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AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

J. H. C.
JUL 1 1975

July 1, 1975

file

Memorandum for T. C. Osborne

Towne Mines
Safford, Arizona

Mr. Davis has carefully reviewed, both in the office and field, all the Towne Mines data. Mr. Courtright and I agree with Mr. Davis that, based on the geological evidence, a valid porphyry copper target exists in Towne Mines' "Skyview" area. However, in view of the fact that for underground mining the average primary grade in the district is marginal — with only one exception PD — the risks appear too great unless control of the property could be obtained cheaply and held cheaply for a number of years. Since this is not the case, I recommend informing Mr. Hoffman we are not interested in joint venturing their Safford property.

W. L. Kurtz/lb
W. L. Kurtz

WLK:lb

cc: JHCourtright
SRDavis

July 17, 1950

Mr. L. Kenneth Wilson, Chief Geologist
Southwestern Division
American Smelting and Refining Company
813 Valley National Building
Tucson, Arizona

ARIZONA, GRAHAM & GREENLEE COUNTIES
AREA SOUTHWEST OF MORENCI
LONE STAR-SAFFORD AREA

Dear Sir:

There is enclosed herewith a copy of Mr. Hart's memorandum to Mr. Pope of July 5 in which he comments upon the possibility of successfully applying geophysical methods to the subject area.

I fully agree with Mr. Hart that no work should be done in the Safford area, at least at present. We must first determine by experiment whether or not the geophysical methods mentioned in Mr. Lacy's letter give usable results. If so they could then be applied at Safford.

Mr. Lacy's recommendation that a few selected traverses be run by magnetometer at Silver Bell is, in my opinion, the proper initial step in experimenting with the application of geophysics to porphyry copper deposits for then we have a good background of known facts to which to tie the results. We could proceed with other methods from that initial step if the results justified it. As stated by Mr. Hart the matter is not pressing so can be done at any convenient time.

Yours very truly,

ORIGINAL SIGNED BY
W. R. LANDWEHR

W. R. LANDWEHR

WRL/cb
encl.
cc: C.F. Pollock
F.V. Richard
J.H. Courtright
R.J. Lacy

J.H. Courtright

July 5, 1950

MEMORANDUM TO MR. D. J. POPE:

ARIZONA, GRAHAM & GREENLEE CO'S.
AREA SOUTHWEST OF MORENCI
LONE STAR-SAFFORD AREA

In view of my recommendation that we investigate the area between the Lone Star district and Morenci, I feel called upon to comment upon the results of Mr. J. H. Courtright's work, together with letters by Mr. R. J. Lacy pertaining to a geophysical study.

In the first place it appears that the region between the two areas mentioned is too deeply covered with post-mineral rocks to permit any geological interpretation of the underlying possible ore-bearing rocks. It appears that Mr. Courtright has attempted to note all details which would reflect the facts pertaining to the underlying geology and that he has observed nothing which we may use to narrow down possible exploration objectives. It is significant that what Mr. Courtright terms "fringe" mineralization is noted passing under the cover southwest of the Morenci pit and again along the edge of the cover in the Lone Star area 12 miles southwest of the first point. This leaves room for interesting speculations as to what may occur in the intervening districts.

Failing to determine any geological criterion on which to base drilling or other testing, Messrs. Courtright, Wilson and Landwehr have considered geophysical work, and after a thorough review of the problem, Mr. Lacy has indicated that some reconnaissance geophysical work might be warranted. He recognizes, however, that the great variations in thickness which are known to be present, together with rather extreme relief, makes the problem one in which no very certain conclusive results could be expected. In fact, the possible reactions of deposits of the type expected in this area are unknown even under ideal conditions and Mr. Lacy advises that some preliminary research work should be undertaken on known deposits before any work could be logically recommended in this area. He has proposed that some trial magnetic and electrical work be carried out on the Silver Bell property in the hope that this will provide some criteria which might be used in the other work.

While I am very much in sympathy with the program proposed, I am inclined to consider the probability of its success in the Lone Star-Morenci area so remote that I would hesitate to support the program at a time when we are trying to sell geophysics as a tool in our exploration program. I feel that it would be far better for us to tackle projects in which we all have greater hopes for useful results until we are all better educated as to the usefulness of geophysics. I believe, however, that Mr. Lacy's suggestion that a test study of the Silver Bell area be made might be worth further consideration, not as immediate business, but something that could be done

under favorable winter working conditions purely as a research program charged wholly to that account. Then if something of interest develops which may change the views I have expressed above with respect to the Lone Star-Morenci area, we could consider geophysical studies in that area at that time. Actually, since Consolidated Copper Mines are carrying on a drilling program in the Lone Star area, I would wish to avoid disclosing any interest in this region at this time.

Going back to my own original thoughts pertaining to the Lone Star-Morenci region, I had apparently erroneously believed that seismic work could give us some better information upon the thickness of cover in the critical area. In general, many of the important monzonitic intrusives which have contained commercial copper deposits have been of a structural character defined by Mr. W. H. Emmons as cupolas which have risen relatively higher than the usual roofs of major batholiths. If any such "highs" exist in this 12 mile gap they might not only have been the likely spots to receive concentrated mineralization but also they might have resisted erosion to remain much nearer the present surface than is indicated in Mr. Courtright's Section AA. It is true that nothing which might be observed at the surface today would give a clue as to this possibility, and if a seismic survey could not be used it seems doubtful to me that useful results could be obtained from magnetic or eletrical surveys.

I raise these questions, however, for the purpose of stimulating further consideration and discussions by all parties concerned.

Original Signed By
L. H. HART
L. H. HART

LHH/cb

cc: G.F. Pollock
F.V. Richard
L.K. Wilson
J.H. Courtright
R.J. Lacy

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 16, 1950

MEMORANDUM FOR MR. W. R. LANDWEHR

GEOPHYSICAL EXPLORATION
Porphyry Copper Prospects
Area Southwest of Morenci
Graham and Greenlee Co's., Arizona

The possibilities of using geophysical methods of prospecting for porphyry copper deposits in the covered areas of the southwest have been discussed with Messrs. F. V. Richard, L. H. Chapman, L. K. Wilson and J. H. Courtright.

The exposed deposits have been examined time and again and the conclusions, based on the same data, are almost invariably similar after each examination. The possibilities of finding a new porphyry copper deposit, then, must depend upon gaining information on the rocks underlying alluvium and volcanic capping. This indicates geophysical work. The porphyry copper deposits are generally very large and expenditures to locate such a deposit may be correspondingly large. Their size is also favorable in considering the possibilities of locating them by geophysical methods.

