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

TRIP THROUGH BISBEE PIT JULY 25, 1952

Talked Milt Lindholm (retires Oct. 1, 1952) and went through Pit with Jim Keim (Penn State?). Also talked to Bill Crawford, Mine Supt. and Mine Foreman ?

Section of pit south of highway on 5100 bench shows wide area of "Glance Conglomerate" - unsorted, generally fragemental, unconsolidated to consolidated; some areas almost entirely schist, others with considerable limestone. One seam of mineralization with little oxide copper, some chalcocite observed; also appears to contain some quartz mineralization irregularly through it. At first appearance is more like a breccia than conglomerate, but wide areal extent suggests another origin. Contacts with limestone and porphyry not clear on this bench, but may be better onnext bench below. Porphyry contact are mainly on small slips, but suggestion is that porphyry has not been eroded and conglomerate deposited upon it. If formation is Glance conglomerate, porphyry is probably intrusive into it. Porphyry itself is probably monzonite as it contains very few quartz eyes. Mineralization on this bench almost entirely oxidized.

Section of pit north of road on 5050 bench shows porphyry on south side and schist with strong pyritic mineralization on north side with some late copper staining. Dividend fault is well exposed in west end of cut with dip of 70° to south. Up to 4 in. black gouge with other irregular gouges along zone. Porphyry is bleached near fault and some chalcocite is developed on pyrite on both sides of fault. Band possibly 100 ft. wide is reported to be ore. On south side of pit another strong zone striking about E-W with steep dip appears to have had both pre-mineral and post mineral movement. No particular structure exposed along north side of pit in schist. Extension of probable fault zone to east obscured by oxidized zones and irregular oxide mineralization. Should be evident on next bech below. On raod in gulch east of concentrator site, strongly sericitized schist on north is bounded to south by strongly iron stained zone - probable mineralized zone along old Dividend movement, but late clays are not apparently present in thsi immediate area.

Trip through pit with Warren Smith, pit Supt., Perry and Velasco, October 10, 1952

Mineralization in Glance conglomerate definitely cuts cong. No good contacts exposed with porphyry as yet. All pit ore reported to be in porphyry. Pit will extend hundred feet below 5100 bench. Crusher to be in pit approximately where present highway crosses pit area.

Trip through Bisbee Pit August 22, 1953

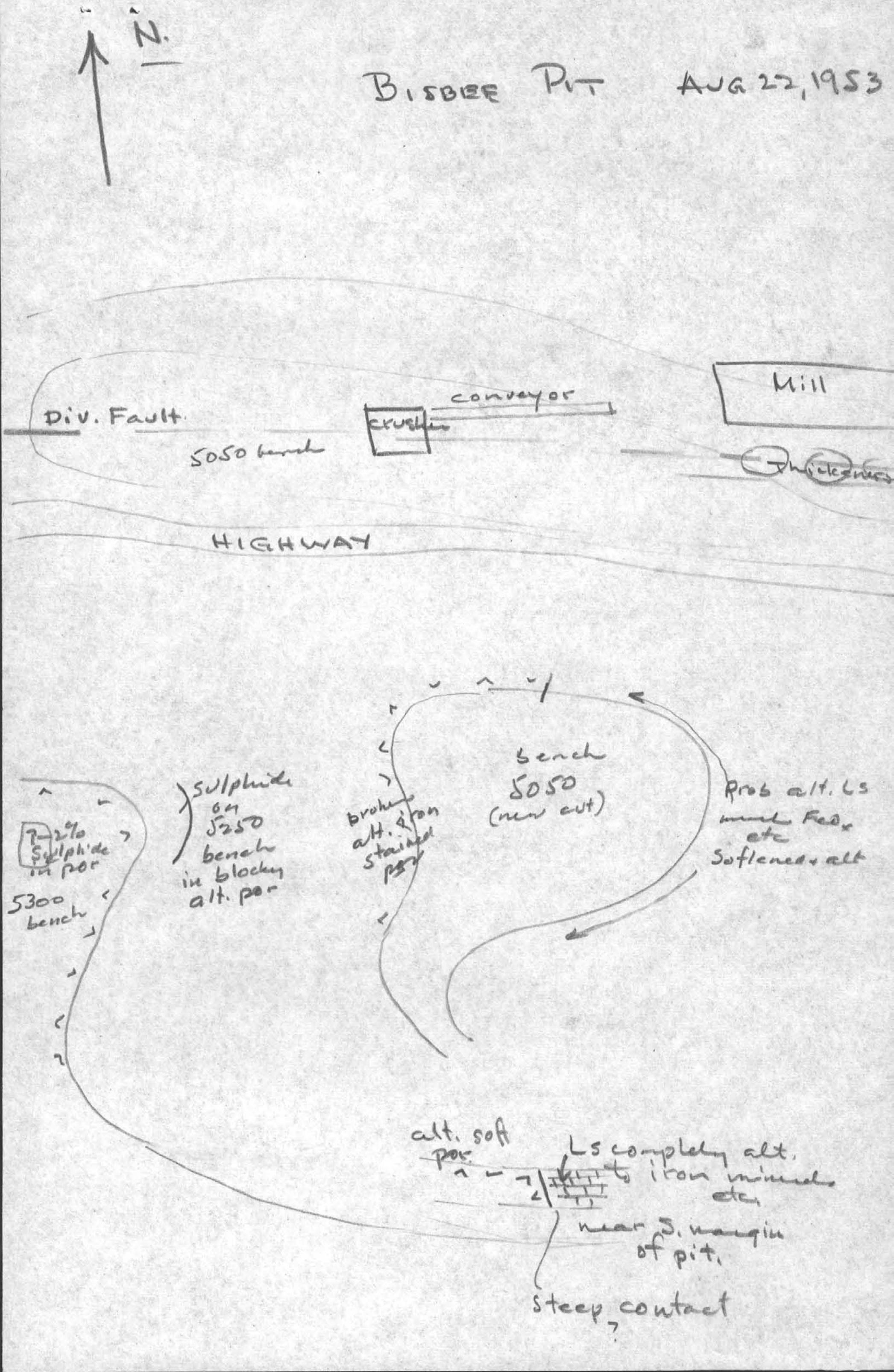
Quick trip through pit with Leo Wilson, pit forman. Sulphide ore in porphyry reported 2% Cu exposed at base of 5300 bench northeast of old Sacramento Hill pit and south of highway and about 100 feet higher. Minerals are pyrite, quartz, chalcocite, possibly little chalcopyrite, alunite in seams and disseminations through well altered porphyry with few quartz phenocrysts. Larger area of sulphides of lower grade probably 0.9% Cu in about same part of pit on 5250 bench.

Near south pit boundary on 5200 bench ? Ls- porphyry contact dips steeply. Porphyry is highly softened and kaolinized, Ls is completely mineralized with iron oxides, probably hematite and magnetite.

On lowest bench south of highway, 5050, porphyry on west side is highly broken and iron stained. On east side rocks are probably highly altered ls. No good bedding structure evident in the Ls.

Are using three Joy dry drilling machines and now use them with enough water to make cuttings damp. Drill up to 400 ft/shift with damp cuttings, but did make up to 800 ft/shift with dry drilling. Drill 7 3/8 in. hole 32-50 ft. deep , deepest dry 72 ft. In sift ground maximum 1800 ft. per bit. Rigs are entirely electric powered and are thus much smaller than original diesel powered machine seen at Silver Bell. Have one large P & H shovel with 7 yd dipper.

BISBEE PIT AUG 22, 1953



CRETACEOUS	Cintura fm. Mural LS Morita fm Glance Cg. } lower			
Permian	Snyder Hill fm.	Chiricahua LS Snyder Hill fm. gypsum beds	Kaibab LS Coconino SS Supai	Hueco fm
Penn.	Naco LS.	Galiuro Naco		
Miss.	Escabrosa	Redwall LS	Modoc LS Lake Valley	
Devonian	Martin { lower Ouray Martin Picacho de Calera	— Morenci Shale		
SILURIAN	NONE			
ORDOVICIAN	NONE			
Cambrian.	Upper —	Abrigo fm. { Peppersauce SS - Rincon LS - Copper Q. LS Abrigo	Cochise fm. Pima SS.	
	Middle	- Troy - Bolsa qtzite		
		No lower Cambrian		
Pre-Cambrian	{ Mescal LS. local basalt Drip. Springs Qtzite Barnes Cg Pioneer Shale Scanlan Cg. } 1400 ft. ± often intruded by diabase			
	Pinal Ps			

PHELPS DODGE CORPORATION
COPPER QUEEN BRANCH, MINES DIVISION

Milling Practice at the New Lead-Zinc Concentrator of Phelps Dodge Corporation at Bisbee

R. C. Thompson,
Mill Superintendent

The lead-zinc mill of Phelps Dodge Corporation, Copper Queen Branch, Mines Division, is located about three miles from the main hoisting shafts of the Junction and Campbell mines at Lowell, Arizona. All of the ore treated in the mill is obtained from these two mines.

The mill was designed for an all flotation treatment of 450 tons of lead-zinc ore per day, and has been operated at that capacity since the start of milling operations on November 17, 1945. At the present time, an expansion program is under way whereby the mill capacity will be doubled. This article describes the original program only and presents results of the 450-ton operation.

GENERAL DESCRIPTION

The milling plant consists of an ore receiving bin, and three steel-constructed buildings housing, respectively, the primary crushing equipment, the secondary crushing equipment, and the ore storage bins, grinding, flotation, and filtering equipment.

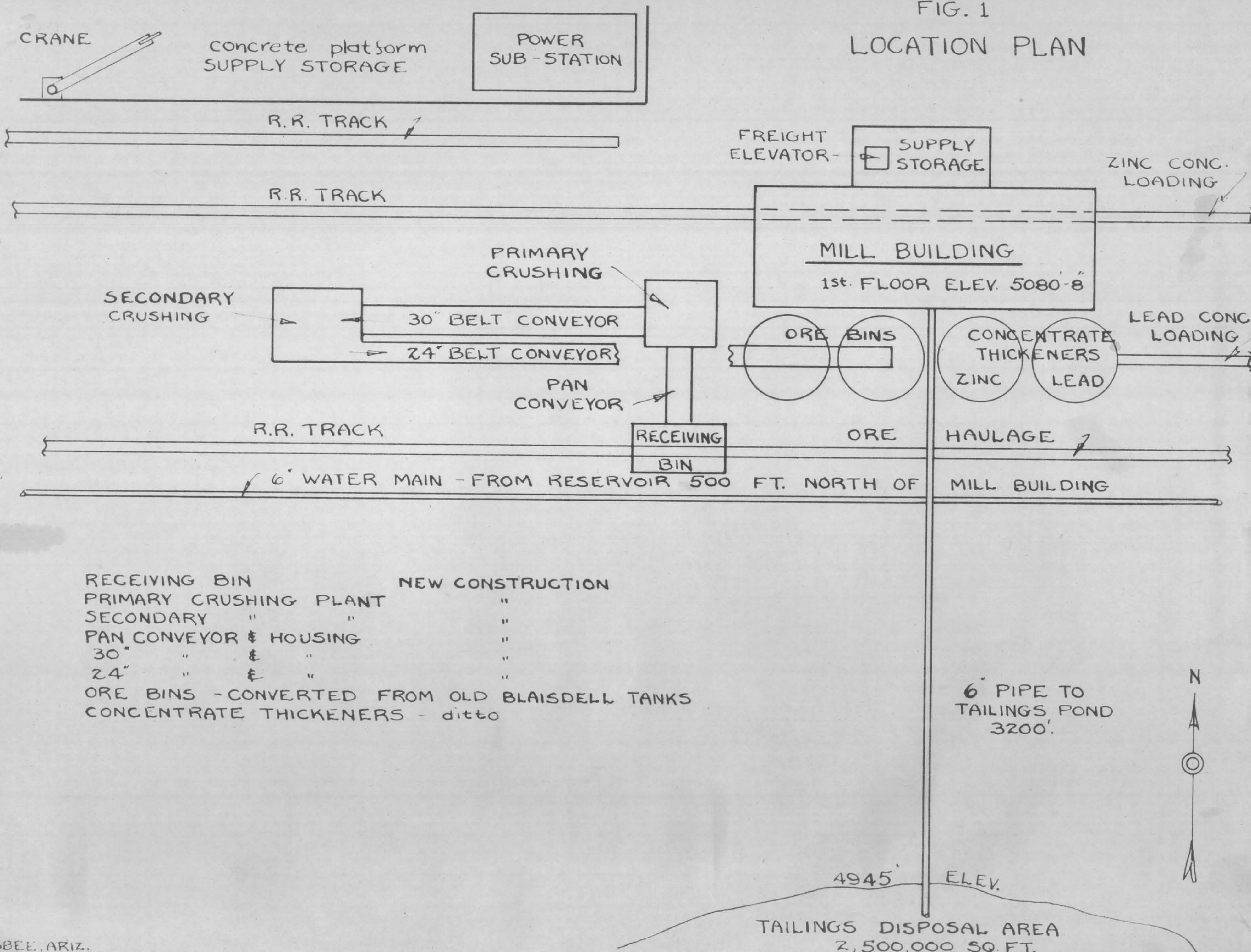
The mill site is the same as was used for a previous copper concentrating plant which was operated over a period of years and then dismantled. There remained from this operation some milling equipment, a reservoir for mill water supply, railroad tracks, tailings disposal ponds, and a steel-constructed building, all of which were incorporated in the design of the present lead-zinc mill. The location plan of the plant layout is shown in Figure 1.

The flow sheet of the mill is based on the conventional lead-zinc treatment scheme; however, several innovations were made necessary in order to utilize the existing building. Placing of equipment was also governed by the design of the building; thus making the mill unique in many respects. A brief description of the mill building as adapted to the flow sheet points out the compactness of the installation and some of its unusual features.

PHELPS-DODGE CORPORATION - COPPER QUEEN BRANCH - MINES DIVISION

FIG. 1

LOCATION PLAN



BISBEE, ARIZ.
AZA 414 1945

The first floor (Figure 2) houses the grinding equipment, with connecting conveyors for ore feeding, also an air compressor, two vacuum pumps, lead and zinc concentrate storage bins with individual conveying systems for loading the two kinds of concentrates. Filtering of concentrates is done on the second floor with the concentrates discharging directly into the concentrate storage bins. On this floor are located the lead and zinc filters, two diaphragm pumps, sample filtering equipment, sample preparation room and a change room for the mill employees. The flotation machines are located on the third floor, at elevations allowing a gravity flow of the lead and zinc concentrates to the thickeners. The annex to the building contains a freight elevator and provides space for all reagent mixing and feeding, also storage of reagents and grinding balls.

All of the water used for milling purposes is pumped from the Junction Mine and none of the water used is reclaimed. Power is brought to the mill from the Company Steam and Diesel Power Plants at 2200 volts and is transformed to 220 and 110 volts for mill use.

