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GEOLOGIC REPORT
THE BASEMENT FAULT
PIMA MINING DISTRICT
PIMA COUNTY, ARIZONA

J.E.Kinnison Oct. 26, 1967

J. E. K.
APR 0 9 1968

Air Mail

April 4, 1968

Mr. J.H. Courtright
American Smelting and Refining Company
Box 5795
Tucson, Arizona

Basement Fault, Pima Area

Dear Mr. Courtright:

This is a belated acknowledgement of your letter dated November 21, 1967 transmitting Mr. Kinnison's review with maps and sketches covering information including recent developments pertaining to the Basement Fault postulated by Asarco geologists and others in the Pima District.

I have now had an opportunity to study Mr. Kinnison's summary and conclusions and note he has firm convictions that the contact between mineralized sediments and other rocks above fresh granite in the district indicated in numerous drill intersections is in reality a low angle post ore fault and not an intrusive contact as claimed by a number of investigators. It seems to me this is one of those geologic controversies that will never be resolved to the complete satisfaction of all. Although I am impressed by the array of expert talent on both sides of the argument, it appears, at least in my judgement, that the best evidence supporting the Fault contact theory is the complete lack of mineralization in the granite. I am assuming the ten selected drill hole logs are representative of many penetrations, none of which I understand show the granite to be mineralized.

True sections constructed through drill holes would have been helpful in visualizing in detail, irregularities in the plane of this low angle contact. The diagrammatic sections which Mr. Kinnison included in his report are not much use in this respect. As you know, some have used the argument that thrust movement of the magnitude exhibited by the Basement structure could not occur because of indicated irregularities in the contact plane. As far as I can determine, there seems to be sharp differences in elevation of the fault penetrations from hole to hole. For instance, there appears to be as much as 180 feet between the Fault intercepts in Hole 278 and Hole 254. I judge these holes are spaced about 2000 feet apart.

This is an intriguing problem and one which needs continuing study. At any rate, there is sufficient doubt as to the interpretation to require maintaining an open mind so that no exploration possibilities will be overlooked below the contact which you and your geologists interpretate as the Basement Fault.

Yours very truly,

C. P. Pollock

CC: WESaegart
JEKinnison

Aa 16.16.0

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

November 21, 1967

Mr. C. P. Pollock, Vice President
ASARCO - New York Office

Basement Fault
Mission San Xavier Area

Dear Sir:

This transmits Mr. J. E. Kinnison's review of information on the Basement Fault, Mission San Xavier area, accompanied by geologic plans, sections and detailed graphic drill logs of selected penetrations.

A total of over 60 drill penetrations have been reported. Of these, 26 are in the Mission and San Xavier Reservation ground. In the Eisenhower ground there are 22 penetrations and 8 in Pima ground. A few penetrations by rotary drill were made SW of Pima by Bear Creek.

The drill intercepts and outcrop information define a gentle east dipping structure extending north-south a distance of over six miles. The evidence that this structure is a fault of post-ore age is clearly depicted on several of the detailed graphic logs which show mineralized sediments in fault contact with the underlying barren granite. This relationship was observable only in certain areas; elsewhere the sediments immediately overlying the fault were barren.

Yours very truly,

JHC:lmi
encl.

J. H. Courtright

cc: WESaegart
JEKinnison

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 26, 1967

Mr. J. H. Courtright
Tucson Office

REPORT ON THE "BASEMENT FAULT"
MISSION-SAN XAVIER AREA
PIMA MINING DISTRICT
PIMA COUNTY, ARIZONA

Dear Sir:

Pursuant to your request, I have reviewed all our data pertaining to the subject heading and herewith submit my report thereon.

CONCLUSION

Having now reviewed all available information from our old files and published literature, I draw the same conclusion which we had reached before. Namely, that the contact between unmineralized granite below, and mineralized sediments and other rocks above, is a post-ore fault of district-wide magnitude. It is not an intrusive contact.

There are numerous references, in company correspondence and on maps, to this "basement fault" (the same structure referred to by J. R. Cooper, as the San Xavier thrust - U.S.G.S. Bulletin 1112-C). The only pertinent new information is a drill penetration near the San Xavier North deposit (D.D.H. 2 SX-18). All other data is contained in our older files and drill hole logs. No serious or persistent question of interpretations regarding this fault had been made in the past, and thus there was no occasion to describe and document the fault as I do in the following.

Very truly yours,

John E. Kinnison

John E. Kinnison

JEK:mc
cc: JHCourtright - 4 extra

BASEMENT FAULT
PIMA MINING DISTRICT, ARIZONA

SUMMARY

The basement fault (Cooper's San Xavier thrust) is, beyond doubt, the single greatest structural feature of the district. During the earlier half of this century, such notable men as F. L. Ransom, B. S. Butler, and Eldred Wilson had made brief reconnaissances in different parts of the district and had interpreted the contact between granite and the mineralized rocks as one of intrusion. Since the work of Butler and Wilson during the depression and World War II, there has been little doubt that it is also a fault contact, but it was believed by them that the evidence of faulting was only evidence of a pre-intrusive structural feature. Shortly following J. R. Cooper's excellent work in the district in which he proposed that the contact was entirely post-intrusive in age and probably middle Tertiary, other geologists -- notably, Professors Lacy and Titley, of the University of Arizona -- have disagreed with this interpretation. Asarco's geologic mapping of the surface and interpretation of drill core intercepts of the same fault led independently to the same conclusion as that reached by Cooper.

Please refer to the district map (Attachment G) for place names when necessary.

The basement fault lies at a depth beneath the Mission Mine (East Pima) of about 1500 feet. As known through drill core intercepts, it rises slowly towards the west and comes to the surface about a mile west of Mineral Hill. In every drill intercept, the contact between sediments above and granite below is one of a fault nature. The fault gouge and breccia at the contact vary in thickness, but they are always present. The magnitude of the fault, while open to some dispute, is certainly large because it "cuts off" the mineralized porphyry copper altered zone at Mission. My current belief is that the displacement of the upper plate is approximately 6-1/2 miles, as stated in my Cholla Flat report of April 12, 1961 (Kinnison to Richard). Our Cholla Flat program was predicated on this theory. This interpretation was not made hastily or without good cause. Our Company had mapped the entire district, mostly on a large scale, with attention given to all details. The outcrop trace of the fault, based on this mapping alone, lends direct support to the belief that it is a large fault of major significance. Every drill hole prior to 1960 had substantiated that conclusion, and had furnished us with enough data to understand the geometry of the fault.

The post-ore age is established unquestionably by the presence of gouge and breccia along the fault contact as seen in drill holes, and crushed sulfides within the fault zone. Also, the alteration and mineralization at Mission would normally extend to great depths, but instead is sharply cut off by the fault and the barren granite beneath it. To this there is no exception.

The great magnitude of the fault is illustrated diagrammatically by Attachment A (the upper half) which illustrates the general course of the fault from Twin Buttes northerly to Black Mountain. An enlarged portion of this section, shown in the lower half of the same Attachment, diagrammatically illustrates the details in the Mission vicinity. In order to provide a view looking north, reference may be had to Attachment B, in the Mission Mine area. The details which form parts of these diagrammatic sections referred to in the foregoing are shown on Attachment C, which is plotted to scale.

I have selected 10 drill holes which are representative and plotted them on a scale of one inch to 30 feet (Attachment D). This Attachment is perhaps the most significant of those which are included within this report. The locations of these holes are shown on Attachment E.

Attachment F illustrates a penetration at the Daisy Mine, and it is significant in the fact that there is no thermal metamorphism at the contact.

There is no really new information obtained from the recent drilling since the mine has been in production. All holes which have been drilled deep enough to penetrate the fault have done so. One hole of recent date near the San Xavier North has penetrated the fault, and thus allows us to project the fault directly into this area (Attachment C).

Attachment G has been prepared to show: (1) that the district has been mapped in detail, and; (2) a simplified overlay shows the general geology of the Pima District, as well as certain place names.

Attachment H is a sketch which I made in the field to illustrate the general appearance of the fault in outcrop (refer to Attachment G for location).

ATTACHMENTS

A. Upper illustration:

Diagrammatic section illustrating Basement Fault from Twin Buttes North through Reservation, looking west.

Lower illustration:

Diagrammatic section looking west through Mission Mine.

B. Diagrammatic section looking North through Mission Mine.

C. Section to scale, through Mission Mine-San Xavier, looking westerly.

D. Representative diamond drill holes (Graphic logs), as follows:

Att D Diamond Drill Holes

Mission (East Pima)	No. 137
Mission (East Pima)	No. 158
San Xavier No. 2	SX- 18
" "	Sx- 217
" "	SX 264
Banner	No. 254
Banner	No. 260
Banner	No. 274
Banner	No. 277
Banner	No. 278

E. Drill hole location map.

F. Section through Daisy Mine.

G. Map of Pima District and simplified overlay, showing fault trace on surface, 1"=1 mi.

H. Diagrammatic section of surface outcrop, near Wilson-Todd claims.

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona
October 26, 1967

REPORT ON BASEMENT FAULT
MISSION-SAN XAVIER AREA
PIMA MINING DISTRICT
PIMA COUNTY, ARIZONA

SUPPORTING EVIDENCE

There are three main lines of analysis to approach a logical conclusion concerning the subject.

1) Features of the fault as seen in drill core.
2) Features of the surface outcrop of the fault (contact).
3) The over-all features of the mining district as related to this fault (contact). This includes the features both in the hanging wall and footwall blocks, such as mineralization, or the lack of it, and other geologic indications.

I find that each of these three methods of analysis will apply to the basement fault, in the common agreement that it is a post-ore fault contact. Those geologists who have objected to the fault-contact conclusion have (1) not had access to as many drill penetrations as has our company (and by inference have interpreted those contacts which were seen, incorrectly); and (2) have relied on some rather vague generalizations of the surface exposure of the fault and other geologic features of the Pima district.

INTRUSIVE CONTACT INTERPRETATION - REVIEW

I believe it will serve a purpose as background to set forth the logic which has caused others to interpret the contact as one of intrusion. Also, this review is a necessity; I do not drag up forgotten history, but summarize beliefs which are still held by some geologists.

Ransom's Reconnaissance

F. L. Ransom[1] spent but a few days in the entire Sierrita Range, and reported his impressions on the geology and ore deposits thereof. He states, "the Sierrita Mountains consist essentially of an intrusive granitic core flanked by more or less metamorphosed rock of sedimentary and eruptive origin. On the east...these

[1]F. L. Ransom, U.S.G.S. Bulletin 725-J, 1922

rocks are folded and faulted, have been invaded by granite, and in places, show pronounced contact metamorphism." Ransom attributed the various tactite deposits, such as Mineral Hill, San Xavier Mine, and Twin Buttes Mines, as being of "contact metamorphic" origin. He related these deposits, by inference, to the granite core of the mountain range.[1]

This thought on the genesis of ores in silicated limestones was then - as it is still - a fashionable line of reasoning. There may well be deposits of this type in the western states. Ransom states in this bulletin, concerning the Mineral Hill Mine, that the limestone "is underlain by granite that is apparently intrusive into it..." I believe it is significant that in the same bulletin another paper by Hess and Larsen is entitled "contact-metamorphic tungsten deposits," and that these authors coin the word "tactite" for the silicated limestones.