The geophysical methods and their applications to porphyry copper deposits were discussed in the memorandum to you dated June 12, 1950. The favorable and unfavorable factors were considered, but it was stated that some experimental work was necessary before any final decision could be made. This test work would consist of a few lines run over known areas in the Safford and Silver Bell areas with the magnetometer and with resistivity and electromagnetic equipment. Company personnel could conduct these tests. The results of this experimental work would dictate further steps. If the magnetic tests are successful then aeromagnetic reconnaissance work is indicated to map general geological structure, major basement trends and monzonite stocks. This work may result in targets sufficiently interesting for a little wildcat drilling supplemented by resistivity surveys of the holes. If the surface electrical methods are applicable, they may be used to check magnetic anomalies interpreted as representing monzonite stocks for mineralization and to confine the target for drilling. The steps of a minimum program, with estimated costs are listed below. The program would be halted at any stage if the preceding step is not successful.

1.	Test work (surface magnetic and electrical)	$3,000
2.	Aeromagnetic	15,000
3.	Electrical surveys of interesting magnetic anomalies	9,000

4. No. 1 drill hole to test interpretation of monzonite stock from magnetic anomaly. $6,400

5. Four additional holes if No. 1 confirms interpretation (4 x 800' x $8) 25,600

6. If no alteration present then anomaly is sufficiently tested within economic limits of the exploration. If there is alteration the drilling would progress outward from the hole or holes which cut altered rock, and the application of resistivity surveys in the holes (20¢/ft.) would be indicated.

It is concluded that geophysical methods may be applicable to exploration for porphyry copper deposits, but that preliminary tests are necessary, and I would recommend that such test work be undertaken in the Safford and Silver Bell area. At least, broad geological trends and structures may be mapped in covered areas, and this information may lead to new geological concepts to direct the search for new deposits.

R. J. Lacy

R. J. LACY

RJL/fh
cc: DJPope
CFPollock
FVRichard
LKWilson
JHCourtright

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 16, 1950

Mr. W. H. Landvehr, Chief Geologist
Western Mining Department
Salt Lake City Office

PORPHYRY COPPER PROSPECTS
Safford-Morenci Area
Graham County, Arizona

Dear Sir:

Messrs. Lacy, Richard, Courtright and I have completed a thorough discussion of our proposal that a geophysical study of the subject area be considered. Please see Mr. Courtright's report of May 2 and my covering letter of May 11.

Mr. Lacy's supplementary memorandum to you, dated today in Tucson, recommends that a test survey be made to determine the applicability of magnetic and resistivity methods to the Safford area. The cost of this initial work is estimated at $3000. If successful the geophysical program he discusses would proceed to the airborne survey of steps 2 and 3 and so on.

If progressively successful, the total estimated cost including initial drilling of an obtained anomaly approximates $59,000. If the test work was successful, but if the subsequent results of steps 2 and 3 showed no anomalies of interest, then the program would be there abandoned at an estimated cost of $27,000.

It is our joint opinion here that the possibilities which exist for a porphyry copper, however remote, and of a magnitude comparable to Morenci, is adequate justification for the estimated cost of the experimental work. This is well displayed on Map No. 896 of Mr. Courtright's report which compares the areal distribution of ore-bearing intrusives at Morenci with the post-ore cover in the western part of the Gila Mountains.

Mr. Lacy states that in his opinion the pattern of Laramide intrusives below gravel cover probably can be determined and consequently we should at least be able to work the Sanches school area, the drainage basin immediately east, and the area west of the San Juan mine. The pattern below the volcanic cover, he believes, would have to be tried, but can possibly be determined.

If the proposed experimental work is successful in delimiting favorable host rocks - stocks of Laramide intrusives that appear to be aligned with the exposed areas of copper mineralization, - then the objective would be considerably narrowed to a target which we could thereupon drill in an attempt to confine a search for mineralization. This is an assumption which is based on the fact that all "porphyry" copper deposits occur in or near such monzonite stocks. For example,

we would consider that an anomaly indicating a shallow-covered area of acidic intrusives, say, one mile wide and several miles long would then justify drilling to identify: (1) the presence or absence of alteration and (2) Leads to cores of mineralization or orebodies. Again considering that the potential target is of the order of magnitude of Morenci and considering its proximity to the exposed fringe-type mineralization, we believe that the highly speculative nature of the drilling that would necessarily follow this geophysical work (and its cost) can also be justified.

You have asked me to reply to your question: "Is it your recommendation that, assuming Mr. Lacy is of the opinion that geophysical methods would be of no help, that the area be dropped from further consideration?" In view of Mr. Lacy's opinion that geophysical work here may be applicable and within the realm of permissible costs, it is my recommendation that the test work he recommends (Step 1) be undertaken. If, as you may determine, the broader considerations of the Smelting Company not known to us here in the southwest, should advise against undertaking this program at the present time, then the objective of further exploration in this area should necessarily be dropped from our present list of projects inasmuch as no other means of identifying the ore host and of narrowing the drill target is now known to us. Under these circumstances, the area would, of course, remain untested until the geophysical work recommended here and by Mr. Lacy could be attempted.

Very truly yours,

L. KENNETH WILSON

LKW/fh
cc: DJPope
FVRichard
RJLacy

June 13, 1950

AIR MAIL

Mr. L. Kenneth Wilson, Chief Geologist
Southwestern Mining Division
American Smelting and Refining Company
813 Valley National Building
Tucson, Arizona

ARIZONA, GRAHAM & GREENLEE CO'S.
AREA SOUTHWEST OF MORENCI
LONE STAR-SAFFORD AREA

Dear Sir:

Herewith is Mr. Lacy's memorandum dealing with the general application of geophysical methods to porphyry copper deposits, and particularly with their application to the area between the Morenci and Lone Star districts.

You will note that with respect to the latter he is not at all optimistic, and suggests that the only method that might be applied at a reasonable cost is the use of the airborne magnetometer supplemented by more detailed surface work if there are any promising anomalies.

However, he states that the airborne method can result at best in the determination that monzonite masses exist under the cover, but it could not be determined whether or not these masses are mineralized.

Personally, I am of the opinion that geophysics would be of no aid in the Morenci-Lone Star examination, but Mr. Lacy will be there this week and you can then fully discuss the matter.

Incidentally, you have not answered the question that I asked in the last paragraph of my letter to you of May 22. I wish you would give me a definite answer. I can see no reason for the delay.

Very truly yours,

ORIGINAL SIGNED BY
W. R. LANDWEHR

W. R. Landwehr

WRL:si
cc:F.V.Richard, w/copy Lacy's memo.
J.H.Courtright, " " "
R. J. Lacy

June 12, 1950

MEMORANDUM FOR MR. W. R. LANDWEHR:

GEOPHYSICAL EXPLORATION
PORPHYRY COPPER PROSPECTS
Area Southwest of Morenci,
Graham & Greenlee Co's., Ariz.

INTRODUCTION

Messrs. L. Kenneth Wilson and J. H. Courtright requested a study of the subject area and of the southwest region in general in order to determine possibilities of geophysical exploration for porphyry copper deposits (see report of May 2, 1950 by Mr. Courtright, and May 11 letter by Mr. Wilson).

