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GEOLOGICAL RECONNAISSANCE
OF
IRON CLAIMS IN GILA COUNTY, ARIZONA
TOWNSHIPS 9 & 10 NORTH, RANGE 15 EAST
SPONGE AND POWDERED IRON

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Mechanical Engineering B.S.
Geological Engineering M.E.

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IRON DEPOSIT NORTHEAST GILA AND SOUTHWEST NAVAJO COUNTIES, ARIZONA

INTRODUCTION

This iron deposit was first noted as probablly significant by myself in 1958. Prior to this, a report was done by Mr. Lincoln Stewart on Swamp Mountain iron deposit on the Fort Apache Indian Reservation, which is part of the same deposit. The earliest, and only, published writing describing iron ore occurrences in the region is that of Ernest F. Burchard and B. W. Dyer, whose U. S. Geological Survey Bulletin #821c is dated 1931. The various outcrops in the area were noted when Mr. Andy Shribe was doing a topography sheet of the area and I was in the area representing a group of people interested in other ores. In 1958, I called this area to the attention of Colorado Fuel and Iron Corporation of Pueblo, Colorado who sent geologists into the area. After approximately two weeks of reconnaissance work this was recognized, by them, to be a probable find. They have been active in the area since that date.

The area encompasses Townships 9 and 10 north, Range 15 east, Gila County, Arizona extending onto the Fort Apache Indian Reservation. A county road extending from Young, Arizona, to Heber passes through the subject area. Approximately 12 miles north of this subject deposit is state highway 160 which traverses the Mogollon Rim between Payson and Heber, Arizona. In the area examined the General Land Office survey has been completed and most section corners, consisting of brass capped iron pipe, are in place. Claims within the area extend to the western boundry of the Fort Apache Indian Reservation. Except for the Reservation, all ground lies within the Tonto National Forest.

HISTORY

History reveals that some drifts were driven in the late 1920's along the base of the iron near diabase contacts by persons not primarily interested in iron ore but seeking gold. Some of these old timers, still living in the area, revealed to me they were hired to take the material from the base contact, between the iron ore and the igneous intrusion, and pan these for gold.

Outcrops of iron ore have long been known in the central portion of the subject area, particularily along the upper reaches of Gentry Creek and Frog Pond. These outcrops are continuous around the Frog Pond Mesa and extending northwesterdly to a diabase fault, then reoccurring again near Cherry Creek where a lesser mineralized zone is indicated. The study of Mr. Burchard and Mr. Dyer was confined to the Canyon Creek area on the Fort Apache Indian Reservation where rather extensive outcrops of ore occur. Although there are a number of exploration tunnels and open cuts in the various exposed ledges of ore, little or no exploration was ensued prior to 1958. Of major importance is the extensive exploratory and deveopment program carried on by Colorado Fuel and Iron Corporation during the past five or six years. They have a large lease block on the reservation which is contiguous with the subject area. After a thorough geologic study and considerable drilling, they have reportedly blocked out substancial economic reserves. It is of my personal knowledge and long experience with the area that the following knowledge was revealed to me by Mr. Jimmy Brooks, resident geologist for Colorado Fuel and Iron, that after they had completed 52 diamond drill holes, 51 were in commercial ore. The diabase in the area in which they put the hole not in ore has displaced the sediments but in no place, so far, can we say that the diabase has replaced the ore.

GEOLOGY

Stratiography

Rocks exposed in the subject area consist of the upper portion of the Apache Group of Pre-Cambrian (?) age, Cambrian and Devonian. Stratae overlie the Apache Group unconformablly. A generalized geologic section of the exposed rock is as follows:

Redwall limestone--brownish grey to grey, very fine, crystalline parts fossiliferous, massive to thin bedding, 0 to 200 feet thickness.

Martin limestone--white to grey to variations of purple, pink and grey, mostly very fine crystalline, occasional thin shale and sandstone beds, lower 100 feet dominantly medium to course grained sandstone, thin to thick bedding, heavily iron stained in places, some thin chert beds highly ferruginous, thickness 0 to 300 feet.

Troy quartzite--light grey to light brown, commonly purple, mottled especially due to weathering, generally well cemented sandstone in lower portion, medium to massive bedded, thickness 200 to 300 ft.

The base of the Troy quartzite in the area is known as chediski--white, fine to medium grained, poorly sorted sandstone, white sericitic cement, thickness 50 to 200 feet.

Mescal limestone--banded and stratified chert, ferruginous in portion merges into iron ore, thickness 10 to 60 feet.

Dripping Springs quartzite--light buff to reddish grey, frequently fine grained, banded with reddish striae, thin to medium bedded, rarely massive, plus 300 feet.

Diabase--laccoliths and sills, intruded Dripping Springs and Mescal formation.