B. S. Butler and Eldred Wilson

The Pima district was studied by students from the University of Arizona during the 1930's under the direction of the late Dr. B. S. Butler. One such study resulted in a doctoral dissertation by M. N. Mayuga in which he attempted to show a spatial relationship of the granite-sedimentary contact as exposed at the surface with the type of mineral deposit. In brief, garnetized limestone and copper ore were believed by him to be the most close, garnet-hedenbergite-copper-lead-lead-zinc, intermediate in distance, and lead-zinc, silver, the farthest from the granite contact. At a later date, Eldred Wilson[2] of the Bureau of Mines, stated: "the fault planes and breccia exposed above the granite indicate the contact to be a low-angle fault zone of general eastward dip. This fault zone may have localized the granite intrusion, or movement may have occurred along it after the intrusion." I was present on a field trip to the district in 1952, guided by Dr. Butler and Eldred Wilson, and I recall that after observing the tactite deposits at Mineral Hill, the group then went down a small wash and viewed a granite. A genetic inference was made very clear.

J. R. Cooper and Asarco

The Pima Mining district became, during the 1950's, the object of intense exploration and clearly a major metal producer for the future. J. R. Cooper of the U. S. Geologic

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[1] F. L. Ransom, U.S.G.S. Bulletin 725-J, 1922, Pg. 412. "The rocks underlying the plain...are not continuously exposed, and detailed geologic mapping would be necessary to establish their relations. In the neighborhood Mineral Hill and Twin Buttes are bodies of rather coarse porphyritic light-gray granite that is intrusive into the limestone and quartzite and has effected pronounced contact metamorphism."

[2] Arizona Bureau Mines Bulletin 156, Part I, Pg 42.

Survey, in 1957, began a district wide geological mapping program. His work resulted in a short bulletin[1] published in 1960, in which he correctly interpreted the significance of the basement fault (his San Xavier thrust). ASARCO's exploration at Cholla Flat was predicated on the same line of reason, although we had access to drill hole information which Mr. Cooper at that time did not have. Cooper's work consisted of outcrop mapping which has displayed a high degree of professional competence and interpretation.

W. C. Lacy and S. R. Titley

Two years later, Professors W. C. Lacy and S. R. Titley co-authored a short paper[2] in contradiction of the post-ore age of the basement fault. They state, in part:

> "The Twin Buttes (Pima) Mining district occurs within a stack of thrust sheets that fringe the eastern edge of a large Laramide granodiorite batholithic complex which forms the core of the Sierrita Mountains...The thrusting has produced imbricate structures that appear to have formed pene-contemporaneously with, and later than, the period of granodiorite intrusive activity."

Both Dr. Lacy and Titley are well known and respected within the profession of geology and ore deposits. They have both studied in a rather hasty fashion some of the features of Pima district[2], with special emphasis on the basement fault (Copper's San Xavier thrust) and its relationship to the geologic history of the Sierrita Mountains and to the ore deposits therein.

Thesis work in the early 1960's was supervised by Dr. Lacy. Some of these have been completed and are in the University of Arizona Library as unpublished manuscripts. Because these works so strongly reflect Dr. Lacy's opinions, which are amply stated in the 1962 Mining Congress Paper heretofore quoted, no purpose will be served by commenting on them here.

INTRUSIVE INTERPRETATION - DISCUSSION

The Years Prior To 1952

When F. L. Ransom first visited Pima district, in 1920, he was strongly influenced by certain laboratory studies and by field evidence which applied to many of the "contact" deposits as they were then known. He had not even a topographic map upon which to rely. His statements are restricted

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[1]U.S.G.S. Bulletin 1112-C, 1960
[2]Mining Congress Journal, April, 1962

to factual observation, and his interpretation to those theories of ore deposits which were then known. Also, he cautioned that a sufficient and detailed geologic map would need to be prepared before obviously complex structure could be interpreted.

Both Butler and Wilson mapped portions of the district near the mines and made observations at widely scattered points. When I visited the Pima district in 1952, guided by Butler and Wilson, I was shown a "granite" near Mineral Hill. This particular granite is Precambrian and obviously has no genetic connection with the ore deposits at Mineral Hill. In like manner Dr. Butler prepared a map of the old Twin Buttes Mining district ---we have a copy in our files---and mapped granite on the footwall side of the Glance fault. As the high-grade deposits are related to the Glance fault, with a granite footwall, Dr. Butler was no doubt influenced in his belief that these are true "contact metamorphic" deposits. This granite, also, is Precambrian.

The above statements are not meant to cast any adverse reflection on Ransom or Butler. I had the privilege of knowing Dr. Butler and believe he was one of the outstanding men in the field of ore deposits. Butler and Ransom, together with Lindgren, collectively advanced the understanding of ore deposits and also general field and mining geology to a higher level than any other trio of their time. Errors are to be expected in some individual cases.[1]

> Within Asarco, it should be remembered, the concept that tactite ores could result from oridinary hydrothermal activity began first with the evidence derived from Mission, in the middle 1950's. It is no longer a "built-in" assumption that tactites must be near an intrusive granite or porphyry, or that a zone-distribution be found in relationship to such intrusives as may be present.

Ransom, Lindgren and Butler were pioneers in the development of the hydrothermal theory of the genesis of ore deposits. The high-grade copper ores and tungsten deposits are indeed related in space, in many areas, to an intrusive igneous rock. Eldred Wilson, of the Arizona Bureau of Mines, was an associate of Dr. Butler, and their views largely coincide.

Laboratory synthesis of the tactite minerals suggested high temperature, and thereby backed up the field association of tactite ores and granitic or porphyry intrusives. Laboratory synthesis indicates an intermediate temperature for sericite.

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[1] I should note that it took ASARCO some four years of very detailed mapping to arrive at an accurate geologic map. This map and related study, also brought to light the distinct characteristics by which the Laramide granite may be distinguished from the Precambrian.

At this time, I can offer no explanation for the contradiction between laboratory data which indicates a high temperature for the lime-silicates and a lower temperature for sericite. We do know, however, that they occur together in a mutual environment at Mission, Emperial, and other such deposits.

The Years Following 1952

John Cooper's map of Pima district, and the interpretations he made from this map, represent a high degree of excellence.

Lacy and Titley---in the article heretofore mentioned---observe that: "J. R. Cooper...noted the striking coincidence of rock pattern and structure between the Pima area at Mineral Hill and the Twin Buttes area..." They further summarize his findings as follows:

> "...(and he) suggested the hypothesis that: (1) Thrusting was post-mineralization and had separated the Pima, Mission and Palo Verde ore bodies from their roots, (2) similarities in the geology of the northern plate and the block to the south suggest that it moved 6-1/2 miles to the north-northwest."

They then stated:

> "The proposed post-mineralization timing of this thrusting and the mechanics by which such a thin sheet could be displaced such a distance without total destruction is questioned. An alternative hypothesis, more acceptable to the writers, is as follows:
>
> (1) The major period of thrusting was pene-contemporaneous with the intrusion of the Sierrita batholith, and these thrust sheets which fringe the intrusive represent rock shed from the roof of the batholith, domed up during intrusion. Thus, the movement of the sheets was aided by gravity, the shouldering action of the intrusions, and partial rafting by the liquid magma.
>
> (2) Mineralization was essentially post-thrusting and was partially controlled by the thrust faults, by the location of the later intrusive differentiates, and by the lateral breaks."

INTRODUCTORY

If a person will stand on the edge of one of the spurs which radiate outward from the mountainous portion of the Sierritas, and look east and north, he will see spread out before him a landscape which consists of a wide bajada which slopes gently downward to the Santa Cruz River bottom. This slope also will be seen to curve, towards the north, arcuately around the mountains. The eye will notice immediately that there are three principal subdivisions on this sloping plain. Nearest to the mountains, extending for about 3 miles easterly, are incised rocky plains. This slope is separated from the alluvial plain which lies farther to the east by a series of isolated hills which, from the vicinity of Twin Buttes, extends northerly to Mineral Hill. In the very northern portion, these hills are characterized by the colors of the Paleozoic sediments, although bedding planes are not apparent. The southerly portion of these hills are characterized by low relief and by mutted brown and gray colors. The alluvial fill of the third division laps upon and between these isolated hills. If a traverse be made across this same area, beginning at the base of the steep declivity of the mountainous center of the Sierritas, a rocky pediment carved on granite will at once be evident. This surface is considerably trenched by arroyos and mantled by a veneer of rocky granitic detritus. The second division (the hill cluster) is more complex. It consists, in the northern part, of Paleozoic limestone and quartzite, and on the south, of andesites of the Silver Bell formation. Between this area of andesite and the Paleozoic limestone at Twin Buttes, are long smoothly rounded ridges which give the appearance of being flat-lying, dissected conglomerate, but which from detailed mapping are known to be steeply dipping beds of the San Xavier formation (Cooper's Helmet Fanglomerate). The arroyos which headwater about Samaniego Peak, in the central core of the Sierritas, traverse through the area of hills heretofore described and merge into the alluvial basin of the Santa Cruz.

The cluster of hills which stretch north from Twin Buttes to Mineral Hill defines, in a sense, the Pima Mining District. No mineralization is known to occur to the west of these hills in the Sierrita pediment, with the exception of those mineral deposits centered about Twin Buttes. The contact between granite on the one hand, and sediments and volcanics on the other, is the surface trace of the basement fault. Attachment G shows the essential features of the Pima District, and also the surface trace of the basement fault and of the Ruby fault which offsets it a few hundred feet.

The outcrop trace

The contact at the surface is not often cleanly exposed, for it is frequently obscured by talus, alluvium and loose detritus. It may be located very closely, however, over most of its trace; there being but a single step required to cross the contact between granite and the overlying rock.

In the vicinity west of Mineral Hill, the fault may be traced southward to the region west of the San Xavier Mine. At this point, it curves westerly and then southerly near the Paymaster Mine, and south of this in the old Wilson-Chilson-Todd claims it circles in an arc, forming a partial half circle, and there is cut off by the Ruby fault.

Details of mapping methods

A study of the basement fault came naturally into Asarco's geologic mapping program. At the same time that we were drilling the Mission (East Pima) deposit, a systematic mapping program was done concurrently for the entire Pima District. In the mineralized area north of the San Xavier formation, mapping was done on a scale of 1 inch to 200 feet using an aerial photograph base. The region of San Xavier formation and near the Paymaster were also mapped in detail, on a scale of 400 feet to the inch. When compiling data in connection with the Cholla Flat drilling, I completed the map into the Twin Buttes region, using in part some detailed maps by B.S. Butler, and some recent master's thesis maps west of Twin Buttes. The Twin Buttes and adjoining regions were mapped by me on a scale of one inch to a mile, thus forming a connection with A. G. Blucher's reconnaissance of the central and western Sierrita Mountains.

Asarco's maps were made originally by various staff members including J. H. Courtright, O. D. Evans and R. E. Cribbs. Prior to compiling these several maps into a single one for my Cholla Flat report, I had field checked all previous mapping -- our own work, as well as that of others which I used -- with special emphasis on the outcrop appearance, and trace of the basement fault. These maps, plotted to various scales, were synthesized first to a scale of 1,000 feet to an inch and then further reduced (by the use of personal judgement in the combination, inference, and, in some cases, elimination of detail) to a scale of 2 inches to 1 mile.