ORE TREATED

The lead and zinc generally occur in the ore as galena and sphalerite, while the iron occurs mainly as pyrite. Anglesite and cerussite have been noticed on rare occasions in amounts sufficient to be observed on the pilot tables. The sphalerite varies from a straw-colored variety to a coal-black variety as seen in the ground condition under the microscope, with varying iron content. Of the sphalerite which enters the lead concentrate, the light-colorec varieties predominate. The major portion of copper exists as chalcopyrite with bornite next in frequency of occurrence. Chalcocite is sometimes present in small amounts. Quartz and clacite are the predominating gangue. Ores from various sections of the mines show marked differences in association of minerals and texture. Some ores are so fine grained as to defy liberation of the mineral with any practical grind, and others are fairly coarse grained. In milling, the practice is to grind to approximately 68% minus 200 mesh as a compromise to the demands of the various ores. Sphalerite-pyrite locking is generally more severe than that between other minerals. Activation of sphalerite in place by copper salts, tarnished galena surfaces, locking of minerals, and excessive fineness of sphalerite all play a part in reducing the selectivity of the mineral separations.

MILLING PRACTICE

A flow sheet of the mill is shown in Figure 3. It gives a comparatively complete picture of the progress of the ore through the various stages of treatment. An outline description of the flow sheet follows.

PHELPS-DODGE CORPORATION - COPPER QUEEN BRANCH - MINES DIVISION

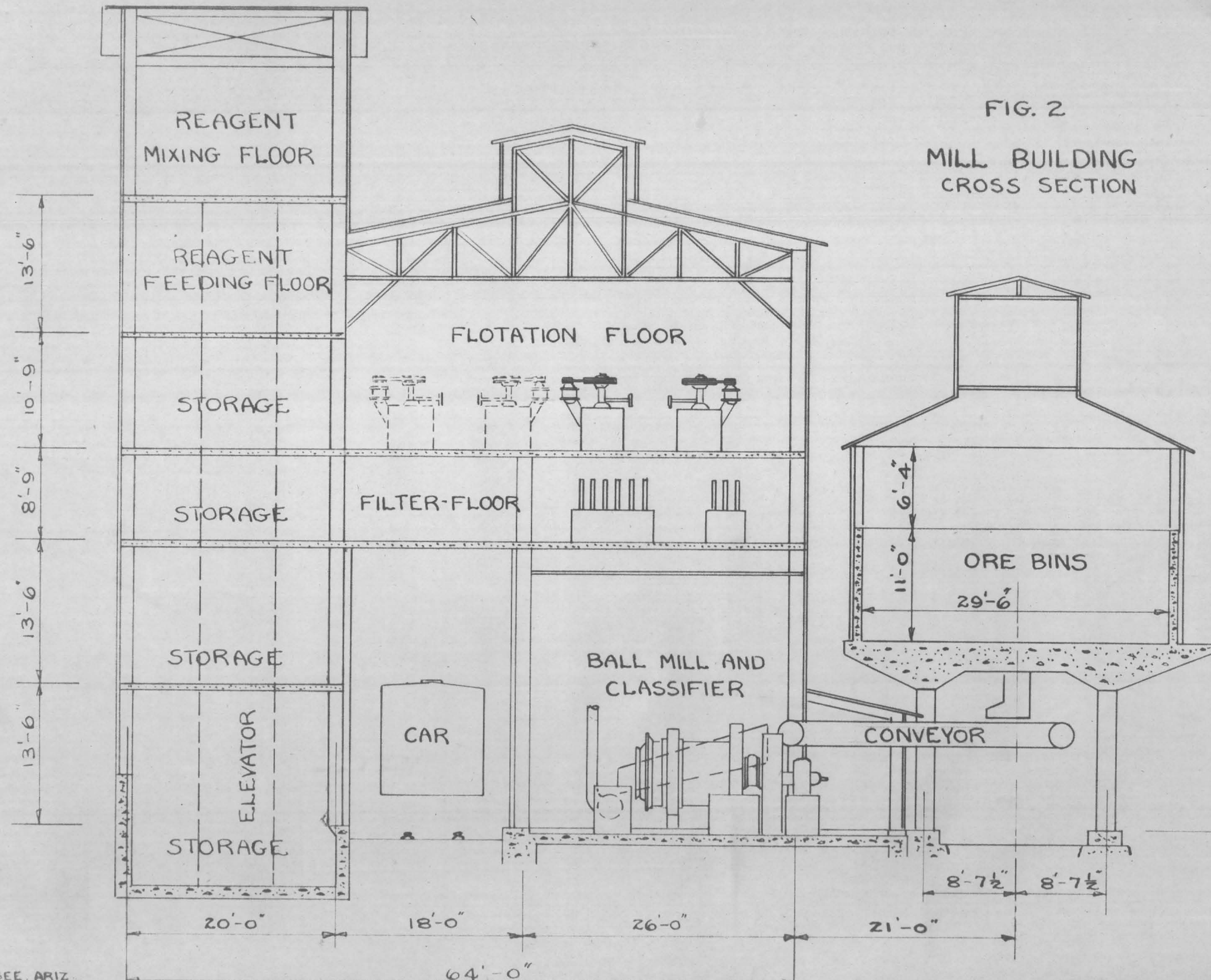


FIG. 2

MILL BUILDING
CROSS SECTION

BISBEE, ARIZ
AZA 415 1945

Unloading and Crushing

Ore is received from the mines in 50-ton capacity gabled-bottom side-dump cars. Loaded cars are weighed on a track scale in the mill yard. The cars are dumped into the receiving bin, a concrete and steel hopper-bottomed bin in an excavation beneath the ore haulage track. The receiving bin is simply a dumping pocket and was not designed to provide any appreciable ore storage. The ore track accommodates 28 loaded cars above the bin and an equal number of empties below, and serves in lieu of a coarse ore storage bin.

Ore is transported from the receiving bin by a 34-inch pan conveyor to a steel grizzly having 2-inch spacings. The conveyor is 45 feet between head and tail sprockets and is on an incline of 22 degrees from horizontal. The conveyor speed may be varied between 8 and 14 feet of travel per minute. Grizzly oversize is crushed to 2-1/2 inches in an 18 x 36 inch jaw crusher. The crusher operates at 240 R.P.M. and is driven by a 75-H.P. motor through Texropes. Crushed ore and grizzly undersize are delivered to a 30-inch conveyor belt which passes under a magnet and discharges onto a 3-x 8 foot vibrating screen, ahead of a 3-foot cone crusher. The cone crusher is driven by a 150-H.P. motor through Texropes and is set to deliver, with a single pass, a product containing 85% minus 1/2 inch. The screen undersize and crusher product are transported by a 24-inch inclined conveyor to an elevated 850-ton ore bin, which was originally one of our old Blaisdell tanks, 29 ft., 6 in. x 11 ft., of reinforced concrete construction. Depth of the tank was increased to 17 feet by adding a ring of 5/16-inch plate. A steel-framed housing was erected over the tank and four feeders installed in the bottom to complete the conversion into an ore bin with a live capacity of 850 tons.

Grinding

Ore is drawn from the bin by four conveyor feeders and is delivered to the ball mill by a 20-inch conveyor equipped with a weightometer. The grinding unit consists of a 7 x 7 ft. grated end ball mill operating in closed circuit with an 8 x 23 ft. duplex rake classifier. The mill, driven by a 200-H.P. motor, operates at 23 R.P.M. Forged steel balls are used, with the daily make-up proportioned at 60% two-inch and 40% three-inch balls. The ball load is maintained at a level about two inches below the center line of the mill. Ball consumption has averaged 1.23 pounds per ton of ore ground. Classifier overflow is maintained between 32 and 35% solids with a sand return circulating load around 400%. Table 2 shows the grinding product.

Flotation

Classifier overflow is pumped with a 3-inch sand pump to a sampling box ahead of the lead flotation circuit on the third floor of the mill building. The pump operated at 1200 R.P.M.

against a head of 45 feet. Figure 3 shows the general arrangement of the flotation flow sheet in which thirty-two 43-inch x 43-inch "Sub-A" cells and one 10 x 10 ft. conditioner are employed.

A bank of twelve cells constitutes the lead circuit with feed entering the No. 4 cell. The circuit consists of a roughing section of six cells, a scavenging section of three cells, concentrate cleaning and recleaning sections of two and one cells respectively. Cells #4 to #9 inclusive produce a rougher concentrate which flows by gravity to the No. 2 cell. Cells #2 and #3 perform the first cleaning operation and produce a concentrate which is cleaned in the No. 1 cell, where the final concentrate is produced. Cleaner and recleaner tails return to the rougher section. Concentrate from the scavenger cells, #10, #11 and #12 are returned to the rougher section and enter No. 6 cell. The lead tailing from No. 12 cell flows to the conditioner tank where it is conditioned approximately 13 minutes, and then is split between two parallel banks of ten cells each, which comprise the zinc flotation circuit.

Feed enters the No. 3 cells of the two zinc banks. Rougher concentrates from cells #3 and #4, go to No. 1 for cleaning and from #5, #6, and #7 to No. 2 for cleaning. Scavenger concentrate from #8, #9 and #10 returns to the No. 5 cell. The first 1 or 2 cells, depending upon the zinc content of the feed, produce finished concentrate, and tailings from these cells join the original feed to the zinc section in the No. 3 cell.

In both circuits all middling products are returned to the different cells by gravity flow in launders. Elevations of the lead banks, conditioner tank and zinc banks of flotation machines permit a gravity flow of pulp through the entire flotation installation and of the final concentrates to the thickeners.

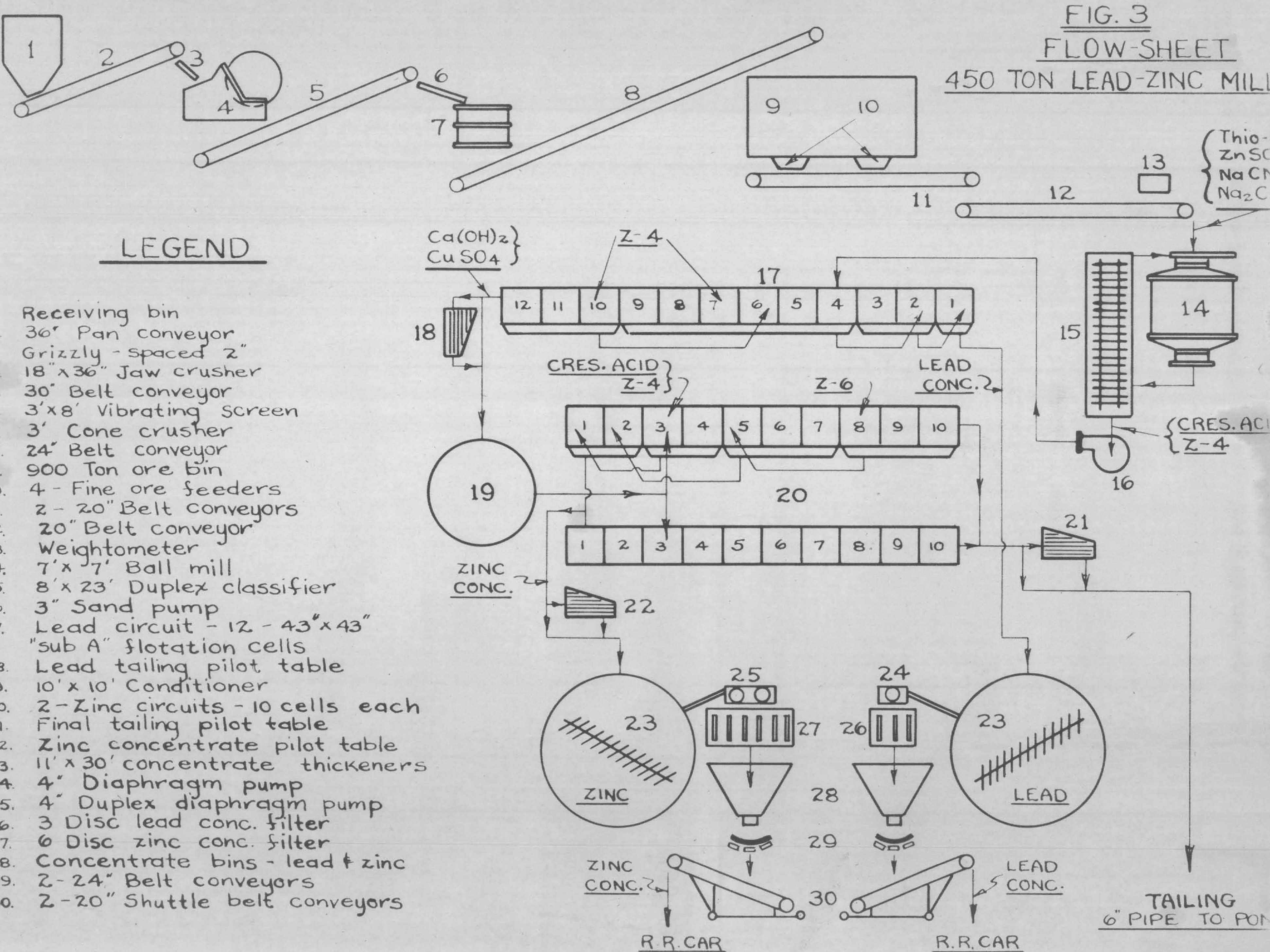
Reagents

A mixture of sodium carbonate, thiocarbanalid and zinc sulphate is added to the ball mill by means of a dry reagent feeder. Additional zinc sulphate, as a 15% solution, and sodium cyanide, as a 10% solution, are also added to the ball mill. Cresylic acid and sodium ethyl xanthate are added to the classifier overflow as the pulp enters the pump sump. Additions of sodium ethyl xanthate are also made to the Nos. 7 and 10 cells in the lead bank. Sodium carbonate is added mainly to produce the desired alkalinity. The pH value of the mill water is 8.2 and lead circuit feed is maintained from 7.6 to 7.8. Thiocarbanalid is used as the collector with a little sodium ethyl xanthate used intermittently. Thiocarbanalid has proved to be more selective and to produce a higher grade of concentrate than xanthate.

Hydrated lime and copper sulphate are added to the lead circuit tailing as it flows to the conditioner. Lime is added by means of a dry feeder but preparations are now under way to change the method to a milk of lime addition. Copper sulphate

PHELPS-DODGE CORPORATION COPPER QUEEN BRANCH - MINES DIVISION

FIG. 3
FLOW-SHEET
450 TON LEAD-ZINC MILL



LEGEND

1. Receiving bin
2. 36" Pan conveyor
3. Grizzly - spaced 2"
4. 18"x36" Jaw crusher
5. 30" Belt conveyor
6. 3'x8' Vibrating screen
7. 3' Cone crusher
8. 24" Belt conveyor
9. 900 Ton ore bin
10. 4 - Fine ore feeders
11. 2 - 20" Belt conveyors
12. 20" Belt conveyor
13. Weightometer
14. 7'x7' Ball mill
15. 8'x23' Duplex classifier
16. 3" Sand pump
17. Lead circuit - 12 - 43"x43" "sub A" flotation cells
18. Lead tailing pilot table
19. 10'x10' Conditioner
20. 2 - Zinc circuits - 10 cells each
21. Final tailing pilot table
22. Zinc concentrate pilot table
23. 11'x30' concentrate thickeners
24. 4" Diaphragm pump
25. 4" Duplex diaphragm pump
26. 3 Disc lead conc. filter
27. 6 Disc zinc conc. filter
28. Concentrate bins - lead & zinc
29. 2 - 24" Belt conveyors
30. 2 - 20" Shuttle belt conveyors

BISBEE, ARIZ.
AZA-416 1945

is added as a saturated solution, overflowing from a lead-lined box. Lime is added in amounts to give a pH of 9.8 to 10.0 in the zinc circuit feed. To accomplish this, 2 to 6 pounds are added per ton of original feed, with the average about 3 pounds. Cresylic acid and sodium ethyl xanthate are added to the pulp from the conditioner as it enters the No. 3 cell in the zinc circuit. Potassium amyl xanthate is added to the No. 6 cell and at times cresylic acid is added to the No. 6 or 7 cell.