There is too much topographical relief for gravitational and seismic methods, although they may have application locally in the mountain basins. Areas of steep rock contacts and tight folding could not be mapped by seismic methods.

Radioactivity surveys would do little more than indicate rock types in areas of rock exposures or very thin cover.

Magnetometer surveys may indicate the diorite and monzonite stocks in alluvium covered areas and sedimentary rock regions. Volcanic rocks may be sufficiently magnetic to mask this effect, but this would have to be tested by ground magnetometer tests, not for the southwest in general, but in each area considered, as the magnetic properties of volcanics vary considerably.

The airborne magnetometer has been suggested in several of the quarterly reports as an aid in mapping geological structure in covered areas and in locating monzonite stocks. The economics of airborne magnetometer surveys, however, dictate areas larger than 100 square miles. There would be little liklihood of indicating porphyry copper deposits directly by magnetic methods in areas of moderate to thick cover.

It may be possible to obtain direct indications of porphyry copper deposits by electrical methods. This would require considerable experimental work, as there would be difficult problems of interpretation caused by extraneous anomalies which would increase with depth of cover.

The magnetic and electrical methods, which are potentially capable of general application in the exploration for porphyry copper deposits in the southwest, are discussed in greater detail below:

MAGNETIC

The magnetic responses of the various rock types in each area within the southwest region would have to be determined by running a few test lines with a magnetometer on the surface. If these indicate that magnetic surveys are effective in the region, then the size of the area to be explored, the size of the geological masses to be detected, terrain conditions, and other factors will determine whether a surface or airborne survey will be most economical and applicable.

A ground magnetometer survey conducted by company personnel would probably cost between $2.00 and $3.00 per acre. The area of interest included between the dotted lines of map No. 896, attachment E of the Safford-Morenci report, is about 51,200 acres (80 square miles). The ground magnetometer survey of this area with 100-foot stations along profile lines 500 feet apart would cost between $153,600 and $204,800. This cost is, of course, out of the question, and the only alternative is to use an airborne magnetometer survey for reconnaissance, supplemented by more detailed surface work on the anomalies indicated by the reconnaissance survey.

An airborne magnetometer survey of the area outlined for exploration on map No. 896, enlarged to 110 square miles to fit the flight requirements, would cost about $5000. Northwest flight lines 1/4 mile apart would give the most detailed coverage practicable for on-line flight and location. This spacing of profile lines indicates that many of the small monzonite stocks could be missed and only those larger than that 1½ miles southwest of the Lone Star prospect may be detected.

The continuous recording of airborne magnetometer work would give better coverage than surface work in the northwest direction, but the 1/4 mile spacing in the northeast direction would result in less total coverage unless a grid is flown. This would bring the cost up to $8500.

Interpretation of the aeromagnetic data for the small area would probably be too restricted to produce good results. A 330 square mile area from the southwest dotted line through the open pit at Morenci would give a better basis for interpretation. Northeast profiles with 1/4 mile spacing would cost about $15,000. The grid, with the addition of northwest lines 1/4 mile apart, would cost about $28,000.

The cross section on map No. 896 would indicate that flight elevation above ground surface would be about 3000 feet over the valley areas to maintain constant elevation and yet clear the mountain peaks. This would result in a very generalized picture as cumulative response of monzonite stocks, spaced as they are in the prospecting area, would be combined into a few anomalies on the profile curves, rather than standing out as individual anomalies for each stock. This effect may be minimized by using variable flight elevations, lower over valley areas and higher over mountain areas. Computations would be increased, but the survey would not be practical otherwise.

The above discussion emphasizes the reconnaissance nature and very generalized geological interpretation of aeromagnetic surveys. They will not map the porphyry copper bodies and they will not result in quantitative outlining and depth determinations of the monzonite stocks. They will indicate qualitatively the surface of crystalline basement complexes like the pre-Cambrian granite, and intrusive stocks in contrast to sedimentary rocks. They will also indicate changes in the magnetic susceptibility and thickness of the volcanic lavas. The volcanic lavas and the pre-Cambrian granites would introduce magnetic variables that complicate and may nullify the interpretation of anomalies caused by the intrusive monzonite stocks. These are all factors that may be determined by test lines with a magnetometer on the surface.

ELECTRICAL

The electrical methods may directly indicate sulphide ore bodies. The cost would be comparable to that for surface magnetometer surveys. If the McPhar electromagnetic equipment can be employed, the cost may be reduced to a reasonable basis for reconnaissance purposes. There is no doubt that large sulphide deposits will be indicated by the electrical methods if the overburden or capping rock is not too thick. Theoretically, this depth of detectability is dependent upon the ratio of wall rock and sulphide resistivities and the size and shape of the sulphide bodies. Practically, the depth of detectability is materially reduced by such factors as extraneous anomalies caused by irregularities in the depth and character of the overburden and capping rock. The current penetration would not be the same in the arid southwest region as it is in the Canadian Shield.

The above paragraph illustrates the problems in applying electrical methods to exploration for porphyry coppers in the southwest, and indicates that there will have to be considerable experimental field work in order to obtain either a positive or a negative answer on their applicability.

CONCLUSIONS

The airborne magnetometer method is the only real mining geophysical reconnaissance method developed to date. It may be used to map geological structures over large covered areas. It may be used to map crystalline basement rocks and intrusives in a generalized manner over large regions. It will not map the basement highs and lows and the intrusive monzonite stocks in detail. The analysis of the magnetic curves to determine whether they reflect the undulations of the surface of pre-Cambrian or Laramide crystalline rocks will be difficult. Volcanics will also complicate the interpretation. The answers to these questions may be indicated by surface magnetometer test surveys.

If zones of the Laramide monzonite stocks may be indicated by the aeromagnetic surveys, then the electrical methods will have to be tested on known deposits in order to determine whether they can be used to indicate possible sulphide mineralization in and near the stocks. Results to date indicate that this is not possible if overburden or capping rock is thicker than 500 feet or so. This statement must not be accepted rigidly as there are too many variables that alter the depth factor upward or downward. It is merely a general statement based on past performance.

If areas of interest are narrowed down to furnish targets for drilling, then geoelectrical surveys in drill holes can increase their range of exploration and reduce drilling footage.

In the final analysis it must be remembered that the decision to drill in covered areas will be based on more generalized and less certain information than that in the window of pre-mineral rocks at the Lone Star and San Juan prospects.

ORIGINAL SIGNED BY
R. J. LACY

R. J. LACY

RJL:si
cc:CPPollock
FVRichard
LEWilson
JHCourtright

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

June 9, 1950

MEMORANDUM FOR L. KENNETH WILSON

AREA SOUTHWEST OF MORENCI
Graham & Greenlee Counties
Arizona

You have requested my comment on the question in Mr. Landwehr's letter to you of May 22, 1950, here quoted:

> "Is it your recommendation that, assuming Mr. Lacy is of the opinion that geophysical methods will be of no help, the area be dropped from further consideration?"