Dip of the Fault

As known through drill intercepts, the basement fault dips at a low angle to the east from Mineral Hill, through the Mission vicinity. It is not a perfectly planar feature, but shows slight undulations (as interpreted from drill-depth intersections).

West of Mineral Hill, small klippen of limestone (which may be fault slices) rest on granite, with an overall flat dip. The undulations of the fault surface may here be clearly interpreted, and dip measurements of the gougy surface ranges from zero to twenty degrees.

This prevailing east-dip continues southerly past the Paymaster Mine. There is also a low, regional north-dipping component, as shown in Attachment A (upper figure).

The arcuate configuration near the old Wilson-Todd claims is caused by a combination of topography and a flat dip near the Ruby fault.

Surface character

The surface character and appearance of the fault is related to the rock types through which it cuts. These may be divided, in a general way, as follows:

1) In the area of limestone west of the San Xavier Mine and Mineral Hill, the fault consists of thin gougy seams coated with serpentine. The granite beneath, for distances ranging from 10 feet to 50 feet, is strongly sheared and the original biotite is altered to chlorite which is streaked out along the sheared planes. The shearing fades gradually away from the fault.

2) In the area of arkose south of the San Xavier Mine, the fault is marked by a more or less brecciated zone of arkose, lying above sheared granite.

3) Further south still, near the old Paymaster Mine, the rock is dominantly an andesite. There the fault shows a low east dip with gouge seams in the andesite. A single fault plane 3 to 5 feet wide made of silicified gougy andesite forms the base of the fault zone.

4) South of the Paymaster Mine and in the area near the Wilson-Todd claims (reference to Attachment H), a fault slice of rock which I interpret to be post-ore batomote andesite is present. This andesite is sheared to the point where recognition is not completely possible, and the rock has been argillized and seams of calcedonic quartz appear along the shears.

Surficial Mineralization

In several areas the fault zone at the surface gives evidence which, to the casual observer, would seem to indicate that the fault was mineralized. None of these are present at depth in the drill holes which penetrate the fault, and they are all of a nature which is probably caused by supergene solutions.

a) Silicification and argillization is prominent in the surface outcrop near the Paymaster Mine and at various points from there on south.

b) A little transported limonite is present in the silicified zones of "A" above.

c) There are minor amounts of chrysocolla, scattered at widely-spaced intervals from the hill west of the San Xavier Mine, south to the Wilson-Todd claims.

There is no evidence of the former presence of hypogene sulphides anywhere along the fault trace. One possible source of confusion might lie in the two areas where the fault cuts across small breccia pipes. Pyrite has been leached from these pre-mineral pipes in the hanging wall block and also limonite is dispersed in the fault zone beneath. These breccia pipes could easily be confused for mineralized fault breccia.

Drill Holes (Attachment G)

There is little that can be said for the representative drill holes which have been plotted to scale to show the details of the fault zone. The graphical representation speaks for itself. I should take note, however, of the section through the Daisy Mine (Attachment F). The Daisy ore zone, operated by the Banner Company, was a good producer of oxide direct shipping ore, and latter of sulphide concentrates. It is close by the Mission altered zone, but nonetheless, is beyond the limits of pervasive alteration. The drill hole near the Daisy shaft penetrated the basement fault -- but the core was not recovered at the contact. It is noteworthy that the shaly limestone which abuts the granite shows no evidence of metamorphism, as would be the case if it were an intrusive contact.

The Ruby Fault

The Ruby fault quite definitely cuts across the post-ore San Xavier formation. Although there is much alluvium in this area, it is, nonetheless, exposed in several places, and is seen to be a high angle narrow fault zone which separates granite from San Xavier formation. In that area where it cuts across the beds of the San Xavier formation, it would appear that it must be a fault of great magnitude; but it cannot be traced as a fault of any great magnitude to the north. A rather simple explanation of this may be had, and I will refer to my report on the Ajo District of 1961 (to Kenyon Richards).

> "....The Chico Shuni fault may have only a few hundred feet of displacement to drop the low-dipping fault out of sight on the east; all but a small remnant of the hangingwall plate was eroded from the west side while 2 miles of tilted strata were preserved on the east, down-dropped side. The Ruby fault in the Pima district effects precisely this outcrop pattern, by dropping the "basement fault" about 200 feet on the east (refer to Pima district map), causing 3 miles of tilted San Xavier formation to be preserved on the east side and leaving a few erosional Klippen on the west. In both these examples, the high angle fault -- the one easily recognized on the surface-- is caused to have an apparently great vertical displacement and hinge-fault action, whereas the great movement actually took place along a low-angle fault."

Post-ore rocks affected

If my interpretation in regard to the Ruby fault (mentioned in the foregoing) is correct, then the fault must pass beneath the San Xavier formation. East of

Wilson-Todd claims, some Bear Creek holes have passed from San Xavier formation directly into granite. These, however, are rotary holes and no core was taken of the contact. Another possibility of post-ore rock affected by the fault is the fault slice of batomote andesite shown in Attachment H.

Mechanics of faulting

W. C. Lacy has objected to a post-ore fault movement on the grounds that he knows of no method by which a thin thrust sheet could move such a distance without total destruction. This objection is not really material, because we know that the fault exists -- regarless of how it got there. Other faults of similar type are known in southern Arizona. I have nothing to add concerning these low-dipping faults since I commented on them in the Ajo report as follows:

> "I have expressly refrained from using the term "thrust fault" in connection with the Ajo basement fault. The Pima basement fault shown on Attachment B is known to have moved the hangingwall plate down-dip, in part at least, as if it were a free-sliding detached mass, propelled by gravity. Thick sections of fanglomerate appear at many places in southern Arizona, and are frequently found to be tilted and involved in low-angle faulting of this type. Little is known at this time concerning the formation of these excessively thick alluvial basins, or of the mountain building processes which then act to tilt and slide them about."

JEK:mc

END OF REPORT

Wilson-Todd claims, some Bear Creek holes have passed from San Xavier formation directly into granite. These, however, are rotary holes and no core was taken of the contact. Another possibility of post-ore rock affected by the fault is the fault slice of batomote andesite shown in Attachment H.

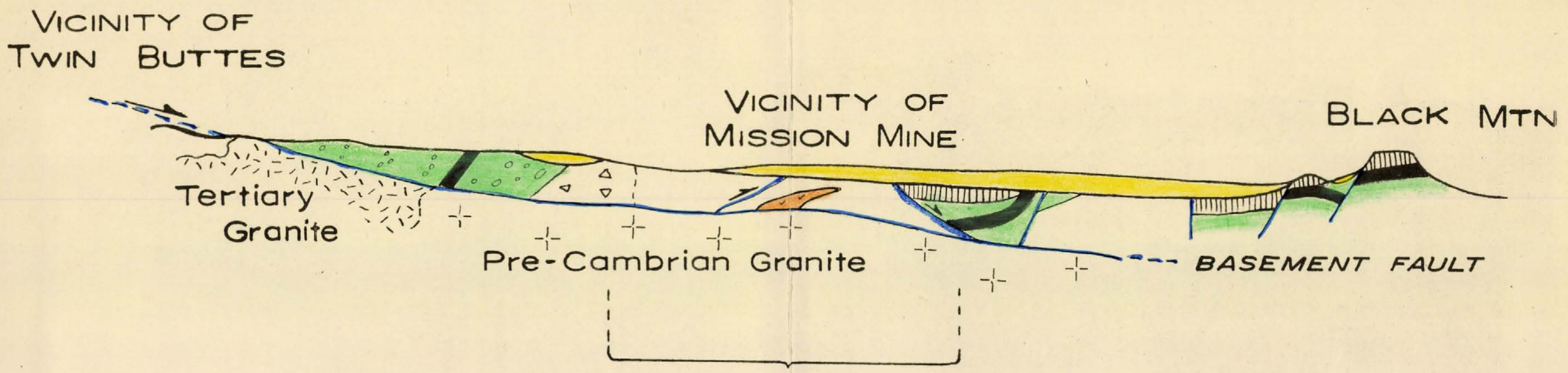
Mechanics of faulting

W. C. Lacy has objected to a post-ore fault movement on the grounds that he knows of no method by which a thin thrust sheet could move such a distance without total destruction. This objection is not really material, because we know that the fault exists -- regarless of how it got there. Other faults of similar type are known in southern Arizona. I have nothing to add concerning these low-dipping faults since I commented on them in the Ajo report as follows:

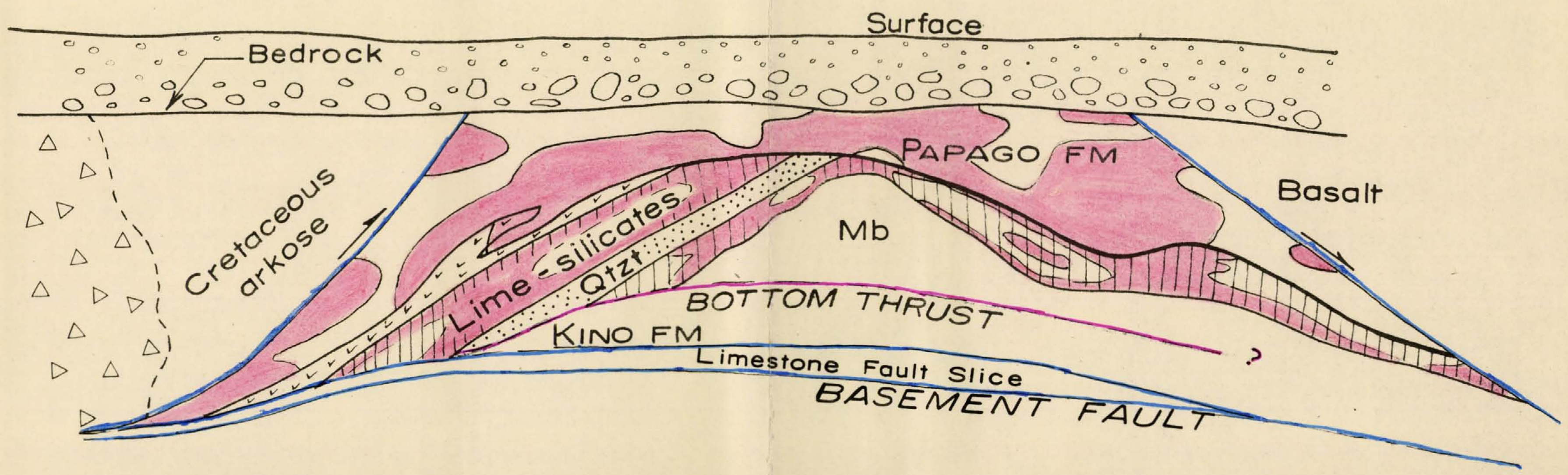
> "I have expressly refrained from using the term "thrust fault" in connection with the Ajo basement fault. The Pima basement fault shown on Attachment B is known to have moved the hangingwall plate down-dip, in part at least, as if it were a free-sliding detached mass, propelled by gravity. Thick sections of fanglomerate appear at many places in southern Arizona, and are frequently found to be tilted and involved in low-angle faulting of this type. Little is known at this time concerning the formation of these excessively thick alluvial basins, or of the mountain building processes which then act to tilt and slide them about."

