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

The following file is part of the Grover Heinrichs Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

Technical Publication No. 1712

(CLASS I, MINING GEOLOGY, No. 111)

DISCUSSION OF THIS PAPER IS INVITED. Discussion in writing (2 copies) may be sent to the Secretary, American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York 18, N. Y. Unless special arrangement is made, discussion of this paper will close June 30, 1944. Any discussion offered thereafter should preferably be in the form of a new paper.

Geology of the Manganiferous Iron-ore Deposits at Boston Hill, New Mexico

BY LAWSON P. ENTWISTLE,* MEMBER A.I.M.E.

(New York Meeting, February 1944)

SUMMARY

INTRODUCTION

Copyright, 1944, by the American Institute of Mining and Metallurgical Engineers, Inc.
MINING TECHNOLOGY, May 1944. Printed in U. S. A.

Miss Jewell L. Glass[8] upon examining manganiferous calcite and quartz occur in

exploration at the principal localizing available for oxidation and the production

for precipitation were present. Analyses of volume and post-ore subsidence. The cor-

R. I. 4237 APRIL 1948

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

RECEIVED
BUREAU OF MINES
APR 26 1948
BERKELEY, CALIF.

REPORT OF INVESTIGATIONS

WEST PINOS ALTOS ZINC-LEAD DEPOSITS

GRANT COUNTY, N. MEX.

BY

JOHN H. SOULE'

R.I. 4237,
April 1948.

REPORT OF INVESTIGATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

WEST PINOS ALTOS ZINC-LEAD DEPOSITS, GRANT COUNTY, N. MEX. 1/

By John H. Soulé 2/

CONTENTS

	Page
Introduction	1
Acknowledgments	2
Location and accessibility	2
Labor and living conditions	3
Property and ownership	3
Physical features and climate	3
History and production	4
Geology	5
Development	7
Work by Bureau of Mines	7

ILLUSTRATIONS

Fig.		Following page
1.	Index map	2
2.	Surface and topographic map	2
3.	Geologic sections	6
4.	Isomilligal map	8
5.	Assay log	8

INTRODUCTION

Appreciable quantities of zinc and lead ores have been produced from the West Pinos Altos district of Grant County, N. Mex. This area was visited many times by engineers of the Bureau of Mines. C. H. Johnson and W. R. Storms visited the district in March 1943 in connection with an access road to the mines. W. R. Storms again visited the area in July 1943 in connection with a Metals Reserve Corporation loan on the Houston-Thomas

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Rept. of Investigations 4237."

2/ Mining engineer, Bureau of Mines

mine. W. R. Storms and R. J. Holmquist sampled the Cleveland tailing dumps in August 1943. These samples were obtained for beneficiation testing. W. R. Storms again visited the area in October 1943 to determine the feasibility of extending the access road from the Cleveland mine to the Houston-Thomas Mine. A study of the district was started by R. J. Holmquist in May 1944 and completed by Felix A. Vogel, Jr. in August 1944. This study was made to determine the merits of the district in justifying a development program by the Bureau of Mines. W. R. Storms again visited the area in August 1945 to gather data pertaining to closed mines.

As a result of the study by Vogel and Holmquist, a development program was proposed, approved, and the funds allocated in 1946. This project was started in August 1946 and terminated in April 1947. A total of 1,824 feet was diamond-drilled.

ACKNOWLEDGMENTS

In its program of development of mineral deposits, the Bureau of Mines has as its primary objective the more effective utilization of our mineral resources to the end that they make the greatest possible contribution to national security and economy. It is the policy of the Bureau to publish the facts developed by each development project as soon as practicable after its conclusion. The Mining Division, Lowell B. Moon, chief, conducts preliminary examinations, does the actual development work, and prepares the final report. The Metallurgical Division, Oliver C. Ralston, chief, analyzes samples and makes beneficiation tests.

Acknowledgment is made of the assistance rendered by J. H. Hedges, chief of the Tucson Branch, Mining Division, and Walter R. Storms, engineer-in-charge of the New Mexico Field Office.

Acknowledgment also is due Andrew B. Stewart and Robert W. Mathis for topographic and geophysical maps, geophysical data, production records of the Houston-Thomas group of claims and other assistance rendered; also to the Hanover unit of the American Smelting & Refining Co. for production records.

LOCATION AND ACCESSIBILITY

The West Pinos Altos district is situated on the western slope of the Pinos Altos Mountains just 2 miles west of Pinos Altos, N. Mex. The area

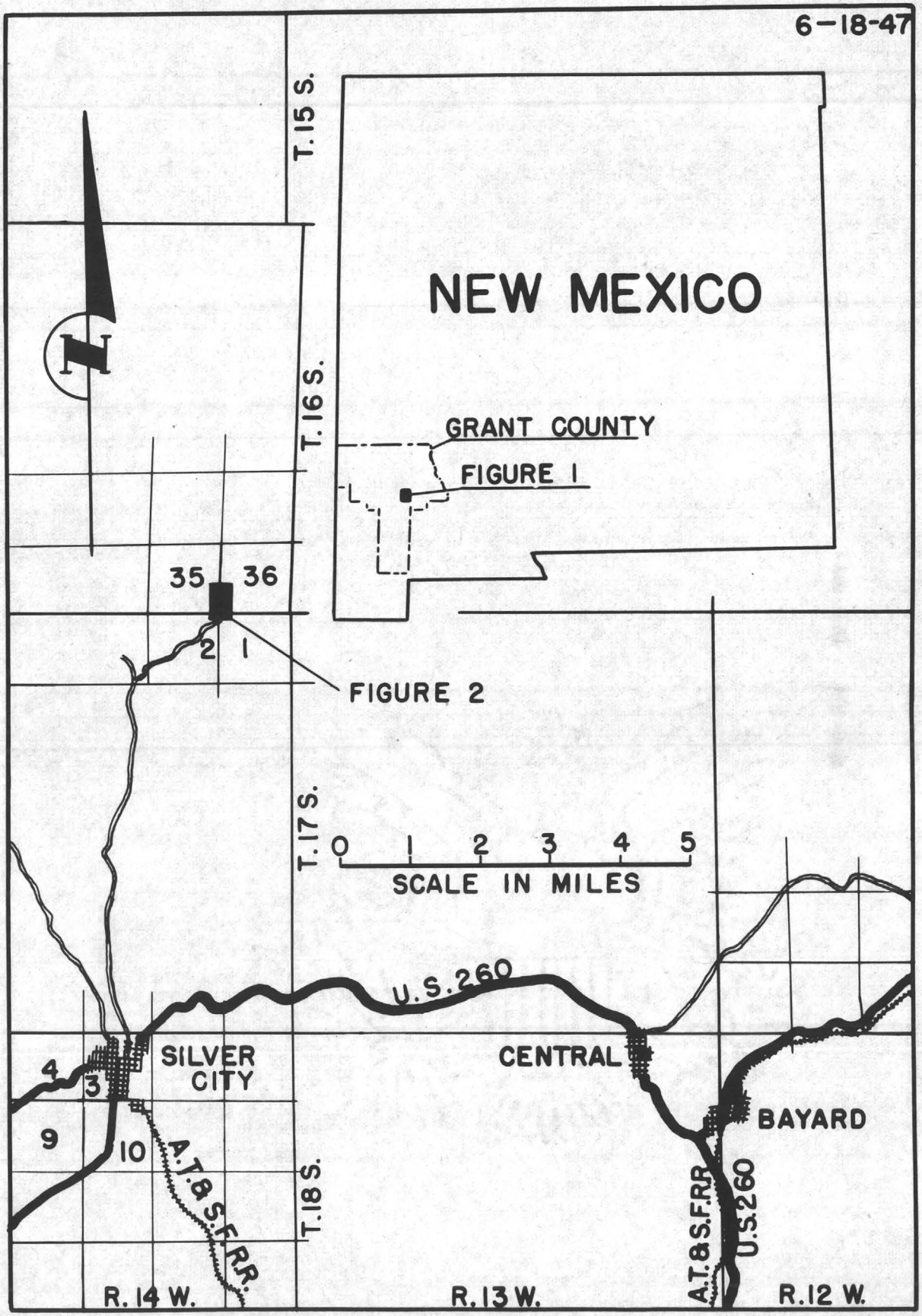


Figure 1. - Index map, West Pinos Altos project, Grant County, N. Mex.

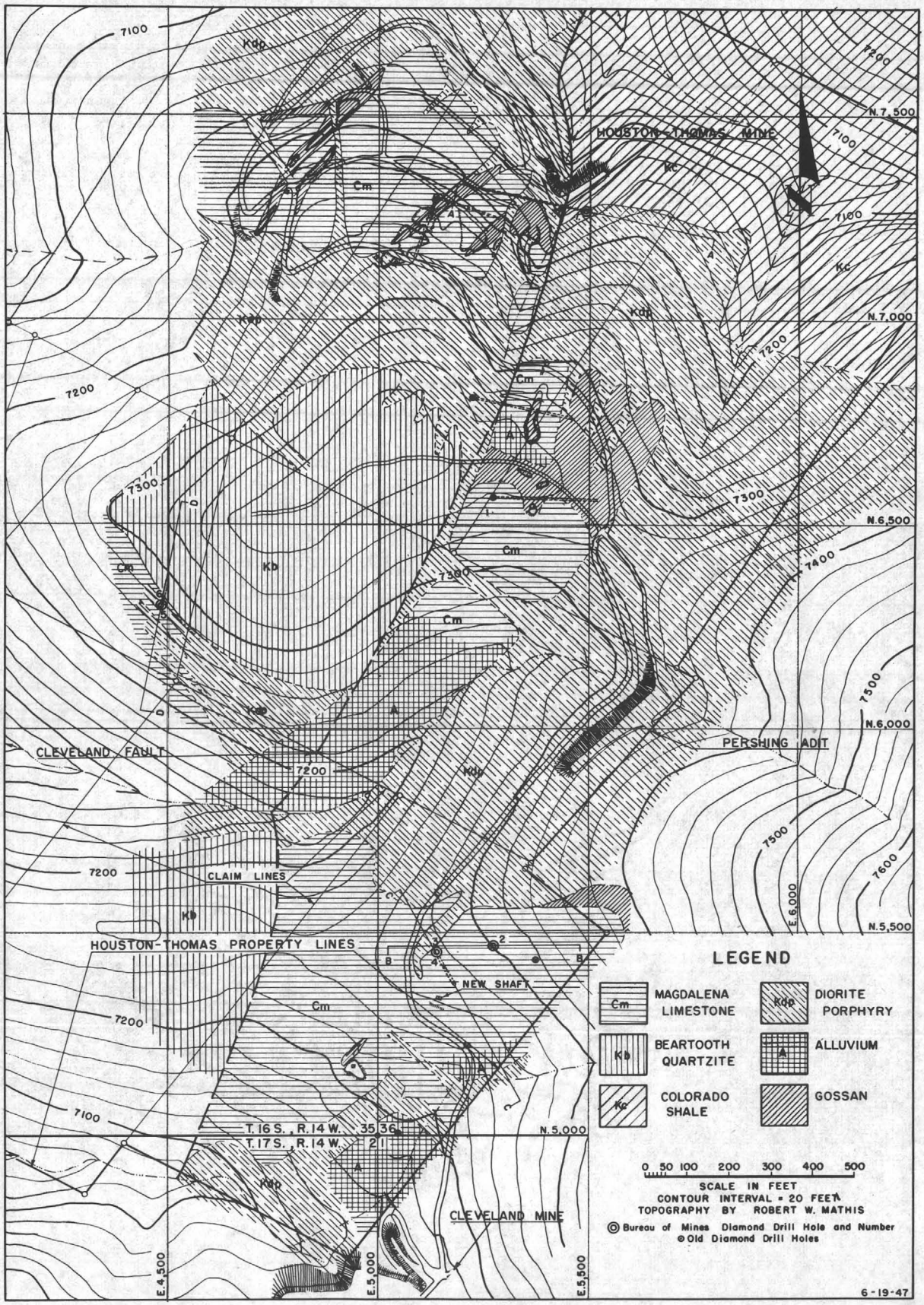


Figure 2. - Surface and topographic map, West Pinos Altos project.

is in secs. 35 and 36, T. 16 S., R. 14 W., and secs. 1 and 2, T. 17 S., R. 14 W. The Bureau of Mines work was confined to secs. 35 and 36 (figs. 1 and 2).