This question was not anticipated in the recommendations of my report on the above area dated May 2, however, the statement in the last paragraph of your covering letter, to the effect that "We should reserve final disposition until the geophysical approach has been considered", appears to contain the answer. Your conclusion was based on your contention that a decision as to the applicability of geophysical techniques to the Lone Star area, or any other area that might be considered in the future, should rest on the results of experimental work conducted by the company on a deposit similar to the one sought and of known character and extent.

I am in full agreement with your view of this matter, believing that successful employment of geophysics as an aid to exploration depends largely on the extent to which theory is put to actual test.

J. H. C.

J. H. COURTRIGHT

JHC/fh

Aa-7B.13.0

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 29, 1950

MEMORANDUM FOR:

Mr. Richard
Mr. Courtright

AREA SOUTHWEST OF MORENCI
Graham and Greenlee Counties
Arizona

Reference Mr. Landwehr's letter of May 22nd with copies to you both, he requests pointed recommendation presumably to drop the area "from further consideration" on the anticipation that no geophysical work will be attempted.

Before I reply to his closing query, please give me your further comment.

LKW:ar

L. KENNETH WILSON

Dllc Personal File

May 22, 1950

AIR MAIL

Mr. L. Kenneth Wilson, Chief Geologist
Southwestern Mining Division
American Smelting and Refining Company
813 Valley National Building
Tucson, Arizona

AREA SOUTHWEST OF MORENCI
GRAHAM & GREENLEE CO'S., ARIZ.

Dear Sir:

This will acknowledge your letter of May 11, transmitting Mr. Courtright's excellent six-page report of May 2 of his reconnaissance of the Lone Star-Safford area.

Both the letter and report have been submitted to Mr. Lacy for his opinion on the applicability of geophysics to the Lone Star problem, and your recommendation that the company embark upon an experimental program in the Southwest designed to determine the applicability of such methods to porphyry copper deposits in general.

Mr. Courtright and you both state in effect that the information obtained and obtainable by straight geological methods of study is not sufficiently revealing of targets and in general not sufficiently encouraging to justify drilling. Is it your recommendation that, assuming Mr. Lacy is of the opinion that geophysical methods will be of no help, that the area be dropped from further consideration?

Very truly yours,

ORIGINAL SIGNED BY
W. R. LANDWEHR

W. R. Landwehr

WRL:si
cc:FVRichard
JHCourtright

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 11, 1950

Mr. W. R. Landwehr, Chief Geologist
Western Mining Department
Salt Lake City Office

AREA SOUTHWEST OF MORENCI
Graham and Greenlee Counties,
Airzona

Dear Sir:

Mr. Courtright's report herewith, shows - and I fully agree - that no exploratory drilling is advisable here at the present stage of our knowledge. However, I cannot feel, and Courtright concurs, that we have exhausted or conclusively sampled the possibilities of the area here particularly referred to as the Lone Star District, west of Bonita Creek on the flanks of Lone Star Divide.

Early in the reconnaissance when it became apparent that no prospects for exploratory drilling could be recognized by conventional surface examination, I directed field work into an investigation of the applicability of geophysics to this area, having in mind that if no geophysical method were recognized by us here, then we should provide ample geologic data for analysis by a competent geophysicist. I have in mind the Company's own Mr. Lacy. (Parenthetically, I should add that to this end, I asked Eric Swanson of Buchans, whose experience includes three years with Hans Lundberg, to work with Mr. Courtright and Ogryzlo and a few days were spent by him on the project before returning to Buchans. However, no geophysical approach was indicated during this part of the survey. Ogryzlo has remarked upon his own experience with similar geophysical problems and his thoughts are now welded with our own.)

It is my recommendation that Mr. Lacy or other competent geophysicist whom you may designate, weigh Mr. Courtright's present report and then come here to Tucson to inspect with us the terrain west of Bonita Creek, and consider on the ground any geophysical methods that might trace out the belt of presumed fringe mineralization (Map No. 896) or, less directly, the productive rock units under the post-mineral cover of Lone Star. The cover here should be less than 500 feet thick.

However, I do not believe it sufficient for us to consider only the geophysical technique that might, or might not, be applicable here. It seems to me that when considering this area, or any other area that may similarly merit a geophysical search for disseminated copper ore, none of us will be able to pass peremptory judgment on different methods until actual experimental field tests have been made by our own men, and until the anomalies are first calibrated to a known deposit similar to the disseminated target sought. Here, the arid southwest not only offers the Company's most logical locale for a new,

domestic deposit of this type, but here also do we have and own such a proven deposit not yet mined. At Silver Bell our geophysicists can test and calibrate their tools with rock types and alteration well-known by detailed mapping, and with copper mineralization fully sampled by abundant drilling. The southeastern extension of Silver Bell structures into the alluvial cover can also be tried.

I believe therefore that we should consider, and I wish to recommend, a program of experimental geophysics in the southwest designed primarily for "porphyry prospects" and calibrated first at Silver Bell. The program I believe should be in the hands of Company geophysicists and should test the practicability of both aerial and ground surveys. Such method or methods as prove responsive can then be applied first to the area reported here - west of Bonita Creek - and thereafter to any other potentially favorable areas now presumed to be sub-marginal, or those under cover that may prove amenable to a geophysical approach. We should be particularly interested in the possibilities of airborne magnetometer surveys developed by Gulf Research of Toronto and the electromagnetic equipment developed for rapid reconnaissance by the McPhar Company of Toronto.

For this work, and I assume that Mr. Lacy will agree that prior experimentation is not only advisable but above all, feasible, I would suggest that an exploration fund - a sum to be tailored by geophysical counsel - be appropriated separate and apart from Silver Bell exploration and development because of its eventual application to general exploration, even though the program would necessarily originate at that Unit. Mr. Richard is in full accord with all phases of this proposal.

Of interest is similar activity on the part of competitors here in the southwest: Newmont has in the past year or so conducted geophysical studies of various kinds in the Jerome district tributary to United Verde; at Emerald Isle near Kingman; and with Magma Copper Company, research originating at the new San Manuel deposit thence surveyed ten to fifteen miles west into Owlhead. Two men also have been working an area recently from near Eagle Picher's San Xavier Mine southerly into Twin Buttes. They represent themselves as "independents" but admit to a former association with the Newmont people.

Aside from the geophysical reservation of the subject area, it is clear that there is no prospect indicated as yet for exploratory drilling, nor any need of further geologic mapping at present. I feel, however, we should reserve final disposition of the covered area, northeast of the exposed fringe (?) mineralization, until the geophysical approach recommended here has been considered.

Very truly yours,

L. KENNETH WILSON

LKW:rw

enc.: Mr. Courtright's report of May 2, 1950, with all appendices

cc: DJPope with above encs.
FVRichard with " "

Mr. Courtright
Aa-73.13.0

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 2, 1950

Mr. L. Kenneth Wilson, Chief Geologist
Southwestern Mining Department
Tucson Office

PORPHYRY COPPER PROSPECTS
Area Southwest of Morenci
Graham and Greenlee Counties, Ariz.

