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

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GEOPHYSICAL DIVISION

3422 South 700 West
SALT LAKE CITY, UTAH 84119

November 24, 1970

RECEIVED
J. H. C. NOV 25 1970
EXPLORATION DEPT.
NOV 30 1970

MEMORANDUM to R. J. LACY:

REVIEW OF GEOCHEMICAL
GROUNDWATER SURVEY DATA,
WEST PINAL COUNTY, ARIZONA
A Correction

Several typographic errors occur on my memorandum of the abovementioned subject of November 16, 1970. These relevant portions of the report should read:----

Page 2, 1st Paragraph, 4th line down,

'.....overburden to the east of Table Top Mountain, ...'

Page 7, 1st Paragraph, 10th line down,

'.....along the E. flank of Table Top Mountain.....'

Page 7, 3rd Paragraph, 3rd line down,

'.....along the east flanks of Table Top Mountain.....'

L. D. James.

L. D. JAMES

LDJ:db

cc:J.J.Collins
J.H.Courtright
W.E.Saegart
N.Whaley

GEOPHYSICAL DIVISION
3422 SOUTH 700 WEST
SALT LAKE CITY, UTAH 84119

RECEIVED
DEC 4 1970
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R. J. L.
DEC 8 1970

December 2, 1970

J. H. C.
DEC 14 1970

MEMORANDUM to R. J. LACY:

REVIEW OF GEOCHEMICAL GROUNDWATER SURVEY DATA, WEST PINAL COUNTY, ARIZONA - An Addendum

Since writing my report of November 16, 1970, entitled "Review of Geochemical Groundwater Survey Data, West Pinal County, Arizona" I have obtained additional data relating to a groundwater survey of the Antelope Peak area (carried out by Mr. Wayne Farley in 1969). This survey extends the previous coverage in a highly critical area to the northwest of the Stanfield anomaly.

The new data indicates that the Stanfield Mo anomaly extends an additional 8 miles to the northwest, along the east flank of Table Top Mountains, only terminating as the Vekol Wash is approached. (Fig. 1) The anomaly is generally weak--falling into the possibly anomalous category. It, like that already known to the southeast, is open to the west--presumably because of lack of wells. The new data does not significantly effect the conclusions and recommendations in my previous report.

Of possible significance is the fact that, where the new sampling area slightly overlaps the previously obtained coverage in the vicinity of Stanfield, there is some disparity between the two sets of data. This could reflect a real change with time in the groundwater, possibly related to local changes in groundwater flow patterns, etc., resulting from the known recent rapid lowering of the water table in the vicinity of Stanfield? Alternatively it might reflect the type of sampling handling or analytical problems discussed in my previous reports.

L. D. James.

L. D. JAMES

LDJ:db
Encl.

cc: J.J.Collins w/encl.
J.H.Courtright w/encl.
W.E.Saegart "
W.G.Farley "
N.P.Whaley "

J. H. Courtright

B.C.M.

NOV 17 1970

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NOV 19 1970

EXPLORATION DEPT.