The district is reached by taking the Little Walnut road north from Silver City, N. Mex., to the Little Walnut picnic grounds in the Gila National Forest. Just before the picnic grounds are reached, the road forks to the right, or east, and this fork is taken to the mines. The road is paved for 2 miles from Silver City. It is 10 miles to the Houston-Thomas mine at the end of the road. Except for the paved portion, the road is a well-maintained dirt road, although it becomes somewhat slippery during inclement weather.

LABOR AND LIVING CONDITIONS

Silver City offers the closest available living accommodations to the West Pinos Altos area. In 1947, these accommodations are scarce because of a housing shortage. Labor is obtainable in Silver City. This town has a population of approximately 6,000, is the county seat for Grant County, and is the supply center for numerous outlying mines and ranches.

PROPERTY AND OWNERSHIP

There are 3 major groups of claims in the West Pinos Altos district. The Cleveland group consists of about 20 lode claims, mostly patented. This group was owned by the Empire Zinc Co. of Hanover, N. Mex., a subsidiary of the New Jersey Zinc Co. Douglas B. White of Silver City, N. Mex., leased the property and was conducting operations on a small scale. The largest production in the area was obtained from the Cleveland mine in this group of claims.

A second group of claims is the Houston-Thomas group, which consists of 15 patented lode claims. These were owned by Andrew B. Stewart of Silver City, N. Mex.. J. B. Mathis, also of Silver City, had a working agreement with Stewart. Appreciable amounts of lead-zinc ores have been mined from this property. All Bureau of Mines work was done on this group.

The third group is the Gold Nugget property, numbering nine patented lode claims. They were owned by George W. Heck, formerly of Silver City, N. Mex., and his associates, until Heck's recent death. Production from these claims has been negligible.

PHYSICAL FEATURES AND CLIMATE

The Pinos Altos Mountains are a small range lying just west of the town of Pinos Altos in north central Grant County. These mountains are about 5 miles long in a north-south direction and about 3 miles wide. The highest peak rises to 8,036 feet above sea level. The mountains are very steep in places, with local areas of ruggedness. The West Pinos Altos district lies on the western flank of these mountains at altitudes ranging from 6,900 feet to almost 8,000 feet. The mines are just over 7,000 feet (fig. 2).

The climate is moderate to cold and typical of those altitudes. The estimated temperature range is from below 0° F. in the winter to about 90° F. in the summer.

The estimated annual precipitation is about 20 inches. This occurs as heavy thunderstorms during the summer months and work-hampering snows in the winter.

There are no permanent streams in the area. One small spring furnished the bulk of drilling water used by the Bureau of Mines. This spring supplied 10 gallons of water a minute during the winter months, but slackened to 5 gallons a minute during the drier spring months. A small mill was operated intermittently on water from a lower level of the Cleveland mine.

Ponderosa and pinon pine, juniper, and scrub oak constitute the arboreal vegetation of the area. The ponderosa pine, though not overly abundant, should furnish enough timber for modest mining operations. Various small shrubs, cacti, and range grasses comprise the remaining vegetation. Cattle graze in the area.

HISTORY AND PRODUCTION

The history of the Pinos Altos district dates back to the discovery of gold placers on the east side of the mountains about 1860. The gold lode mines were found shortly thereafter, and the area was productive until the early part of the 20th century.

Other than prospecting, little was done during this time on the western side of the mountain. A few tons of oxidized surface ores were shipped, and a small gold property was operated. The Empire Zinc Co. acquired the Cleveland mine in 1913 and started operations. It constructed a magnetic concentrator and operated until 1919. In 1929, it undertook an extensive exploratory program on its own and adjoining properties. In 1942 Douglas B. White leased the Cleveland group. Mining of new ore was done by sublessees while White constructed a small mill to treat the old tailing dumps. White produced some ore from the Cleveland mine prior to July 1947.

Early operations on the Houston-Thomas group were confined to the easily accessible oxidized surface ores. B. O. Shepherd acquired these claims in 1943 and started mining sulfide zinc-lead ores. Andrew B. Stewart purchased the property from Shepherd in late 1945 and confined his operations to a small gold-bearing vein. This operation was not satisfactory because of the high smelter penalties exacted on the high bismuth content of the ore.

Stewart, through lessees, conducted a geophysical survey of his property in 1946. This survey was made coincidentally with the Bureau of Mines development project, and some of the data were used by the Bureau. One anomaly was drilled by the Bureau of Mines, and a lead-zinc ore body was disclosed. Exploitation and development of this ore body were started immediately upon its discovery.

Production figures for the district are shown in the following tables:

TABLE 1. - Houston-Thomas mine

Year	Ore, tons	Ounces per ton		Percent			Remarks
		Au	Ag	Cu	Pb	Zn	
Prior 1905	200 - 300	-	-	-	-	-	Oxidized surface ore.
About 1918	Small amount	-	-	-	-	-	Oxidized and sulfide ores.
1922	6,398	-	-	-	-	-	Lead carbonate ore.
1923	628	-	-	-	-	-	Do.
1943	302	0.032	5.316	0.546	1.577	6.407	Sulfide ore.
1944	2,018	.02	4.4	.4	2.9	8.0	Do.
1945	322	.01	2.9	.2	2.5	6.9	Do.
1946	45	.03	5.8	.4	3.4	9.5	Do.
to 7-1-47	1,102	.01	4.5	.129	1.307	9.945	Sulfide ore, new ore body.
Total	11,115						
1946 - 1947	1,018 of bismuth-bearing gold ore containing $19,773 in gold.						

TABLE 2. - Cleveland mine

Year	Ore, tons	Ounces per ton		Percent			Remarks
		Au	Ag	Cu	Pb	Zn	
1915	2,085	-	-	-	-	10.4	Sulfide ore.
1916	40,838	-	-	-	-	14.9	Do.
1916	3,487	-	-	-	-	-	Zinc carbonate ore.
1916	31	-	-	-	-	-	Copper carbonate ore.
1917	43,949	-	-	-	-	11.1	Sulfide ore.
1918	28,786	-	-	-	-	10.4	Do.
1919	2,364	-	-	-	-	9.8	Do.
1943	4,095	0.002	4.24	0.563	0.517	12.04	Do.
1944	5,305	.01	2.7	.2	2.2	9.7	Do.
1945	3,404	.01	1.5	.2	.9	8.9	Do.
to 7-1-47	Small amount	-	-	-	-	-	Zinc sulfide ore.
Total	134,344						

GEOLOGY

The oldest exposed rocks in the West Pinos Altos district are the Magdalena limestones of Pennsylvanian age. These are overlain by the Beartooth quartzite of Cretaceous age, which in turn underlies the Colorado sandstones and shales, also of Cretaceous age. The limestones generally dip gently to the east while the other sedimentary rocks generally dip gently to the west. The generalized areal geology is shown in figure 2.

Diorite porphyry intrudes these rocks. The intrusives occur as irregular dikes and sills, and possibly as stocklike masses of varying size. The small dikes and sills seem confined to the Magdalena limestones, while the larger intrusives occur throughout the sedimentary series. Small andesite dikes were noted in the shales.

The diorite underlies all known ore-bearing areas, and data are not available to show whether this is a very thick sill or a stocklike mass. One old diamond-drill hole shows the thickness of the diorite to exceed 600 feet. If this is a sill, the limestones beneath it should present favorable locations in which to prospect for ore, as the Hanover limestone, which is the principal ore-bearing formation in the Central mining district, occurs there.

Faulting is complicated in detail. Three faults of large magnitude are known as well as many minor ones. The earliest large fault is shown by the displacement of the sandstone and shale beds. This is a reverse or thrust fault and occurs in the northern part of the area near hole 1. It probably strikes northwest to southeast. The dip is to the southwest. This fault is premineral and preintrusive. Subsequent activity has obliterated its traces other than that of displacement of the beds. Also, no mine openings were made between the displaced beds, and a surface trace of the fault may be concealed by detrital material. Section A-A in figure 3 shows the emplacement of older limestone beds upon the younger shales and sandstones which was caused by this fault. The apparent vertical displacement of this fault exceeds 1,000 feet. No data are available as to its horizontal displacement.

A later major fault, which bounds the western part of the district, has butted the limestones against later igneous rocks. This fault is normal and has been traced for a considerable distance.3/ It does not traverse the mapped area, as shown in figure 2. The Cleveland fault seems to be a spur from this fault and traverses the area as shown in figure 2. The Cleveland fault is normal, postintrusive, and presumably postore. It strikes a little east of north and dips steeply to the west with the down throw to the west. The vertical displacement is about 300 feet, and the horizontal displacement may be as much as 500 feet.

Many minor faults and shear zones traverse the area. They usually strike northeast-southwest and dip steeply, generally to the northwest. Some of these faults are mineralized.

Gossans, some quite extensive, occur in the limestone and it is from these that the production of carbonate ores was derived. These gossans seem to be the residuum of exposed altered sulfide ore bodies. Some gossans represent completely oxidized sulfide ore bodies, others incomplete alteration where unaltered sulfides underlie the gossans, and other sulfide ore bodies were so deeply buried that no gossan was formed.

The sulfide ore bodies are the most important. They occur as irregular, flat-lying, tabular replacement deposits of varying dimensions. One old stope measured almost 200 feet in length, 50 feet in width, and was 15 feet high.

3/ Paige, Sidney, Silver City Folio, N. Mex.: Geol. Survey Folio 199, 1916, 19 pp.