JEK:mc

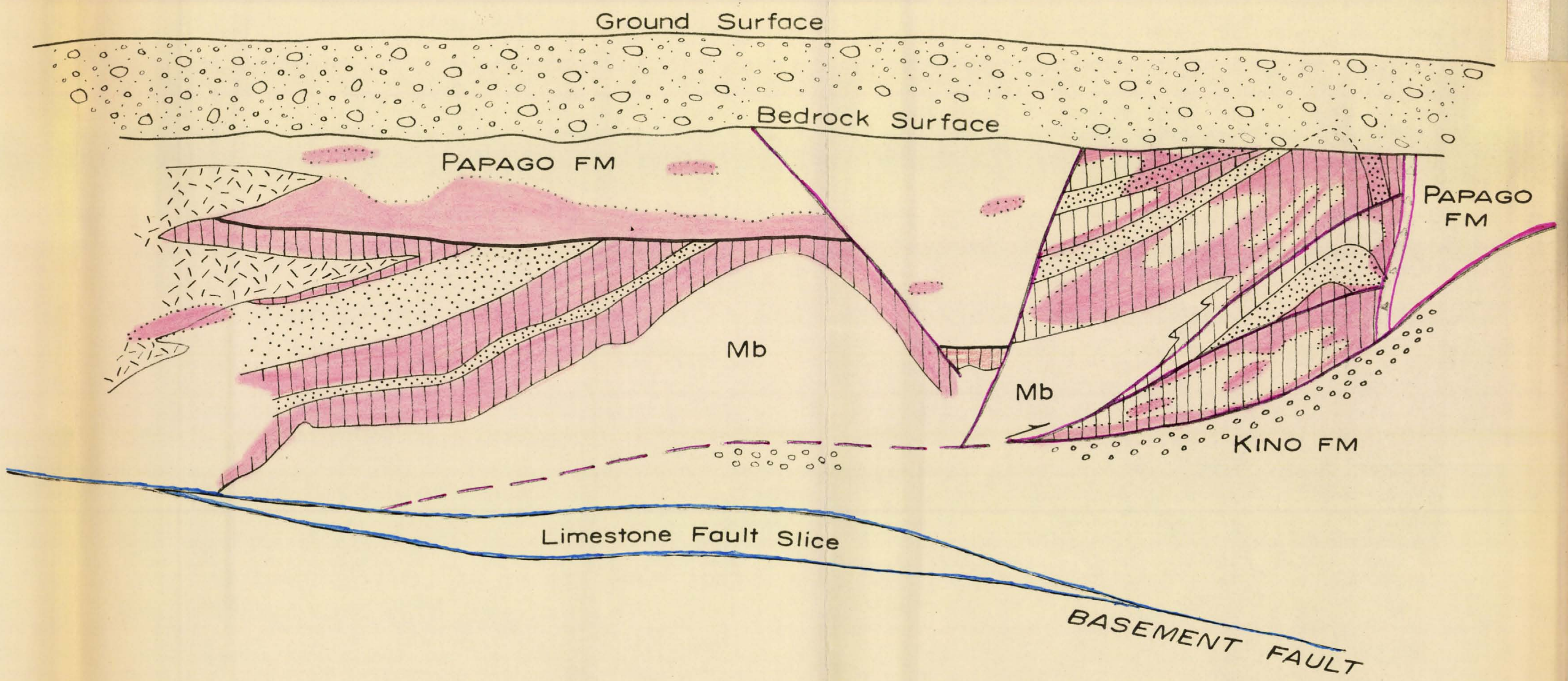
END OF REPORT



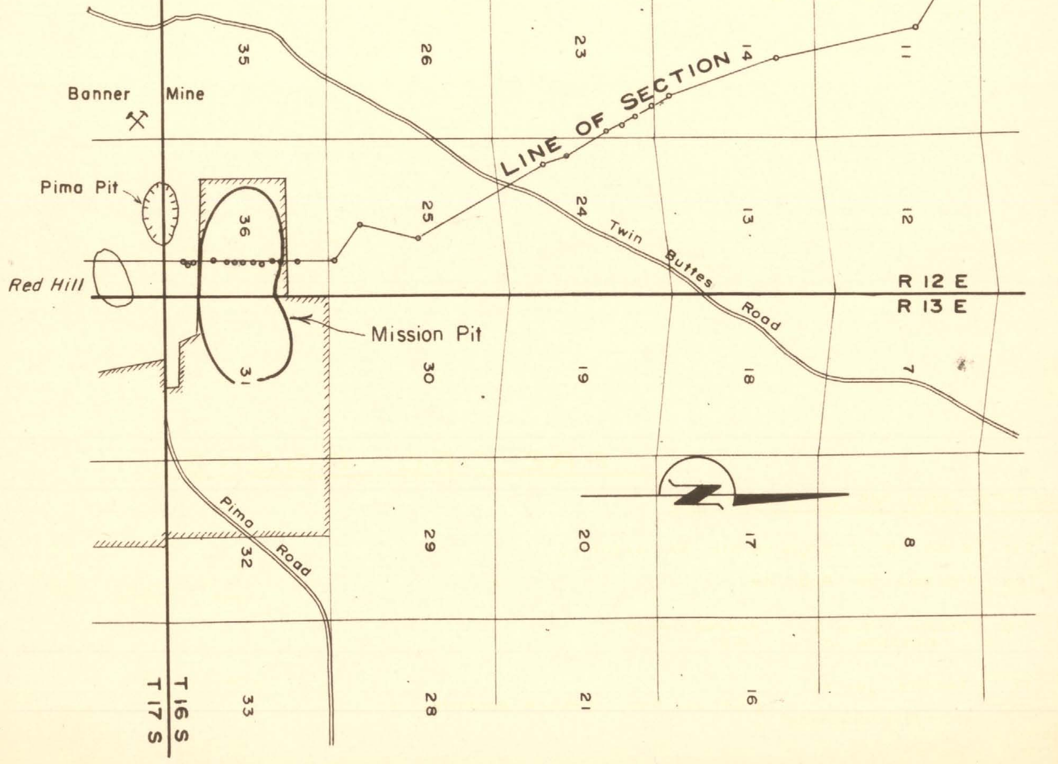
DIAGRAMMATIC CROSS SECTION: LOOKING WEST



LOOKING WEST, MISSION MINE AREA



DIAGRAMMATIC SECTION
MISSION ORE BODY
Looking North



NOTE: This section was originally compiled during 1958-1959. Additional drilling and mining in the Mission - Pima - Eisenhower area will undoubtedly make possible revision of the details of ore distrubution and geology, and ultimate pit slopes. No such changes are incorporated herein.

John E. Kinnison – June, 1965

PRE-ORE ROCKS

SEDIMENTS AND META-SEDIMENTS

Age	Symbol	Unit	
Lower Tertiary(?)	Tkf	Kino fm (Conglomerate and Argillite)	
	Tpg	Papago fm (Argillite)	
Cretaceous	Ka	Amole group (Gray arkose, minor siltstone in this area)	
Pennsylvanian-Permian (Pima Fm)	Tt	Tactite (garnet)	Derived from limestone/dolomite
	Hf	Hornfels (diopside)	Derived from limestone/dolomite
	Mb	Marble	
	Qtzt	Quartzite	

IGNEOUS

Age	Unit	
Lower Tertiary	Meta-facies	Monzonite porphyry
		Monzonite porphyry
	Biotite rhyolite (intrusive and flow)	
Lower Tertiary (?)	Sierrita granite	

POST-ORE ROCKS

Age	Symbol	Unit	
Tertiary-Quaternary	TQal	Alluvium & valley gravels	
Upper Tertiary	Toc	Older conglomerate and siltstone	
	Tb	Black Mt. basalt	
Middle Tertiary	Tsu	Upper San Xavier (conglomerate and siltstone)	San Xavier Formation
	Tbp	Basalt porphyry (flow)	San Xavier Formation
	Tsl	Lower San Xavier (conglomerate and siltstone)	San Xavier Formation

MINERALIZATION

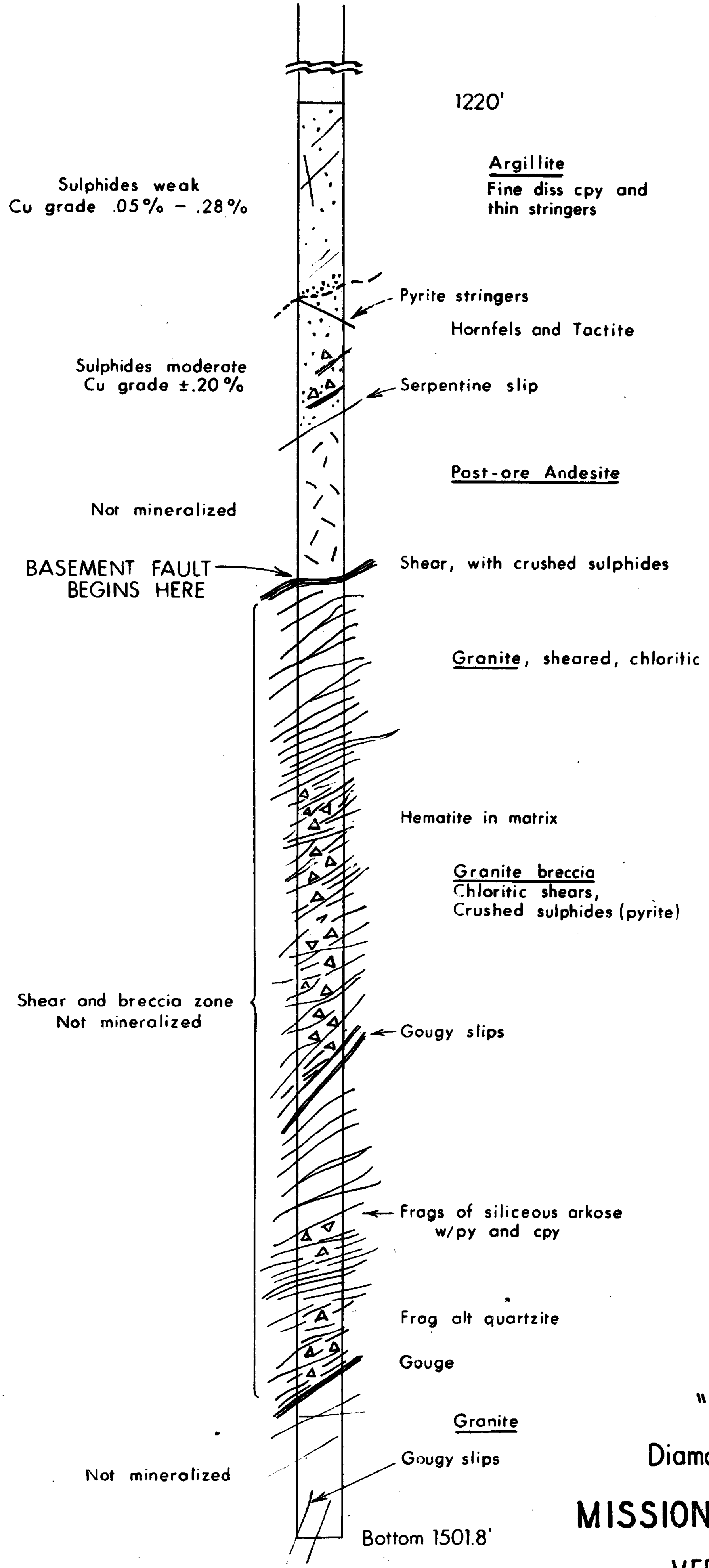
(Disseminated)