J. H. C.

DEC 15 1970

REVIEW OF GEOCHEMICAL GROUNDWATER SURVEY DATA

WEST PINAL COUNTY, ARIZONA

L. D. JAMES

November 16, 1970

REVIEW GEOCHEMICAL GROUNDWATER SURVEYS

WEST PINAL COUNTY, ARIZONA

1. Introduction

2. Recommendations for Further Studies.

3. Groundwater Survey Procedures:

   (a) Sample Collection

   (b) Sample Handling

   (c) Sample Analysis

4. Geochemical Data:

   (a) General

   (b) Validity

5. Data Interpretation:

   (a) General

   (b) Sacaton Area

   (c) Poston Butte Area

   (d) Stanfield Area

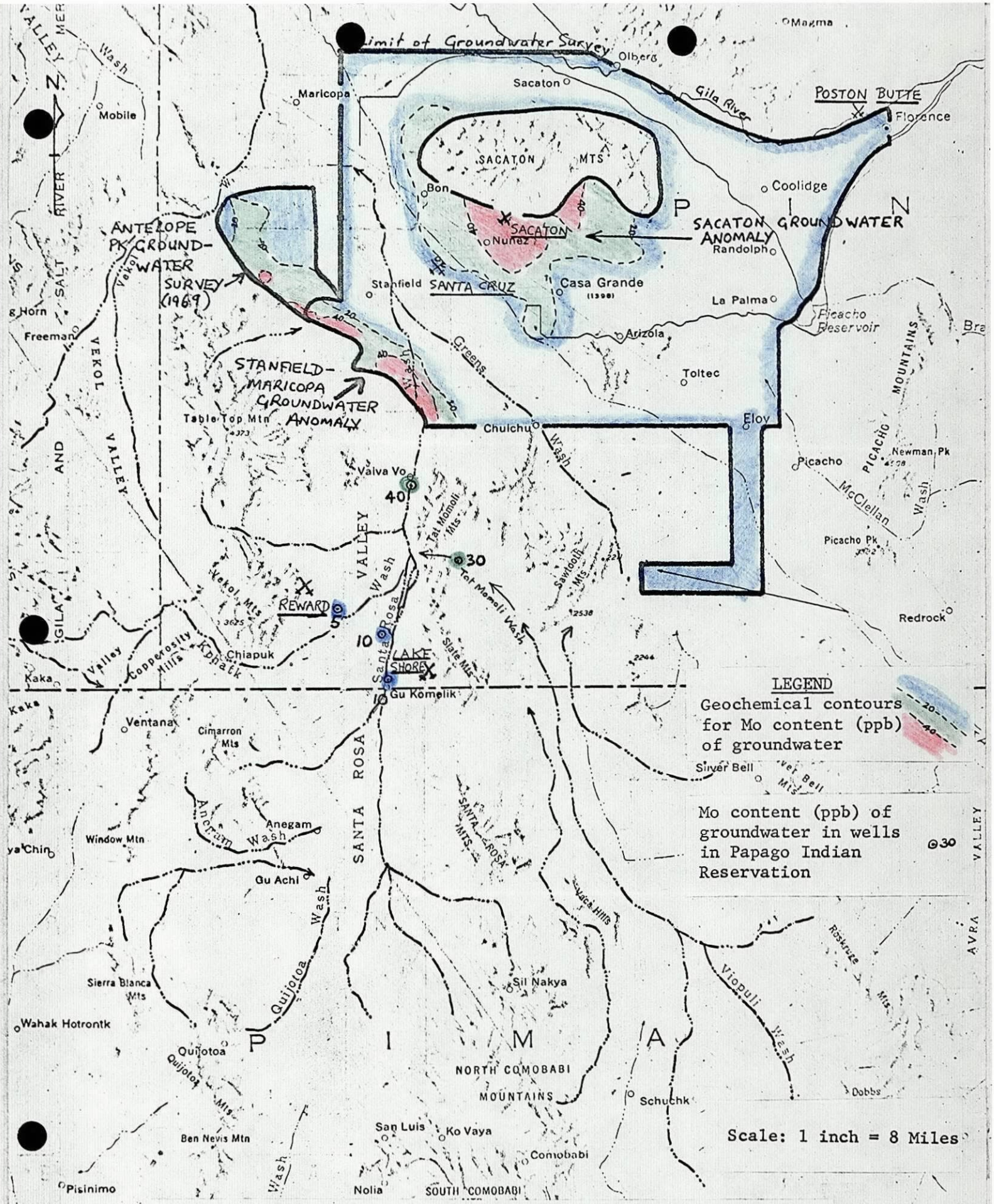

Fig. 1. GROUNDWATER DATA (ASARCO 1961, 1963, 1965, 1967 & 1969) WEST PINAL COUNTY, ARIZONA.

GEOPHYSICAL DIVISION

3422 SOUTH 700 WEST

SALT LAKE CITY, UTAH 84119

November 16, 1970

MEMORANDUM to R. J. LACY:

REVIEW OF GEOCHEMICAL
GROUNDWATER SURVEY DATA,
WEST PINAL COUNTY, ARIZONA

1. Introduction

In 1961 Mr. D. B. Beck of the Tucson Office carried out a geochemical groundwater survey of an extensive, mainly alluvial covered area, in West Pinal County, Arizona. The resultant data (memorandum by D. B. Beck to W. E. Saegart of July 10, 1961 entitled 'Geochemical Prospecting for Mineral Deposits beneath Alluvium') indicated the presence of anomalous Mo concentrations in the Stanfield Area which have never been adequately explained, despite subsequent programs of more detailed groundwater sampling, I. P. surveys, drilling, etc. Hydrotechnics of Albuquerque recently proposed a field study designed to determine groundwater flow patterns in the area but, for the reasons given in my memorandum of November 5, 1970, I do not consider this to be the best initial approach in a program designed to locate the source(s) of the anomaly. The present report is particularly concerned with alternative methods of enabling the anomaly source(s) to be located but some attention is also given to important relevant aspects of groundwater data obtained in the remainder of the area surveyed.