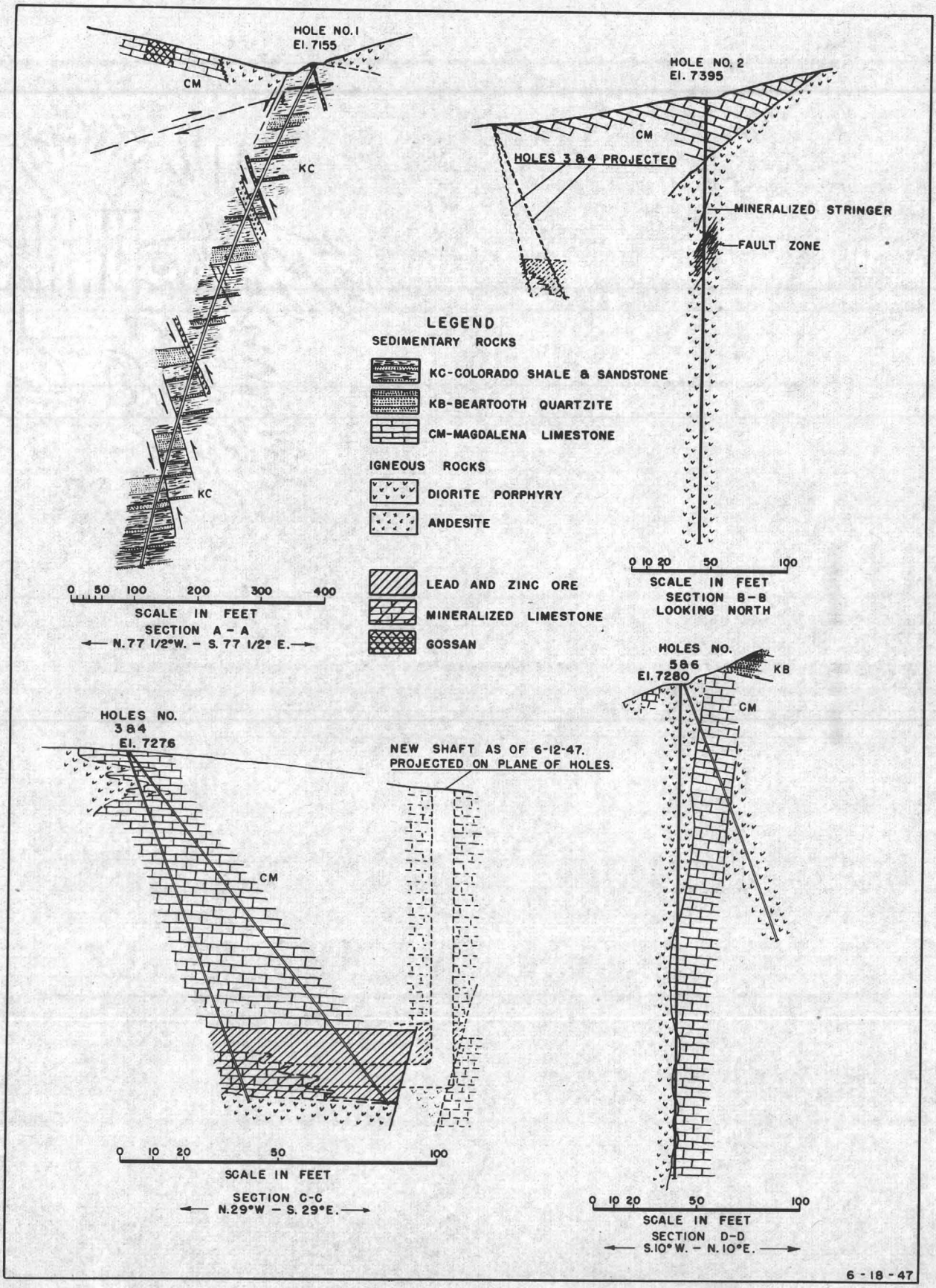


Figure 3. - Geologic sections, West Pinos Altos project.

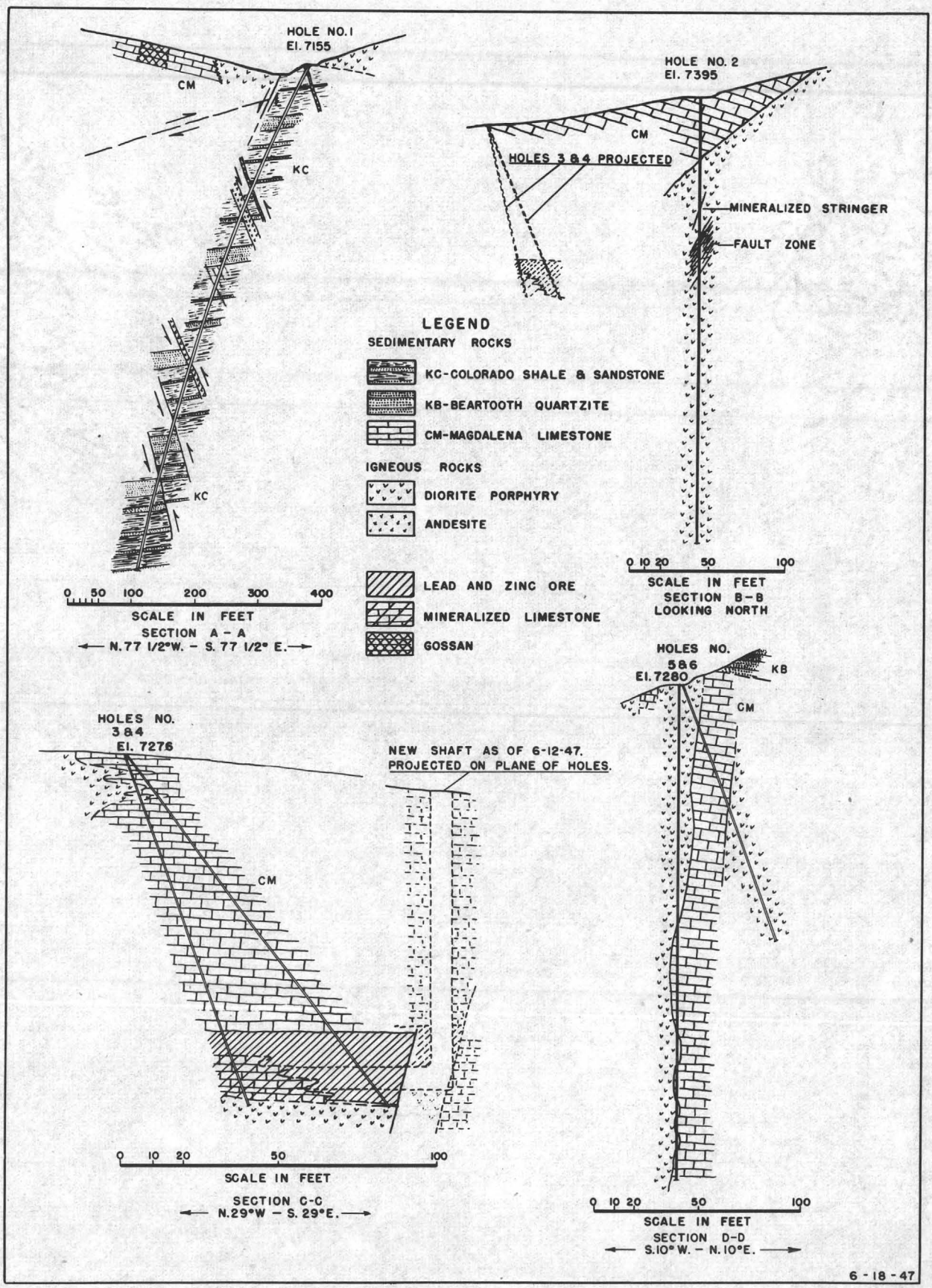


Figure 3. - Geologic sections, West Pinos Altos project.

The sulfide ore is a complex zinc-lead ore with both carbonate and silica gangue. Pyrite is plentiful. Marmatite, an iron-rich sphalerite, is the major economic mineral, followed by galena. Copper occurs as chalcopyrite. The silver content of the ores is appreciable and probably occurs with the galena. Gold is found in minute quantities.

The carbonate minerals, smithsonite, cerussite, and malachite, occur in the gossans, along with hematite, limonite, pyrolusite, and some unaltered minerals of the original sulfide ore body.

In the northern part of the district, two small veins were worked for the gold content. Bismuth minerals were an important constituent of one of these veins. The bismuth occurred as the sulfide bismuthinite, probably as the native metal and also as an oxidized mineral. Most of the gold was free.

Alteration of the sedimentary rocks by the intrusives was not severe. Some garnetization was noted, as was silification. Recrystallization of the limestone as marble was not pronounced. The sandstones and shales were, in places, quartzitic.

DEVELOPMENT

All major development work was done by means of adits. This was possible because of terrain features. The larger mines were interconnected with winzes and raises. One of the small gold mines was developed by a shaft. As the ore bodies were generally flat-lying, room- and pillar-stoping was practiced. The backs were very strong and the pillars few. Most of the gossan ore bodies were mined by "gophering" and by surface cuts.

The ore body discovered by the Bureau of Mines was being developed by a shaft a little over 100 feet deep.

WORK BY BUREAU OF MINES

Work on the development project was started in August 1946 and completed in April 1947. This work consisted of diamond drilling a total of 1,824.2 feet of hole.

Hole 1 (see fig. 2) was started to explore the Magdalena limestone beneath the Colorado shale, across the Cleveland fault from the Houston-Thomas mine. The hole was drilled beneath and parallel to the Cleveland fault. Faulting, not evident on the surface, caused a repetition of the shale beds, giving them an abnormal thickness. The hole was drilled to 880 feet, the limit of the equipment. As the Beartooth quartzite was yet to be penetrated, the Magdalena limestones must be at least 1,000 feet from the collar of the hole.

While hole 1 was in progress, R. W. Mathis procured a La Coste-Romberg gravitymeter and made a geophysical survey of the Houston-Thomas claims. The survey was based on a topographic map made by Mathis. A number of anomalies were noted, two of which were large. Final isomilligal maps of

these anomalies are shown in figure 4. The Bureau of Mines equipment was moved and spotted on a geophysical high on one of the anomalies. Hole 2 penetrated limestone to 43 feet, and the remaining 253.6 feet was in diorite. A small 1/2-inch stringer of lead-zinc ore was logged in the core at 77 feet. Section B-B (fig. 3) shows a graphic log of hole 2.

Closer spacing of the survey stations and recalculation of the instrumental readings changed the shape of the isomilligal map, and hole 3 was drilled to penetrate under the highest gravity meter reading (map 2, fig. 4). The hole was drilled on a slope to crosscut a possible steep vein, as well as a bedded deposit. This hole penetrated zinc-lead ore from 96.5 to 105.5 feet. Low-grade mineralized material underlies the ore. Hole 4 was drilled from the same set-up to test ground about 40 feet from hole 3 at the ore horizon. This hole also penetrated ore from 112.5 to 137.6 feet. Both holes bottomed in diorite porphyry. Section C-C (fig. 3) is a log of both holes.