The thicknesses listed above are only estimates, based on observations of partial exposures throughout the area. Both the Martin and Redwall limestones are known to be as much as 400 feet thick in other places and the Troy quartzite is reported to obtain a thickness of 700 feet to the west and south. However, it is estimated that the combined Troy and Chediski beds probably do not exceed 600 feet in the area investigated. Since the Troy quartzite was subject to errosion prior to Martin deposition, it is difficult to assess its thickness in the subject area. On Gentry Mesa and Lost Tank Ridge a maximum of 300 feet can be observed and over most of these two areas considerablly less than that remains. This would indicate a slight thickness to the south and east. This being the case, it is anticipated that up to 300 feet of Troy may be present under the Martin Redwall cover in the eastern portion of the northeast area. The Chediski sandstone, member of the Troy formation, was no where observed to be more than 180 feet thick. In many places it was found to be considerablly less, however, it may be that it was not well exposed. In contrast to outcrops on the reservation, few typical exposures of Chediski were noted in the subject area. Very excellent exposures of Mescal are found in the Frog Pond area and the Sheep Springs area where the relatively steep wall canyons cut through the entire section. The whole section can also be seen in Cherry Creek in the southwest corner of section 33. Elsewhere, only partial exposures are found. Most of the Mescal is composed of chert, the upper beds of which are massive to thin bedded and of a cryptocrystalline variety. This passes into a crenulated algal form which generally carries iron ore. Some shales are present, in the upper portion, which develop a somewhat granular texture and can be confused with basal Chediski in a restricted outcrop. In the northern part of the area only partial exposures of Mescal can be found, although continuous outcrops are shown along Parallel Creek in section 29. This is largely a projection, as the formation is covered with tallis, except in a few places. This is true, also, of a portion shown above Cherry Creek in section 32 and 33. In Gentry Creek, from Shell Mountain on down stream, Mescal crops out along the stream bottom. There is some evidence that the Mescal varies considerablly in thickness over the area along the upper reaches of Gentry Creek, from the center of section 21, northward, it appears that the Chediski rests directly on Dripping Springs. In some of the exposures along Cherry Creek and in Parallel Creek only about 30 feet of Mescal is found. In both of these areas faulting occurs and this may obscure true conditions. The wide spread occurrences of Mescal throughout the subject area, however, lead to the conclusion that it is perhaps ubiquitously present. Frequent exposures of Dripping Springs quartzite were observed throughout the area, however, as a deliniating factor. Little study was made of this formation. The greatest thicknesses of quartzite occurs on Shell Mountain in section 28, Township 9 north. In the north about 250 feet of Dripping Springs is exposed in section 32. Rather large areas of diabase are found in the region, except for one small outcrop in the southwest corner of section 14, Township 10 north, all of the diabase exposures lie in Township 9 north. Gentry Mountain, a dominant topographic feature centered in section 20, probably represents a laccolith center. The diabase is thought to have been intruded in laccolithic form, probably as sills, into Dripping Springs beds. No evidence was found of its intruding beds younger than Mescal. In Naegelin Canyon a conglomerate was found which contained fragments of all formation from Dripping Springs through Martin. The Matrix appeared to be weathered or alter diabase and the fragments varied in size from grains to blocks 10 feet long. Large boulders of diabase were also included. Both here and in section 14, the diabase is overlain by Martin and Redwall. This would indicate that either the diabse was raised by faulting or it intruded later than is generally thought. Very little metamorphism seems to have resulted from the intrusion of the diabase. Near the junction of the Frog Pond fork and Gentry Creek, both diabase and Dripping Springs quartzite have a baked appearance, both have a brick red color and in the diabase feldspars are slightly sericitized, aside from this one observation, no contact effect was noted.

STRUCTURE

A cursory inspection of the geologic map indicates a regional dip to the southeast. In Gentry Creek, at the south end of Gentry Mesa, the Chediski top is approximately 5,840 feet in elevation. On the ridge, north of Parallel Canyon Creek, in section 29, it is at an elevation of approximately 6,520 feet. Actually, this is not a true measure of dip because, as will be noted, a number of faults intervene. The 840 feet of structural relief, however, occurs in about 7 miles giving a southeast dip component of a little over one degree. Dips measured throughout the area exceeded this considerably; ranging from 4 to 16 degrees in general, and getting as high as 39 degrees.

A number of faults were located, but most could not be traced for more than short distances. Those shown as solid line are felt to be reliably located; those shown with broken line are more hypothetical. It will be seen that faults strike in two major directions, approximately northeast and southeast. There are undoubtedly more faults than are shown. This is particularly true in the

Xerox area where outcrops are of limited extent. Also, much of the area here is unconformably overlain by post-fault Martin and Redwall limestones. It is thought that the significant faulting is pre-Devonian.