I have discussed the groundwater data for Pinal County with Mr. N. Whaley of the Tucson Office on several occasions. He has also supplied me with several groundwater publications, etc.

2. Recommendations for Further Studies

In view of their potential significance, additional studies designed to locate the sources of the anomalous Mo concentrations (Fig. 2) in the groundwater of the Stanfield Area (and the Papago Indian Reservation) are probably warranted. These studies would provide an ideal opportunity for an attempted refinement of our present groundwater survey procedures in the alluvial covered areas of the southwest particularly as there are nearby, suitable areas for orientation studies around known mineralizations (i.e. Sacaton and Poston Butte). Any investigation of groundwater procedures should naturally include a study of the metal concentrations in mesquite twigs as these can commonly be related to the metal content of underlying groundwater and access to groundwater is not always obtainable. Hopefully, it might be possible to develop diagnostic geochemical criteria, utilizing the different mobilities (in groundwater) of trace elements, etc., concentrated in porphyry Cu deposits (e.g. Cu, Mo, Hg, SO_4, Se, etc.), which would enable potential 'target' areas (for say I.P., etc.) to be indicated within broad favorable areas covered by post-mineral overburden.

In order to precisely locate the sources of the Mo concentrations in the groundwater of the Stanfield area, which available evidence suggest are either in the Papago Indian Reservation or in the Reservation and beneath the overburden to the west of Table Top Mountain, it is first necessary to complete the delineation of this anomaly. Presumably this cannot be completely achieved by groundwater sampling due to lack of suitable wells, hence, indirect means of determining the presence of anomalous groundwater must be attempted, (i.e. sampling mesquite and also possibly in some localities basal surficial conglomerate) if orientation studies at Sacaton, etc., provide favorable results. Admittedly the U.S.G.S. found that in the Pima Mining District the Mo content of mesquite apparently depends on both the Mo content of groundwater and the depth of the water table. However, they did find anomalous Mo concentrations in mesquite ash over a large area 1 - 3 miles wide extending irregularly down the pediment for about 8 miles. If our preliminary orientation studies provide evidence of its advisability, consideration might also be given to a program of resampling of all the accessible wells in the Stanfield area so that more precise and accurate as well as more comprehensive trace element data might be obtained.

derived from outcropping mineralization

If evidence is (or has previously been) produced that mesquite sampling is not likely to be an effective tool in the Stanfield, etc., area, it might be considered expedient to drill a small number of holes designed to provide access to groundwater in critical areas where there are no water wells. The acceptance of this suggested technique would naturally depend upon the cost of drilling such 'temporary' holes as well as the possibility of developing suitable techniques to enable water samples to be withdrawn from them. The generally large extent of significant Mo anomalies in groundwater would probably enable relatively wide spaced drilling (i.e. order of several miles) to be used.

If it proves possible to delimit the Stanfield groundwater anomaly(s) the problem might conceivably still remain of determining groundwater flow directions in some critical areas. This could probably be done, with sufficient accuracy for our purposes, by construction of contour maps displaying the water table. Obviously this would only be possible in areas with sufficient information (probably obtainable from the Water Supply Division of the U.S.G.S.). Knowledge of groundwater aquifer patterns as well as information as to which aquifers are tapped by individual wells might also aid interpretation.

It is recommended that in the proposed program of groundwater sampling, as well as in any future similar program, the pH of the water be routinely determined with a reasonably precise pH meter at the sample site. Knowledge of this basic parameter would be of value in later data interpretation. Possibly the Geophysical Division could obtain a suitable instrument and lend it out as required?