	Grade	Type
	> 0.4 % Cu	Hypogene sulphides
	< 0.4 % Cu	Hypogene sulphides
San Xavier Reservation only	> 0.4 % Cu	Supergene chalcocite blanket
San Xavier Reservation only	> 0.4 % Cu	Oxides

Geologic Section
PIMA - MISSION - BANNER SAN XAVIER RESERVATION
(Looking Westerly)

SCALE 1" = 500'

D

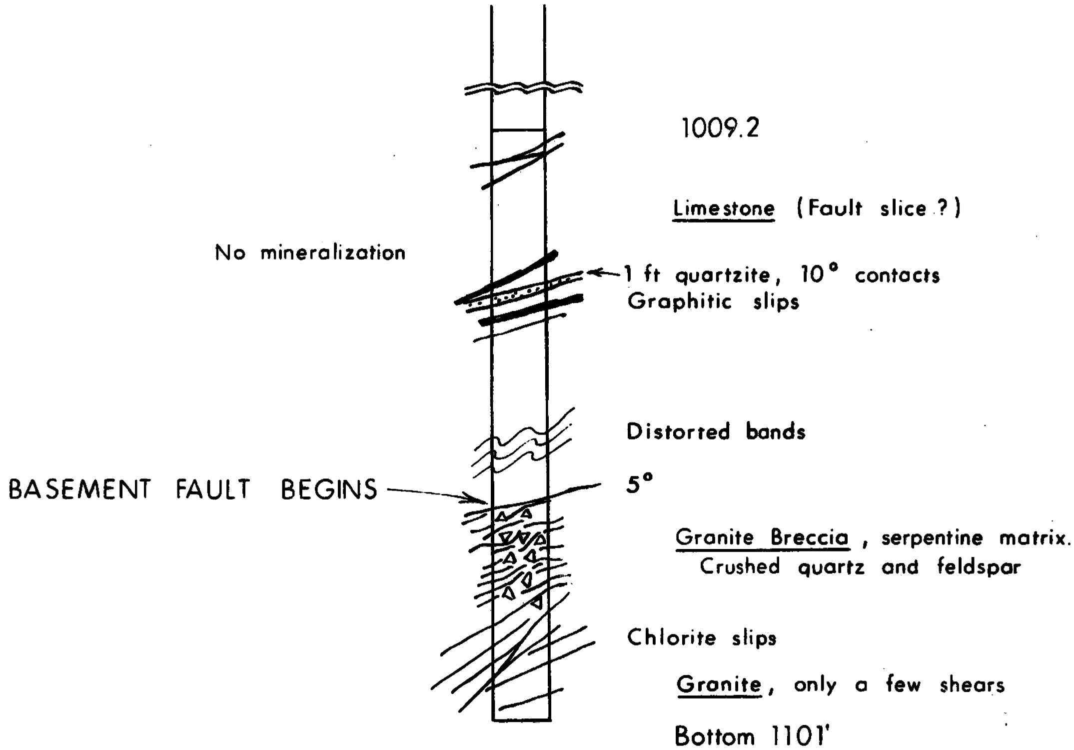


"BASEMENT" FAULT

Diamond Drill Hole Penetration

MISSION (EAST PIMA) No. 137

VERTICAL SCALE 1" = 30'



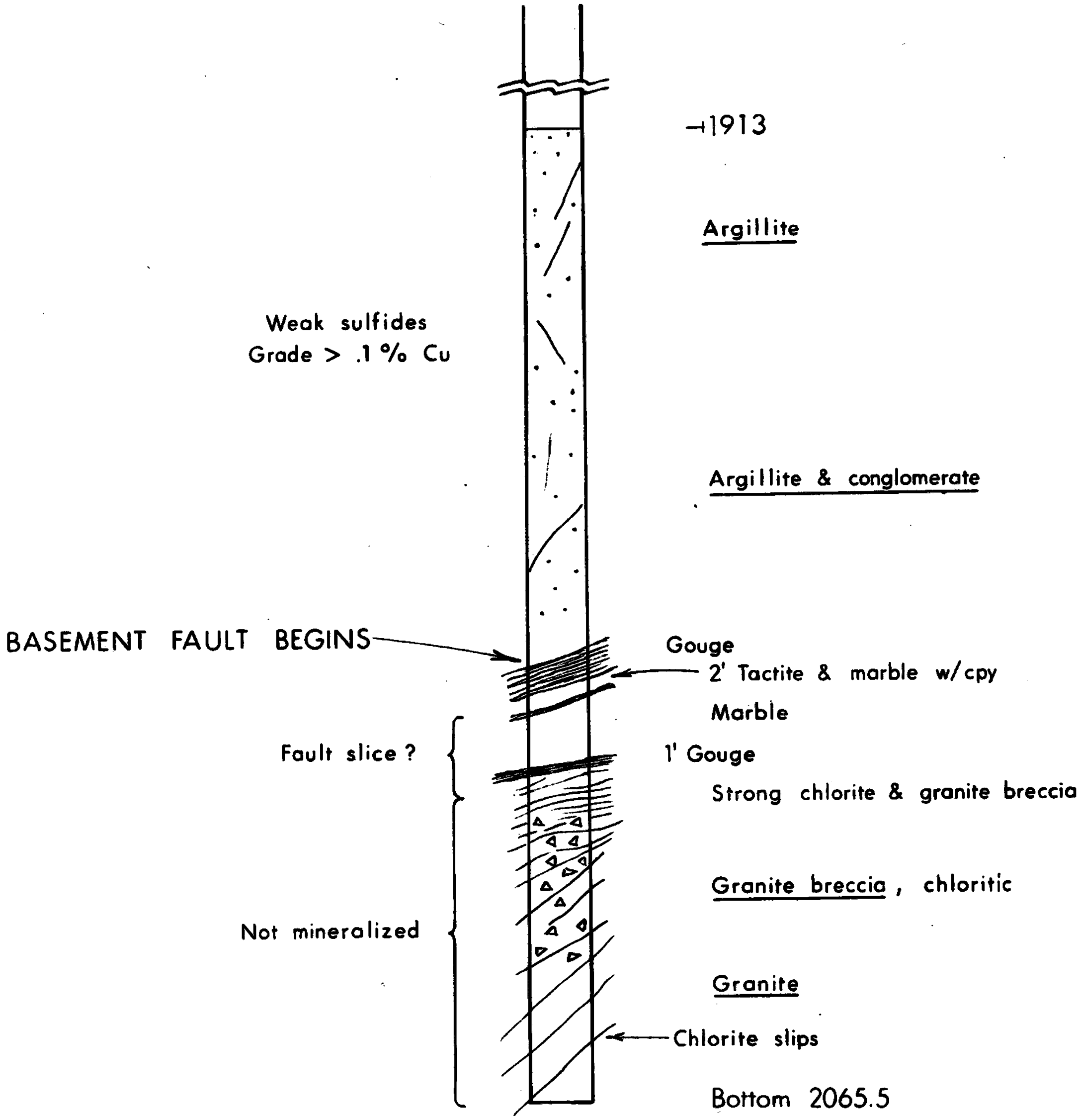
NOTE: Mineralized tactite and argillite higher up in hole, above limestone slice

"BASEMENT" FAULT

Diamond Drill Hole Penetration

MISSION (EAST PIMA) No. 158

VERTICAL SCALE 1" = 30'



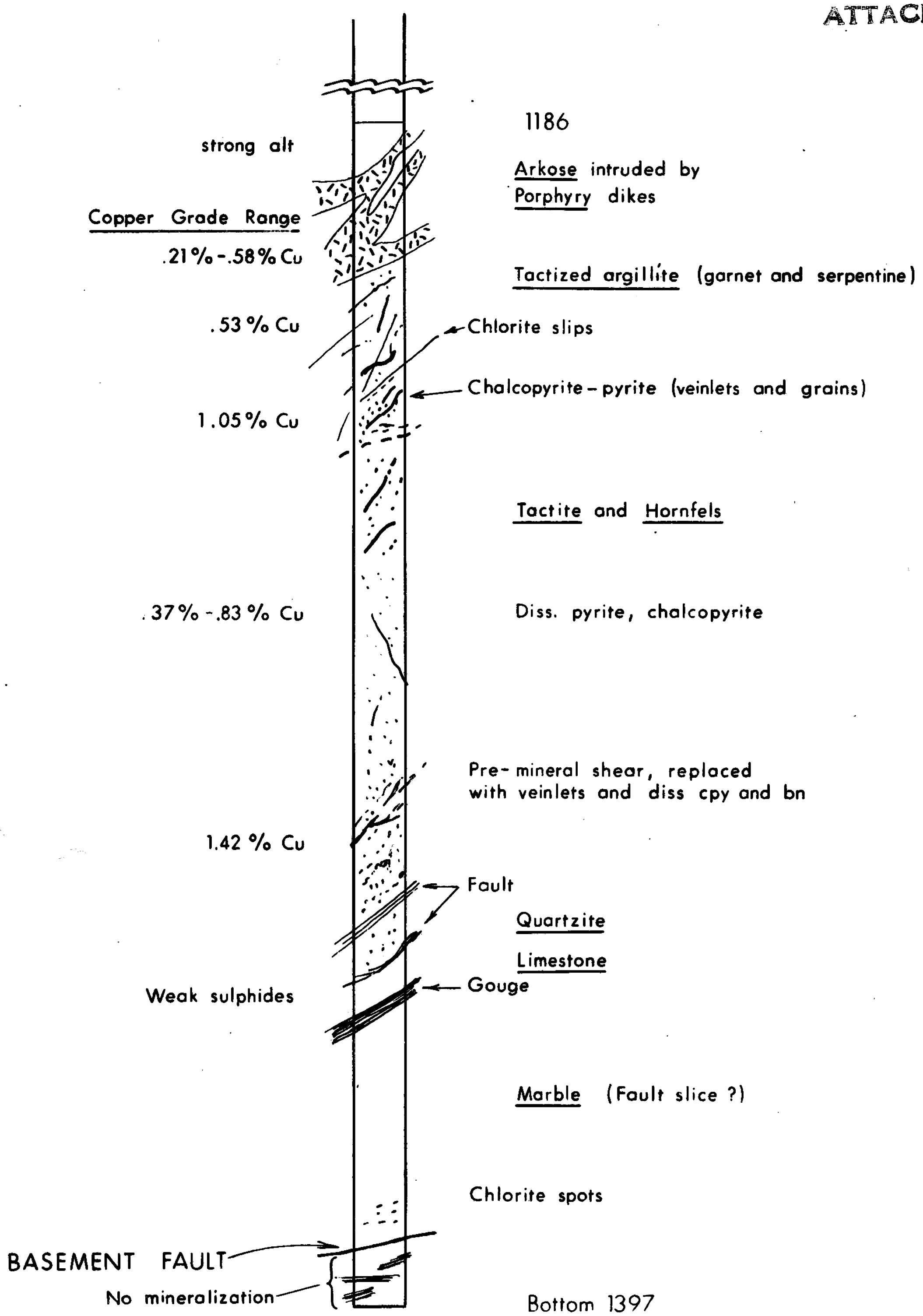
"BASEMENT" FAULT

Diamond Drill Hole Penetration

San Xavier No. 2 SX 18

VERTICAL SCALE 1" = 30'