The largest displacement observed occurs on the Gentry Creek fault, opposite Shell Mountain, where the Mescal is raised some 500 feet on the southern upthrown side. In Cherry Creek, the short fault shown in section 33 has a throw of about 150 feet as it juxtaposes the top and bottom of the Chediski sandstone on either side. A possible major fault, not shown, extends from the tri-furcation of Bear Spring Creek, on the Reservation, to between drill holes 2 and 2A in section 34, Township 10 north. It is possible that this fault may be an extention of the northeast trending fault parallel to Cherry Creek. It was not put on the map because it was not examined anywhere in the field. The inferential evidence for it lies in the fact that it is noted in Bear Spring Canyon by Burchard.

The fault crossing Parallel Creek, near the center of section 28, is of significance because, upthrown to the northwest, it displaces the ore zone at least 100 feet shallower than it would be otherwise.

Intrusive diabase is perhaps more directly responsible for local structural effects than any other factor. A southeast trending anticlinal flexure is present on Gentry Mesa as evidenced by dips at the north and south ends. That this flexure is caused by intrusive diabase may be deducted by noting the higher than normal elevation of diabase at the point where the jeep trail starts down to Gentry Creek in the east central portion of section 21. Troy quartzite on Lost Tank Ridge has an anomalously high position as does the diabase contiguous to it. This is construed as resulting from uplift caused by doming of the igneous intrusive. The two faults in Parallel Canyon, in section 29, suggest the presence of an underlying diabase sill, also. In the extreme northeast corner of the subject area, diabase is exposed at its highest strato-graphic position. Since it is here overlain by Martin, it is obvious that sufficient uplift ensued that the pre-Martin strata were completely eroded.

Surficially it would appear that much of the faulting is related to intrusion of the diabase. However, since faulting is post-Troy, it is much younger than the time of igneous intrusion. Furthermore, it can be seen that diabase itself is faulted so it must be concluded that most of the faults observed are not genetically related to the tectonics of the diabase intrusion.

ORE CHARACTERISTICS AND GENESIS

As mentioned previously, the iron ore is associated with the chert of the Mescal formation. It most frequently occurs in the algal type chert, although it is not uncommon to find it in the overlying thin bedded variety. The ore grades into chert in all directions, but is particularly restricted in its occurrence above the algal section.

Distribution of the ore bearing Mescal formation is widespread, as can be seen by inspection of the map. Analogously, the ore is also widespread, but not ubiquitously. Although some ore was noted in each of the outcrops mapped, its thickness, quality, and extent is highly variable. The best ore seen occurs in the Frog Pond area. Here it is of good grade for as much as 20 feet vertically. In Cherry Creek, in the west half of the southwest quarter of section 33, a 10 foot bed of ore is of commercial grade. About 30 feet of soft ore was noted in the canyon of the middle fork of Parallel Creek, but as the zone was largely covered with detritus, the quality of the ore was not ascertained. Along the fault crossing Gentry Creek, at the center of the west line of section 15, about 10 feet of soft ore is exposed. Because of the fault (?) only 20 feet or so of the bed crops out. In the northeast corner of section 27 five feet of low grade ore occurs. Across Gentry Creek, on Shell Mountain, a farther downstream good exposures have been noted.

Ore exposures on the reservation are indicated by hachures, and the holes drilled by CF&I are also shown. according to Jimmy Brooks, their geologist, 51 of 52 holes drilled penetrated ore. This distribution of outcrops and drill holes certainly implies a widespread occurrence of mineralization within the Mescal formation. It is logically deduced that where the Mescal is present in the subject area, ore will also be found.

The iron ore is hematite with, occassionally, some minor amounts of magnetite. It ranges from soft, pulverulent bright red to hard and dense blue oxide. Considerable amounts of specularite are often associated with the hard ore.

the ore ranges in thickness from less than 5 feet to at least 30 feet. An estimate of average thickness is not of significance at this point, because, for exploration, the grade factor is equally important. The best ore runs from 50 to65 percent in metallic iron with silica ranging from 4 to 26 percent. Phosphorous varies between 0.12 and 0.40 percent. From this quality, the ore diminishes in grade to non-commercial. Although it is not within the scope of this examination to assess reserves, it is felt that nominal reserves could be developed wherein the ore would average better than 50% in grade. See attached assay results.

In considering the potential ore development within the subject area, its genesis becomes important. It is not presumed that this facet could be adequately pursued in a reconnaissance examination, but some discussion of the probable genesis is warranted. It has been suggested by Burchard and others that the ore is a replacement of siliceous beds of the Mescal formation. Cursorily observed, the ore appears to be an original ferruginous sedimentary deposit. However, no oolitic or granular material is present. Moreover, much of the ore retains vestiges of the algal structure of non-mineralized chert. Assuming that the ore constitutes a replacement deposit, the question arises as to the source of the iron. Certainly the diabase must be considered as a very probable source. Typically rich in ferromagnesian minerals and frequently containing magnetite, this rock could readily impregnate solutions with iron.