Three laboratory concentrating tables are incorporated in the flotation flow sheet; one on lead circuit tailing, one on finished zinc concentrate, and one on flotation final tailing. These pilot tables present at all times a reliable picture of the performance of the different circuits and enable the operator to quickly note changing conditions throughout the plant.

Reagents are mixed on the day shift in quantities adequate for 24 hours of operation. The mixing tanks are piped for air agitation, and are connected to smaller drums located on the feeding floor below. Single and double stainless steel feeders are used for all wet reagent feeding and 18-inch cone type feeders for the dry reagents. Facilities for close measuring and distributing of the various reagents are very good. Table 4 summarizes reagent information for operations to date.

Concentrate Handling

Finished lead and zinc concentrates flow by gravity to two 29 ft., 6 in. x 11 ft. thickeners which were constructed by installing mechanisms and superstructures on two Blaisdell tanks. The underflows from the thickeners, at from 55 to 65% solids, are delivered by diaphragm pumps to a 3-disc filter for lead and a 6-disc filter for zinc concentrate. The lead filter discharges the concentrate directly into a storage bin of 200 tons capacity. The lead concentrate is conveyed from the bin by means of two connecting conveyors which deliver the material to a car loader when loading box cars, or over the side of gondola cars when that type car is supplied. The zinc filter discharges concentrate onto an 18-inch conveyor which delivers the material to a bin for box-car loading, or to a cross conveyor which discharges directly into a gondola car when that type of car is being loaded. The zinc concentrate storage bin has a capacity of 400 tons. Vacuum for filtering is normally maintained around 21 inches of mercury by a 16 x 12 inch single cylinder vacuum pump, converted from an air compressor. The overflows of the concentrate thickeners pass to settling ponds which in turn produce waste overflows.

Shortly after the start of operations and at the request of the smelters, the method of shipping concentrates was changed from box car to gondola shipments. This was the cause of some concern for it was thought that excessive losses in transit would result from the use of open gondola cars, especially in the case of the zinc concentrate where the distance to the smelter is 1100 miles.

Gondola shipments have proved entirely satisfactory, however, and now the gondola type of car is actually preferred to the box car for concentrate shipping. Of a total of 232 cars of zinc concentrate shipped to date, 191 were gondola cars, and the average loss in transit for all shipments was 189 pounds per car.

Tailings Disposal

Approximately two-thirds of the total tonnage milled leaves the plant as waste tailing. This tailing pulp flows by gravity through a 6-inch line constructed of transite and wood pipe to an old tailing pond 3200 feet from the mill. The pond has an area of approximately 2,500,000 square feet and a border about 10 feet in height encloses the pond. No further border building will be required for a long period of time, so the mill tailing is simply spilled into the pond and a clear overflow drawn off through a weir. No tailing water is recovered.

Sampling and Testing.

A sample of the crushed ore as it discharges into the storage bin is manually collected at 30 minute intervals. This sample is dried and the moisture content applied to the mine shipment scale weights for the dry ore receipt figure. Weightometer tonnage, as ball mill daily feed, is adjusted to meet the ore receipts. Shift samples are taken at 30 minute intervals, of the flotation feed, lead concentrate, zinc concentrate, and mill tailing. The feed and tailing samples are cut by electrically controlled automatic samplers and the concentrate samples are cut by hand. Lead and zinc concentrate shipment samples and car weights supply metal statistics for use in checking mill production calculations. All sample pulps are prepared for assaying in the sample preparation room at the mill and the sacked pulps are sent to the mine assay office for assay.

Dust Control

Every effort is made to provide working conditions that are not injurious to the health of the employees. All chutes, junction boxes, and crushing equipment are enclosed and connected to the dust collecting system. Equipment for the control of dust created in crushing operations consists of a 6500 C.F.M. exhauster and a 7-foot dry collector. Dust settled in the collector is intermittently discharged onto the stream of ore conveyed to the fine ore bin. In filtering lead concentrate, it developed that a small amount of the material, as fine dust, was carried back into the mill by an uprising current of air through the lead concentrate storage bin. A hooded enclosure around the filter, with connections to an exhauster, has proved effective in controlling this condition.

The nature of the concentrate loading operations is such that some dust escapes around the loading area, and makes the matter of clean-up of great importance in minimizing the hazard of lead contamination. In this connection, the frequent washing of floors is insisted upon, also the wearing of rubberized gloves in performing certain concentrate loading operations.

Approved respirators are furnished men engaged in ore unloading, crushing and concentrate loading.

MILL DATA

In the following tables are shown data covering results obtained to date, from November 17, 1945 to March 19, 1946. Since this four months' period represents the break-in period of a new mill, subsequent operations will no doubt result in additional improvements in metallurgy.

Table 1 summarizes metallurgical data for the mill operations to date.

Table 2 presents screen analysis of mill feed and grinding products.

Table 3 presents screen assay analyses of a monthly composite of mill products.

Table 4 shows the reagent consumption for operations to date.

Table 5 shows the power distribution for operations to date.

Table 1

Metallurgical Data
November 17, 1945 - March 19, 1946

Wet tons of ore milled	52878.00
Percent of moisture	1.82
Dry tons of ore milled	51916.19
Operating days	121
Dry tons milled per operating day	429.06
Dry tons milled per 24 hours of running time	466.45
K.W.H. per ton of ore milled	20.37
Ball consumption per ton of ore milled	1.23
Dry tons lead concentrate produced (Smelter Receipts)	6409.029
Dry tons zinc concentrate produced (Smelter Receipts)	11614.830
Percent moisture lead filter product	8.0
Percent moisture zinc filter product	9.2
Ratio of concentration lead concentrate	8.1005
Ratio of concentration zinc concentrate	4.4698

Product Analysis

	Ounces per ton		Percent			
	Gold	Silver	Copper	Lead	Zinc	Iron
Heads	0.017	3.42	0.82	6.41	13.60	9.93
Lead Concentrate	0.059	15.72	4.49	43.46	9.64	12.99
Zinc Concentrate	0.014	3.84	0.79	2.75	50.96	6.28
Tailing	0.010	0.95	0.13	0.66	1.55	10.60

Product Recovery

	Gold	Silver	Copper	Lead	Zinc	Iron
Lead Concentrate	43.62	56.79	67.77	83.70	8.75	16.15
Zinc Concentrate	18.73	25.14	21.61	9.60	83.82	14.15
Tailing	37.65	18.07	10.62	6.70	7.43	69.70

Table 2

Typical Screen Analyses of Mill Feed and Grinding Products

Percent of Total Weight

Mesh	Mill Feed	Mill Discharge	Classifier Sand	Classifier Overflow
.525 in	13.75	-	-	-
4 mesh	43.62	12.94	-	-
6	7.46	1.93	-	-
8	4.79	1.40	-	-
10	3.74	1.24	-	-
14	3.76	1.74	-	-
20	2.93	2.19	30.85	-
28	2.15	2.98	4.87	-
35	1.91	4.98	7.22	-
48	1.65	7.80	9.95	-
65	1.56	10.97	12.70	4.01
100	1.48	11.95	12.41	6.58
150	1.38	8.47	8.08	10.19
200	1.36	6.47	4.58	12.04
-200	8.46	24.94	9.44	67.18

Table 3

Screen Assay Analyses - Month Composite

Screen Size Mesh	Percent Weight	Assays - Percent Copper	Lead	Zinc	Metal - Percent of Total Copper	Lead	Zinc
Heads							
on 65	3.40	0.22	0.74	3.91	1.03	0.40	1.07
on 100	6.80	0.29	1.37	6.53	2.70	1.47	3.60
on 150	10.30	0.53	2.05	10.90	7.48	3.34	9.11
on 200	13.00	0.54	2.68	14.20	9.53	5.50	14.97
thru 200	66.50	0.87	8.50	13.21	79.26	89.29	71.25
	100.00				100.00	100.00	100.00

Screen Size Mesh	Percent Weight	Assays - Percent Copper	Lead	Zinc	Metal - Percent of Total Copper	Lead	Zinc
Lead Concentrate							
on 65	0.10	15.33	8.85	3.50	0.32	0.03	0.05
on 100	0.30	15.33	8.85	3.50	0.97	0.05	0.15
on 150	1.60	10.96	24.00	5.45	3.69	0.72	1.27
on 200	5.40	7.08	36.29	6.37	8.05	3.66	5.01
thru 200	92.60	4.46	55.27	6.94	86.97	95.55	93.52
	100.00				100.00	100.00	100.00
Zinc Concentrate							
on 65	0.60	1.65	7.88	39.58	1.32	1.70	0.45
on 100	2.80	0.82	3.35	47.40	3.07	3.38	2.51
on 150	9.20	0.80	3.45	48.63	9.81	11.44	8.46
on 200	14.40	0.92	2.96	49.76	17.67	15.36	13.54
thru 200	73.00	0.70	2.59	54.39	68.13	68.12	75.04
	100.00				100.00	100.00	100.00
Tailing							
on 65	4.40	0.15	0.94	2.47	3.93	4.29	8.89
on 100	8.00	0.19	0.99	1.49	9.05	8.21	9.75
on 150	11.10	0.24	1.18	1.23	15.83	13.58	11.16
on 200	12.00	0.19	0.89	1.08	13.57	11.07	10.60
thru 200	64.50	0.15	0.94	1.13	57.62	62.85	59.60
	100.00				100.00	100.00	100.00

Table 4

Reagent Consumption

	Pounds per ton of ore milled	Point of addition
Sodium cyanide	0.67	Ball Mill
Zinc sulphate (25.5%)	1.85	Ball Mill
Sodium carbonate	0.36	Ball Mill
Thiocarbanalid	0.12	Ball Mill
Lime (Hydrate)	3.24	Lead circuit tailing box
Copper sulphate	1.78	Lead circuit tailing box
Cresylic acid	0.24	Classifier overflow Zinc circuit cells 3, 7
Sodium ethyl xanthate	0.12	Classifier overflow Lead circuit cells 7, 10 Zinc circuit cell 3
Potassium amyl xanthate	0.05	Zinc circuit cell 6

Table 5

Power Distribution

	K.W.H. Per Ton of Ore Milled	Percent of Total
Unloading and crushing	1.42	6.95
Grinding	9.79	48.07
Flotation	6.60	32.38
Concentrate handling	0.95	4.68
Miscellaneous	1.61	7.92
Total	20.37	100.00

Supplement

Since the preparation of this article, the mill capacity has been doubled and the flow sheet for the zinc circuits changed. Doubling the capacity was effected through duplication of the original installation for fine grinding and flotation, addition of a 75-foot thickener and an 8-foot, 6-inch, 6-disc filter for zinc concentrate handling, and changes in the lead concentrate handling scheme to provide for the greater tonnage of lead concentrate produced. Operations to date with the increased tonnage, indicate a slight improvement in metallurgy. Recoveries of all metals are approximately the same as shown in the preceding data and grade of the zinc concentrate has been raised.

6/18/56

Name changed to THE ANACONDA COMPANY

ANACONDA COPPER MINING COMPANY

Butte, Montana

RETURN TO R.B. MULCHAY

RENO H. SALES
Consulting Geologist

ANACONDA from mine to consumer

Gallatin Gateway, Mont.
June 8, 1956

Mr. Roland B. Mulchay
28 West McCormick Street
Tucson, Arizona

Dear Roland:

Received your letter of May 31, also the two papers on Bisbee.

I wish Metz had offered his own ideas of the general geology around Bisbee. I wish also they would quit calling that Mule Pass rock intrusive granite. It is a porphyry, a highly feldspathic one. The "dikes and offshoots" from it are exactly of the same texture and composition - they are not "granite" or "rhyolite" dikes. I gathered a lot of specimens and all are alike, with a surprising uniformity in texture and mineralogical composition. I do not know the genetic relation between the Sacramento Hill porphyry and the Mule Pass intrusion, but undoubtedly they are from different closely allied sources, but maybe only in respect to age. They are quite different in mineralogical composition and texture.

It is very strange indeed that no garnet was developed in connection with these intrusions. Can you tell me why? Maybe there was no excess silica in either magma - my suggestion!

I think Metz is mixed up on his age relations between the Sacramento Hill porphyry and the various faults and fissures. For example, he says the intersection of the Mexican Canyon fault and other fissures was the loci of orebodies and I quote: "The large Cole-Dallas ore bodies of today are the result of the juncture of the Olive, the Dallas and the Mexican Canyon." And further p.4, he says "In post-Paleozoic and pre-Cretaceous time, probably Triasic or Jurassic, there was initial movement on the Dividend, Mexican Canyon, Campbell faults and many others. These provided channels for the intruding porphyry. The main stock was formed along the Dividend fault, and the dikes and sills along the others." All this according to Metz was pre-Cretaceous, and following the porphyry intrusions, according to Metz there was a period of intense mineralization of quartz and pyrite. Then he says, "A period of fracturing followed the initial pyritization more or less along the older fractures, and brecciated the sulphide bodies along or adjacent to them, Metz says, "The next mineralizing stage was copper-bearing, apparently following the same channels as the earlier porphyry, pyrite, and intrusive breccia." He adds that the copper minerals did not get into the interior of pyritic masses where the latter were unfractured, but that the copper minerals were concentrated around the pyrite-limestone contact. My personal observations do not check Metz in these respects, because in 1906 I saw massive pyrite rich in chalcopyrite and bornite, and this was typical of the ore bodies of the Copper Queen, Irish Mag, Holbrook, and adjoining properties.

But to return again to the geological story. Metz explains that there was a great unconformity between the Cretaceous and older rocks, a peneplanation, subsidence and whatnot; during which time the Bisbee chalcocite blanket ore was formed. Then came the Cretaceous, the lowest member being the glance conglomerate. According to Metz there was no primary mineralization of consequence after the Cretaceous rocks were laid down on the older erosional surface, although he admits there are "small veinlets of quartz cutting the glance" and that these "show a zone of bleaching for a few inches on either side," but says "a similar condition should have occurred along the porphyry contact if the mineralization had been later." Metz lists six specific reasons, or facts, why the main mineralization period could not have been post-Cretaceous. He does not point out any specific locality where these facts were observed.

In my trips through Bisbee I have been struck with the possibility that the dark pebbly conglomerates in the valley at Lowell and to the south were, in fact, arkose material of more recent origin made up of material derived through erosional processes, and that because of the fact that we are dealing with a pre-Cretaceous surface, much of this arkosic material may have come from the glance conglomerate.