As time was becoming limited, further drilling on this ore body was terminated, and the equipment moved to the second anomaly shown by the geophysical survey. A final isomilligal map of this anomaly is shown in map 1 (fig. 4). Hole 5 was drilled to 150 feet, and as it was barren, hole 6 was drilled to penetrate under the high points of the anomaly as known at that time. Hole 6 was drilled to 136 feet but was barren. To test deeper areas, hole 5 was deepened to 246 feet. No mineralization was encountered. The final isomilligal map (map 1, fig. 4) suggests drilling more to the north and west. As the equipment was needed on another project, this completed the field work in the West Pinos Altos area.

Over-all core recovery was good (especially so when drilling ore), so no sludge samples were saved. The core samples for analysis were split, and one-half was submitted to the Metallurgical Division of the Bureau of Mines at the Southwest Experiment Station, Tucson, Ariz. The results of the analytical work are tabulated in figure 5.

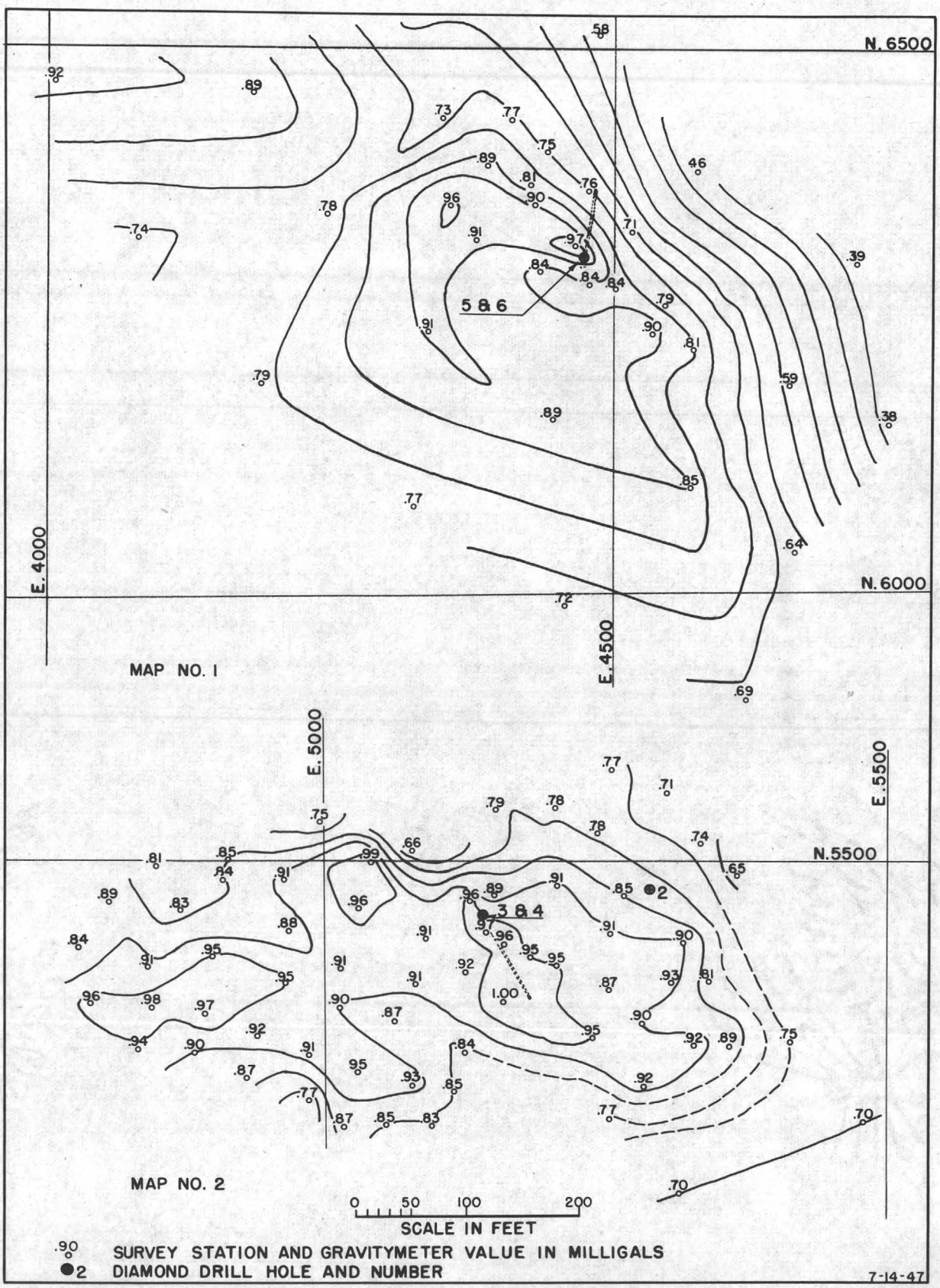


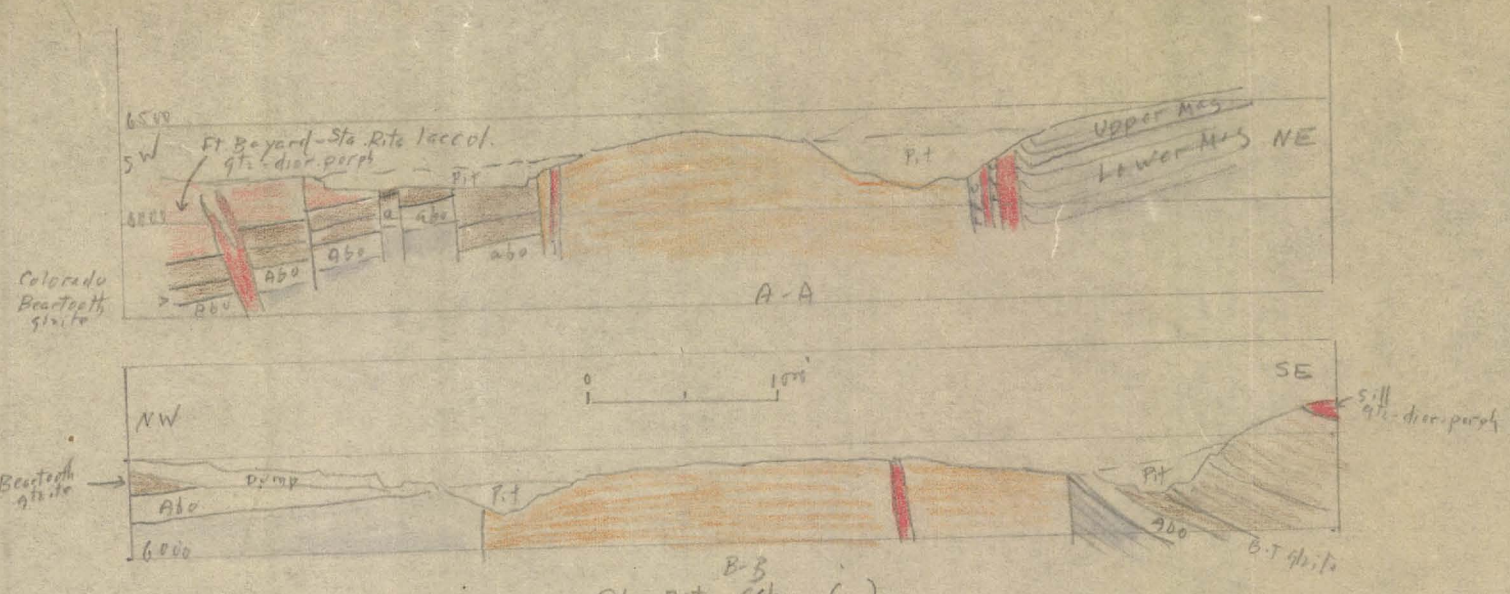
Figure 4. - Isomilligal maps, West Pinos Altos project.

6-24-47

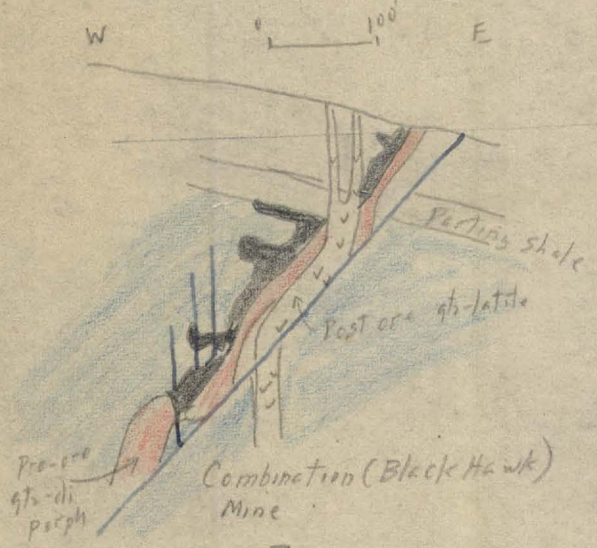
HOLES 3&4

FOOTAGE		ANALYSES				
		OZ./ TON		PERCENT		
FROM	TO	AU	AG	CU	PB	ZN
HOLE NO. 4		ALL CORE SAMPLES				
112.5	117.5	0.02	2.60	0.53	0.35	11.5
117.5	120.0	.01	1.10	.21	.25	12.4
120.0	125.0	.01	2.00	.18	.48	11.0
125.0	127.7	.005	1.10	.16	.24	9.2
127.7	132.7	.01	2.60	.23	.45	14.75
132.7	137.6	.01	3.00	.16	1.40	13.0
137.6	141.6	TR.	.30	.10	.20	.2
HOLE NO. 3		ALL CORE SAMPLES				
96.5	105.5	0.03	3.50	0.18	4.02	9.25
105.5	107.5	.01	.40	.10	.72	3.7
107.5	120.0	TR.	.10	.16	.11	.3

Figure 5. - Assay log, holes 3 and 4, West Pinos Altos project.