The proximity of ore to faults strongly suggests a genetic relationship. The faults would, of course, provide the necessary channels for ingress of iron pregnant solutions. It is logical to assume that the richer ore should be near faults, although there is evidence that replacement extends for considerable distances within the Mescal formation.

Postulating that the iron mineralization derives from replacement, it follows that ore bodies will be spotty and irregular. This has been cursorily noted in the examination. On the other hand, the geometry of the holes and outcroppings on the CF&I property indicates good continuity of ore.

Carbox claims are of limiting extent primarily because of the extant level of erosion. These showings are of significance, however, in that they imply a widespread occurrence of potential ore deposits.

On the North Carbox claims there are two factors which enhance their ore potential. One is the copious amount of rich iron float to be found in the creeks below the Mescal horizon. Another is the degree to which even the overlying Martin limestone is mineralized. Although no ore per se occurs in the Martin, the basal sands are frequently heavily iron stained; sometimes so highly ferruginous as to constitute low grade ore. It is not uncommon to find high grade float associated with this formation. With so much evidence of strong mineralization, commercial ore bodies must unquestionably be present.

Recognizing that the properties examined in this investigation constitute only a prospect, it is none-the-less implicitly manifest that they do possess excellent potential for economic iron ore reserves. That this prospect can be evaluated for a relatively modest cost, that it is within ready access of western smelters, and that there is a general paucity of iron prospects in the west are basic arguments favoring a further look at this promising iron ore environment.

IRON OCCURRENCES IN FROG POND AREA

The property belonging to Archean Corporation consists of several groups of claims, some of which have outcrops showing, but this portion of this report considers only the "Lady Bug" group of claims.

The foregoing has been a general outline of the iron occurrences in the subject area. A much more detailed study was made in the Frog Pond area belonging to Archean Corporation. Please see enclosed map.

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 area between the surface exposures.

The deposit has apparently been formed by replacement of a limestone bed by hematite and chert. The hemitie is a very good grade of ferric oxide. Chert is a crpto-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 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	" "	@ 46.30 % 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 percents and the lower 60 percents, so an average of 55% was used. This, again, is quite conservative but it is well known that in sampling outcropped material the percentage tends to run high. Considering all the factors, an average iron content for the entire deposit of 52.0 percent 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.

MARKET INVESTIGATION FOR IRON ORE

In the early 1960's, after approximately 50% of the Colorado Fuel and Iron drilling program had been completed, this author attempted to find a market for the iron ore owned by Archean Corporation. After discussing the project with many major steel companies, other than C.F.& I., it became apparent that if this find was to be put into production in the near future, a market other than the major steel companies must be found. This writer aconsulted with Mr. W.P. Leweiki, steel plant consultant, of Studio City, California, who recommended that we investigate the possibility of sponge iron and powdered iron for consumption in western United States, since all the producers of these products were either in the east or overseas.

It was at this time this writer visited Cambridge, Mass. to investigate the use of the E.R.L. Process owned by Arthur D. Little Research organization. I also investigated the

R. N. Process, The Madris Process, The Hoeganaes Plant at Riverton, N. J.; also, the direct reduction processes in France and Sweden. After this, I came to the conclusion that the manufacture of sponge iron was not nearly as complicated as I had been lead to believe.

Once this research was completed, I immediately started on the design of a sponge iron furnace, which could be employed by Archean Corporation, which would produce sponge iron comparable to any of the before mentioned processes. A small pilot plant was first built in Colton, Calif. and batches, up to 25 pounds, of sponge iron were produced, using bituminous coal as a reagent, also, reformed natural gas. This project was deemed successful.

In 1964, a much larger pilot plant was built in Phoenix, Arizona, using a U. S. Smelting rotary furnace in which the atmosphere could be controlled. This furnace would reduce as much as 1,000 lbs. per charge, using bituminous coal as a reagent. Sponge iron was manufactured in this plant using temperatures up to 1800°F. and using hematite with an Fe content of 52 to 55%.

Assay of Bituminous Coal

Moisture	Volatile Material	Fixed Carbon	Ash	Sulphur
9.88	32.64	46.86	10.62	1.12
9.88	36.22	52.00	11.78	1.24
9.88	41.06	58.94	11.78	1.41

Hydrogen	Carbon	Nitrogen	Oxygen	BTU
5.42	62.00	1.13	19.71	10,800
4.79	68.80	1.25	12.14	11,984
5.43	77.98	1.42	13.76	13,585

Natural gas was used as energy.

It is quite understandable that at 1800°F. this coal begins to make CO, a very unstable gas. When it is brought into contact with $Fe\ 2O_3$ in an inert atmophere then the only O_2 available to the CO is contained in the $Fe2O_3$. It was learned that if the iron ore and coal were kept at this temperature in an inert atmosphere for a minimum of one hour and fifty minutes a degree of reduction in the high 90's could be achieved. After reduction was achieved, it was extremely important this material be cooled to at least 600°F. , also, in an inert atmosphere. After this was done the material was ground to minus 200 mesh and, by the use of air and magnetic separation, a metallic iron product from the mid to high 90 percentages was the result. See attaches assays.