But there is one glaring inconsistency in Metz's story, one plainly evident to anyone observing Bisbee geology, even during a casual visit, which is, that the Mexican Canyon fault cuts and displaces all of the Cretaceous sediments. The down throw of the Mural limestone of the Cretaceous series, hundreds of feet in fact, is plainly evident from any vantage point around the Campbell shaft. But according to Metz, this post-Cretaceous fault is pre-Sacramento Hill porphyry and therefore must also be pre-mineral. During a trip in the Campbell mine in 1917, Joralemon said it was extremely difficult to identify the Mexican Fault in the Campbell mine south of the Dividend fault. He pointed out a small fissure he thought might be it. But Metz says, of course, that the mural limestone replacement above mentioned is a re-opening of the older fracture after the deposition of the ore. He says on page 3, and I quote, "The major fracture zone in the Junction (Junction shaft) are as the Mexican Canyon. It is a zone possibly 1,000 feet wide, which has an overall displacement of 400 to 500 feet. Ore has been found intermittently in this zone for a vertical extent of over 2,000 feet." It seems to me fair and proper to ask Mr. Metz whether the ore at any point in the Mexican Canyon fault zone is squeezed, crushed, broken, or in any respect, exhibits strong evidence of post mineral strike faulting, or shows an addition of his "post-Cretaceous mineralization - - entirely different from that which resulted in the important ore deposits."

Metz's answer to arguments 1 and 2, page 7, are not convincing. Assuming what he sets up for arguments in 1 and 2 to be true, it would take quite a lot of factual evidence to disprove the post-Cretaceous age of Bisbee mineralization.

As for the breccia dikes, it is difficult to form an opinion without an inspection of one or more of them. I saw beautiful pebble breccia cut by sphalerite along side the Campbell pipe. As to the genetic relation between the dense FeS_2 - SiO_2 core of the pipe and the breccia along side I have no opinion.

When anyone speaks of a pebble breccia, or any breccia of that nature being intrusive, he should not neglect the very important problem as to the nature of the carrier which made the intrusion possible. I doubt if just a plain mess of sand and rock fragments can be forced into anything. There must be a medium, or carrier if you please, such as air, gas, water, or magma, or a liquid material of some sort. And, breccias made up of sand and wall-rock fragments, can fill fissures or other open spaces without being injected by force from anywhere. Most of the Mt. View breccias in Butte are of this type. Certainly the Oversight and Capote breccias were not injected from below. They fell in from above.

I think Metz's hypothesis for the origin of the Bisbee breccias, paragraph 5, p. 4 of second paper, is very good, in fact, it is the best thing in either paper. I see nothing wrong with it. From the facts supplied I don't see how he could have reached any other conclusion.

I hope we can visit the Bisbee pit together the next time I am in the southwest.

Are you attending the A. M. C. Meeting in L.A. in October?

We have moved to our cabins for the summer.

Shall I return the Metz papers to you?

Regards,

/s/ Reno

RHS:KM

RENO H. SALES km

cc: Mr.V.D.Perry, N.Y.

MINING GEOLOGY DIVISION

ARIZONA SECTION, A.I.M.E.

MEETING AT BISBEE, ARIZONA, MAY 26, 1956

SCHEDULE FOR THE DAY

7:30 - 8:30 a.m.	-	Registration - Junction Mine, Lowell
8:30 - 11:00 a.m.	-	Underground Tour
12:00 - 1:00 p.m.	-	Buffet Luncheon at Copper Queen Hotel
1:30 - 3:00 p.m.	-	Pit Tour
3:00 - 5:00 p.m.	-	Technical Session
6:30 p.m.	-	Cocktails and Dinner at Copper Queen Hotel - Stag

HARRY METZ CHIEF GEOL

BILL HOGUE CHIEF ENG.

ED TORGERSON STOPE ENG.

PINCOCK PIT PLANNING ENG.

STEVE ALLEN GEO-PHYSIST

JIM? KEIM GEOL.

KUZELL V.P.

MILLS GEN. MGR.

1908-53 ROLAND B. MULCHAY

17-53 335.3

Phelps Dodge Corporation
Copper Queen Branch

ORE DEPOSITS OF BISBEE DISTRICT

by

Harry E. Metz

A great deal has been written on the ore deposits of the Bisbee District. Much of this paper is simply a summary of earlier literature. In some cases it has been necessary to modify the older ideas as well as develop new ones to explain some of the more recent discoveries.

ROCKS

The oldest rock of the district is pre-Cambrian Pinal schist. Resting unconformably on the schist is over 4,000 feet of Paleozoic sediments. The base of the Paleozoics is represented by 400 feet of Cambrian Bolsa quartzite. This is followed by 770 feet of sandy, thin bedded Abrigo limestone of late Cambrian age. Ordovician and Silurian sediments are missing. Following the Abrigo limestone is 350 feet of Devonian Martin limestone which, in turn, is followed by the Carboniferous limestone, consisting of 700 feet of Escabrosa limestone of Mississippian age and over 2,000 feet of Naco limestone which is Pennsylvanian.

Resting on a very irregular erosion surface of pre-Cambrian schist and Paleozoic sediments with their intruded rocks are about 5,000 feet of early Cretaceous sediments. The lower member of this series is the Glance conglomerate, from 20 to over 500 feet thick; followed by 1,800 feet of shales and sandstones, the Morita formation; 650 feet of fossiferous Mural limestone which has formed the conspicuous cliffs to the northeast; and this, in turn, by at least 1,800 feet of shales and sandstone - the Cintura formation.

Cutting the schist and Paleozoic sediments is a large stock of granite, the main exposure of which is in the northwestern part of the district and forms the very rough terrain north of the road on the west side of the Divide. Branching out from the granite stock are numerous sills and dikes of granite and rhyolite porphyry, which are scattered throughout the western part of the district. They are relatively unaltered and have a composition like that of the granite and are believed to be part of the same intrusion.

The most important igneous rock of the district, because of its relationship with the ore deposits, is a stock-like mass of highly altered quartz monsonite porphyry. It is about a mile in diameter. A major fault, the Dividend, splits it into two different geologic settings. On the north, or footwall exposure, it intrudes the Pinal schist. The porphyry, and schist surrounding the porphyry, are highly altered and silicified. On the west side of the stock is a considerable zone of bleaching in the schist. On the south, or down thrown side of the fault, the porphyry has intruded the Paleozoic sediments. Branching dikes and sills spread out from the stock in much more profusion in the limestone than in the schist. This is more evident in the underground sections than is indicated on the surface where a good part of the stock is hidden by cover. Alteration due to intense mineralization has practically made the original composition indeterminate; however, recent thin section studies have indicated that it was probably quartz monzonite porphyry. The usual contact metamorphic minerals are conspicuously absent in the limestone surrounding the stock. There is a highly silicified, iron-soaked zone of limestone adjacent to the stock which may have been caused by contact metamorphism but which was more probably the result of mineralization.

Seemingly quite closely associated with the porphyry are dikes and sills of breccia consisting of rounded pebbles and cobbles of the formation through which they passed. It is not unusual to find rounded schist fragments in dikes cutting the Naco limestone and in nearly all are pebbles or fragments of Bolsa quartzite. This type of breccia is designated as intrusive breccia and will be more fully described in the next paper.

FAULTING

The producing area of the district is terminated abruptly on the north by the Dividend fault, which was mentioned earlier. It has split the porphyry stock and dropped the Paleozoics on the south against the pre-Cambrian schist to the north. The general strike of the fault is about N 70° W with a southerly dip of from 65° to 80°. Remnants of Bolsa quartzite on the north, coupled with the Paleozoics to the south, give a fairly accurate record of the vertical displacement which, in the vicinity of the Saginaw shaft to the east, is over 5,000 feet and, at the Copper Queen Glory Hole in Bisbee, 2,000 feet. A short distance east of the Saginaw shaft, the fault is lost under the surface gravels, while to the west it passes into the schist above Bisbee and is lost in the complex south of the Juniper Flat granite.

The Paleozoics in the productive area are cut by a series of northeast fractures which have been segregated into a number of fault zones. They have a strike which is complementary to the Dividend fault, roughly N 20° E, and dip steeply to the west. Individually, the fractures seem insignificant and little more than a joint, but collectively over a wide zone may account for considerable displacement. Ore occurrence is intimately associated with these northeast fractures. The major fracture zone in the Junction area is the Mexican Canyon. It is a zone possibly 1,000 feet wide which has an overall displacement of from 400 to 500 feet. Ore has been found intermittently in this zone for a vertical extent of over 2,000 feet. Another important zone, which is a major producer today, is the Dallas fault zone. In all, over twenty fault zones have been segregated.

Complementary to the northeasters are the northwesters. They are a series of fractures with a northwest strike and in all respects are similar to the northeasters, but do not have their persistency. These, too, are important ore producers, particularly where they join with the northeast system.

Cutting diagonally to the southeast across the productive area is the Oliver fault. It has a dip of about 45° to the southwest, and has a normal displacement which is confined to a fairly definite plane rather than a zone, of about 500 feet. The northeast fault zones cut the Oliver fault. Areas where these zones cross the Oliver have been particularly fruitful in regard to ore. The large Cole-Dallas ore bodies of today are the result of the juncture of the Oliver, the Dallas and the Mexican Canyon.

Age of the initial movement on these faults can only be placed as post-Paleozoic and pre-Cretaceous. Many show post-Cretaceous movement also, which has led to considerable controversy in regard to the age of the ore. The post-Cretaceous movement is due to reopening of the earlier fractures in post-Cretaceous time.

GEOLOGIC HISTORY

The very early historical events of pre-Paleozoic time are omitted here and only those that are more closely associated with the ore occurrence are related.

In post-Paleozoic and pre-Cretaceous time, probably Triassic or Jurassic, there was initial movement on the Dividend, Mexican Canyon, Campbell faults and many others. These provided channels for the intruding porphyry. The main stock was formed along the Dividend fault, and the dikes and sills along the others. The intrusion, which must have engulfed large portions of the limestone, displaced portions of it also, causing new faults and fractures as well as intensifying old ones.

Following the porphyry intrusions there was a period of intense mineralization, principally of pyrite and silica, which resulted in heavy replacement throughout the porphyry stock and the surrounding schist and limestone.

The pyrite mineralization in the porphyry and schist was more of the disseminated type, while in the limestone it formed large irregular lenses of massive pyrite. A period of fracturing followed the initial pyritization more or less along the older fractures, and brecciated the sulphide bodies along or adjacent to them. Intrusive breccia then invaded the area along the existing fracture channels, picking up fragments of low grade pyrite as well as fragments of the other formations along its course. The next mineralizing stage was copper bearing, apparently following the same channels as the earlier porphyry, pyrite, and intrusive breccia. Fractures in the brecciated pyrite were filled with copper sulphide along with slight replacement of the pyrite itself. The reaction on those pyrite masses which were not brecciated was confined principally to the pyrite-limestone contact resulting in lenses of copper ore around low grade pyrite. Fractures were not present to permit penetration of the copper mineralizers to the interior of these masses in any appreciable amount. Where fractures did exist, lenses of ore resulted in the low grade core. The main activity of the copper mineralizers was in the limestone, but there was some introduction of copper in the main porphyry stock. Lead-zinc mineralizers followed the copper, replacing the limestone in the extremities of the pyrite-copper bodies.

Next was a period of erosion which cut down the upper Paleozoic into a very rough irregular surface. The upper portion of the porphyry stock was leached and the copper redeposited at the water table as a chalcocite blanket. Displacement on the Dividend fault then dropped the southerly side into a protected basin under a shallow sea, and the northerly side was elevated into a range of mountains which was subjected to intense erosion. Rapid erosion not only stripped the Paleozoics from the north side but the chalcocite blanket of the porphyry stock as well, and finally resulted in a peneplane at sea level. The basin to the south was, in the meantime, filled with detrital material. Finally the entire area was dropped below sea level and a thin blanket of detrital material was deposited on the north as well. This detritus became the basal conglomerate of the Cretaceous. The remaining Cretaceous sediments were then deposited in shallow seas. The entire area was elevated;

there was additional displacement on the Dividend fault; regional tilting to the east; and erosion which stripped off the Cretaceous cover over the porphyry stock and surrounding limestone.

AGE OF MINERALIZATION

The age of the mineralization in the Bisbee district has long been controversial. It is believed that evidence uncovered in recent Pit operations has settled the question beyond reasonable doubt. This evidence places it as post-Paleozoic and Pre-Cretaceous and is as follows:

1. Pebbles of altered porphyry in the Glance conglomerate, which even microscopically are indistinguishable from that in the main porphyry stock. Alteration of the porphyry was an effect of the mineralization. It is evident that the porphyry pebbles were altered prior to their deposition in the Glance. The abundance of the porphyry pebbles in the conglomerate increases as the porphyry contact is approached, indicating that the pebbles were derived from this stock, and not from some other remote source of supply.

2. Pebbles of ferruginous silica in the Glance conglomerate which were obviously derived from the oxide zone of the porphyry stock.

3. Pebbles of silicified limestone in the conglomerate in all respects similar to silicification accompanying the mineralization of the limestone.

4. Complete lack of alteration of the Glance conglomerate where it is in contact with the porphyry. The porphyry is altered yet the Glance conglomerate is unaffected. Small veinlets of quartz cutting the Glance show a zone of bleaching for a few inches on either side and a similar condition should have occurred along the porphyry contact if the mineralization had been later.

5. The porphyry blanket of chalcocite and its capping more or less conforms to the pre-Cretaceous surface under the Glance conglomerate. This indicates that

the enrichment is related to that early erosion period and not the one going on today.

6. No ore has ever been found in the Glance conglomerate or above it.

Against such overwhelming evidence, the following arguments may be presented:

1. Fracture zones which cut the Cretaceous sediments are also important ore zones in the Paleozoics. This is true, but is due to reopening of older fractures after deposition of the ore.

2. Veinlets of quartz cutting the Cretaceous contain copper mineralization. This post-Cretaceous mineralization is entirely different from that which resulted in the important ore deposits. The post-Cretaceous type is fissure filling, while the pre-Cretaceous type is strictly replacement.

ORE BODIES

Ore has been found in all the Paleozoic limestones; however, the most productive horizons have been the upper 300 feet of the Abrigo limestone, all the Martin and the lower 300 feet of the Escabrosa, a total of about 1,000 feet. Most of the production has been from these horizons. The reason for these productive horizons is due to the physical property of the lime beds in that they are very brittle and any slight movement would tend to shatter them, which permitted penetration of the ore solutions. The beds above and below these horizons are elastic and tend to either bend or break along one main fracture. The Paleozoic beds have an average dip to the northeast of from 20° to 25° and the productive horizon conforms to this average dip, ever becoming deeper to the east.

A horizontal projection of the ore bodies shows a semicircular arrangement around the main porphyry stock with offshoots resembling the spokes of a wheel. This arrangement is the result of replacement in the fracture and fault zones mentioned earlier. The semicircular pattern is due to replacement in the intense fractures caused by the porphyry displacing the limestone. The radiating spokes are along the northeast zones.