ATTACHMENT D

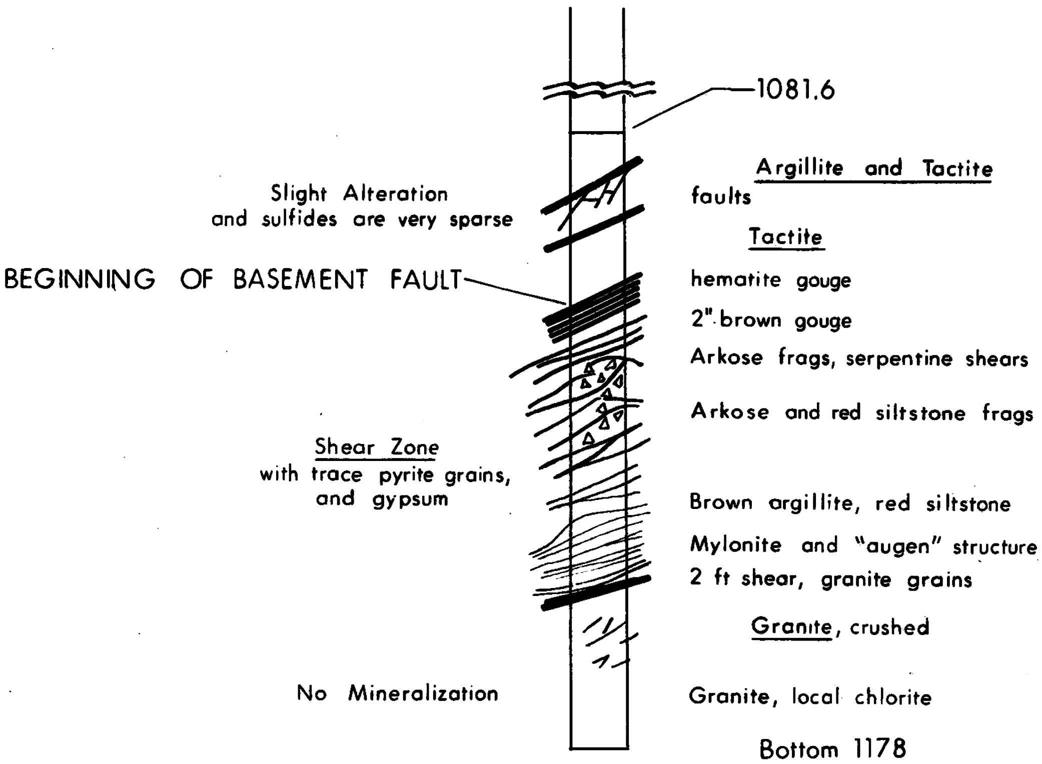


"BASEMENT" FAULT

Diamond Drill Hole Penetration

San Xavier No. X217

VERTICAL SCALE 1" = 30'

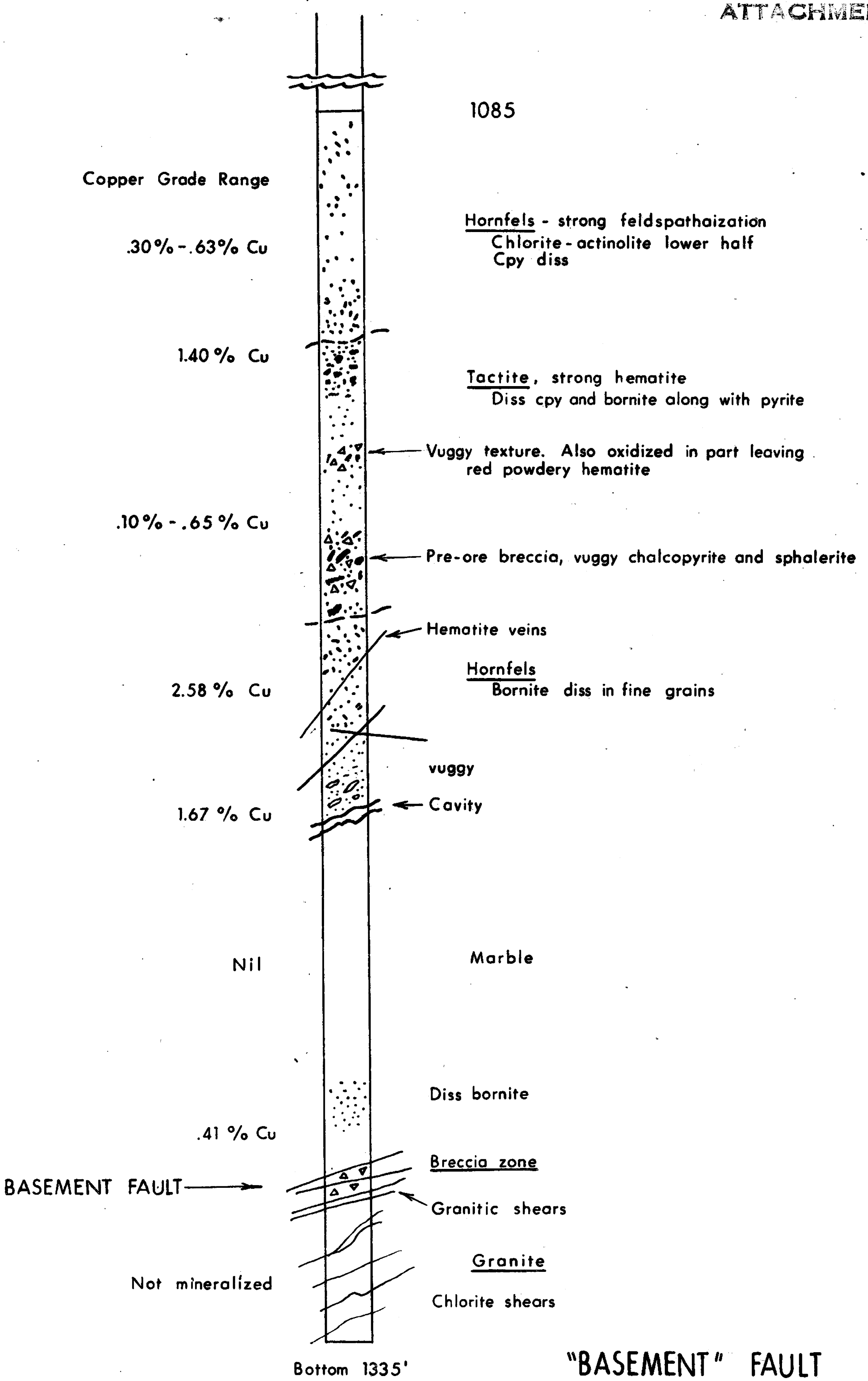


"BASEMENT" FAULT

Diamond Drill Hole Penetration

San Xavier No. X 264

VERTICAL SCALE 1" = 30'

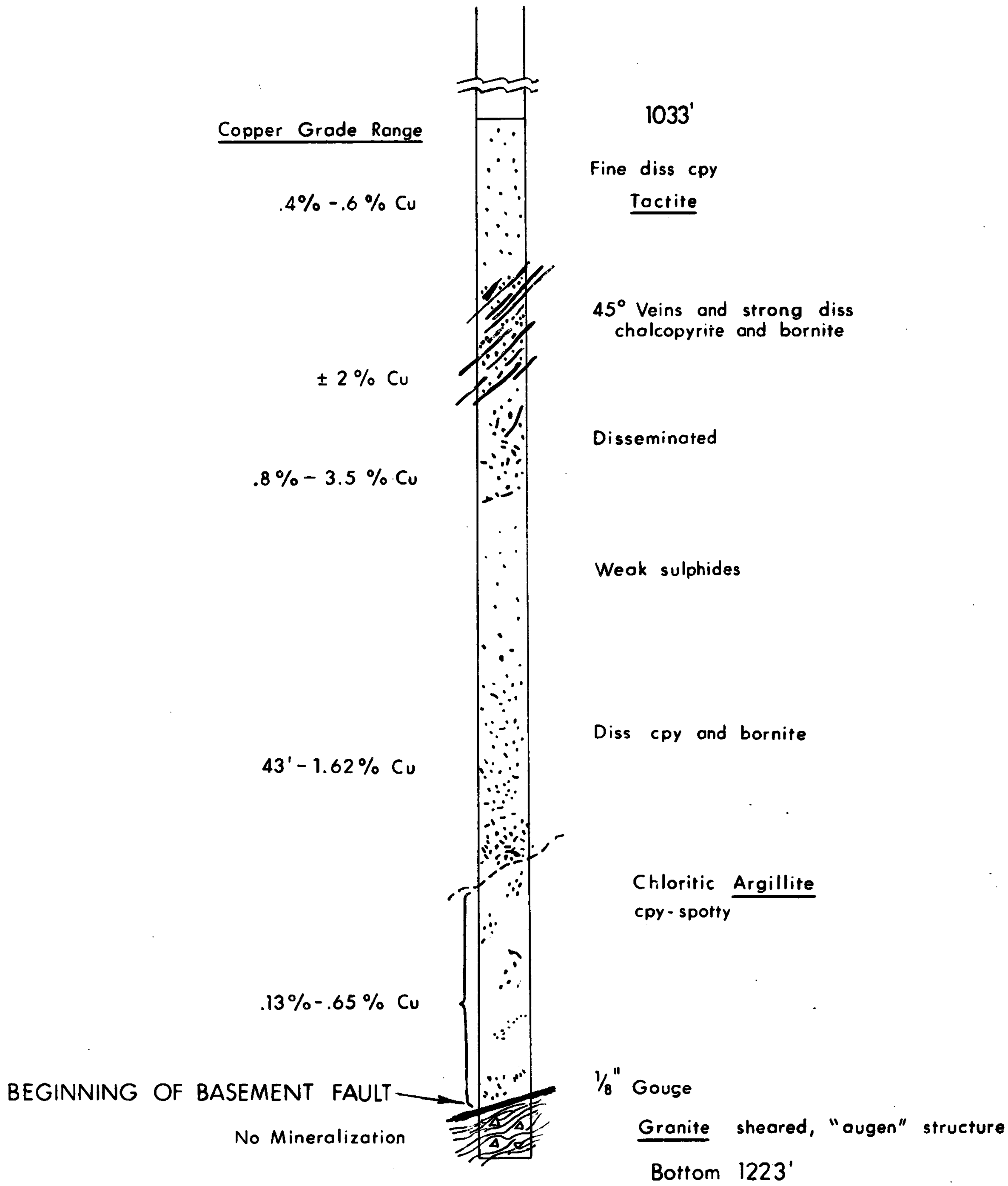


"BASEMENT" FAULT

Diamond Drill Hole Penetration

Banner No. 254

VERTICAL SCALE 1" = 30'