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
PHONE 254-6181 817 WEST MADISON ST. P. O. BOX 1888 PHOENIX 85001
Chemist . . . Engineers

For Archean Exploration Company
Mr. Allison

Date September 24, 1964

Sample of Ore

Received: ----

Submitted by: Mr. Allison

ASSAY CERTIFICATE

Gold figured at $ 35.00 per ounce   Silver figured at $ 1.00 per ounce

LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)	
158099	#3, 210'-215'					22.70	
158100	#3, 215'-231'					51.20	
158101	#4, 26' -29.5'					46.30	
158102	#4, 29.5' -32'					26.90	
158103	#4, 32' -37'					44.20	

Loftin's

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean, Jr.

Claude E. McLean, Jr.

ATL
A R I Z O N A   T E S T I N G   L A B O R A T O R I E S
A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
PHONE 254-6181   817 WEST MADISON ST.   P. O. BOX 1888   PHOENIX 85001
Chemist . . . Engineers

For Archean Exploration Corp.   Date August 3, 1964

Sample of Ore   Received: 7-31-64

Submitted by: Mr. D. H. Jardine

ASSAY CERTIFICATE

Gold figured at $ 35.00 per ounce   Silver figured at $ 1.00 per ounce

LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)	
157824	#3 12' sample from outcrop in Frog Pond Creek					56.10 %	

Loftin's

REGISTERED ASSAYER
CERTIFICATE EXPIRES
CLAUDE E. McLEAN
DEC. 31, 1964
ARIZONA, U.S.A.

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
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For Archean Exploration Corp. Date August 3, 1964

Sample of Ore Received: 7-31-64

Submitted by: Mr. D. H. Jardine

ASSAY CERTIFICATE

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LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)	
157826	#5 Core Drill Lady Bug Claim, Hole #1 141.5' to 152.5'					50.30 %	

Loftin's

REGISTERED ASSAYER CERTIFICATE EXPIRES CLAUDE E. McLEAN DEC. 31, 1964 ARIZONA, U.S.A.

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean

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LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)	
157823	#2 18' sample from Southwest Ridge in open cut.					55.80 %	

Laflin's

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Respectfully submitted,

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Claude E. McLean

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ASSAY CERTIFICATE

Gold figured at $ 35.00 per ounce Silver figured at $ 1.00 per ounce

LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)
157822	#1 Lady Bug Claims, 15' sample from Southeast Ridge in Canyon					57.90 %

Loftin's

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LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	IRON (Fe)	
157825	#4 22' sample taken 40' North of 260' drift in Frog Pond Canyon					46.70 %	

Laftin's

REGISTERED ASSAYER CERTIFICATE EXPIRES CLAUDE E. McLEAN DEC. 31, 1964 ARIZONA, U.S.A.

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E. McLean

When this had been accomplished, this writer recommended a production size mill be put into production.

A production size furnace was built by Allen and Sons of San Bernardino, Calif. and the combustion engineers who designed the burner, blowers and controls was Hirt Combustion of Montebello, California.

The before mentioned furnace and accompanying equipment was designed and installed under this writer's supervision. This furnace was operated approximately four months by this writer and after a few minor changes performed as was expected.

MANUFACTURE OF SPONGE IRON

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:

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

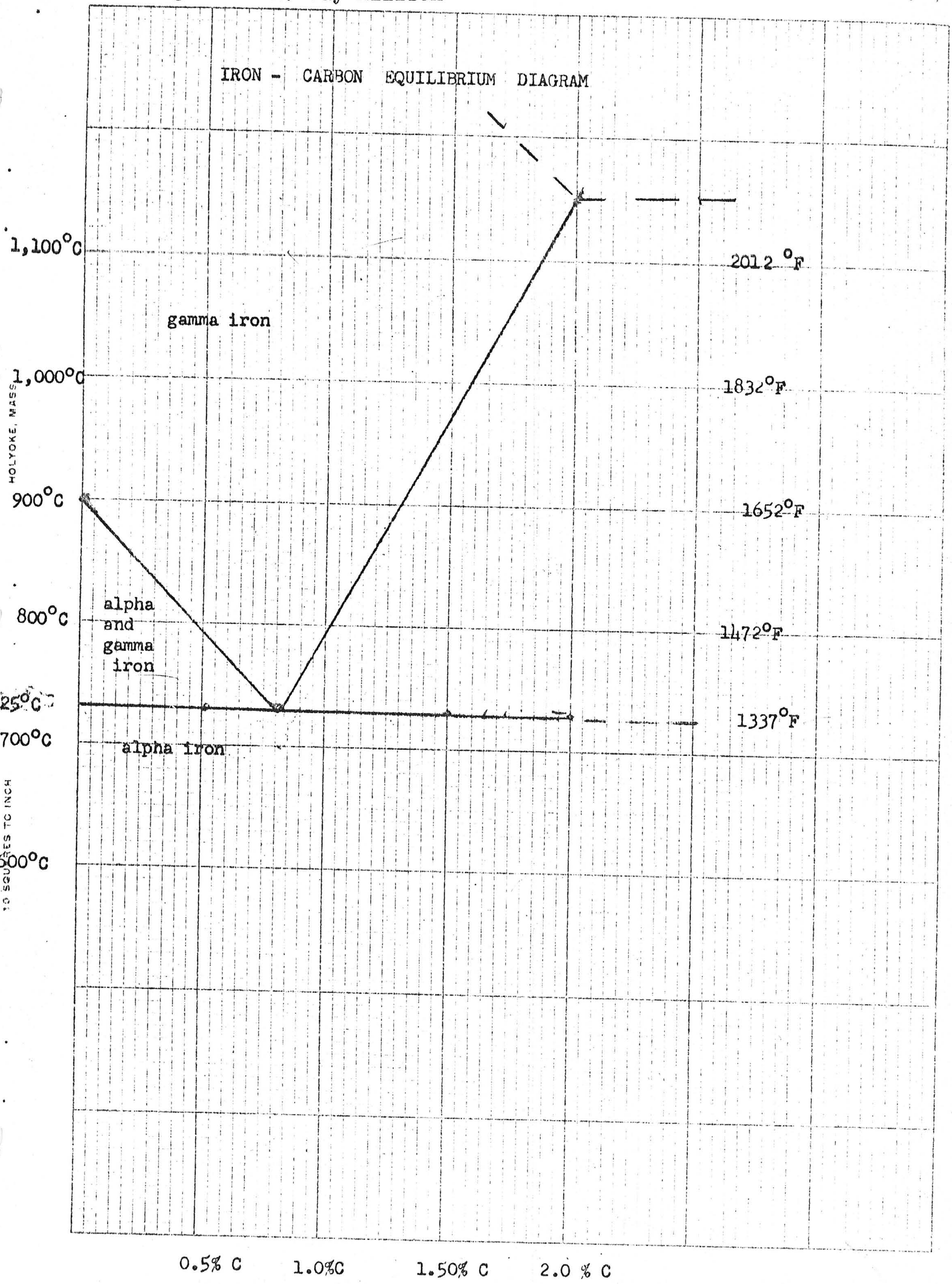
$$Fe_2O_3 + 3CO = 2Fe + 3CO_2$$

$$CO_2 + C = 2CO$$

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

$$Fe + CO_2 = CO + FeO$$

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 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.


IRON - CARBON EQUILIBRIUM DIAGRAM
1,100°C
1,000°C
900°C
800°C
725°C
700°C
600°C
gamma iron
alpha
and
gamma
iron
alpha iron
2012 °F
1832°F
1652°F
1472°F
1337°F
0.5% C
1.0%C
1.50% C
2.0 % C

The Iron-Carbon Equilibrium Diagram

The pertinent areas of this diagram are given on page 11A. 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 hundredths of one percent of iron. In the area marked alpha and gamma, gamma iron which is a face-centered cube and which dissolves 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 of carbon 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.

Heat Required to Raise the Reactants to the Temperature of 1800°F.

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 $\Delta H = \int \Delta C\, dt$,

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 = 144,437,325 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 (3.968×10^{-3}) = 249,721 B.T.U. and the total B.T.U. required for one ton of iron ore is 823,216.

Coal

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.

Heat Available for Raising the Temperature

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 monoxide is only about 3,200 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 for the 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 4,140,000B.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 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

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

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 mechanical 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 waste heat in the exit gases for pre-heating the incoming charge. 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 efficientcy. It is not necessary to try for 100 percent 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 percent 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, 2000 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 Produced

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

This figure does not included amortization charges.

R. Jay Allison
Box 704
Tucson, Arizona
85702

August 12, 1965

SPONGE and POWDERED IRON

HISTORY

Direct reduction of iron ore has been practiced in Sweden for over 40 years. The product sponge iron has, in increasing amounts, been utilized as a raw material for quality steel production primarily in acid open hearth induction furnaces and basic electric arc furnaces. In the following paper an attempt has been made to compile some of the present day knowledge, and it is thereby a necessity to draw from Swedish sources.