3. Groundwater Survey Procedures

(a) Sample Collection

The great majority of groundwater samples collected in the survey area came from operating well pumps but some were obtained from storage tanks, particularly in the Papago Indian Reservation. Obviously the possibility of Mo contamination or losses (due to scavenging by Fe and/or Mn hydroxides or sorption by fine clay size particles, organic complexes, etc.) should not be overlooked in the case of the water tank samples. However, if the tanks are in fairly constant use these problems should be minimal, especially as they are generally comprise 'sealed' systems designed to minimize contamination by extraneous materials. (Verbal communications - N. Whaley).

The fact that after the 1961 groundwater survey additional fill-in and check sampling was carried out during several widely separated periods could present a problem. It is possible that groundwater geochemistry might display subtle annual and/or long term variations. The former could be related to highly seasonal rainfall (normally, composition of groundwater is relatively stable during dry periods) whilst the latter might result from the known rapid lowering of the water table in the district (resulting from irrigation pumping.)

The nature of groundwater flow could have a significant influence on the effectiveness of well sampling particularly in cases where flow is confined to several narrow, relatively widely separated aquifers of varied geochemistry. Resultant sample data would not necessarily be representative of groundwater as a whole and could be confusing in cases where adjacent wells tap different aquifers.

(b) Sampling Handling

Recommendations for modification of sample handling procedures were given in my memorandum of October 13, and November 11, 1970. These are primarily designed to avoid loss of trace metals from water samples as a result of precipitation sorption by fine particles, or adsorption on container walls. In the case of the samples collected in the 1961 groundwater survey the samples were apparently collected and analyzed by Mr. D.B. Beck so there was presumably too small a pre-analysis time lapse to result in any significant trace metal losses. The same cannot be necessarily assumed for the samples collected in later field seasons.

(c) Sample Analysis

Samples collected in the 1961 Survey were analyzed for Mo by Mr. D. B. Beck using a standard stannous chloride--potassium thiocyanate colorimetric technique on 100 ml. sample aliquots. Although the general procedure is valid the sample aliquot is probably too small to allow precise and accurate data to be obtained, particularly in view of the extremely low Mo concentrations involved (i.e. apparently generally in the range $\leq$ 5 - 60 ppb).

Presumably similar analytical techniques were used by the various other laboratories which were involved in the various stages of later sampling programs. However, even using broadly comparable procedures, the resultant data will not necessarily be strictly comparable, as, with this type of analysis, operator bias can be a significant problem. In addition, the competency of these laboratories in the field of geochemical analysis likely varies widely. One extreme but not typical example of variation between laboratories is displayed by data relating to water samples collected from the same well on widely separate occasions. In 1961 and again in 1963 Beck found 50 ppb Mo but in 1965 Hawley and Hawley reported only 6 ppb Mo. Again in 1967, data relating to replicate water samples (SRS Series) submitted to the Asarco Geochemical Laboratory and Rocky Mountain Geochemical Laboratory displayed wide variance. The Asarco data was generally far higher than those obtained by the commercial laboratory.

The need for greater accuracy and precision in the determination of Mo in water samples is, I think, obvious and the Asarco Geochemical Laboratory is taking steps to develop procedures so that this can be achieved.

4. Geochemical Data

(a) General

Mr. Beck's 1961 groundwater survey extended over an area of more than 600 sq. miles, which included the Sacaton and Poston Butte prospects (Fig. 1). He was encouraged in this project by favorable data previously obtained by Lyman C. Huff of the U.S.G.S. in a study of the mainly alluvium covered Pima mining district near Tucson. (A geochemical study of alluvium-covered copper deposits in Pima County, Arizona, by Lyman C. Huff - U.S.G.S. Bulletin 1312-C-1970). Mr. Huff's data appeared to indicate a distinct relationship between the orebodies and anomalous concentrations of Cu and Mo in groundwater. Anomalous Cu and Mo concentrations in groundwater were in fact found to extend in fan shaped areas for 2 - 3 miles and more than 10 miles respectively down drainage from the orebodies.