Ordinarily, the copper ore bodies occur in close association with larger bodies of massive pyrite. Commonly, copper ore lenses are found peripheral to a larger pyrite lens on the limestone contact. Another type of occurrence is as filling and partial replacement of the earlier brecciated pyrite. Lead-zinc mineralization occurs in the outer fringes of the pyrite and copper mineralization, sometimes on the contact and sometimes as outliers. At times, in the thin bedded Abrigo deposits, there will be a bed of copper ore sandwiched between two beds of lead-zinc.

Much of the ore, particularly in the Briggs, Junction and Campbell areas, is closely associated with porphyry dikes and sills. Ore may occur along the porphyry in contact with it, particularly where there is an irregularity or, more favorably, an embayment in the porphyry contact. This association is due to structural relationships. Fractures which formed the channels for the intrusion of the porphyry likewise were channels for the mineralizers. In addition, fracturing adjacent to the porphyry was intensified, due to the actual displacement of the limestone, making an ideal host rock. With the exception of the main stock, replacement of the porphyry by copper minerals in sufficient amount to make ore is rare. In the main stock there were important ore bodies of this type but in the outlying limestone, apparently the affinity for the limestone and pyrite was too great for this to occur.

The shape of the ore bodies is nearly always influenced by the bedding of the limestone which it replaces. Some limestones influence it more than others. Deposits in the thin, shaley beds of the Abrigo are practically always tabular, in conformance with the limestone beds. Unreplaced shale and different textures of the sulphides in the ore body clearly show the original bedding of the limestones. Likewise in the Martin, with its dirty but more massive beds, the deposits are usually bedded but have greater relative thickness than the Abrigo type. Deposits in the clean Escabrosa limestone are usually thick and massive, with a tendency for the vertical dimension to be greater than the horizontal, but even they plunge with the bedding, but normally at a greater angle. The bedded type of deposits in the Abrigo and Martin occur at the intersection of a fracture and a favorable bed, resulting in a deposit with elongation along the break, and a rake corresponding to the trace of the bed and fracture intersection.

The type of limestone in which the deposits occur also influences the ground conditions for mining purposes. Deposits occurring in the Abrigo and Martin limestones usually require some timber method of mining because of the poor bond between the beds due to the shaley partings. The thick, massive ore bodies of the Escabrosa usually stand better, permitting some open type of mining method.

Size of individual ore bodies is quite variable, from a few thousand tons to--in exceptional cases--over a million. Possibly a third of the production today is from ore bodies of less than 10,000 tons, a third from ore bodies of 10,000 to 25,000 tons, and the remainder from ore bodies of over 25,000 tons.

In the ore zones, intermittent lenses of ore may be found over quite a long range, both vertically and horizontally. The Denn Side Line ore zone has been productive for over 2,000 feet vertically in an area about 2,000 by 500 feet horizontally more or less parallel to the Dividend fault. The Baras-Home-Reindeer ore zone has a vertical extent of over 1,000 feet and a horizontal of about 300 feet by 1,200 feet.

The depth of oxidation is extremely irregular. Practically all the mining in the western part of the district was from oxide ores. In fact, Dr. Ransome held little hope for the primary zone when he first examined the district. As the deposits became deeper to the east, the proportion of primary ore increased. Certain zones of oxidation are very persistent and extend to a considerable depth. A small oxide ore body of native copper and cuprite was recently mined on the 2433 level of the Campbell mine, and another oxide zone was cut on the 2700 level of the Junction. This deep oxidation is due to downward flowing ground water in the ore zone fractures.

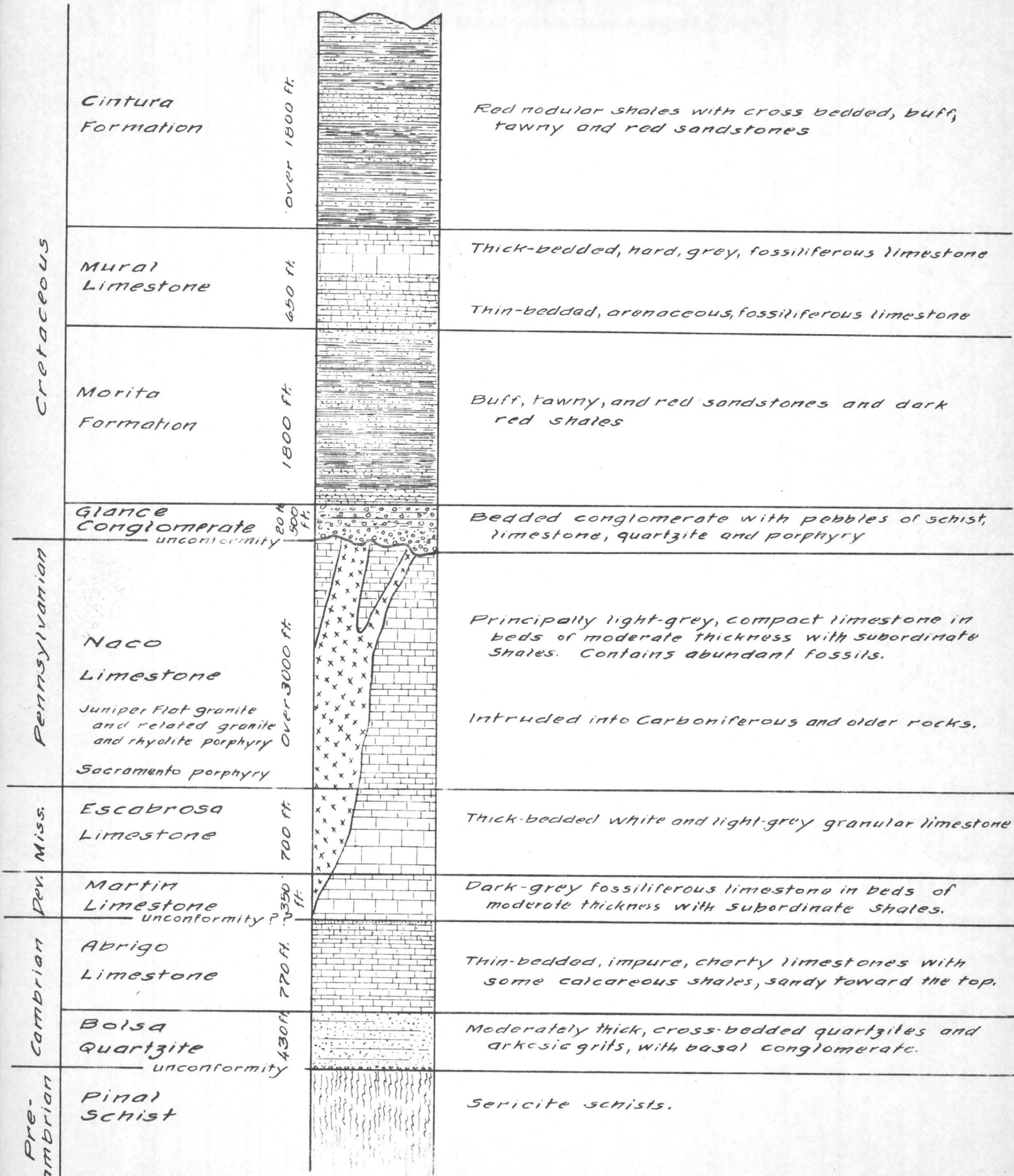
PORPHYRY ORE

Leaching and redeposition of the copper in the main porphyry stock south of the Dividend fault has produced a chalcocite blanket of copper ore. Fracturing of the stock influenced the enrichment process by permitting thorough leaching, channelling of the percolating waters, and by permitting intimate contact with pyrite grains for precipitation. The transition from the oxide capping to the sulphide zone, although abrupt, is very irregular. Pendants of oxide extend to considerable depths along fractures in the sulphide zone and, likewise, sulphide of the undisturbed porphyry into the oxide zone. Leaching of the capping is thorough. It contains, in general, only traces of copper. There is no mixed oxide-sulphide ore such as is common in this type of deposit. Sulphide content of the ore is from 15% to 18%, practically all pyrite. The pyrite has been fractured and a thin film of chalcocite has been deposited on its many surfaces. This intimate filming of chalcocite on the pyrite adds to the metallurgical complication.

The chalcocite blanket dips to the east in conformance with the bottom of the Glance conglomerate which covered a considerable portion of it. The ore is from 50 feet to as much as 400 feet thick, the thinner portion being to the west at Sacramento Hill where the porphyry is very siliceous and compact. The oxide capping, too, is thinnest at Sacramento Hill where the leaching process was slow, and also where it was exposed to erosion.

NOT FOR PUBLICATION

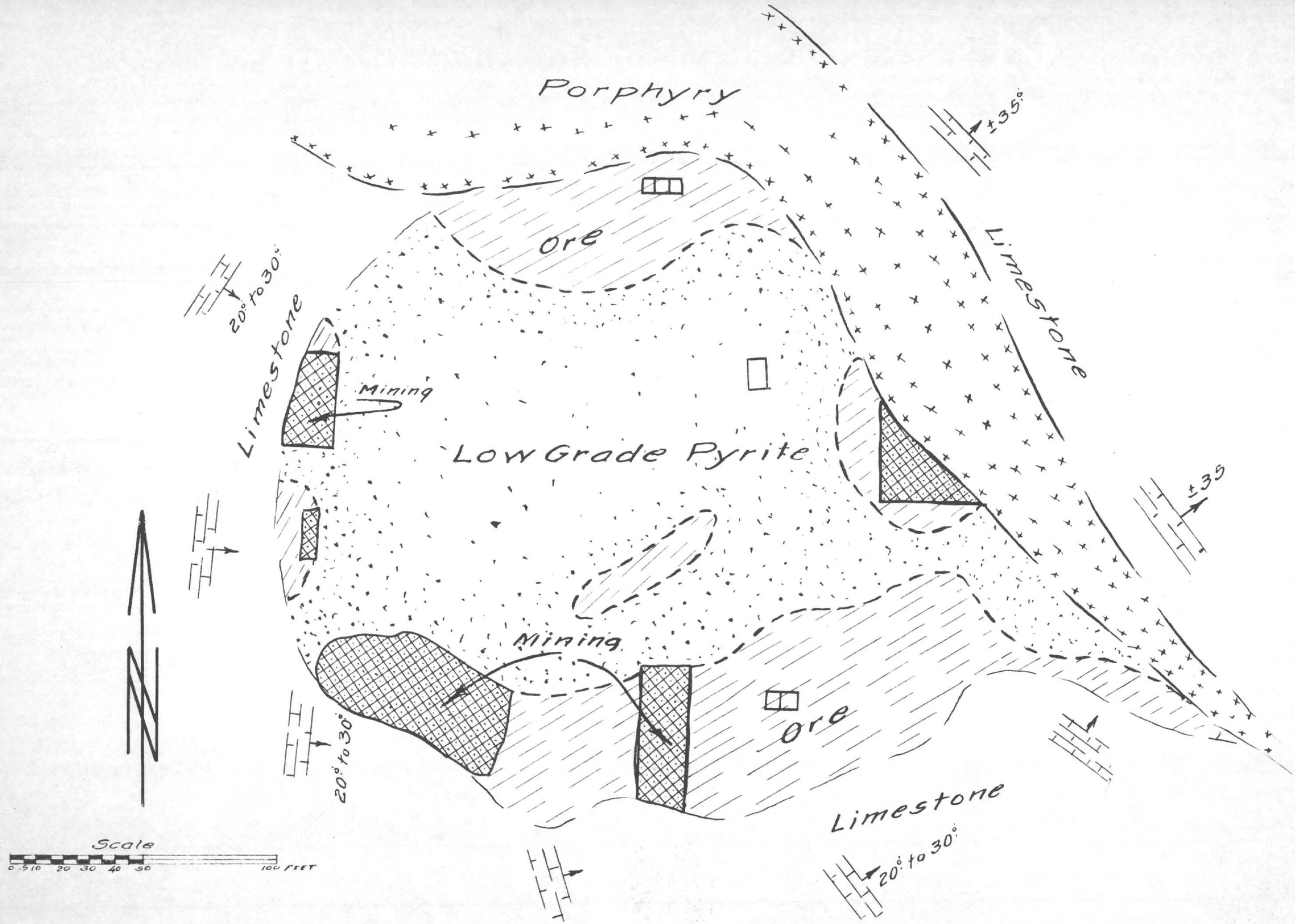
A. I. M. E.
Geology Subsection
Bisbee, Arizona
May 26, 1956
HEM:c



COLUMNAR SECTION
SEDIMENTARY ROCKS BISBEE, ARIZ.

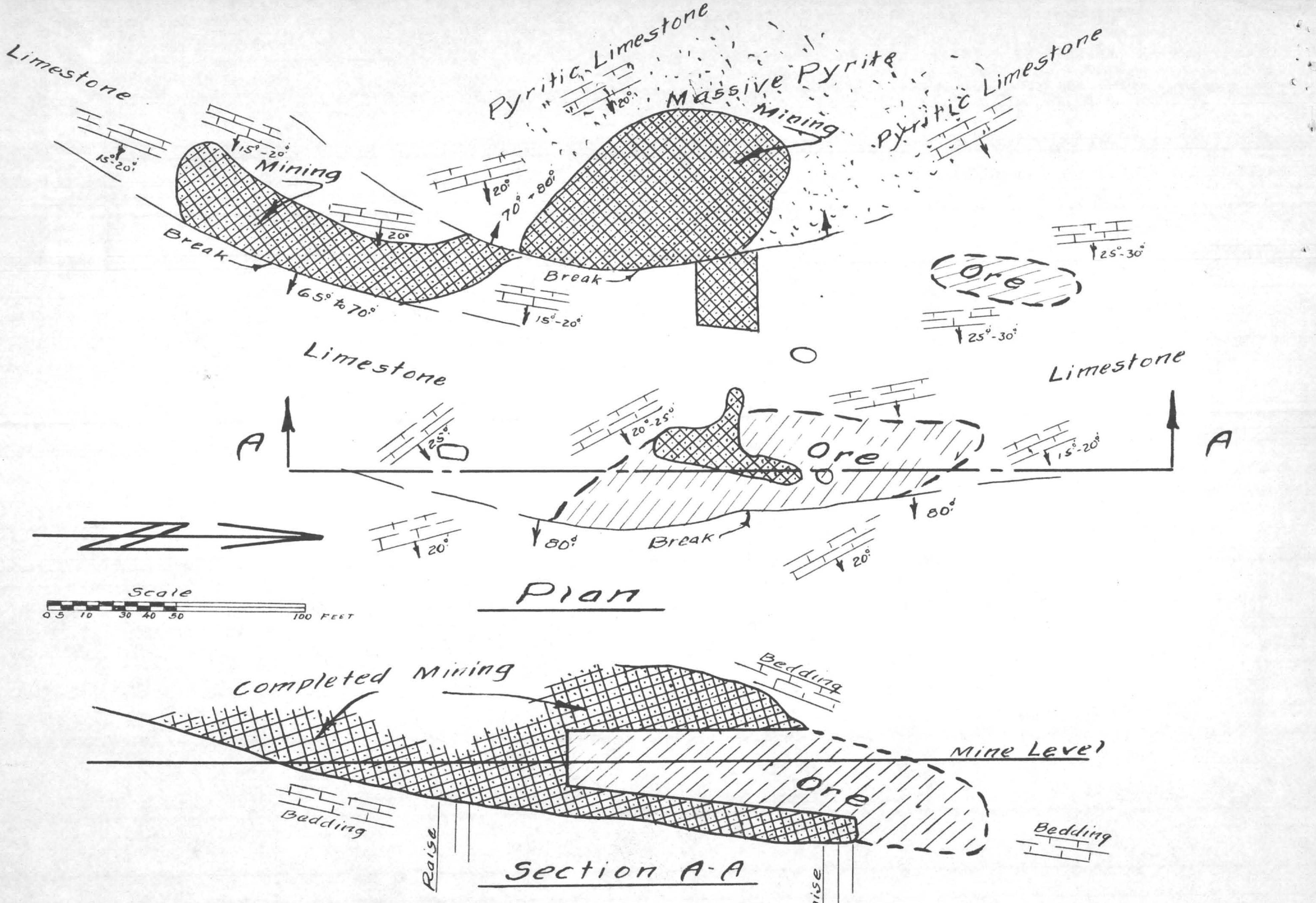
BISBEE, ARIZ
4-20-56

From F.L. Ransome



PYRITE PERIPHERY - PORPHYRY CONTACT DEPOSIT

BISBEE, ARIZ.
4-20-56



TYPICAL ABRIGO TYPE ORE DEPOSIT

BISBEE, ARIZ.
4-20-56

JCTI

75 sq min.