Sponge iron is a metallic product reduced from iron ore at such a low temperature that melting of the iron of the gangue constituents has not taken place. Sponge iron is, therefore, more or less porous, which accounts for its name. On the other hand, it cannot contain impurities that are normally introduced to the iron from the reducing agent or from additives to other processes where the iron becomes molten. Contrary to scrape, sponge is virtually free from alloying elements and from so-called tramp elements. Sponge and powdered iron have been in use for many years in France and Germany also. The Swedes introduced sponge to this country especially for the making of stainless steel, and since that time it has been used in many fields where quality steels are a "must".

Sponge iron is recommended by many aircraft companies for the manufacturing of steels for their use that must have a very high P.S.I. rating. Powdered iron is now increasing in use at the rate of about 65,000 tons per year with the small users. Ford Motor Company alone is using about 55,000 lbs. per day in only three small castings, and this is expected to double by mid-1965. In 1959, Ford Motor Company used 750,000 lb. of powder. In 1963, Ford Motor Company used 2,250,000 lbs. of powder and this is expected to grow to 16,000,000 lbs. by 1968.

Many other companies have also started its use in the manufacturing of bearings, gun steel, saws, mining equipment, tool and die steel, and many others. How much this will increase will depend entirely upon a good supply of the material. There are now some 27 users of sponge iron in California alone who use from 30% to 100% charge in electric furnaces making high-quality products. This sponge must come from the East or from Sweden. They pay approximately $144.20 per ton f.o.b. Los Angeles. At this price it is more economical than pig or scrap because:

1. The low amount of slag.
2. High yield.
3. Low energy consumption.
4. High production,
5. No corrosion in refractory linings.

For instance, one ton of 96% reduced sponge can be melted with 495 KWH, as opposed to 550 KWH for the melting of pig or scrap. Powdered iron is being used in pressed castings as opposed to poured castings because there is very little, if any, labor used in finishing; whereas, the molten casting must be ground and finished in a lathe with much loss in time and material waste. For instance, some large castings must use two tons of material to make a 1-ton casting. Since sponge briquettes are very dense and react much like low carbon pig, it is seldom necessary to consider any changes in furnace practices when this material is used for the first time. Economics of the use of virgin melting stocks in electric steel making are not only a matter of relative cost of melting stock as charged. Savings also result from lower furnace operating costs, lower rolling, forging and annealing costs, resulting in a known and uniform quality steel.

INDUSTRIES NOW USING SPONGE and POWDERED IRON

Foundries employing:

1. High frequency furnaces.
2. Electric arc furnaces.
3. Acid induction furnaces for manufacturing of any high-grade or alloy steels.
4. Aircraft industry in pressed castings.
5. Automobile industry in pressed castings.
6. Curring and scarfing of alloys.
7. Welding rods and welding rod flux.
8. Tool and die industry.
9. Castings for the copper industry.
10. Charge for open hearth furnaces.
11. Filters.
12. Paints.

and many others.

SPONGE IRON and THE COPPER INDUSTRY

There now exists in the copper industry a great need for sponge iron in the leaching pits to replace the tin can which becomes more scarce every day. All the major copper companies have tested sponge iron as a replacement with very good results, but as of now, no one has proven they can supply adequate tonnage to meet their needs. I believe this field is wide open.

For many years a great portion of our domestic copper has been produced from copper oxides by precipitation. This entails the use of thin sheets of iron such as used tin cans which are placed in launders over which an acid solution containing copper is circulated. The copper oxides which are suspended in the sulphuric solution then replace the iron in the tin can, thus forming copper cement. In 1964, Arizona produced 93 million pounds of copper by the leaching method which consumed approximately 285 million pounds of tin cans, of which approximately 80% was usable iron, which indicates approximately 2.4 lbs. Fe per lb. Cu. produced. This is largely due to the contamination of the cans used, since the cans must be taken from city dumps to a processing plant where they are burned in an attempt to remove the plastic, lacquer, solder, etc. These cans begin to oxidize very rapidly after burning. In route to the consumer, therefore, the can is further contaminated. In the leaching process, copper will only replace the metallic iron contained in the can.

One operation near Globe, Arizona, used 385 tons of cans to produce 200 tons of copper cement. This consumption of one larger producer in this area was at a ratio of

1.8 to 1.

Due to the increased use of plastic , aluminum, and fiber containers, tin cans are becoming more scarce daily, and the demand is becoming much greater due to the increase in production of copper cement. This has forced the suppliers of cans to go as far away as Houston, Texas, and in some instances to Florida to supply their contracts. This also prevents the supplier from obligating himself to additional contracts. Both Phelps Dodge and Kennecott Copper have attempted to produce sponge iron from the iron pyrite contained in their slag dumps or floatation mills, with very poor results. Both of these companies have expressed a desire to purchase sponge iron when a source is available.

These companies--as well as many others--have tested sponge produced at the test plant in Phoenix, and are anxious to see a production plant in operation. There are in Arizona, at the present time, four very valuable new properties being readied for production. The average production from these four properties will be approximately 25,000 tons per day each. These plants must also have a supply of iron for leaching.