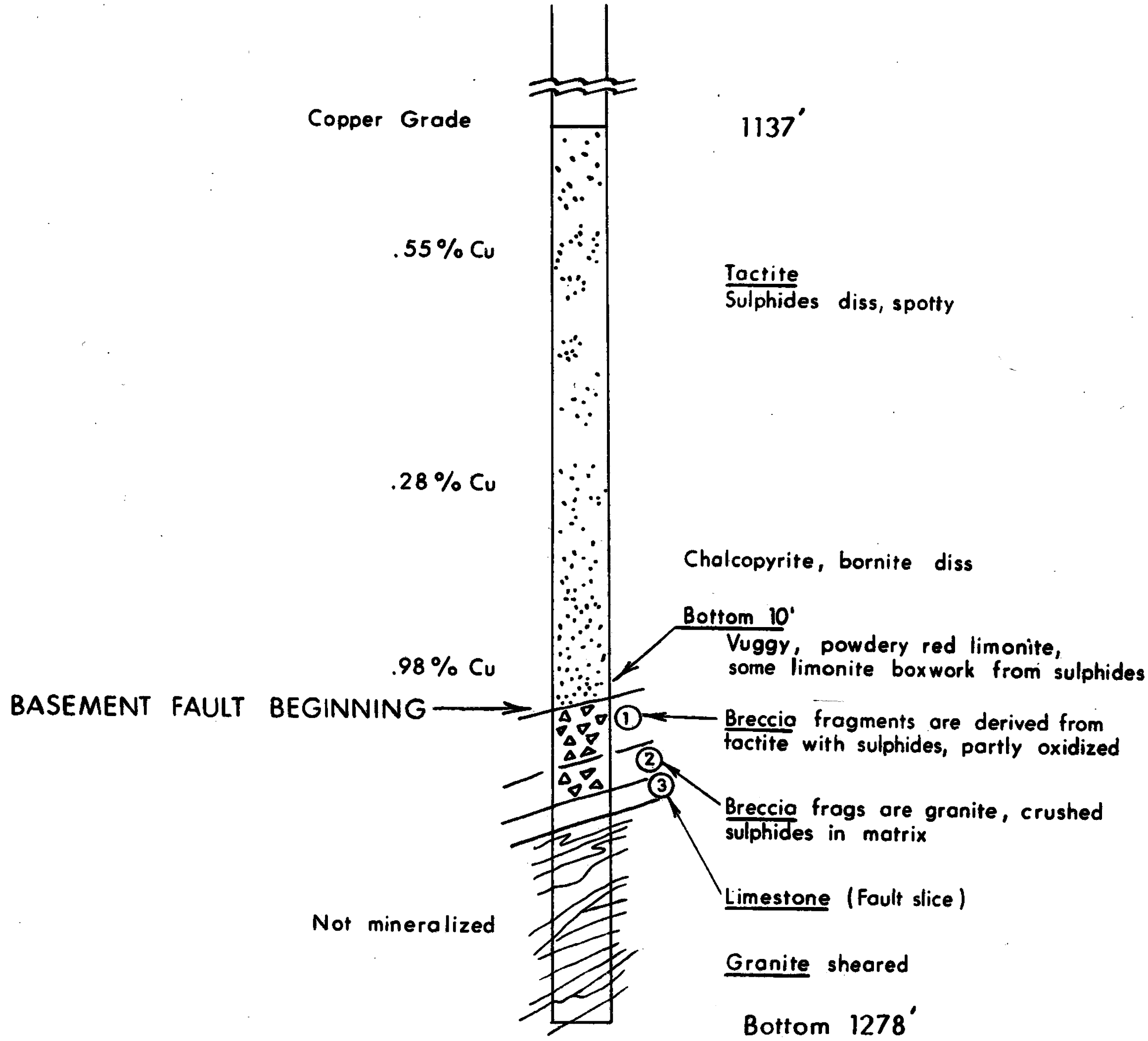


"BASEMENT" FAULT

Diamond Drill Hole Penetration

Banner No. 260

VERTICAL SCALE 1" = 30'



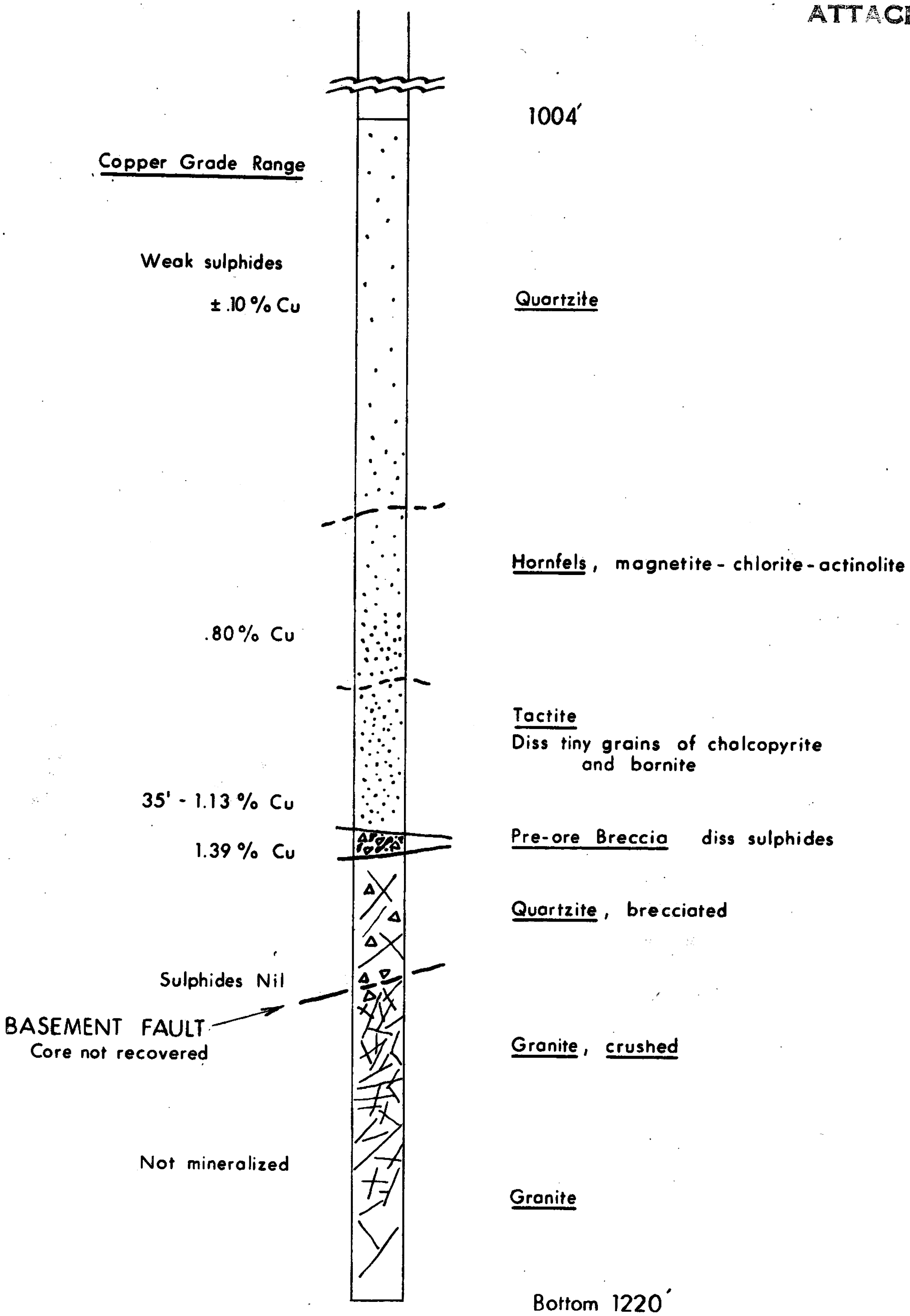
NOTE: Contacts between ①, ②, ③ ground out and lost when core drilling

"BASEMENT" FAULT

Diamond Drill Hole Penetration

Banner No. 274

VERTICAL SCALE 1" = 30'

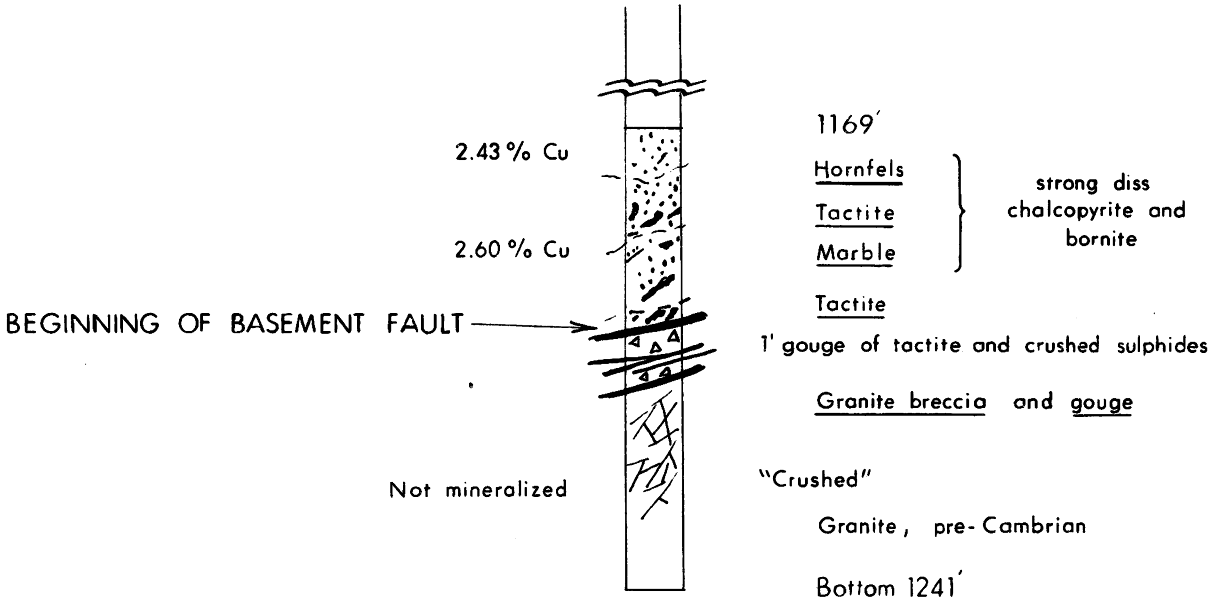


"BASEMENT" FAULT

Diamond Drill Hole Penetration

Banner No. 277

VERTICAL SCALE 1" = 30'