Dear Sir:

This report, based on two weeks' field work of recent date, chiefly of a reconnaissance nature, includes the information believed essential to a preliminary appraisal of the district's possibilities in respect to undeveloped porphyry copper deposits, in accordance with objectives set forth in your letter to Mr. Landwehr of September 20, 1949 and the procedure modifications advised in his reply of September 22nd.

Mr. S. P. Ogryzlo assisted on the project which included, in addition to reconnaissance, semi-detailed mapping of the Lone Star district on Soil Conservation aerial photographs, scale: One inch to one-half mile.

For reference purposes the map accompanying your above-mentioned letter is included in the report.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Safford-Morenci area, situated in southeastern Arizona, is part of a much broader area consisting of some 10,000 square miles concealed almost completely by lavas and gravels of post-mineral age -- a condition which leaves ample room for conjecture in view of the fact that of the two relatively small exposures of pre-mineral rocks which are known to exist, one contains the Morenci porphyry copper deposit; the remaining exposure, the Lone Star district, is not barren -- containing numerous discontinuous patches of alteration and porphyry-type mineralization. Further, a preponderance of the copper-bearing fissures strike northeasterly toward Morenci, some 20 miles distant, coinciding with a possible southwesterly continuation of Morenci structure and associated mineralization, as you have emphasized previously.

Attention directed specifically toward the possibilities existing in the area between these two deposits produced the following conclusions as to limitations:

(1) No features were recognized in the post-mineral rocks which might be interpreted as reflections of underlying and earlier zones of shearing connected with mineralization. Some faulting and a few narrow dikes occur in the lava capping; no relation, however, appears to exist between these and structures associated with copper mineralization in the basement rocks.

(2) No additional "windows" appear to exist.

(3) A prohibitive thickness of cover (1000 to 4000 feet) occurs in well over three-fourths of the area between the Lone Star and Morenci.

(4) Relatively shallow cover (under 500 feet) probably occurs along the flanks of Lone Star Ridge, on either side of the existing outcrop of pre-mineral rocks. Outside of this area depths to bedrock are probably too great to warrant consideration of exploration by any means, in the absence of closely defined objectives.

The only specific target recognized in the area is the possible northeasterly extension of the partially exposed Lone Star deposit, assuming that the exposed portion may represent a weakly mineralized extremity of a commercial ore deposit. Consolidated Copperminer Corporation has recently completed the drilling of five holes on the outcrop of this deposit — results not available.

In the absence of even poorly-defined "leads", no exploration in the form of drilling is advised at this stage. The sparse distribution and small size of the altered and mineralized zones of the Lone Star district provide little encouragement to search beneath the surrounding lava cap or gravel for extensions. The rather slender chance does exist, however, that this represents the outlying fringe mineralization of a potentially commercial porphyry copper deposit — an objective of sufficient magnitude to justify the expenditure of a reasonable sum on exploratory work. Admittedly, such a bet is in the "long shot" class, but from the gambling standpoint the odds are favorable, providing the total cost of the initial venture is kept in a range commensurate with the risk involved. It is considered that a sum of $25,000 falls within the limits of this qualification.

The application of one or more geophysical methods in the area of permissable depths of cover around the Lone Star district might reduce what is now defined as a possibility to terms of probability, in respect to extensive zones of mineralization; that is, the use of such techniques might provide results which would serve to narrow the target to a size that could be tested with a reasonable number of drill holes.

As the first step it is recommended that the opinion of a specialist in this field be secured.

LOCATION

The area referred to as the "Area Southwest of Morenci" is located in southeastern Arizona between the two named towns. Other porphyry copper deposits, San Manuel and Ray, are situated some 75 miles westerly. The two prospects of interest in the past, the San Juan and the Lone Star, lie 9 miles northerly from Safford.

The attached geologic map and section (Attachment E), scale one inch = 1 mile, provide essential geographic data.

Mr. L. Kenneth Wilson

OWNERSHIP AND TITLES

The area of possible interest (outlined on Attachment E) is mainly U. S. grazing land, open to mineral location. Exceptions: (1) A few patented claims around the San Juan prospect and a few around the Lone Star prospect. (2) Consolidated Coppermines Corporation have leased the latter and located 55 additional claims on the southwest slope of the main ridge in the vicinity of the Lone Star prospect. Descriptions of these filed at Safford, the county seat, contained nothing specific as to position. We found no evidence of claim markers on the Bonita Creek drainage system, other than one very ancient notice near the divide, less than a mile northeast of the Lone Star Peak. (3) Farming land in the vicinity of the Sanchez School, on the Gila River.

HISTORY

The San Juan and Lone Star properties produced minor amounts of copper during the first World War and have been idle since. In 1915 both were examined for this Company and turned down by Mr. Kruttschnitt. As stated in your letter of September 29, 1949, to Mr. Landwehr, Mr. Hart also examined and rejected these prospects several years ago.

DEVELOPMENT

As stated by W. H. Remington in a letter to this Company dated June 24, 1922, development on the Lone Star consists of two shafts, 485 and 585 feet deep, with drifts totalling around 1000 feet in length. Roughly 1500 tons of direct smelting copper ore, of both oxide and sulphide types were shipped.

Development in the San Juan as reported by J. Kruttschnitt, April 23, 1915, consisted of some 1500 feet, including a shaft 327 feet deep; the property is credited with a production of $240,000 worth of copper ore; eight churn drill holes had been drilled. These range up to a depth of 535 feet and average about 350 feet.

During the past year Consolidated Coppermines of Kimberly, Nevada, has carried on considerable reconnaissance work in the district, and recently completed the fifth exploratory drill hole on the Lone Star prospect. (See photograph, Attachment D.) The first two holes were completed and the third partially completed by churn drill (reported depth around 500 feet.) Extremely slow progress and difficulty in keeping the hole straight caused the change to diamond drill methods. No data on assay results were obtained; however, it is known that the sulphide zone was reached, progress was 20 feet per shift, and core recoveries with a rigid type barrel were over 80%. These results suggest the absence of strong alteration or mineralization. The fifth hole was drilled minus 45° northeast. There is no activity at present; however, a Company engineer stated that additional drilling was planned.

GEOLOGY

The district is situated in the southeast portion of the Gila Mountains. Late Tertiary lavas blanket most of the country; basement rocks are exposed in but two relatively small windows, representing topographic highs along the mountain ridges of an earlier erosion surface. The Morenci porphyry copper deposit

is located in the larger of the two windows. Here, a northwest-trending block composed of pre-Cambrian granite and overlying Paleozoic sediments is cut by late Cretaceous or early Tertiary plutonics of the monzonite type commonly associated with porphyry copper deposits. These intrusives are roughly aligned in a northeast direction, conforming to the dominant vein and fault pattern. The disseminated copper deposit, now being mined by open pit, appears to occupy a zone formed by the intersection of the two major structures -- the northwest basin-range structure and the northeast fissure and vein system.