In his memorandum of July 10, 1961, Mr. Beck stated that the initial target areas of his survey extended 5 to 10 miles....."down drainage from the Sacaton and Poston Butte prospects. It was determined before sampling took place that the groundwater moved in the same general direction as the surface flow. Both prospects had extensive well irrigation within these target areas thus collecting of water samples was conducted rapidly and easily. Water samples were taken every two miles whenever possible and if any samples showed metal content of greater than 15 ppb, the sampling distance was cut to every half mile. After this initial coverage more sampling was conducted in well irrigation areas both to the south and to the west of Sacaton and Poston Butte prospects with sampling distances extended to every three or four miles. It was determined by wide-spread coverage that in this particular case the background, area which reflects no covered mineral deposits, should be fifteen ppb or less. The threshold readings, which might or might not be influenced by the presence of a covered mineral deposit, had a range of 20 to 40 ppb. The anomalous content of 40 ppb or greater were concluded to be definitely influenced by covered mineralized zones undergoing secondary or supergene dispersion of ore metals".

An anomalous fan-shaped area was detected to the south and west of the Sacaton and "new Casa Grande" prospects. The Poston Butte prospect had no anomalous content of molybdenum but it was suggested that a small anomalous zone in the southwestern part of the survey area (i.e. Stanfield) might be of interest after further sampling had been conducted.

In testing for copper no anomalous quantities were found. Mr. Beck considered that this was probably due to the fact that the pH of the water tested ran from 7.2 to 8.2 and in order for copper to stay in solution for any length of time the pH would have to be on the acidic side of 6.

Additional ground sampling has been carried out in the district on several occasions subsequent to the 1961 survey. Of particular relevance to the present study is more detailed sampling carried out by Beck (1963 and 1965) and Whaley (1967) in the Stanfield area and by Beck (1963) in the Papago Indian Reservation to the immediate south of 1961 coverage.

(b) Geochemical Data Validity

Certain weaknesses, some of them unavoidable, in groundwater sampling techniques, as well as sample handling and analytical procedures, have probably resulted in data of only moderate accuracy and precision. However, patterns of Mo distribution displayed by the Asarco groundwater data for Pinal County are likely to be broadly correct. Areas of anomalously high Mo concentrations almost certainly occur in the Sacaton and Stanfield areas.

5. Data Interpretation

(a) General

Mr. D. B. Beck's selection of basic geochemical parameters for Mo in groundwater (i.e. threshold 15 ppb; possibly anomalous $> 15 \leq 40$ ppb; probably anomalous > 40 ppb) in the Pinal County appear valid taking into consideration the available data. They are broadly comparable with those selected by the U.S.G.S. for groundwater in the Pima Mining District (Bulletin 1312-C referred to previously).

Apparent lack of anomalous Cu concentrations in groundwater is likely, as Mr. Beck suggested, related to the relatively low mobility of the element in the prevailing high pH environment. In the Pima Mining District the U.S.G.S. reached somewhat similar conclusions although a Cu anomaly was found extending 2 - 3 miles from the Pima and Mission orebodies. again! derived from outcrop

(b) Sacaton Area

In view of their close spatial relationship it seems reasonable to assume that the Mo anomaly in the groundwater of the Sacaton Area is mainly derived from the known orebodies. However, the fact that the anomaly does not have a typical fan-shaped form and also extends along the pediment adjacent to Sacaton Mountains further than might reasonably be expected as a result of groundwater movement from the general vicinity of the known

mineralization, the possibility of additional sources should not be overlooked. This might conceivably take the form of additional sub-outcropping mineralization or as was previously suggested by Mr. Saegart (letter to R. J. Lacy September 7, 1961) relatively high background Mo concentrations in the local granitic bedrock.

Of potential significance when considering the Stanfield area data (see below) is the generally abrupt termination of the Sacaton anomaly to the S.W. along the Santa Cruz Wash. Presumably groundwater recharge flowing beneath the wash is carrying background Mo values which severely dilute the smaller anomalous recharge from the Sacaton Area.

(c) Poston Butte Area

Mr. Beck suggested that the reason for the failure of the 1961 survey to detect anomalous Mo concentrations in the groundwater near Poston Butte could be due to the fact that the oxidized portion of the mineralization is submerged beneath the present day water table. However, as Mo is generally mobile in the reducing/neutral-alkaline environment likely to be encountered in the groundwater, this is not necessarily a valid explanation. Probably of greater significance is the fact that groundwater sampling was apparently confined to the area to the south of the prospect. These samples were likely mainly derived from groundwater underflow of the Gila River. Any anomalous groundwater recharge from the prospect in this area is probably severely diluted by the Gila River underflow.