CONCLUSION:

Since the only large producer of sponge iron is in the East and overseas, and the copper companies in the West must purchase sponge with added freight cost, I feel this is the time and place to construct a plant.

Respectfully submitted,

R. Jay Allison
Geological Engineer

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.
PHONE 254-6181 817 WEST MADISON ST. P. O. BOX 1888 PHOENIX 85001

Chemist . . . Engineers

For Archean Corporation
1416 East Thomas
Phoenix, Arizona

Date March 9, 1965

Sample of Pulps

Received: ----

Submitted by: -----

ASSAY CERTIFICATE

Gold figured at $ 35.00 per ounce

Silver figured at $ 1.29 per ounce

LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	TOTAL IRON (Fe)	
159062	S-5B -32 Mesh					73.20	%
159063	S-7A -20 Mesh					77.20	
159064	S-8A -20 Mesh					76.40	
159065	S-8A -32 Mesh					75.80	
159066	S-10A -32 Mesh					74.60	
159067	X-6 Stuler					79.80	

Laflin's

REGISTERED ASSAYER
CERTIFICATE EXPIRES
CLAUDE E.
McLEAN
DEC. 31, 1965
ARIZONA, U.S.A.

Respectfully submitted,

ARIZONA TESTING LABORATORIES

[signature]

Claude E. McLean

PRODUCT DEVELOPMENT APPLIED RESEARCH

ARC LABORATORIES

Division of Arizona Research Consultants, Inc.

9236 NORTH 10TH AVE. PHOENIX, ARIZONA 85021 WINDSOR 3-3573

FOR: R.J. Allison
Southern Iron Co.
5449 W. Camelback Road
Phoenix, Arizona

DATE March 25,1965

LAB No.

RESULTS

Lab. No.	Description	Ferrous iron
8502	S-8A * C	74.1 %
8503	S-7A-32	77.5
8504	S-10A-20	75.3

Respectfully submitted,
ARC LABORATORIES

John T. Long, Jr.

ARIZONA TESTING LABORATORIES

A DIVISION OF CLAUDE E. McLEAN & SON LABORATORIES, INC.

PHONE 254-6181 817 WEST MADISON ST. P. O. BOX 1888 PHOENIX 85001

Chemist . . . Engineers

For Southern Iron Company
Mr. R. Jay Allison
5449 West Camelback Road
Phoenix, Arizona

Date June 16, 1965

Sample of Ore

Received: 6-15-65

Submitted by: Same

ASSAY CERTIFICATE

Gold figured at $ 35.00 per ounce Silver figured at $ 1.29 per ounce

LAB. NO.	IDENTIFICATION	GOLD		SILVER		PERCENTAGES	
		OZ. PER TON	VALUE	OZ. PER TON	VALUE	TOTAL IRON	
159654	F.S. - 1					72.80 %	
159655	D.E. -40 M					97.90 %	
159656	D.E. -100 M					96.25 %	

Loftin's

Registered Professional Engineer (Chemical) CERTIFICATE EXPIRES CLAUDE E. McLEAN, JR. DEC. 31, 1965 ARIZONA, U.S.A.

Respectfully submitted,

ARIZONA TESTING LABORATORIES

Claude E McLean Jr

Claude E. McLean, Jr.

RECONNAISSANCE GEOLOGICAL MAP
OF
IRON CLAIMS IN T9-10N, R14E
GILA COUNTY, ARIZONA
R. Jay Allison Revised in October 1965
1500 0 1500 3000 4500
SCALE (feet)
Base Map by Joe Lyon Jr.
LEGEND
Martin Limestone
Troy Quartzite
Chediski Sandstone (Troy)
Mescal Formation
Dripping Springs Quartzite
Diabase
Fault
Formation Contact
Drill Hole
NORTH CARBOX GROUP
101 - 232
Red Lake Guard Station
Redman Cave
ROSS GROUP
C.F.&I. Drilling Program
ZEROX GROUP 1 - 119
Lost Tank Ridge
Lost Tank Canyon
Frog Pond
LADY BUG GROUP 1 - 18
SIDEHILL GROUP
FEE LAND
Nail Ranch
SOUTH CARBOX GROUP 1 - 100
COLORADO FUEL & IRON CORP. LEASE
FORT APACHE INDIAN RESERVATION
Gentry Mountain
Gentry Tank
Shell Mtn
Pine Spring
Boundary Tank
Rock Creek
Bear Creek
Chediski Mountain
Chediski Farms
Mountain Lion Canyon
Swamp Creek Mountain
Miners Gulch
Bear Spring Canyon
The Pyramids
Cave Canyon
Willow Creek
Carroll Spr
Bottle Spr
Cherry
Canyon
Gentry
HEBER ROAD
JEEP TRAIL
AIRSTRIP
GILA CO
NAVAJO CO
T10N
T9N
T8N