Dallas - hoist Cole ore

Dean lower waste, develop on 3100 L.

ROLAND B. MULCHAY

INTRUSIVE BRECCIAS AT BISBEE

At Bisbee there are a great number of unusual breccias whose existence is not generally known to outside geologists. They are called intrusive breccias and, as the term implies, the breccia fragments were intruded into the formations where they are now found.

The Bisbee intrusive breccias are a hetergeneous agglomeration of rock fragments comprising rocks from underlying formations. By some mechanism, not clearly understood, the component fragments have been forced through the overlying rocks for great distances following whatever path offered the least resistance to their passage. The fragments may have migrated a short distance only and be similar to the wall rock enclosing the breccia or they may comprise all lower formations including the Bolsa Quartzite and Pinal Schist as well as porphyry.

Fragments of nearly any size are locked in a matrix of cementing material. Thin section examination of the matrix reveals that it is composed of smaller fragments of the same rocks that make up the breccia; the matrix is often cemented by calcite and silica introduced after the breccia was intruded.

In form, the breccias are extremely irregular. A few are dike-like but characteristically they may follow a joint for a short distance, then switch abruptly to a bedding place or an intersetting fracture. Sometimes they are tabular but often they swell out to occupy irregular volumes in the limestones.

The breccias may be very small masses of perhaps pencil width occupying joints or fissures or they may be masses of considerable size with dimensions on a single level of several hundred feet.

Component fragments also vary in size as is evidenced by the specimens on display. The biggest specimen observed by the writers was a perfectly rounded boulder perhaps three feet in diameter in a bench of the Lavender Pit. It was not accessible so its composition could not be determined.

The relative age of the intrusive breccias seems to be clearly established. They frequently contain rounded boulders of porphyry and are, therefore, post porphyry.

They also often contain rounded pebbles of barren pyrite showing that a period of intense pyritization had occurred prior to instrusion of the breccias. The breccias themselves are sometimes more or less completely replaced by ore minerals.

Assuming a genetic relationship between the porphyry and the pyritic mineralization the sequence of events would then be:

1. Intrusion of the quartz monzonite porphyry into the Paleozoic limestones;

2. A period of pyritic mineralization in which the porphyry was sparsely pyritized and portions of the surrounding Paleozoic limestones suffered massive replacement by pyrite;

3. Intrusion of "pebble dikes" or intrusive breccias into the Paleozoic limestones, the porphyry stock and into the schist;

4. The period of ore mineralization which resulted in the "halo" of limestone replacement ores as well as the disseminated protore of the Sacramento Stock.

An interesting feature of the breccias is that the degree of rounding of the fragments appears to be a function of the distance traveled. A breccia whose component fragments are predominately limestone may be made up of angular boulders; the quartzite and schist boulders observed in the breccias are usually rounded and resemble stream worn boulders.

In a number of places it has been possible to observe the mechanics of assimilation of wall rock fragments into the clastic stream of intrusive breccia fragments. Intrusive breccia material occupying irregular channels isolates and engulfs projecting blocks of the host rock or surrounds big blocks of rock cut on all sides by fractures. The next stage is a breccia whose angular fragments would all obviously fit together like pieces of a jigsaw puzzle but are held apart by the matrix material. The final stage is a breccia of rounded boulders which have been moved thousands of feet from their source.

The intrusives are found throughout the productive area and are seemingly most abundant in the immediate ore area. They are particularly abundant in the main Sacramento Stock. They have also been observed in the limestones outside of the known productive area and in the schist above Brewery Gulch north of the Dividend Fault. They occur in every formation up to and including the Naco Limestone. The intrusive breccias form a "halo" around the Sacramento Stock area just as the limestone replacement ores do but of greater radius; some are well over a mile horizontally from the closest porphyry of the Sacramento Stock.

Increasing familiarity with intrusive breccias disclosed they they are closely associated with ore deposits in a great many cases. Mineralizing solutions frequently tended to follow the same paths followed by the breccias and in many cases the breccia was replaced more or less completely by ore. Schist and quartzite fragments were more resistant to replacement than were the limestone fragments. In many of our ore deposits the intensity of replacement actions has nearly obliterated the breccia structure but often a careful examination will reveal ghosts of the old rounded or subangular fragments.

It is probable that over 90 percent of Bisbee ore bodies are directly associated with intrusive breccias; if it were possible to study every stope round by round as mining progressed it might develop that the percentage is even higher.

If it is borne in mind that the ore in Bisbee occurs not in an ore body but in literally hundreds of isolated, separate and discreet ore deposits, this association of intrusive breccias and ore becomes truly remarkable.

ORIGIN OF BRECCIAS

A great many theories have been offered by various geologists as to the origin of the Bisbee breccias. Many of them are subject to some serious objection. For purposes of discussion, a few of the most commonly held theories are summarized.

1. The fragments were "floated" through the rock under very high pressure. The matrix probably contained a high percentage of sulphide and thus formed a high density slurry to float the rock fragments.

Objection: While some of the breccias have a sulphide matrix this is undoubtedly due to subsequent replacement. Thin section examination shows the average matrix to be identical in composition to the larger fragments which can be identified megascopically.

2. The dikes were plugs of solid material driven ahead of an advancing magmatic intrusion.

Objection: The dikes are post Sacramento Stock porphyry. No evidence of another intrusion has been found.

3. The "contact breccia" represents explosion material which has blown high in the air and tumbled back into the void of what is now the Sacramento Hill Stock. The porphyry was intruded later and engulfed most of the explosion breccia leaving only patches around the stock. This theory has enjoyed considerable popularity and has been expressed in a number of publications.

Objection: The breccia dikes are definitely post porphyry. The theory entirely ignores the dikes which extend for a mile or more out into the surrounding rocks. The writers know of no evidence whatever that the breccias were formed by this means.

4. The entire area was under extreme pressure. There was a sudden release of pressure caused by an eruption of molten material or gas through to the surface. This sudden release of pressure caused a violent migration of material toward the point of release.

Objection: The spider web of dikes out from the Sacramento Hill Stock shows that material was forced up or out by a deeper seated pressure rather than inward toward a point of sudden release.

5. The magma of Sacramento Stock was intruded into the limestones but was not extruded onto the surface. Cooling and crystallization started with a consequent rise in pressure of the remaining magmatic solution. This resulted first in the release of hydrothermal solutions which pyritized the surrounding rocks. Later

as crystallization progressed and solution pressures rose sufficiently, an escape of gases or liquids along all available paths occurred. The gases, having velocity, were then able to force along their myriad channels fragments of the outer solidified shell of porphyry together with fragments of all rocks traversed. Fragments of this clastic stream helped abrade the walls of the channel and enlarge it; gas pressure ahead of the intrusive pressure helped open channels for the fragmental material. Later, ore solutions followed these breccia dikes replacing susceptible portions of the dikes on the adjacent limestones.

This last explanation is favored by the writers. While it is hardly susceptible of proof, it does answer most of the problems posed by the Bisbee breccia dikes.

The same idea of rising pressure due to crystallization of a silicate system has been used by others to account for intrusive breccias--notably by W. H. Emmons and F. M. Chase.

Not for Publication

W. G. Hogue & H. E. Metz
Bisbee, Arizona
May, 1956

mbb

INTRUSIVE BRECCIA SPECIMEN INDEX

Lavender Pit Specimen No. 1 to No. 5 inclusive.

All show intense hydrothermal alteration.

No. 1 - Fragments of Pinal schist and Bolsa quartzite. Cluster of pyrite blebs near top of specimen believed to be intrusive.

No. 2 - Rounded porphyry fragment at the top left. Other fragments too altered to identify.

No. 3 - Note the rounded pebble of sulphide near the bottom of the specimen. Other fragments of porphyry and Bolsa quartzite.

No. 4 - Fragments of Pinal schist and porphyry.

No. 5 - Rounded boulder - probably Pinal schist.

Breccia specimens from the Abrigo Limestone No. 6 to No. 12 inclusive.

Minimum distance of travel normal to the bedding: Pinal schist - 1000 feet
Bolsa quartzite - 600 feet

No. 6 - Sawed face shows fragments of porphyry and pyritic limestone. Schist fragments are identifiable on the rough sides.

No. 7 - Small dike consisting of fragments of Pinal schist, limestone and pyrite. Massive pyrite on the walls probably pre-dike. Note the bornite stringers cutting pyrite and dike material on the rough face.

No. 8 - Fragments of Schist, Bolsa quartzite and porphyry. Nearest known porphyry instrusive is 400 feet.

No. 9 - Rounded fragments of Pinal schist, Bolsa quartzite and pyrite.

No. 10 - Specimen from an ore body showing incomplete replacement by ore minerals. The unreplaced fragments are Bolsa quartzite and Pinal schist.

No. 11 - Specimen from an ore body, like No. 10 shows incomplete replacement by ore minerals.

No. 12 - Pebble of Bolsa quartzite from the same breccia as No. 10.

No. 13 to No. 17 inclusive - Breccia specimen from the Campbell pipe showing dissimilar limestone and various degrees of replacement.

No. 19 - Quartzite boulder.

No. 20 - Limestone boulder.

No. 21 - Quartzite boulder.

OLAND B. MULCHAY
GEOLOGIST
CANANEA, SONORA, MEX.

COPIA

November 7, 1950

Mr. C. E. Weed, Vice President
Greene Cananea Copper Company
Room 1726, 25 Broadway
New York 4, New York

Dear Mr. Weed:

Recently I had an opportunity to talk briefly with Mr. Elmer Maillot, who is a geologist with the Phelps Dodge Corporation with headquarters in Douglas. Maillot has been doing general work for Phelps Dodge in the Nacozari District and in the Southwest for the past three or four years. He has done some geo-physical work during his various examinations for them and is apparently in charge of the geo-physical investigations they have recently made.

Maillot stated that some geo-physical work by gravimetric methods had been done at Bisbee and that seven anomalies had been discovered. Five of these were known to contain mineralized areas. Whether or not these were all new discoveries or whether work was done to test out the method was not ascertained. He stated that two of the anomalies had been drilled and ore discovered, but no mention was made of amount or grade.

Valenzano, our drilling contractor, has not done any drilling for exploration in Bisbee for some time. If new ore discoveries have been made, Phelps Dodge must have done the exploratory drilling on company account. An orebody in the Cole ground is currently reported under development. However, this ore has been known since the early 1930's, shortly before Mr. Pennybaker was engaged to do consulting work in Bisbee. It is not unlikely that Maillot's work has been to test the method against previous discoveries, although some new ore may also have been found.

During the summer months Maillot and his crew have been engaged in geo-physical work at Tyrone in New Mexico. Indirect reports state that no important finds have been made there to date, but more work is planned in the future. Maillot stated that additional work will be done underground at Bisbee during the winter months.

ROLAND B. MULCHAY
GEOLOGIST
CANANEA, SONORA, MEX.

COPIA

At Bisbee, a considerable number of churn drill holes have been drilled near the highway to the northeast of Sacramento Hill. These holes are reported in Bisbee to have been drilled to check previous drilling results in the area. Conflicting reports of a possible open pit operation at Bisbee are obtained locally, but a rather direct source reported that Mr. James Douglas, Jr., stated in Phoenix that a pit operation at Bisbee was assured.

None of the above information can be accepted at its face value, and I have written you about it only because of your questions in Salt Lake about geo-physical work done in Bisbee. As the information may not be accurate, I know you will consider it confidential.

With best regards.

Yours very truly,

Roland B. Mulchay

RBM:jc

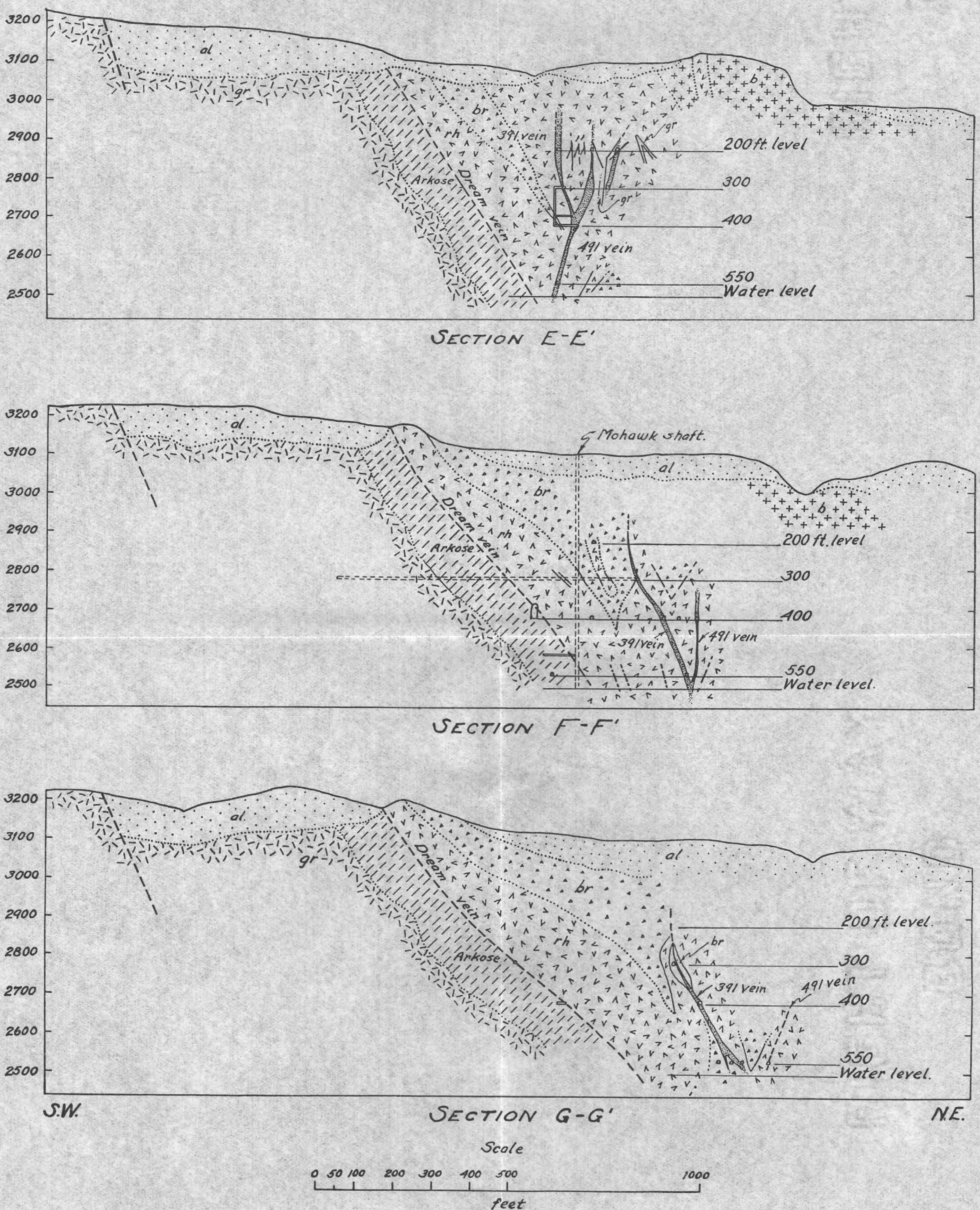


Plate XXXVIII.—Structural sections along lines E-E', F-F', and G-G' of Plate XXXVI, Mammoth Mine area.