Sta Rita (Chino Co)
Fig. 6



Combination (Black Hawk)
Mine
Fig. 7

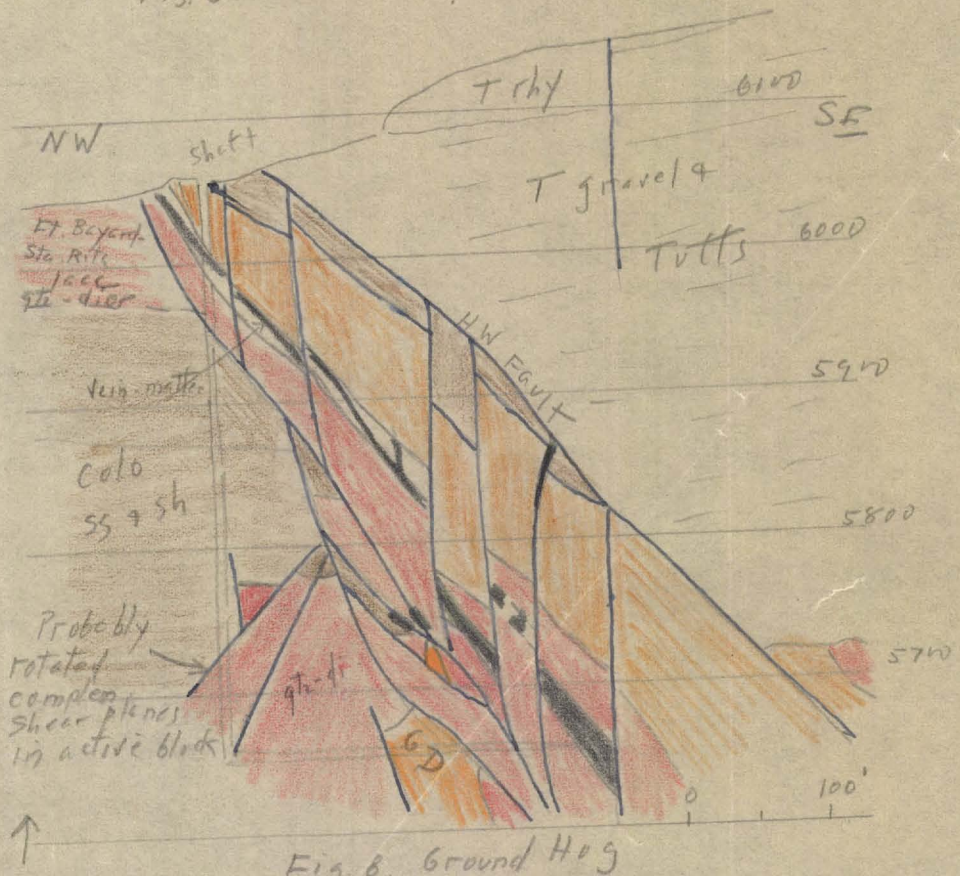
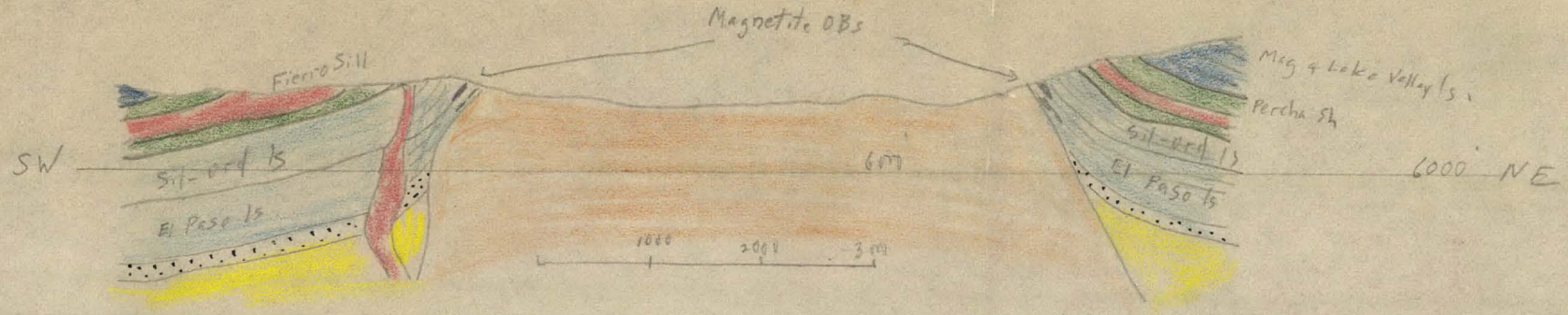


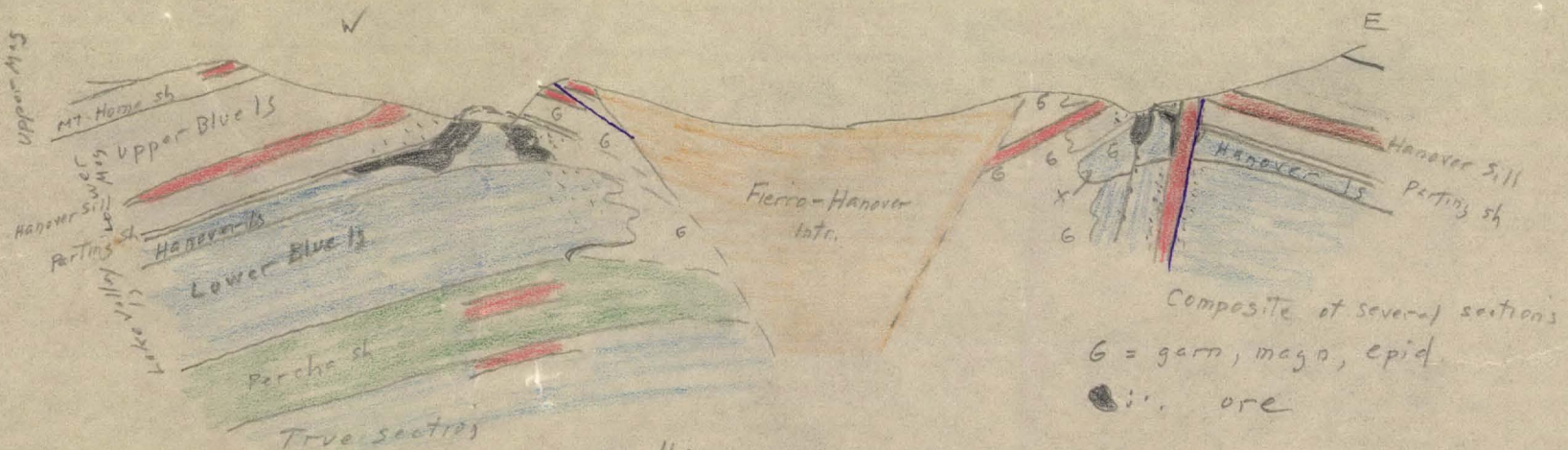
Fig. 8 Ground Hog

Tert. gravel, sands
tuff, flows
colo.
Hanover Mt
D1000
FIERRO
Barringer Flt.
Fierro Sill
Lake Valley ls
Abo Shale
Hanover Sill
HANOVER
Republic
Tert. Hanover Basin
Pewabic
Fig. 3
Fig. 4
Fig. 7
Blackhawk (Combination)
Black Hawk Fault zone
Cu Flat (Broad Dome)
SANTA RITA (dome)
Fig. 6
paige Flt
3 Bros
FORT BAYARD - SANTA RITA
LACCOLITH
Ground Hog Fault zone
Gold Gulch
Betty
Fig. 8
Ground Hog
Tert.
Section
Cret. Colo. Sh, ss, ls 2000
Up Com. Beartooth qtzite 100
Penn. Abo Sh 0-100
Penn. Upper Magdalena
Humboldt at top Mt. 391
Home sh at base
sh 60%, ls 40%
Lower Mag ls Parting 457
Shale at base
Miss. Lake Valley ls 343
110' Hanover ls at top
Dev. Percha Sh 200
Sil-Or ls (Mg) 225
Ord-€ El Paso ls (Mg) 500
€u Bliss ss 145
(ls Mg, sh, qtzite
Pre-€ sch & granite
Igneous
Granite, gd, qtz mona. stocks etc
Gd porph sills & laces
Brown
grey
Dk green
azure
yellow
0
5000'
10000'
1 mi

Fig. 1



Section through Main Intrusive, Fierro, N.M.
Fig 3



Hanover Area - Diagramatic Section:
No Scale (beds drawn @ 1" = 500', but intrusive 1/3 ± true width)
at X - represents S, not E, side of intrusive - Hanover ls. squeezed out - undergoes plastic flow when subjected to great unbalanced pressure.

Fig. 4

INFLUENCE OF PREEXISTING STRUCTURE ON LATER DEFORMATION

VOLCANIC SUCCESSION AND POSSIBLE MINERALIZATION IN THE DWYER QUADRANGLE, SOUTHWESTERN NEW MEXICO*

Wolfgang E. Elston
Department of Geology, Texas Technological College, Lubbock, Texas

1955 AM

[redacted]

EDWARD WISSER
MINING GEOLOGIST
422 ACHESON BLDG.
2131 UNIVERSITY AVE.
BERKELEY 4, CALIF.

TELEPHONE ASHBERRY 3-1366

CENTRAL DISTRICT, NEW MEXICO.

Source Data: Central Mining District, N.M.Harrison Schmitt,Tr.AIME 115 ('35),187-208; Ore deps.related to structural features, Certain Ore Deposits in the SW, Central Mining District,73-77.

Regional Setting.- Granodiorite porph.and qtz-monzonite porph stocks (with which are assoc.all imp.OBs of Silver City distr.) are grouped around structural basin 15 mi.in diam. Upper Cret.Colo.crops out in cente r;rks as old as pre-Є crop out on rim.Middle depressed 3000' below W,S,E edges. Trave lling clockwise around the outside, following camps met: Fierro, Hanover,Sta.Rita, Ground Hog, Lone Mt., Silver City,Chloride Flats, Cleveland, Pinos Altos.

Section.-

Late Upper Cret.
3. Qtz-dior. GD & QM porphs. Dikes.
2. Gran, GD, QM stocks and/or chonolith
1. GD porph. sills & laccs.

Main mineraliz.

Major faulting began

Tertiary Qtz-la tite vitrophyre dikes,PM.
Basalt,andesite,latite,rhy.,flows,tuffs brecc.1500 $
Gravel,sand,tuff 300'
Unconfor.
Cret.
Lower Upper Colo.sh,ss,ls. 2000'
Upper Comanchean,Colo. Beartooth qtzite 100'
Unconformity.
Lower Permian? Abo? red shale,10 pc.ls cgl. 0-100'
Unconformity
Penn. Upper Magdalena (261'Humboldt format top,130' Mt.
Home sh.at base. 60 pc.sh, 40 pc.ls. 391'
" Lower Mag.ls,18'Parting sh.at base. 457'
Unconformity
Lower Miss. Lake Vally ls.(110'Hanover ls at top*) 343'
Upper Devonian Percha sh. 200'.
Unconformity
Silurian-Ordov. Fusselman,Montoya ls(mg) 225'
Ordovician,upper Є El Paso ls(mg) 500'
Upper Є Bliss ss(Mg-ls,sh,qtzite,cgl 145'
Unconformity
Pre-Є schist, gran., pyrox.

(2,3 continuous,differentiating intrus.) Several stocks when 1st intruded were feeders for laccs & sills.

* Ha nover ls varies from 80-150'thick due to centrifugal peripheral thrust during intrusion of Hanover stock,max.measurement on crest, min.on E limb of peripheral anticline (Figs 1,4). No other formations in Hanover are a greatly deformed,but at Fierro the sub-Percha ls horizons are stretched thin by doming along their contact with main intrusive.