(d) Stanfield Area

Anomalous Mo concentrations have been detected over an area of around 10 x 2 miles, trending S.E. - N.W. over the pediment and, to the south, over the alluvium of the Santa Rosa Wash, lying to the west of Table Top Mountain (Figs. 1 and 2). The overall dimensions of this anomalous zone are unknown due to the restricted sample coverage which is in turn largely related to lack of water-wells. At present it has not been delimited to the S.W., S.E., or N.W. (Although recent work by Mr. Wayne Farley in the Antelope Peak might have possibly resulted in closure of the anomaly to the N.W.).

Applying the geochemical parameters established by Beck it would appear that 'probably anomalous' Mo values occur in several scattered areas within the broad 'possibly anomalous' zone. However, the precise pattern of Mo distribution indicated should be accepted with reservation until it can be verified, in view of the limited sample coverage and possible weaknesses in sample handling and analytical procedures.

Obviously discussion of the possible location of any bedrock sources of the Stanfield anomaly is somewhat speculative as the full extent of the anomaly is not yet known and available data suggests Mo anomalies in groundwater can persist for large distances (i.e. $>$ 10 miles in the Pima Mining District and $\leq$ 8 miles in the Sacaton area). However, it seems reasonable to conclude that the sources of the Mo anomalies should be sought either up drainage (i.e. in terms of groundwater) and/or in the general vicinity of these anomalies. Published data indicates that groundwater which is recharged to the water-table in the vicinity of Table Top Mountains can be expected to flow in a N.E. direction and merge with the N.W. moving ground-

water being recharged from the Santa Rosa Wash. Hence, it is possible to suggest several alternatives for the location of bedrock sources of the anomalous groundwater. The more likely on the evidence of available data appear to be either:

(1) In the catchment of the Santa Rosa Wash in the Papago Indian Reservation to the south of present known extent of the Stanfield anomaly and in fact of the main area of previous follow-up studies.

or (2) both area (1) and beneath the alluvium and/or pediment overburden along the W. flank of Table Top Mountain. In the case of both (1) and (2) the apparent weakening and westward 'drift' of the anomaly to the north could be explained by dilution by background groundwater flowing from beneath Greens Wash.

Fortunately some data are available for groundwater in the Papago Indian Reservation. These are highly significant as they provide strong evidence that part at least of the anomalous Mo concentrations of the Stanfield anomaly are coming from within the Reservation. In fact, they suggest that the Stanfield anomaly might simply represent the tail end of a large anomaly related to sources within the Reservation. Anomalous Mo values (i.e. 40 and 30 ppb respectively) were detected in the groundwaters below the Santa Rosa Wash at Vaiva Vo and the Tat Momoli Wash a few miles from its confluence with the Santa Rosa Wash. The former could be related, at least in part, to the known major Cu porphyry mineralization in the vicinity (i.e. Lakeshore and Reward) although the possibility of a contribution from Lakeshore is somewhat diminished by the apparent presence of background Mo in nearby groundwater. The presence of anomalous Mo concentration in the groundwater below the Tat Momoli Wash could be highly significant as no (?) major mineralization is known in the catchment (> 800 sq. miles) of this drainage.

Any sources occurring in the more immediate vicinity of the Stanfield anomaly could lie beneath the Santa Rosa Wash or beneath the pediment overburden lying along the west flanks of Table Top Mountain or the Vaiva Hills.

Obviously the possibility exists that the Mo anomalies in groundwater could, in part at least, be related to anomalous Mo concentrations in the post-mineralization cover (i.e. recent alluvium, etc., or post-mineral conglomerates) resulting from previous chemical and/or physical weathering of mineralized bodies. If this were the case, however, the Mo anomalies in groundwater would still be indicative of the nearby presence of sulphide mineralization in bedrock.