The basement rock exposure of the San Juan-Lone Star Peak area forms an elongated strip, some twelve miles in length along the southwest slope of the mountain range. Here the "bed rock" is composed mainly of Cretaceous or early Tertiary volcanics with dikes and small stocks of diorite or monzonite. Narrow veins, conforming roughly to two systems, northeast and east-southeast, occur sporadically along this belt. Moderate alteration and disseminated copper mineralization occur in small isolated patches. These appear to be associated with intersecting vein systems. The areal extent of these zones is shown on Attachment C. In some the leached outcrops show moderate amounts of limonite residual after chalcocite, characteristic of outcrops over porphyry-type copper deposits.

The so-called Cretaceous or early Tertiary volcanics of pre-mineral age have not been separated from the later post-mineral (in respect to porphyry copper mineralization) lavas in some areas on the state geologic map. Obviously, from the economic standpoint a distinction is important and such is made on the map (Attachment E) accompanying this report.

The early lavas, exposed in the "window" of the Lone Star district are rather dense, fine-grained medium basic rocks occasionally showing porphyritic textures. An agglomerate of similar composition appears to be the latest member of this series locally. The outcrops generally display a greenish tone. Nodules of epidote are common. This same series occurs in the eastern half of the Silver Bell area.

The post-mineral volcanic capping, late Tertiary and Quarternary, has been deposited on an old erosion surface of the Cretaceous lavas and diorite. These are for the most part vesicular flow rocks, ranging from basalt to andesite, with interbedded tuffs and agglomerates. The latest rocks, rhyolite tuffs, conglomerates (Gila) and basalt flows, occupy the valleys, unconformably overlying the relatively thick series of earlier, post-mineral lavas.

EXPLORATION POSSIBILITIES

As may be seen on the attached maps, the occurrences of disseminated copper mineralization are limited to rather small isolated areas. The unfavorable conclusions reached during previous detailed examinations of the San Juan and Lone Star prospects (Messrs. Kruttschnitt and Hart) are, I believe, quite valid.

The supergene enrichment in the San Juan deposit is confined principally to a few intersecting, narrow veins and stringers; disseminated mineralization and alteration is insignificant. The Lone Star shows weak to moderate alteration and mineralization for some 1500 feet along the edge of the post-mineral lava capping. Southwestward within 1,000 feet there are numerous exposures of very weak or unaltered rocks. The nature of the limonite in the leached outcrops indicates the presence of typical porphyry copper mineralization of the enriched type; however, the intensity,

or amount of limonite present indicates rather feeble mineralization. Quantitatively, therefore, nothing more than submarginal values may be expected in the enriched zone. However, there is no evidence to preclude the possibility of the Lone Star deposit representing a southwesterly fringe of a commercial deposit lying to the northeast under the lava capping. The character of the terrain is shown in photographs, Attachment D. The likelihood of such a deposit occurring within a half-mile or less is probably remote, in view of the sparsely spotted pattern of small, altered areas exposed in the "window" cross-sectioning the northeast trend.

In appraising the possibilities of the area in general, the apparent structural relationship of the Lone Star to the Morenci district, including similarity of intrusive host rocks and mineralization, are the favorable features. Those unfavorable are: (1) The great thickness of capping known to occur between Bonita and Eagle creeks, (2) the apparent absence of post-mineral structures which might in the lava cap reflect structures associated with large-scale mineralization of basement rocks, (3) lack of definite "leads" in basement rock exposures which would limit the target area under post-mineral cover to reasonable dimensions for exploration purposes.

This study of the area included reconnaissance trips covering a radius from Lone Star of some 30 miles. No additional "windows" were found. The mineralization at Morenci dies out about 3 miles northeast of the open pit; southwest, feeble mineralization and alteration (comparable in general to that in the Lone Star area) extends to the edge of the rhyolite tuff capping. The zone of more intense mineralization at Morenci is about 4 miles long northeasterly, and 2 miles wide.

The foregoing statement is partly based on observations during a jeep cruise which was taken up the San Francisco River for a distance of 17 miles from Clifton. It was necessary to cross the stream 30 times to reach this point. The northeastern extremity of the Morenci basement rock outcrop was examined by traveling on foot up Sardine Creek for three miles. The earlier rocks, Paleozoic limestone and basal quartzite, stand out in some relief as an elongated mass against the surrounding post-mineral lava capping. Fault scarps, as well as differential weathering appear to have produced the northeast striking lineation apparent on the aerial photographs. Other than traces of copper carbonate in the sandy limestone at the top of the quartzite horizon, no mineralization worth mentioning was noted. Down the river, about 6 miles from Clifton, another reconnaissance trip was taken northwestward over the same outcrops, but somewhat closer to Morenci. Here, the pre-Cambrian granite contained some limonite; however, this is believed to have been at least partly derived from specularite and/or ferromagnesian minerals. Monzonite porphyry occurrences showed little or no alteration.

In brief, the possibilities "boil down" to narrow strips on both sides of the Lone Star divide, shown on Attachment E as the approximate limits of the area in which post-mineral cover is estimated to be less than 500 feet in thickness.

The structure of the accompanying section (A-A) is based on the assumption that a broad downwarped basin exists between Morenci and the Lone Star. Alluvial fill in the Gila valley is undoubtedly deep, probably exceeding 3,000 feet, if the reported depth of the wildcat oil well near Safford is reliable. A number of artesian flows have been encountered in drilling for water; the valley is probably

underlain by ancient lake bed deposits.

Near the Sanches School, a small outcrop of diorite near the road indicates possible shallow cover extending southeasterly under the Gila River. A mile north of the school a small patch of rather strong porphyry-type copper mineralization is present in the diorite.

CONCLUSIONS AND RECOMMENDATIONS

Of the rather extensive area included in this investigation, some 300 square miles, but a small portion falls in a class possessing the two essential features: (1) A reasonable chance of containing commercial ore deposits, and (2) sufficiently shallow cover to be within reach of present-day exploration methods. Within this portion which is made up of two strips, one to two miles wide, along the outer limits of the long, narrow basement rock outcrop of the Lone Star District, no specific targets are recognized, other than the possible northeasterly extension of the Lone Star deposit, thus exploratory drilling on other than a purely wildcat basis is not justified. It is improbable that there is room in either of these two areas for a mineralized zone of important dimensions (comparable, for instance, to Morenci) but there is ample space to contain a significant extremity of such a zone.

A possible solution may be found in the use of one or more geophysical methods. It is recommended that a study of the applicability of such methods be made, on the assumption that any very broad zone of sulphide mineralization that might be indicated under the gravel or volcanic cover is worthy of investigation. A few suggestions are listed below:

1. Earth Resistivity. This method, which has been used successfully in some instances involving depths greater than 500 feet, might provide indications of the existence of an extensive and broad zone of disseminated type sulphide mineralization beneath several hundred feet of cover. As applied in the past, a serious limitation of the method is the relatively slow rate of aerial coverage, or high cost per square mile.