Structure.- A n inlier of pre-Tert.seds & intrusives 8 mi.diam. surrounded by Upper Cre t.& Tert.volcs & Quat.sand & gravel.Inlier a dome,on E limb of large basin mentioned.Closure given on NW by Barringer f ault,down 1000' on NW;on NE side by normal flt at Georgetown,NE side down much.Dome closed on S and W by S & W dips of seds.

Secondary structures modifying the dome: (1) N-S anticline with Fierro-Hanover GD,gran.stock as axis;(2)broad flat dome,Cu Flat QM por stock as center;(3)syncline,S continuation of (1) axis. (3) starts just S of Hanover,extends S toward Ground Hog.Largely result of faulting. Synclines E and W of Fierro-Hanover anticline.

Tertiary (not age)structures: (1) local dome around Sta.Rita stock;(2) tilted dome over Fierro lacc.(3) assymetr.peripheral anticline borders S end Fierro-Hanover stock,app.caused by centrifugal thrust from latt er,for form of assymetry and associated (marginal) thrusts point to stock as source of active pressure (Fig.4).Hanover ls thickened on anticlinal axis,thinned on limbs.At one place at least sub-Percha beds not

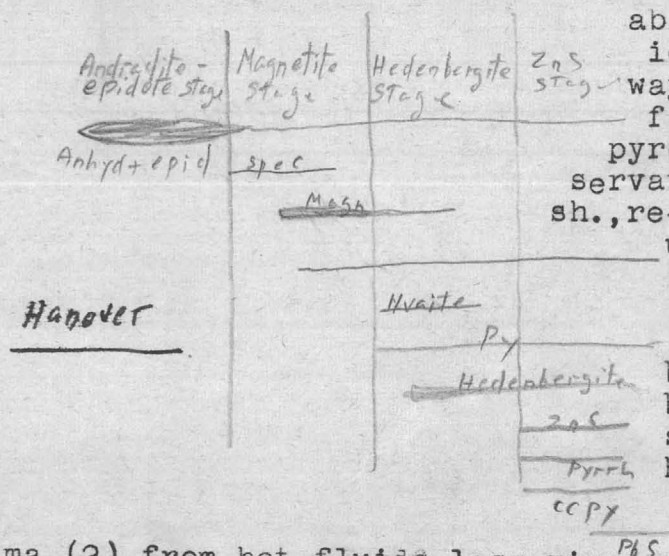
folded into the anticline. Intrusive probably has a floor, supra-Percha formations shoved outward over sub-Percha beds, 500' thrust. Hanover ls. acted as a plastic mass when subjected to the active thrust under gre at confining P. Shown by shape of deformed ls in Fig. 4. Plastic deformation facilitated by large polysynthetically-twinned calcite xx, recrystallize d crinoids, of which ls is composed; can deform them with a knife blade.

Limb of periph. syncline nearest the stock seems thinned by stretching caused by subsidence (sounds fishy) following solidifcation of stock. Subsidence of stocks in district following solidification shown by inward-dipping normal contact faults and by occurrence of normal-fault bloc k subsidence in are as underlain by intrusive masses. (Graben faulting a fter uplift). Some of these "s ubsidence "normal flts cut Fierro-Hanover stock and localize pre-pyrometasomatism dikes. (Shows merely that intrusive solidified before the faulting-solid top pushed up, stretching cover, graben formation etc. Pyrometas. always later than solidif. of intrusive—Conc. del Oro).

Major faulting began between between intrusion of sills and that of the stocks (see section) and continued with decreasing intensity until post-ore time; PM displacements small., any flts reopened often thru period from pre-early dike, pre-ore to post-ore.

Igneous structures: Stocks: Fierro-Hanover, Sta. Rita, Copper Flat "stocks". Laccoliths: Fierro (in Percha sh. just W of Union Hill); Fort Bayard -Sta. Rita intrusive sheet or laccolith is near base of Colo. formation. Fierro-Hanover stock ma y be inverted-cone-shaped (Fig. 4). (In ODs rel. to struct. features, 1938, Schmitt says DD has proven floors for S end, Fierro-Hanover intrusive, mine development, floor for Ground Hog ditto. N or Fierro part of F-H intrusive has ouward-dipping contacts, but occurr. of G at many pla ces along the intrusive contact and nowhere else suggests this part of the mass also a laccolith. This is not necessarily so-e.g. diapir. Says some of doming at least is result of blistering by the many sills.. There is a concentration of sills near the post-sill GD intrusives so intrusive centers were earlier feeders for the sills & laccs.)

Mine ralization.- At Hanover & so far as known, elsewhere in distr. MIN. Came after intrusion of qtz-dior., GD and QM por. dikes, before Tert. volcs.



Roots and branches of ZnS OBs extend vert. above and below the OBs, sols. moved vertically, at least locally, not radially away from main intrusive (Hanover) as a focus. Source for magma, on one hand, pyrometas. on other, far below zone of observation. Two types at Hanover: (1) hornsfelsized sh., re-xx ls, 1000'-3000' halo around F-H mass, uninfleunced by fractures, faults, brec.; (2) pyrometasomatism, inner irreg. zone ave. 600' in Hanover ls, less than 200', unfavorable horizons; sharply controlled by structural forms; as roughly tabular bodies goes more than 1500' from intrusive contact. (1) from pressure & the heat & possibly other properties of rapidly infiltrated hot tenuous gases-contemp. with marginal thrust of magma. (2) from hot fluids less viscous than magmas but with appreciable surface tension. Garnet formed after Hanover ls. deformed.

Fierro mineraliz.largely repl.of dolomite and Mg ls that make up most of the section be low Percha sh. Here,as opposed to Hanover,mass. serp.,wollastonite,not garnet-epid. Serp.probably hypogene.

Localization and form of the OBs.-

Fierro.

The magnetite OBs at Fierro follow the intrusive contact & replace favorable beds;tabular bodies 25'thickmsep.by tabular horses of wollastonite rk. Magnetite-silicate zone 200'wide. Magnetite also found in places along Barringer flt. & at sill contacts. At Hanover Mt.,in HW Barringe f lt,qtz-se r-Cu-py dissem in Colorado sh,ss;Cu2S enrichment. Due to brec of flt.HW.

Hanover.

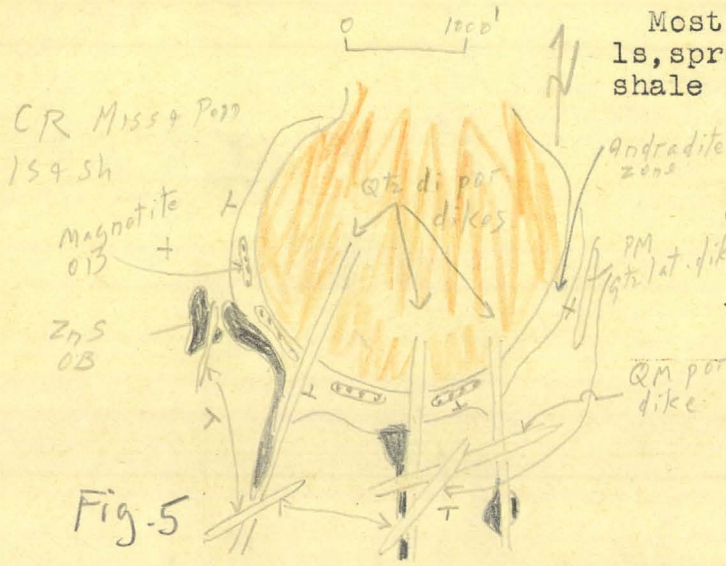


Fig-5

Most of ore in 110' crinoidal Hanover ls,spreading out under superjacent Parting shale (Fig.4);always in ground prepared: fractured, faulted.Closely associated with earlier silic ates. Some of largest OBs along faulted outer edge of garnet zone (Fig.4,5).Horiz. blankets,1'-45'thick,to 200' diam., associated with gentle antic.,sync under Parting sh. Fault-dikes yield steep tabular OBs,max.width 30', ht.110',length 1000'.

Sta.Rita.

Cu disse m.ore horseshoe 4000'diam.350 'thick, S limits undefined, envleoping a GD stock (Fig.6)

Black Hawk,Ground Hog.

Blackhawk OBs chimney-like,ma de along fault intersections and junctions;Fig, 7 shows vert. feather joints or compementary shear planes off main FW "normal" flt.(Incidentally since Schmitt says minimum vert.displ on Barringer, Bull Frog and Ground Hog faul t zones 1000'kthe Black Hawk FW falt.,with the small displacement shown, cannot be the main Bull Frog or Bla ck Hawk fault). The qtz-dio-por.shown in Fig.7 is a nec k coinciding with an intersection. Along each chimney ore favors pure ls,avoids sh,imp.ls,sills. Lower parts of shoots in Hanover ls,end abruptly downward in shaly ls .Upper parts of chimneys in alt.ls with minor sh.of Lower Magdalena. BH ore IM in type between pyromet,Hanover ore & Ground Hog: pyrom.silicate s plus abundant qtz,py;gal as well as ZnS;Ag.

Ground Hog: Ore in levels above 800 prob.formed at lower temp.than Combination ore, for gal.,ccpy,Ag more imp.ZnS.Gangue directly ass.with ore:qtz,seric.py. According to Lasky, ODs rel.to structural features,244, veins of GH area follow walls of GD dikes that were injected a long earlier faults (Ground Hog flt zone). Dikes commonly pronged;crotches and we dge ends of prongs were guideszthat directed the fissures.Main shoot to 25'thick,500'~~long~~ "broad",stope length 1200'.Lies in a narrow strip between two overlapping mod.-dipping GD dikes,one of which has a FW prong.

Post-dike ore fossuring confined to this strip.Main break,throw 240', along HW of lower dike,but filled with gouge,brec.,practically no ore. S hoot in HW of this faultin sheeted zone following under-side of upper dike and its FW prong?, Qtz-py first minerals, occupy joint grid,original pattern;not replaxed by late r minerals. At one place sheeted zone fa ulted by pre-min.antithetic faults from main fault.Looks like PM faulting.

Shoot pitches at angle of only 11o;has been explored for a pitch length of 3500'. (This refers to main ore band within which GH shoot lies;pitch of that shoot the same as the general band).

Note s by E.W.- Igneous uplifts,complex. General dome bigger than Fig.1. Barringer fault a synthetic fault related to this,as is Georgetown fault. Looks like doming persisted into Tert. Fierro-Hanover anticline seems to persist to Ground Hog area as a horst. Whole thing curved,probab ly coincides with rim of major basin.Note radial dikes and faults at S end of Hanover anticline.Marginal thrusts,perippheral anticline. Fig.4, may be resemblance to Loon Lake pluton.