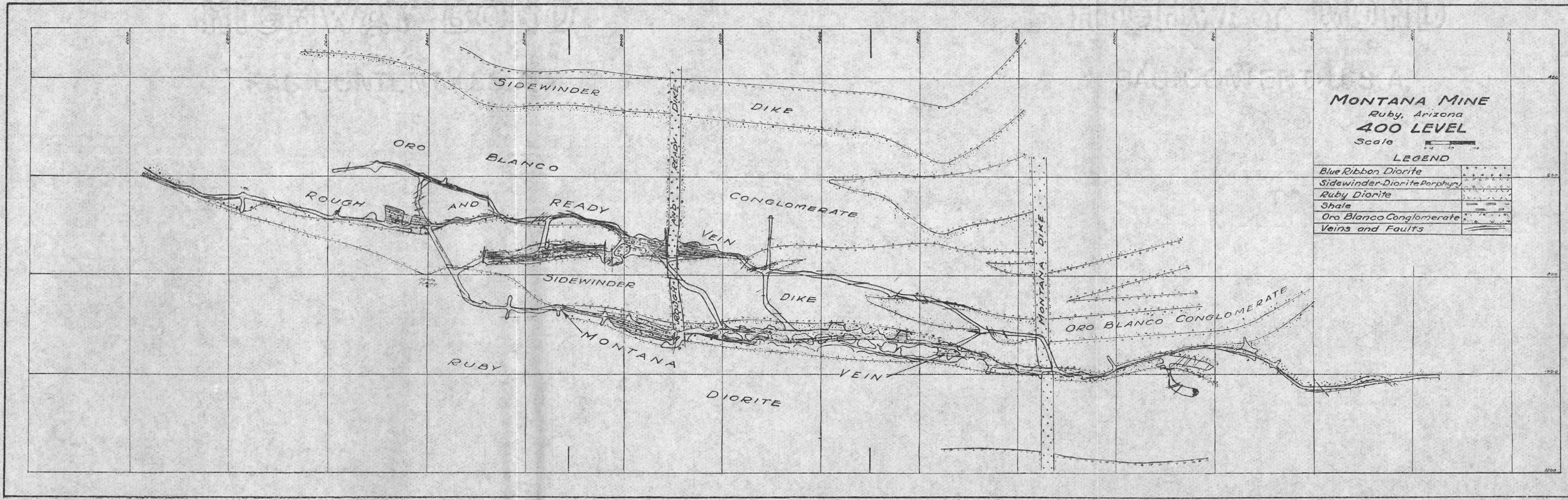


Plate XXXIII.—Montana Mine, 400 level.

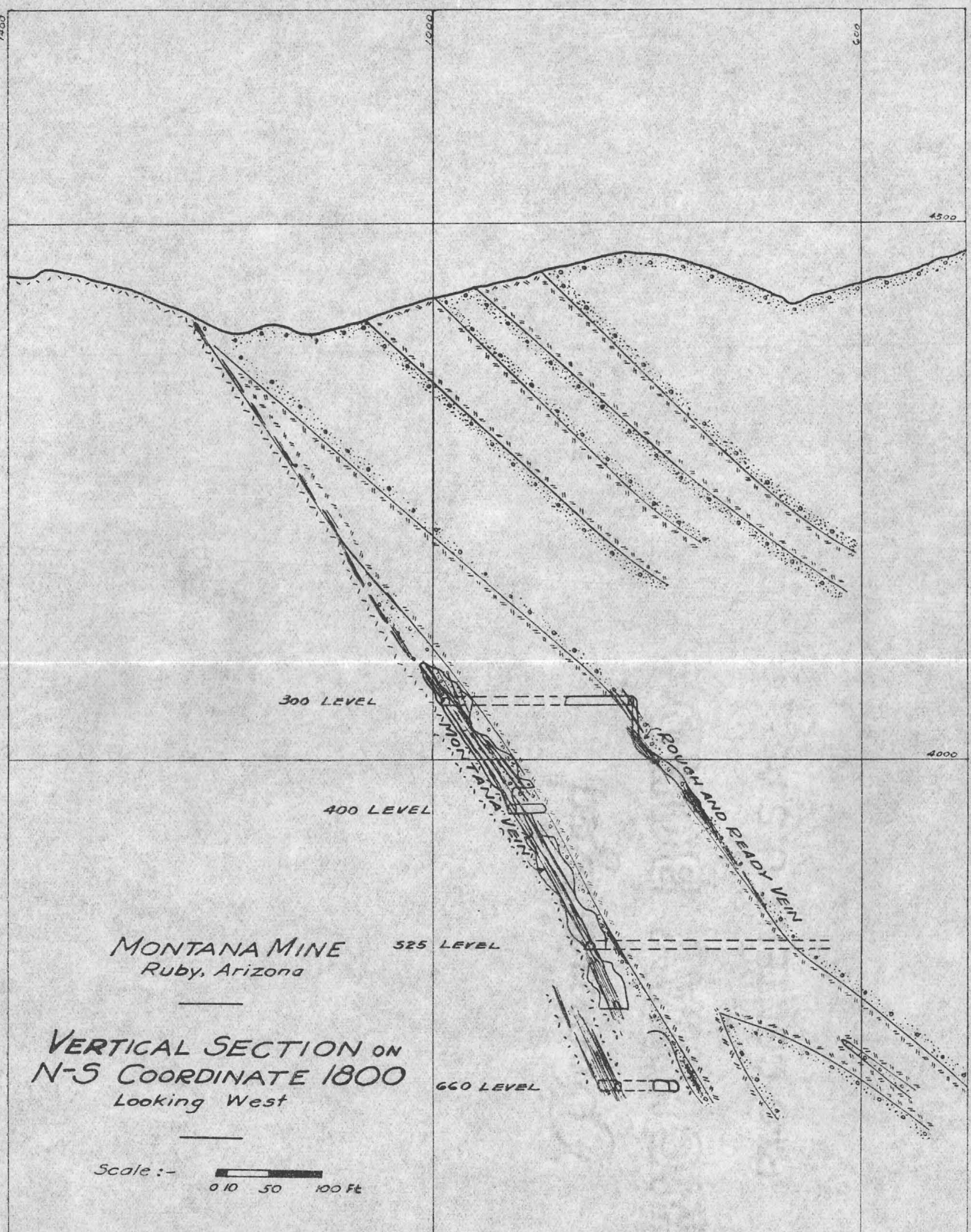


Plate XXXIV.—Montana Mine, vertical section.

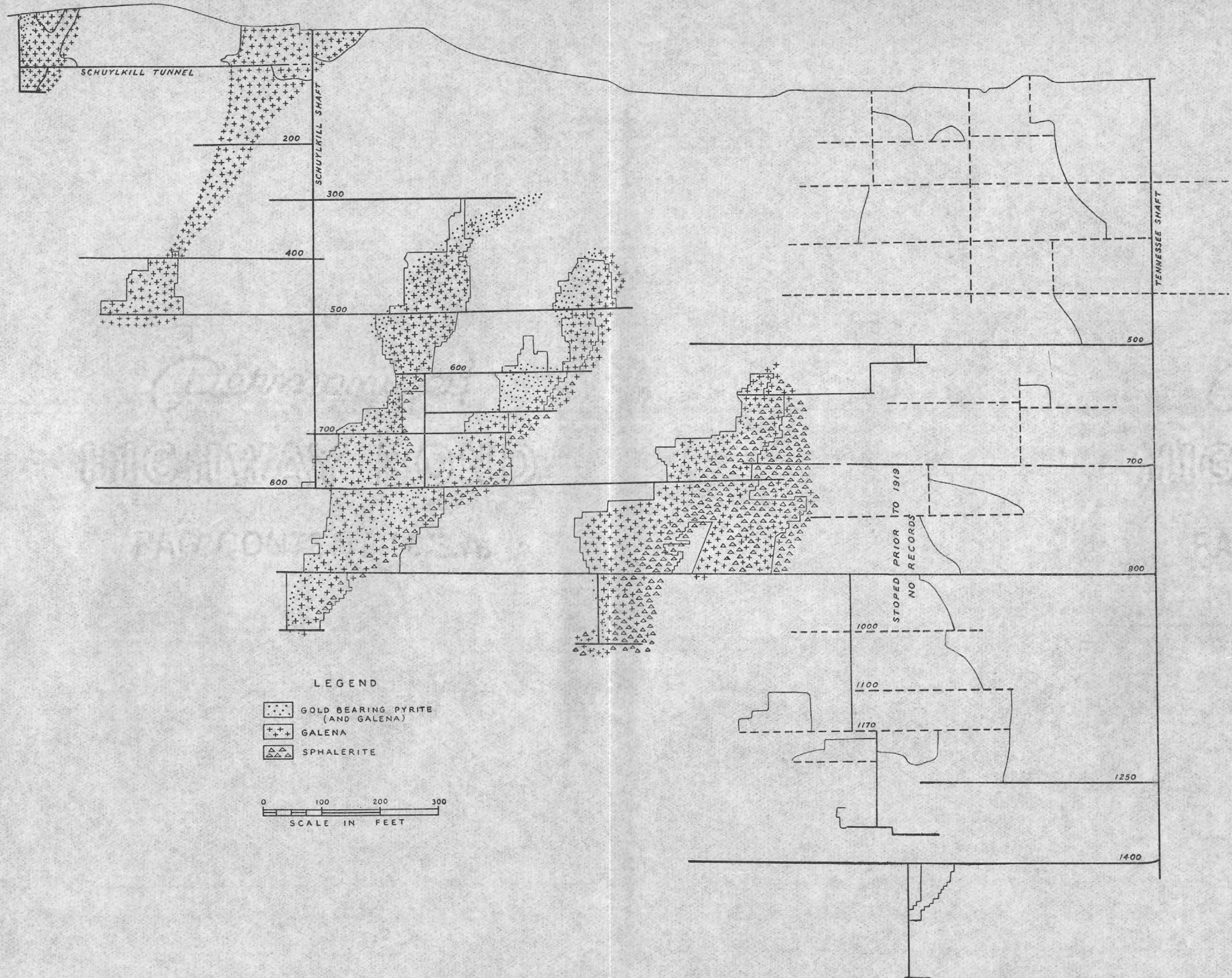


Plate XXX.—Tennessee-Schuylkill Mine, longitudinal section.

Plate XXXI.—Tennessee-Schuylkill Mine, cross section.

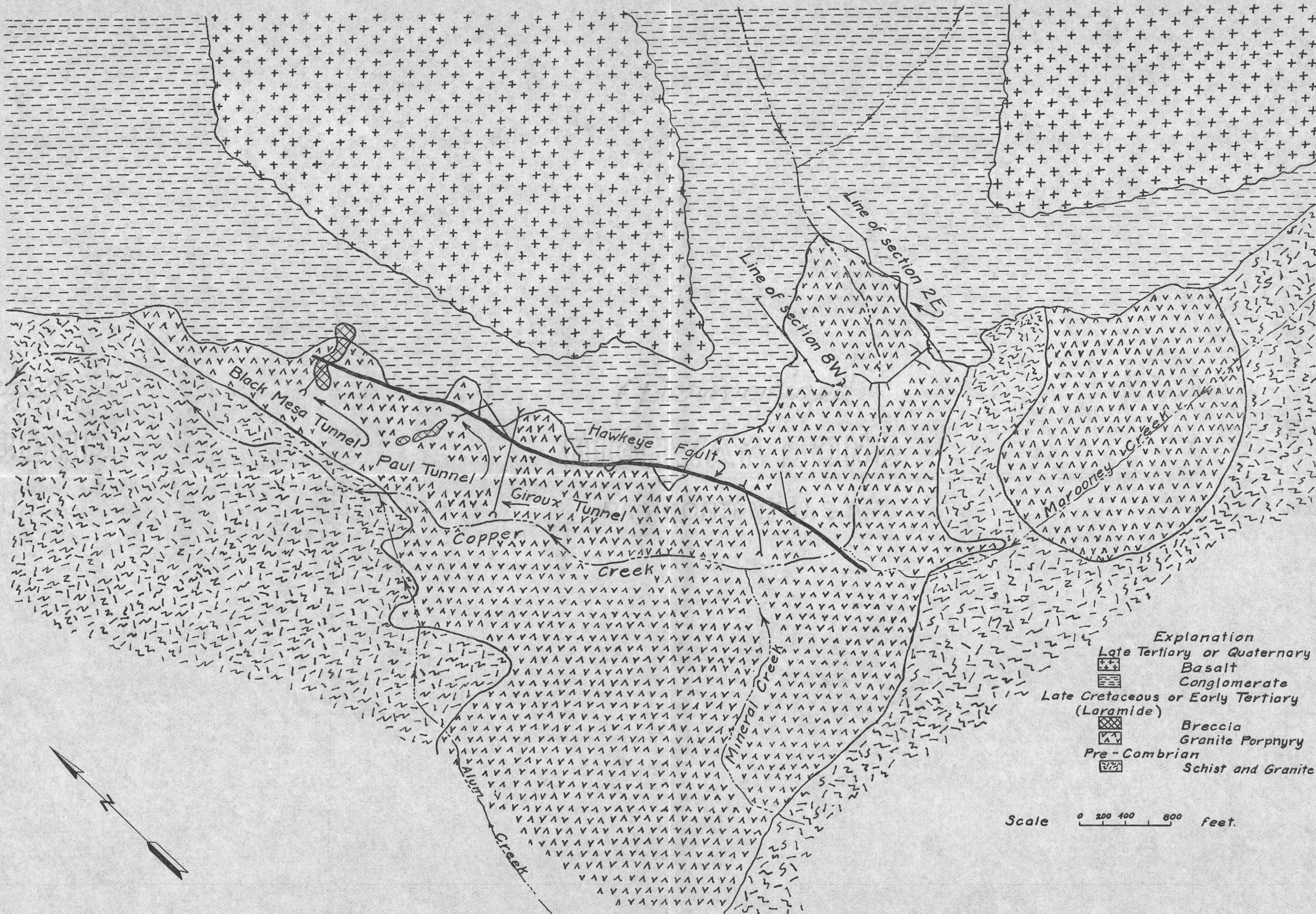


Plate XXV.—General geologic map of Bagdad Mine area. (After Rogers, Mayer, and Ball with modifications by H. N. Witt and P. C. Benedict.)