A wider application to metal exploration in the future will depend to some extent on increased efficiency of operation, to the point where a cross-section several miles in length can be run in a few days, providing a rapid "screening" of potentially ore-bearing areas to depths of 500 or 1,000 feet.

2. Magnetic. The possible application of this method to porphyry copper exploration is questionable. However, at Kimberly, Nevada, the results of a ground magnetometer survey by Consolidated Coppermines Corporation clearly indicated the east-west zone of mineralization as a low intensity belt. This anomaly was apparently due to the relatively low magnetic content of the mineralized zone in contrast with the unaltered wall rocks. A narrow zone of garnetized limestone along and within the fringes of the belt showed extremely high intensities. Airborne surveys have shown that different rock units may be distinguished by magnetic anomalies; thus the presence of a large body of favorable host rock, such as monzonite, might be roughly defined. However, any appreciable amount of cover may preclude such an application.

3. Gravimetric. This method has been used to delineate rock units; probably

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is not applicable in the case under consideration.

4. Geothermal. The results of recent experimentation (USGS) at San Manuel indicate that temperature measurements in drill holes may be used to an advantage in exploration for such deposits. In the event some exploratory drilling is done in areas obscured by post-mineral cover, temperature gradients of the holes might point up the proximity of, and the direction to, stronger sulphide mineralization.

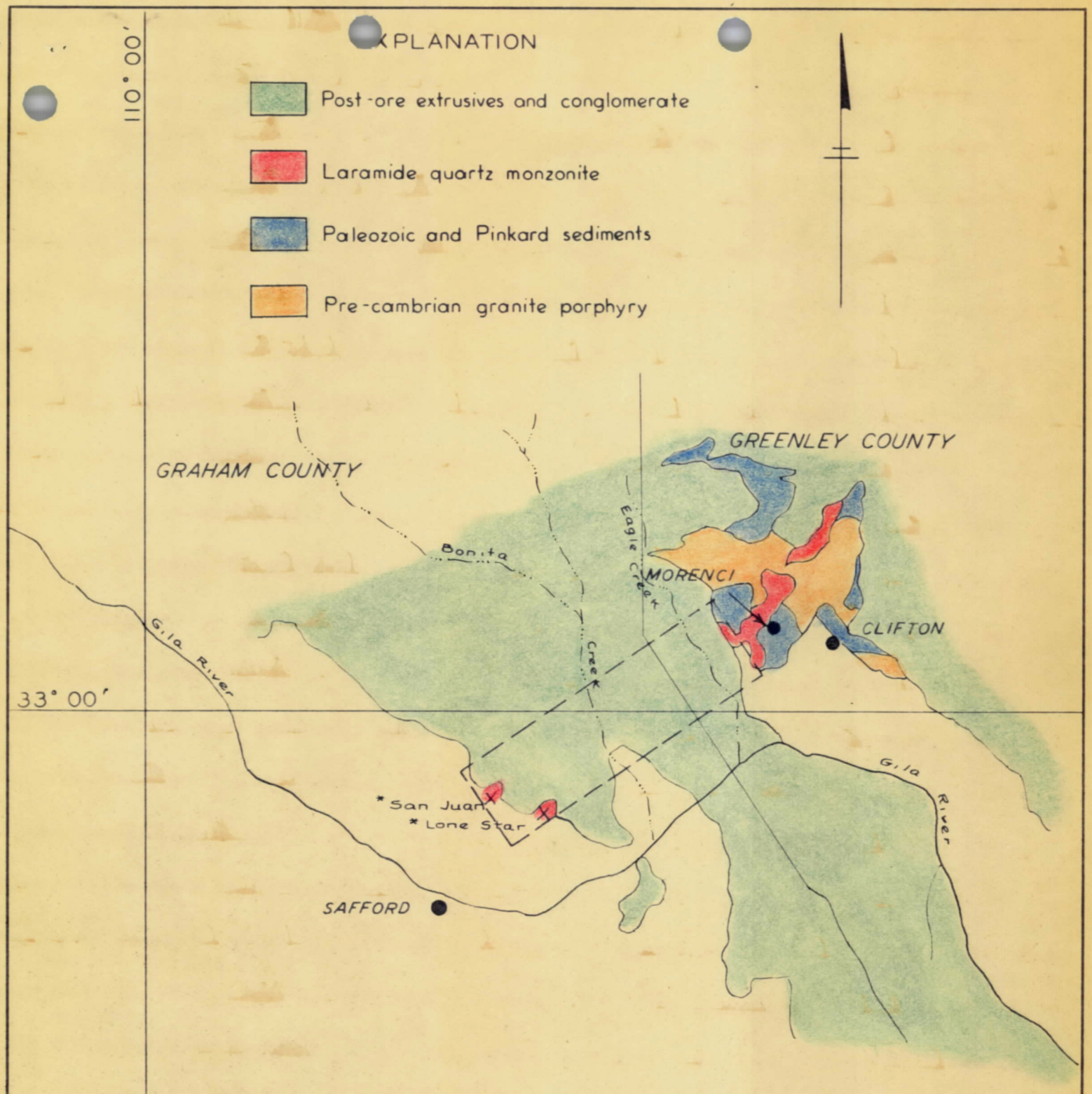
Yours very truly,

JHC

J. H. COURTRIGHT

JHC:ar

Appendixes:
- A - Index Map
- B - Proposed Exploration Southwest of Morenci (by L. K. Wilson) Map No. 824
- C - Mineralization Map Lone Star District - scale 1" = 1 mile, Map No. 895
- D - Photographs
- E - Geologic Map Safford-Morenci Area, scale 1" = 1 mile, Map No. 896



PROPOSED EXPLORATION SOUTHWEST OF MORENCI

TO ACCOMPANY Report
DATED May 2, 1950
BY J. H. Courtright

MILES
0 5 10 20

* NOTE: The Lone Star district is included in the proposed study for correlation purposes only. The mines are not recommended for exploration. L. Kenneth Wilson