A STRUCTURAL AND TECTONIC ANALYSIS OF THE CENTRAL MINING DISTRICT NEW MEXICO

by

Joseph G. Wargo

Introduction

The Central District is located in southwestern New Mexico, near the town of Silver City. (See Fig. 1) Zinc and iron deposits of contact metasomatic origin occur in the vicinity of Hanover and a major disseminated copper deposit is found at Santa Rita.

Structure

The Central District lies near the southern periphery of the Colorado Plateau. The trends of faults, the elongation of mountain chains and the distribution of intrusives outline a major northeast and northwest structural grain in this part of New Mexico. Within the district numerous intersecting faults are found, but no direct evidence exists that the intersection of these structural elements is influential in the localization of ore bodies.

West of the Central District lies the axis of a NNW trending shallow synclinorium. The eastern flank of the the synclinorium, in the district itself, is modified by the northwest trending Bayard Arch and at least two smaller domes as well as by numerous sills and transgressive stocks. (See Fig. 1)

Geologic History

The geology and history of the area during the Pre-Cambrian is not well known. It is possible that some geosynclinal sedimentation occurred here, in what Schuckert (1922) has called the Ontarian Geosyncline which may have existed in the southwestern United States and extended to eastern Canado. Northeast trending structures in the Pre-Cambrian are common and they may have been formed during the destruction of this geosyncline.

During the Paleozoic, sedimentation was more or less continuous, but not heavy, suggesting that the region was a foreland rather than an active trough. No Triassic, Jurassic or Lower Cretaceous sediments are recognized in the Central District. The first major period of volcanic activity occurred in Upper Cretaceous (Colorado time) during which breccias and flows were interbedded with shale. This period of volcanism was followed by (1) intrusions of sills on a grand scale (2) intrusion of stocks and formation of the Bayard Arch and (3) alteration and mineralization. During the Tertiary period the region was covered by extensive flows of volcanic rocks ranging in composition from rhyolite to basalt. (See Fig. 2)

Ore Deposits

Zinc and iron deposits of contact metasomatic origin are found around the Fierro-Hanover stock. The deposits occur on the sediment side of the contact aureole. Limestone is the most important host rock for the deposits. (See Fig. 3d)

The copper minerals at Santa Rita are disseminated throughout a granodiorite stock. The deposit has a roughly annular shape. (See Fig. 3a) The Santa Rita stock has been strongly fractured and highly altered. Areas of strong pyritization upon which argillic alteration has been superimposed are the most favorable for disseminated copper mineralization. The deposit has undergone at least one and possibly 2 periods of supergene enrichment and the value of present deposit is due largely to the secondary copper minerals formed during those periods of enrichment.

In view of Martin & H.'s paper which mentions strong faulting on the N. side of Santa Rita, I tried to orient the discussion toward a possible fault control relating the Chino pit, which may not have served as magma dykes & copper aureoles around the Santa Rita stock, to Bisbee & also at Hanover/Fierro by mineralization. Similar aureoles occur at Bisbee & also potential in north alt'n/granite

Tectonic Analysis of various features

1. Influence of sills on folding---The shales on the east side of the major NNW synclinorium have been intruded by thick sills of Upper Cretaceous age, (see Fig. 2) while the rocks on the west side were not invaded by sills. (see Fig. 3b) Subsequent tectonic activity has caused the westernmost rocks to fold into a series of minor anticlines and syncline, with only minor faulting. On the east side of the synclinorium however, the rocks were broken by numerous faults. The different behaviour of the same kind of rock (shale) appears to be related to the presence of sills. Where the sills are found, the section becomes more competent, allowing faults to form, whereas in an area of no sills the incompetent shales respond by folding. The economic significance of this silling is felt in the Bayard area, SW of Santa Rita where rich zinc-bearing veins (Groundhog mine) are found associated with faulting and intrusion.

2. Influence of basement structures on overlying rocks---West of the Central District, in the vicinity of Silver City, are found at least two major monoclines. The southwest side of each monocline is a normal fault, which apparently was re-activated after Paleozoic and Mesozoic sediments were deposited over it. With the re-activation of the fault, the sediments were draped over it and subsequent erosion exposed the top of the fold. (See Fig. 3c) The presence of rather thin sediments and of fault-controlled monoclines suggests a basement control not unlike that found in the Bighorn-Beartooth area of Wyoming and Montana.

3. A hypothesis concerning the occurrence of porphyry copper deposits in the Central District---Although the Santa Rita stock and the Fierro-Hanover stock are close together and are probably connected at depth, the Fierro-Hanover stock does not contain a disseminated copper deposit. The structural setting of the two stocks in question may have a bearing on the reason why one stock contains a disseminated deposit and the other does not. The Fierro-Hanover stock occurs on the top of the Bayard Arch which is structurally high with respect to the surrounding country. During the time of intrusion and ore formation the area was also topographically high. It is possible then, that if an ore deposit was formed near the surface of the stock, subsequent erosion would quickly expose it. If erosion proceeded at a greater rate than enrichment, the net result would be to strip away the deposit, leaving the barren rock beneath. In contrast, the Santa Rita stock is structurally lower, and hence is less likely to have undergone excessive erosion. Kerr et. al. (1950) points out that the long axis of the Santa Rita stock, which corresponds to the axis of uplift at the time of intrusion, is less altered and less mineralized than the sides, suggesting that erosion tended to outdistance enrichment along this structural high.

SELECTED REFERENCES

Kerr, Paul F. et.al.(1950) Hydrothermal alteration at Santa Rita, New Mexico, Geol. Soc. Am. Bull., vol. 61, p. 275-347.

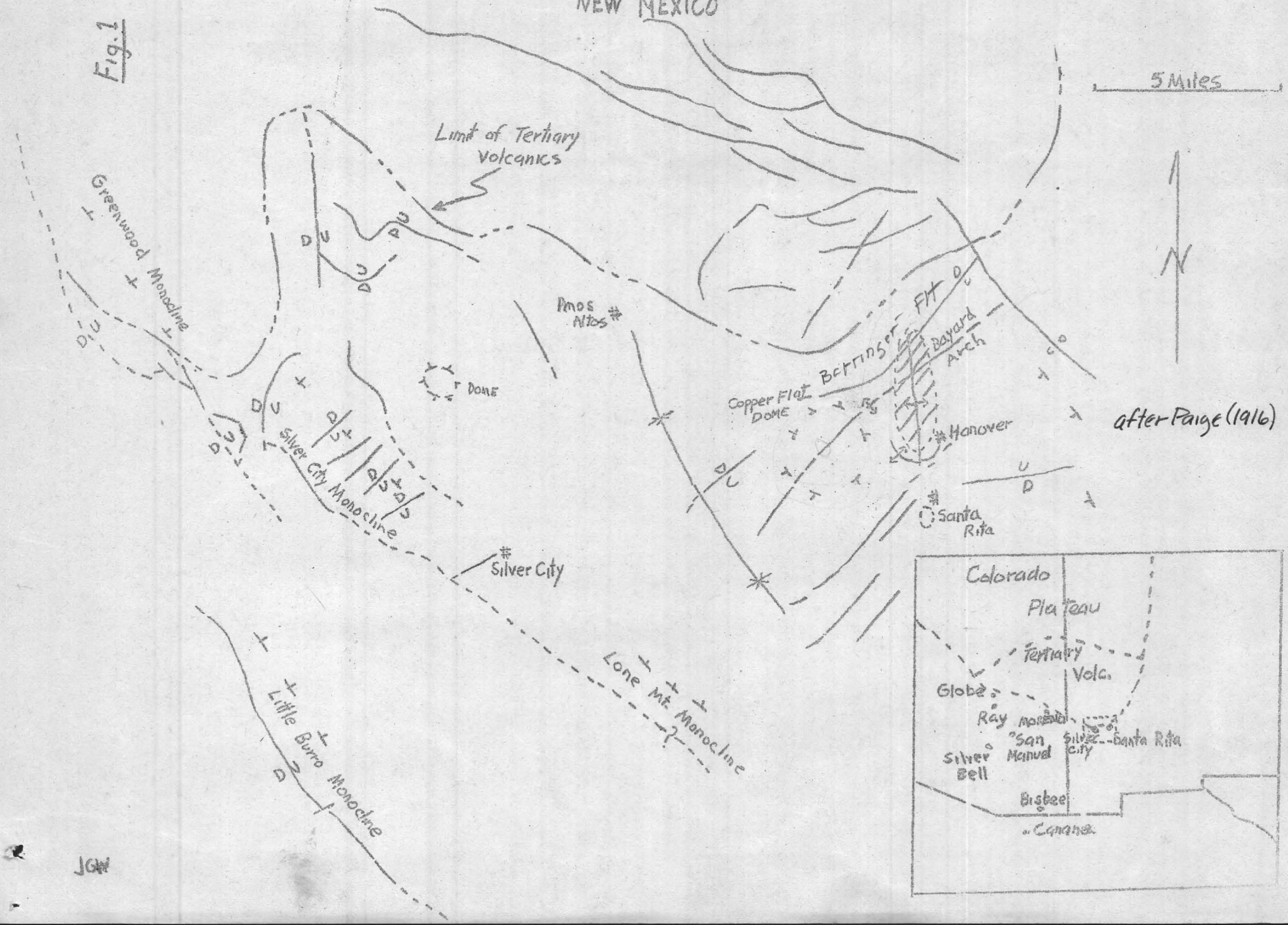
Laskey, S.G. (1936) Geology and ore deposits of the Bayard Area, Central mining district, New Mexico, U.S. Geol. Survey Bull.,870.

Paige, Sidney (1916) Silver City folio, No. 199, U.S. Geol. Survey.

Spencer, A.C. and Sidney Paige (1935) Geology of the Santa Rita Mining area, New Mexico, U.S. Geol. Survey Bull. 859.