L. D. James

L. D. JAMES

LDJ:db
Encls.
cc:J.J.Collins - J. H. Courtright
W.E.Saegart - N. Whaley

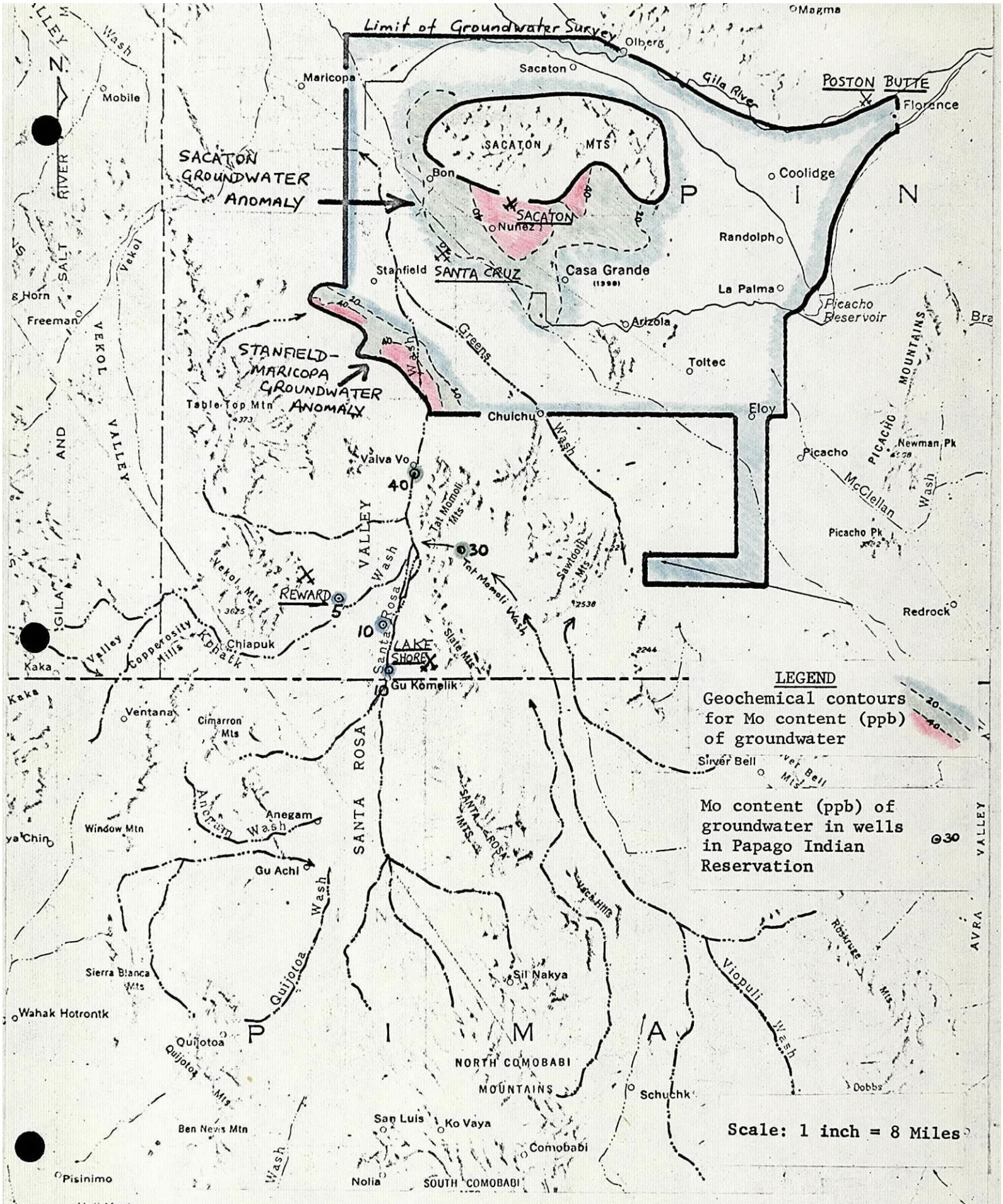

Fig. 1. GROUNDWATER DATA (ASARCO 1961, 1963, 1965 & 1967)
WEST PINAL COUNTY, ARIZONA.