MAP NO. 824

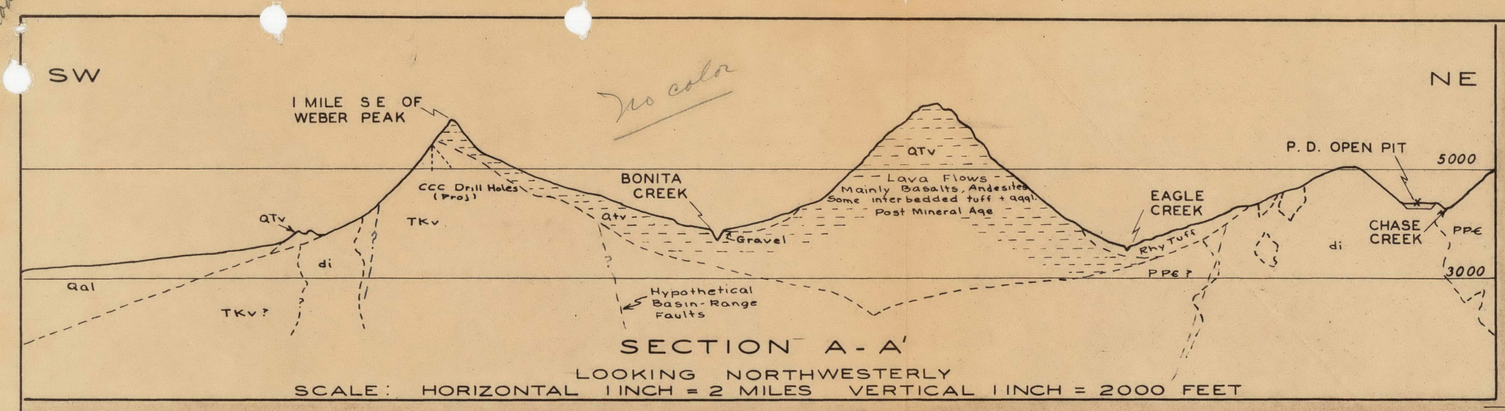
ATTACHMENT E

Panoramic view of terrain northeast of Lone Star Mountain - near Safford, Arizona.

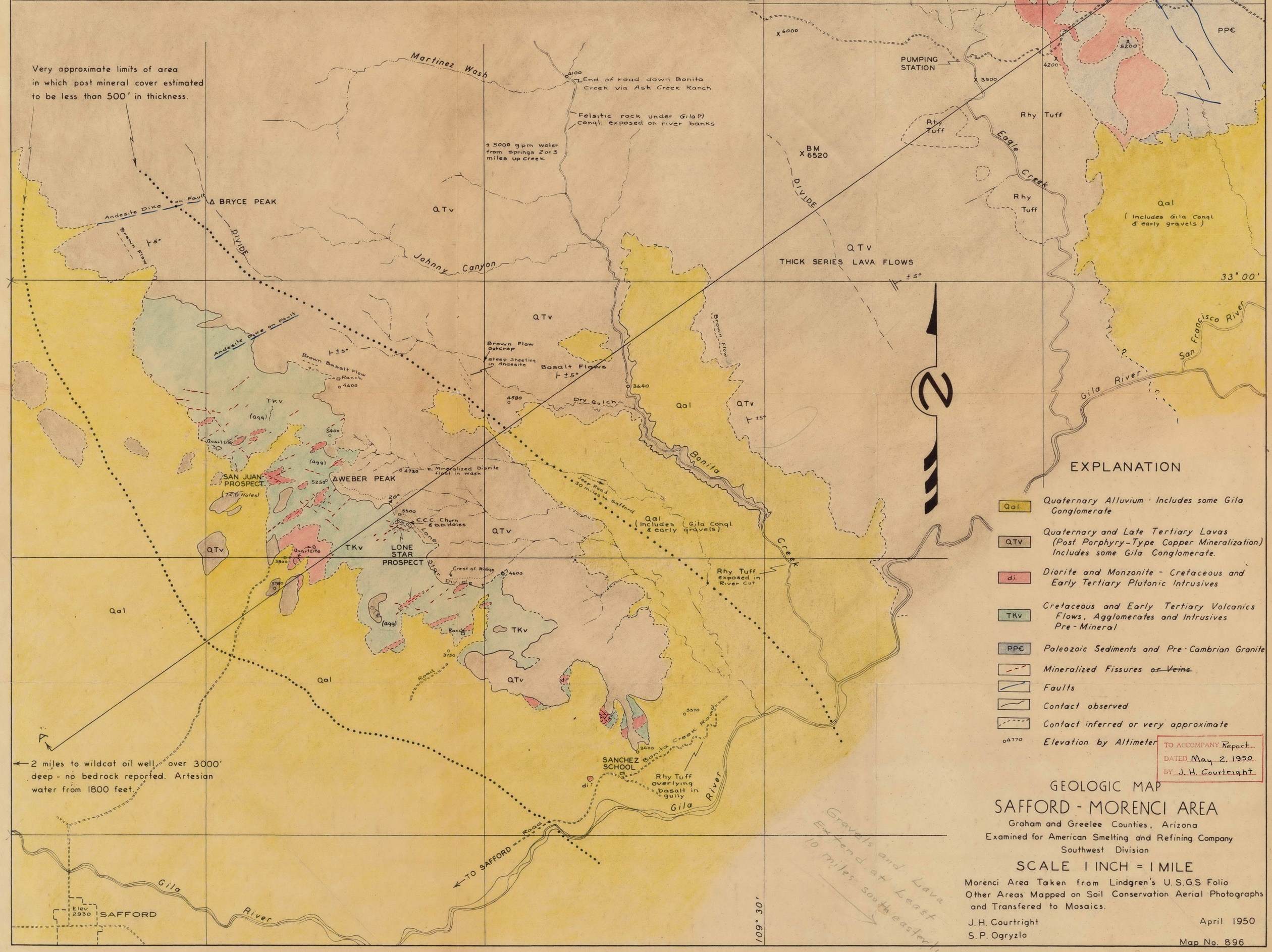
Consolidated Coppermines drill location.

View from alluvial slope south of Lone Star Mountain - showing post-mineral lava capping on ridge. Note churn drill road in altered basement rocks near contact.

ATTACHMENT D



SECTION A-A'
LOOKING NORTHWESTERLY
SCALE: HORIZONTAL 1 INCH = 2 MILES VERTICAL 1 INCH = 2000 FEET



EXPLANATION

- Qal — Quaternary Alluvium - Includes some Gila Conglomerate
- QTV — Quaternary and Late Tertiary Lavas (Post Porphyry-Type Copper Mineralization) Includes some Gila Conglomerate.
- di — Diorite and Monzonite - Cretaceous and Early Tertiary Plutonic Intrusives
- TKv — Cretaceous and Early Tertiary Volcanics Flows, Agglomerates and Intrusives Pre-Mineral
- PP€ — Paleozoic Sediments and Pre-Cambrian Granite
- Mineralized Fissures ~~or Veins~~
- Faults
- Contact observed
- Contact inferred or very approximate
- o4770 — Elevation by Altimeter

TO ACCOMPANY Report
DATED May 2, 1950
BY J. H. Courtright

GEOLOGIC MAP
SAFFORD - MORENCI AREA

Graham and Greelee Counties, Arizona
Examined for American Smelting and Refining Company
Southwest Division

SCALE 1 INCH = 1 MILE

Morenci Area Taken from Lindgren's U.S.G.S Folio
Other Areas Mapped on Soil Conservation Aerial Photographs and Transfered to Mosaics.

J. H. Courtright
S. P. Ogryzlo

April 1950

Map No. 896

ATTACHMENT E