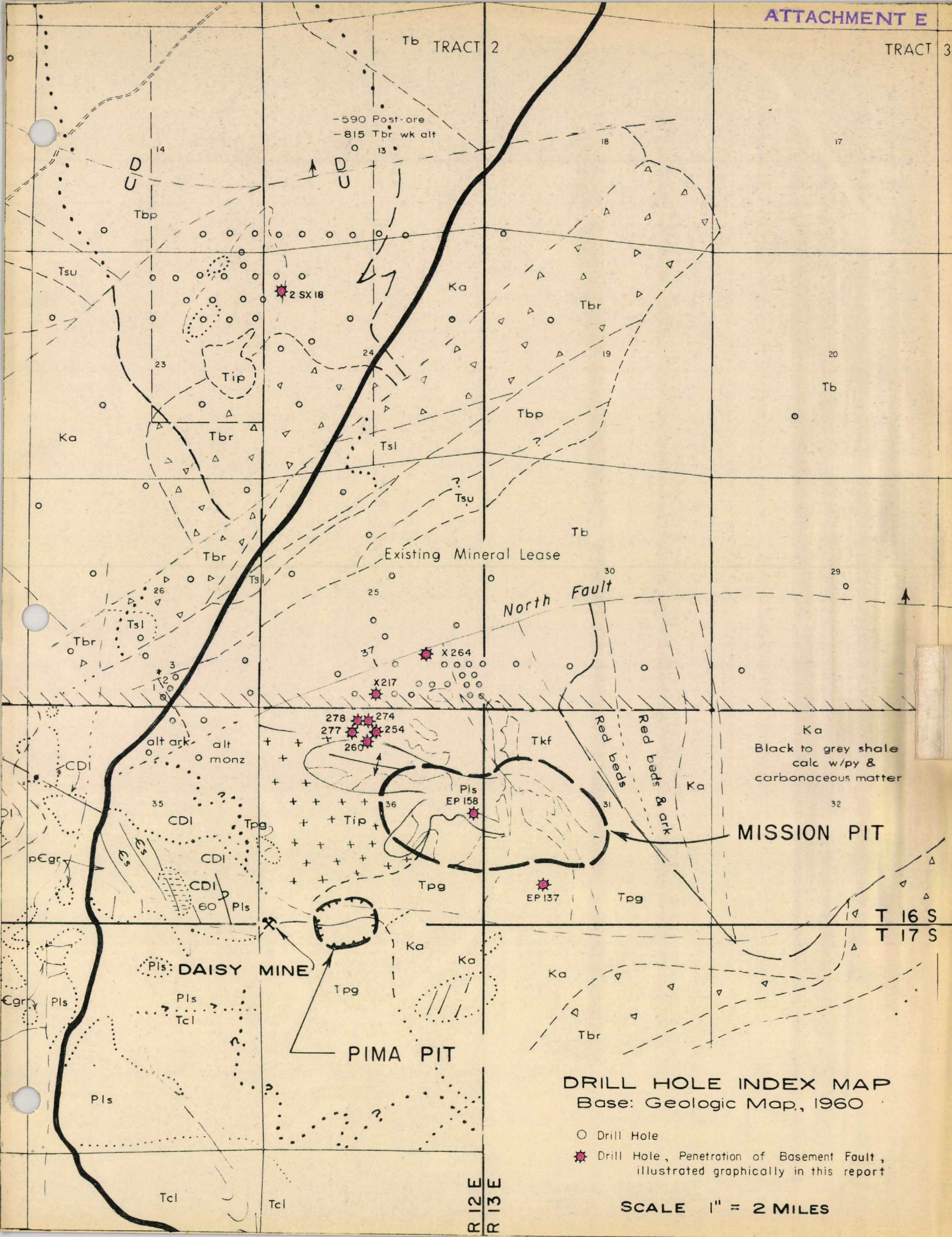
"BASEMENT" FAULT

Diamond Drill Hole Penetration

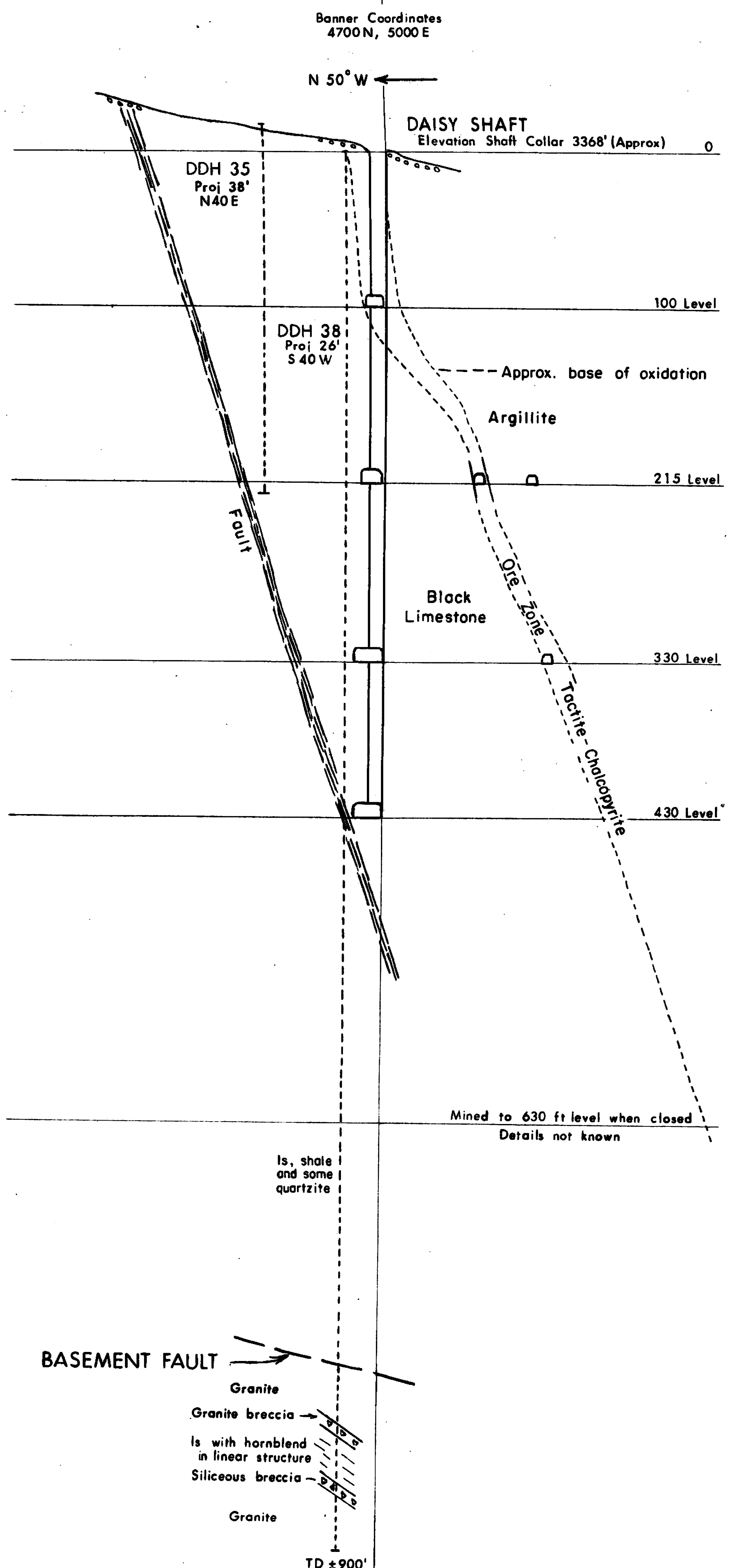
Banner No. 278

VERTICAL SCALE 1" = 30'

ATTACHMENT E



E



DAISY MINE

GEOLOGIC SECTION N 50° W THROUGH COORD. 4700 N, 5000 E

Looking Northeast

Scale 1" = 100'

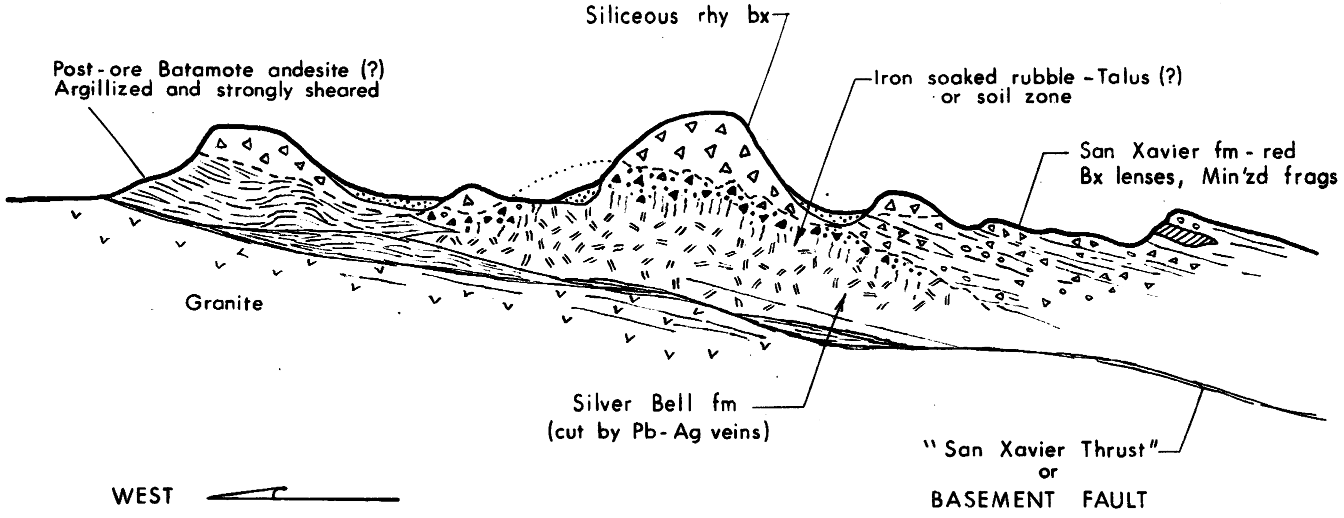
J.E.K.

January, 1955
1993

F


LIMESTONE KLIPPE
MINERAL HILL
DAISY
MISSION PIT
PIMA PIT
Area of interpretations based on ASARCO drilling and related studies
T16S
T17S
NORTH FAULT
BOTTOM FAULT
PIMA FOOTWALL FAULT
RED HILL FAULT REVERSE-POST ORE
BASEMENT FAULT
SAN XAVIER
PORPHYRY
BIOTITE
RHYOLITE
OLIVE CAMP
POST-ORE SURFACE
PROJECTED
based on magnetic survey and Banner drill holes
DOGTOWN
DOG TOWN MINE
PAYMASTER
BASALT FLOW
WILSON
CHILSON
TODD
TERTIARY CONGLOMERATE
RUBY FAULT
SAHUARITA
Sahuarita Road
PROJECTED
LARAMIDE GRANITE
Outcrops gr. not mapped
PRE-CAMBRIAN GRANITE
BASEMENT FAULT
OLD ASARCO WG CLAIMS
CHOLLA FLAT
BANNER 204
Mc Gee Road
MC GEE RANCH
GLANCE
GLANCE FAULT
ANACONDA ORE BODY
T17S
T18S
CONTENTION MINE
MORGAN FAULT
SENATOR MORGAN MINE
See Map, Att A for detail of alteration
Banner Claims
Duval Claims
Duval Mine Road
Mineralized Andesite dikes
ESPERANZA PIT
Duval Sulphur Co
Esperanza Mill
Possible Cu Deposit (Not Drilled)
Kern Co Land Co Drill Holes
Mill Tailings Pond
OLD CALAMINA (Esperanza) Pb-Zn-Ag veins
R12E
R13E
ASARCO
GEOLOGIC MAP
PIMA MINING DISTRICT
Note: Reduced Photographically to:
1 inch = 1 mile
October, 1967

G



The Basement Fault

DIAGRAMMATIC SECTION

Looking North

SW Corner of Hanging Wall Block

Length of Section about 1/2 Mile

(Wilson, Chilson, Todd Claims)

H