitating agents result in higher cost and less pure cement copper. Reduced iron pellets were tried and found unsatisfactory (10).

Sponge-iron precipitates copper sulfate in one-third the time with about eighty percent of the iron used compared to cans. Labor savings are also considerable. Sponge iron is certainly perferable to other types for precipitating ~~iron~~ copper and should sell for $60.00 to $65.00 per ton.

Respectfully Submitted

Robert Ford, Mining Geologist

May 9, 1967

REGISTERED GEOLOGIST
CERTIFICATE NO.
5451
ROBERT
FORD
Date Signed 5-9-67
ARIZONA, U.S.A.

BIBLIOGRAPHY

1. Black, A.E.: Use of Particle Iron in Precipitation of Copper from Dilute Solutions. Presented 95th Annual Meeting of AIME, New York, New York.

2. Harrer, C.M.: Reconnaissance of Iron Resources in Arizona. U.S. Bureau of Mines Information Circular. 8236, 1964, 204pp.

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***6. Monninger, Frank M.: Precipitation of Copper on Iron. Mining Congress Journal, Vol.49, October, 1963.

7. PINGS, W.B. and RAU, Earl L.: Recent Trends In Copper Metallurgy. Mineral Industries Bulletin, Vol 11, No. 4, July, 1968,

**8. Spedden, H. R., Malouf, E.E. and Prater, J.D.: Cone-Type Precipitators for Improved Copper Recovery. Mining Engineering, Vol 18, April, 1966, pp. 57-62.

9. Wideman, F. L.: Copper: Mineral Facts and Problems, 1965 Edition. U.S. Bureau of Mines Bulletin 630, 1965, pp. 276-278.

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ARIZONA IRON MINES, INC.

(Iron King Group)

Pickands Mather
Hibbing Laboratory
W. S. Moore Mining Co.

3-23-61

MAGNETIC TUBE TESTS

SAMPLE	SIZE	PRODUCT	%WT.	ASSAY % IRON	ASSAY % SILICA	% TOTAL IRON
1.	-100M	Mag.Conct.	79.06	66.23		98.11
		NonMag.tails	20.94	4.82		1.89
		TOTAL	100.00	53,37	9.57	100.00
2.	-100M	Mag.Conct.	22.12	54.33		92.32
		NonMag.Tail	77.88	1.29		7.68
		TOTAL	100.00	13.02	5.36	100.00
3.	-100M	Mag.Conct.	82.69	69.60		97.60
		NonMag.tail	17.31	8.32		2.40
		TOTAL	100.00	58.99	3.84	100.00

CRUDE ANALYSIS

SAMPLE	Fe	SiO2	P	S	TiO2
1.- South Outcrop -	53.37	9.57	.072	.007	.04
2.- South-Low Grade-	13.02	5.37	.348	(High in CaCO3)	
3.- North trenches-	58.99	5.84	.021	.003	.11

Explanatory Notes:

Above samples taken by Irving Moore, Geolégist of Duluth, Minn.

Special attention is called to the # 3 sample, where at 100 M grind, the iron content is 69.60.

At 325 M, which was not tried, the grade would be 70. % Fe. This is probably as high grade concentrate as can be found in a natural deposit, this side of Brazil.

May 9, 1967

Mr. Jerry Anderson, Chief Geologist
The Cleveland Cliffs Iron Company
Ishpeming, Michigan

Re: Iron King Mine
Gila County, Arizona

Dear Jerry:

Under separate cover I have sent one set of plan geology and cross section maps of the subject property for your inspection. If any additional sections are needed for your use please advise me.

The attached report on the mine is based largely upon data received from Cerro Corporation, the former lessee. The data has been field checked by me. In addition there are other contact deposits available which would lend much additional iron reserves.

You may find the "notes on reduced iron for copper precipitation" interesting and informative. Please remember that the mines in which I hold an interest will consume seventy tons of scrap iron daily. I can also attest to the increasing difficulty, rising cost, and poor quality of material available. It would seem that this would be an ideal time for Cliffs to consider a direct-reduction plant on a small scale to gain both experience and profit.

John Ortman advised that you and Jim Villar are coming west on May 15. Perhaps this would be a good time to meet.

I take the liberty of sending a copy of the report, without maps, to Messrs. Villar and Ortman in case any of you are absent so that circulation before the westward trip might be possible.

With kindest regards,

Sincerely,

RF/pc
cc: James Villar
John Ortman

ARIZONA IRON MINES, INC.

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Ion exchange recovery of copper promising

[redacted]

[redacted]

[redacted]

Available in commercial quantities unless otherwise noted.

[redacted]

APRIL 17, 1997 [illegible]