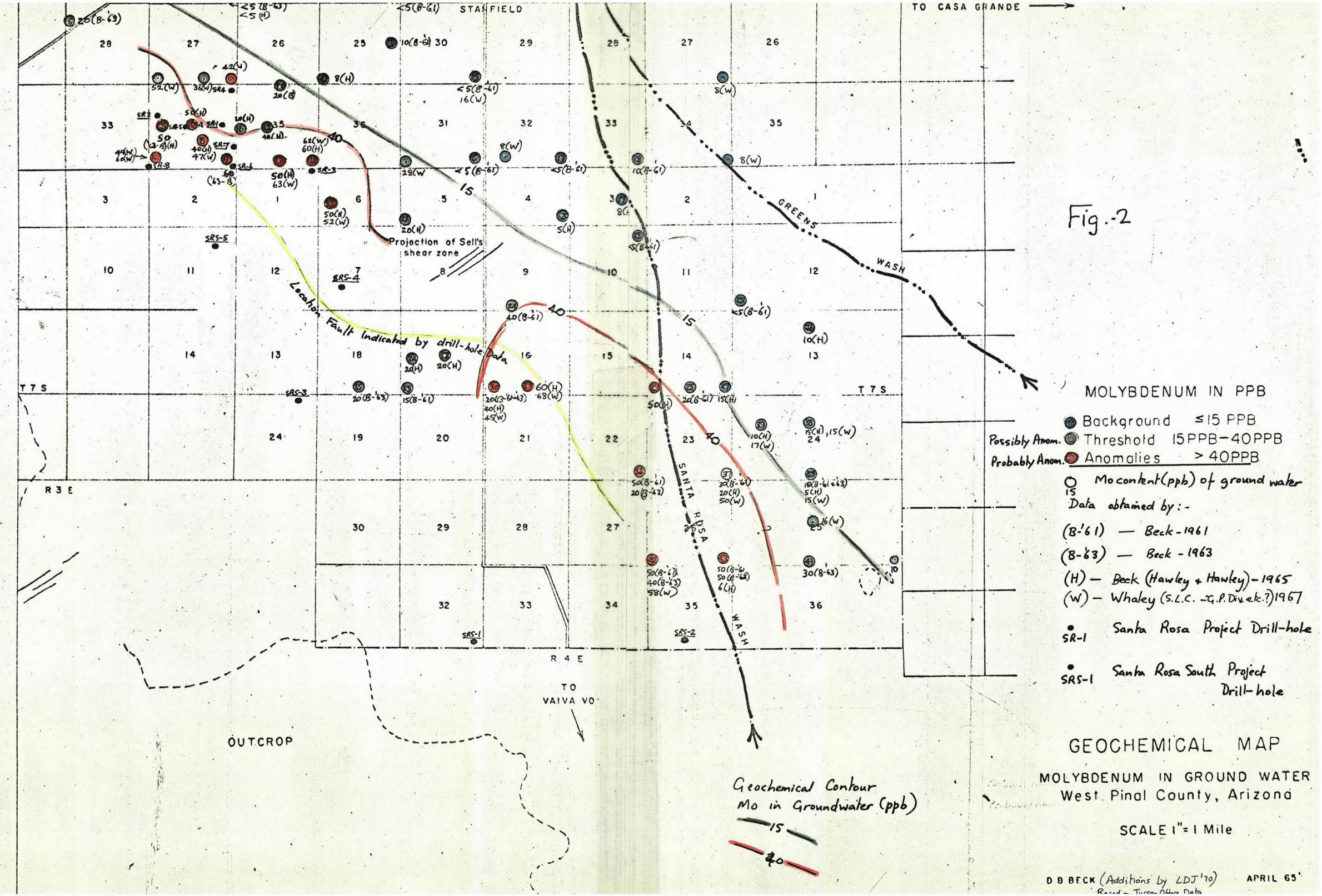
STAHFIELD
TO CASA GRANDE
GREENS WASH
SANTA ROSA WASH
Location Fault Indicated by drill-hole Data
Projection of Sell's shear zone
T 7 S
R 3 E
R 4 E
TO VAIVA VO
OUTCROP
MOLYBDENUM IN PPB
Background ≤15 PPB
Possibly Anom. Threshold 15PPB–40PPB
Probably Anom. Anomalies > 40PPB
Mo content (ppb) of ground water
Data obtained by:-
(B-'61) — Beck-1961
(B-'63) — Beck-1963
(H) — Beck (Hawley + Hawley)-1965
(W) — Whaley (S.L.C. -G.P. Div. etc.?) 1967
SR-1 Santa Rosa Project Drill-hole
SRS-1 Santa Rosa South Project Drill-hole
Geochemical Contour
Mo in Groundwater (ppb)
15
40
GEOCHEMICAL MAP
MOLYBDENUM IN GROUND WATER
West Pinal County, Arizona
SCALE 1" = 1 Mile
D B BECK (Additions by LDJ '70)
APRIL 65'

Fig.-2