Fig. 1

MAJOR FAULTS AND FOLDS IN THE SILVER CITY QUAD NEW MEXICO



after Paige (1916)

JGW

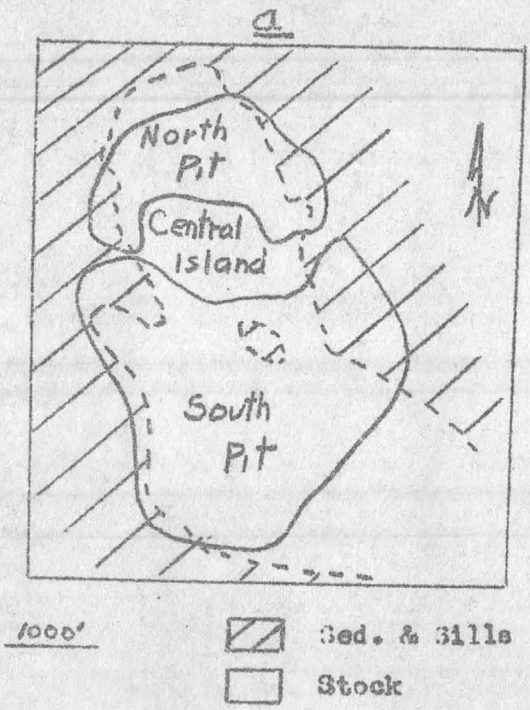
Fig. 2

SEQUENCE OF GEOLOGIC EVENTS IN THE CENTRAL DISTRICT, NEW MEXICO

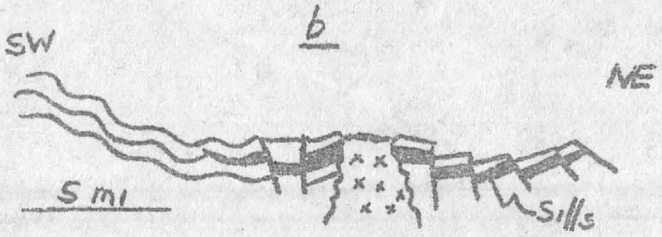
Period	Events	Remarks
Tertiary	Faulting, minor volcanism	faulted gravels and volcanics
	Erosion, enrichment of primary copper to form present deposit	major ore forming stage (Supergene)
	Basalt and rhyolite flows, breccias	
Upper Cretaceous	Hydrothermal alteration, primary ore deposits, few dikes	faulting, major ore forming stage (Hypogene)
	Emplacement of stocks, formation of Bayard arch, contact deposits	
	Emplacement of sills, faulting	
	Deposition of Colorado fm, some volcanism	pre-ore volcanics
TR, Jur. Lower K.	Unknown. Erosion (?)	
Paleozoic	Sedimentation	no major tectonic activity
Pre-Cambrian	Sedimentation, intrusion, metamorphism, erosion	possible development of major NE structural trends (?)

JGW

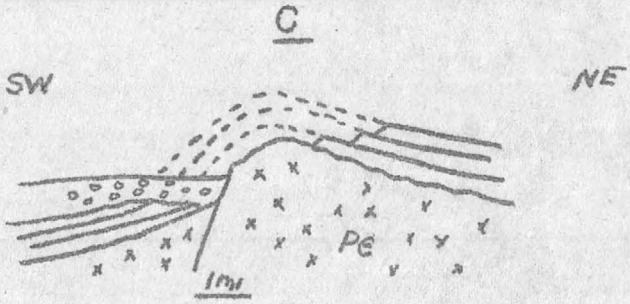
Fig. 3



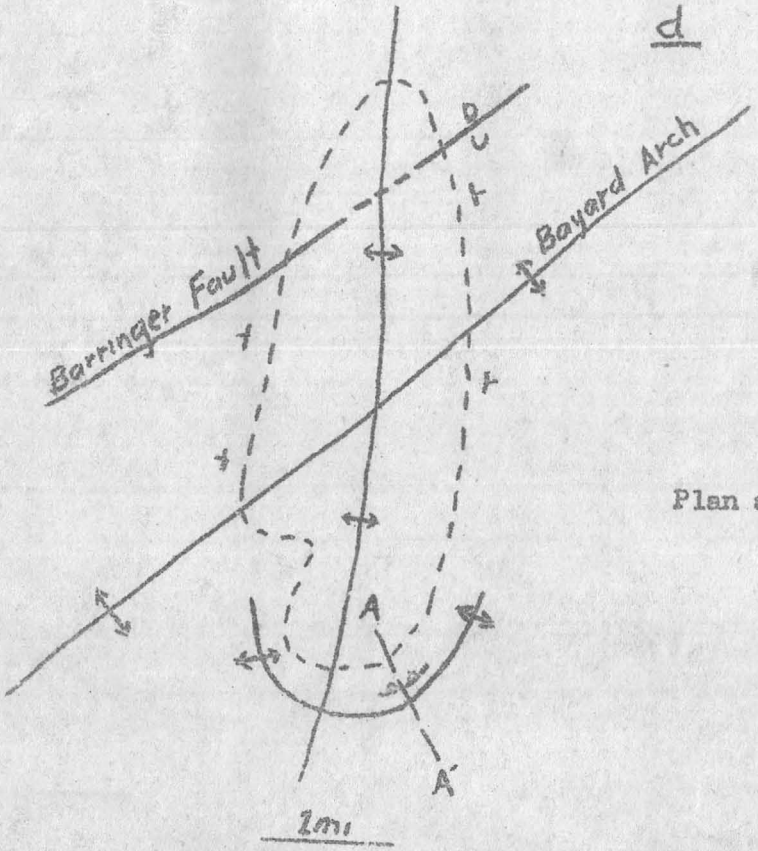
Santa Rita Copper Deposit

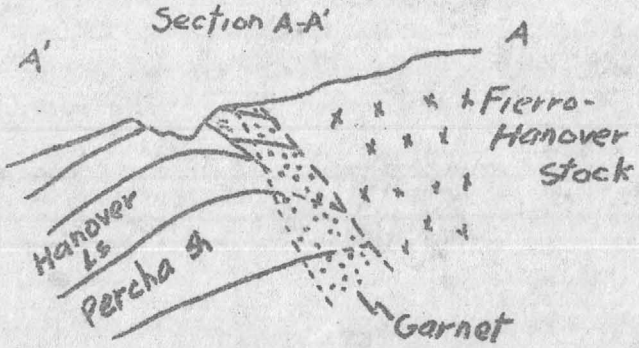


Cross section across Synclinorium
(Schematic)



Cross section across typical monocline,
near Silver City





Plan and section--Hanover-Fierro Stock (Schematic)
(Cf. Fig. 1)

Wisser

Pewabic Mine

BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
VOL. 50, PP. 777-818, 2 PLS., 6 FIGS.

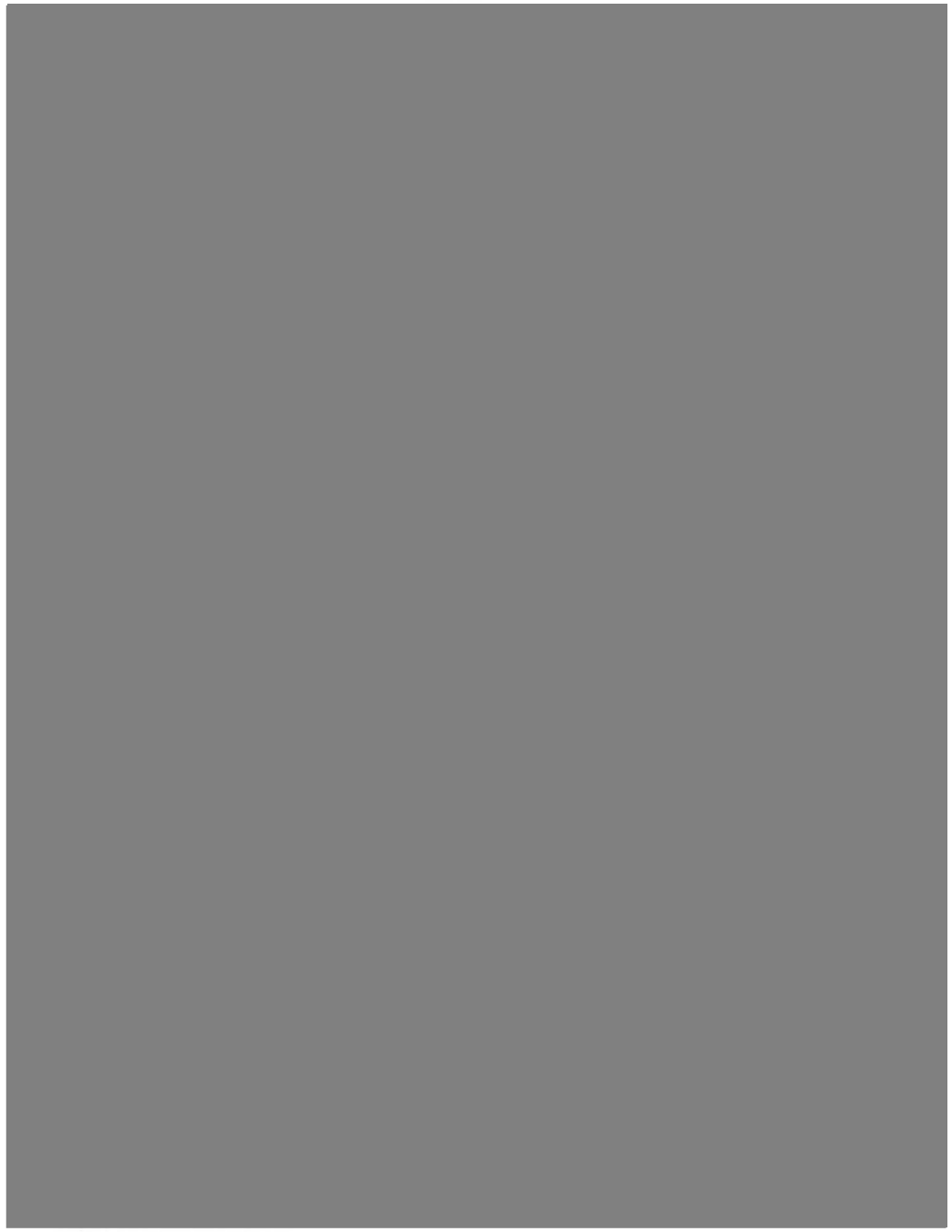
THE PEWABIC MINE

BY

HARRISON SCHMITT

NEW YORK
PUBLISHED BY THE SOCIETY
1939

DIKES



To Edward Wisser
from Harrison Schmitt

BULLETIN OF THE GEOLOGICAL SOCIETY OF AMERICA
VOL. 50, PP. 777-818, 2 PLS., 6 FIGS. MAY 1, 1939

THE PEWABIC MINE

BY HARRISON SCHMITT

CONTENTS

Page

Abstract 777
Introduction and acknowledgments 778
Sedimentary rocks 778
Igneous rocks 782
Structure 786
  Folds and faults 786
  Dikes 788
Minerals 789
Metamorphism 797
Paragenesis 804
Spatial concentration of minerals 806
  General statement 806
  Localization of ore bodies 807
Theory of origin of mineralization 810
Summary of conclusions 815
Works to which reference is made 817

ILLUSTRATIONS

Figure — Page

1. Key map of the Central Mining District 779
2. Relative age-composition curves for the igneous rocks 785
3. Geology of the 228-foot level 788
4. Paragenesis 802
5. Longitudinal section BB′ 803
6. District section XX′ 803

Plate — Facing page

1. Metamorphism of three typical rocks 798
2. Areal geologic map and sections of Pewabic Mine and vicinity 818
2a. Composite plan of ore bodies ..... in pocket, back cover
2b. Endomorphism and exomorphism ..... in pocket, back cover

ABSTRACT

The Pewabic mine is in the southeastern part of the zone of pyrometasomatism which surrounds the intrusive quartz monzonite at Hanover, New Mexico. Extensive development has proved that the south lobe of the intrusive is floored and that the sedimentary rocks, chiefly limestones, shales, and intercalated quartz diorite sills,