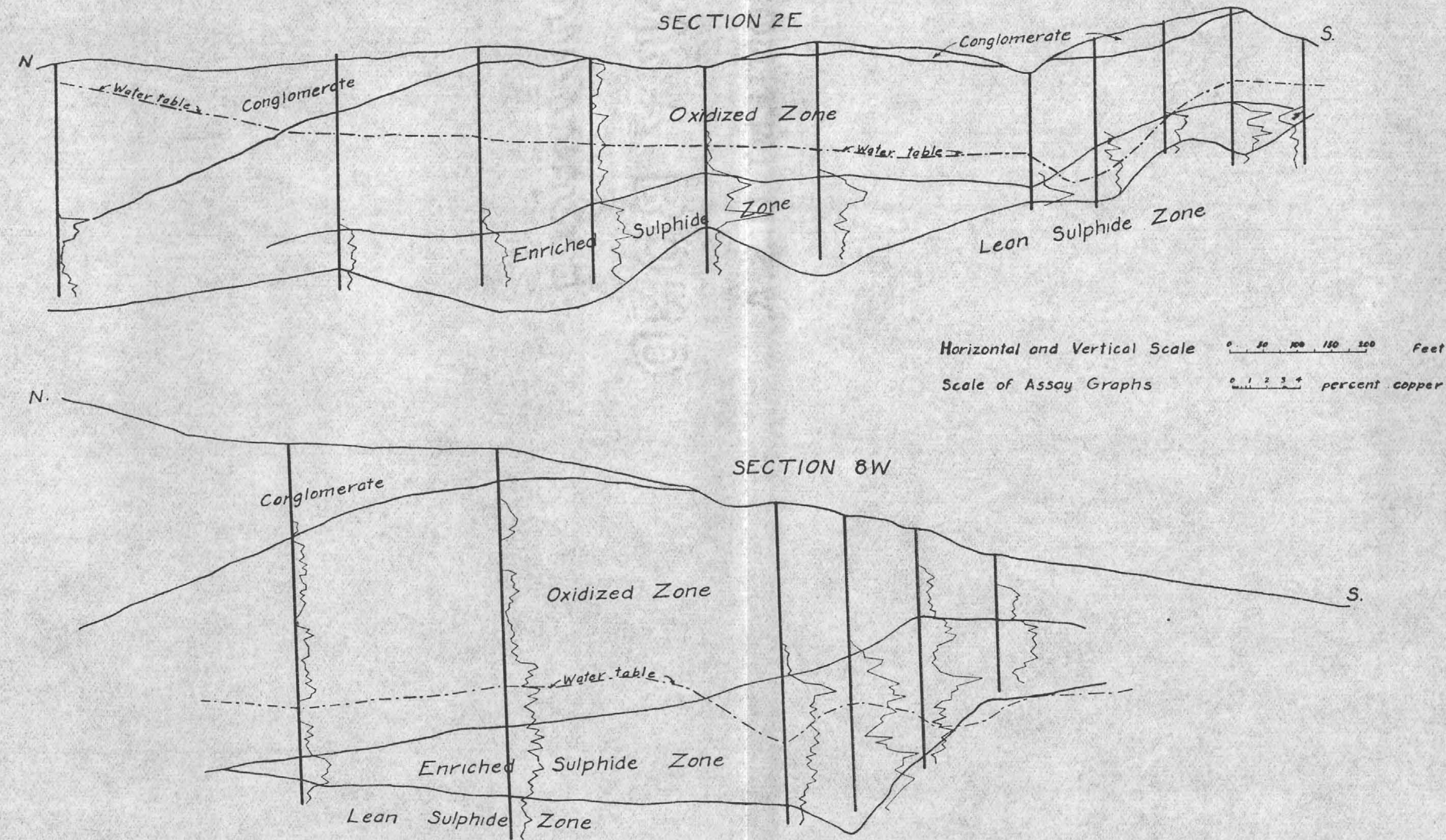


Plate XXVII.—Sections through Bagdad ore body along lines 2 E and 8W of Plate XXV. Drill holes indicated by heavy lines.

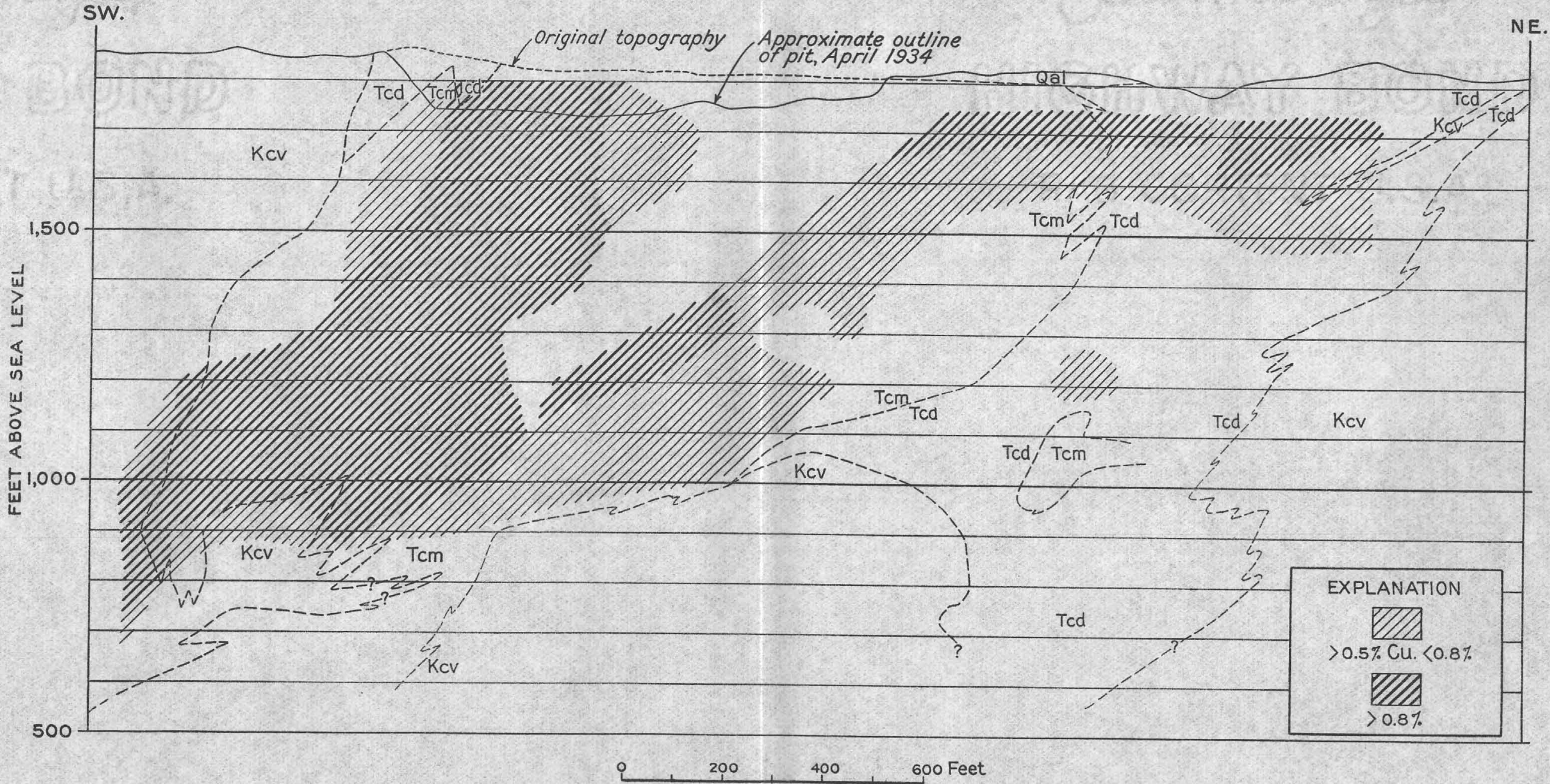


Plate XXII.—Northeast cross section through the New Cornelia Mine, Ajo, Arizona, showing distribution of ore and geology with depth. *Kcv*, concentrator volcanics; *Tcd*, dioritic facies of Cornelia quartz monzonite; *Tcm*, Cornelia quartz monzonite; *Qal*, alluvium.

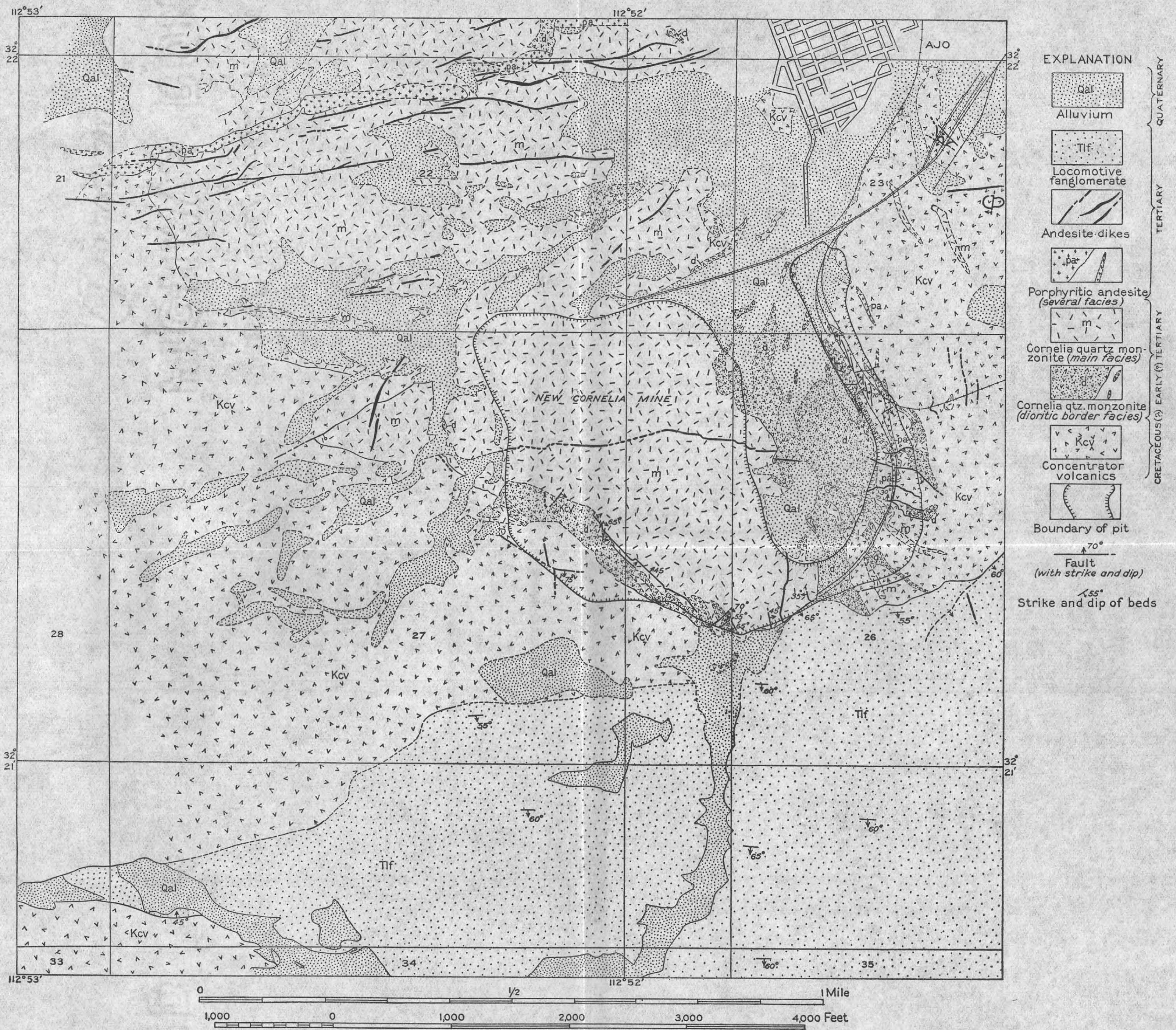


Plate XXI.—Geologic map of the mining area of the Ajo district, Arizona.

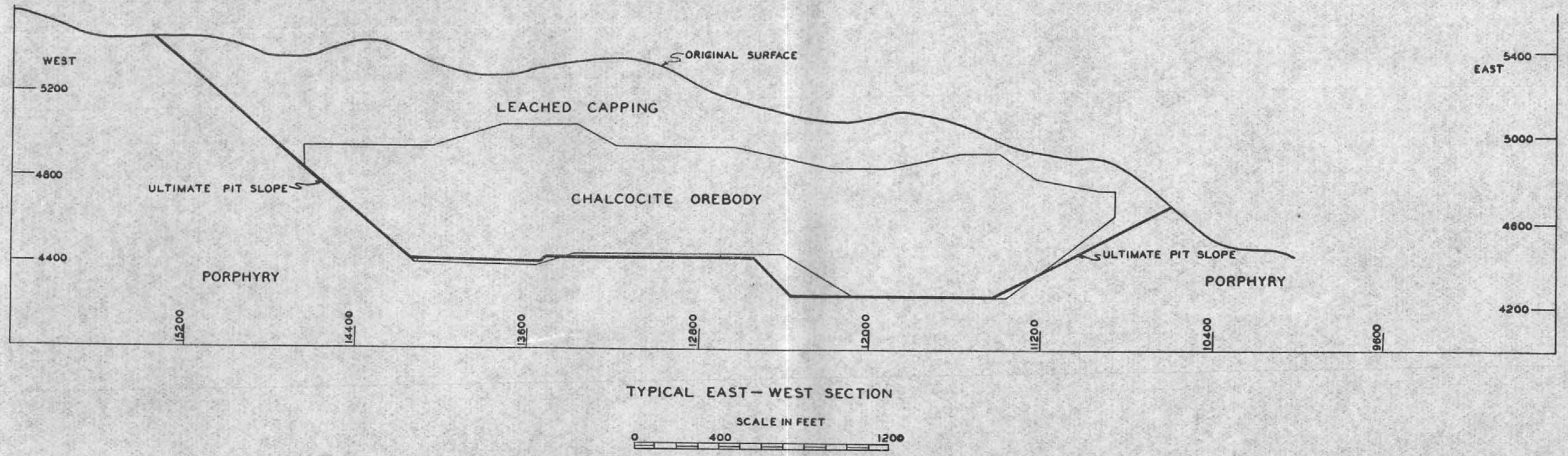


Plate XX.—Typical east-west section through open-pit ore body.

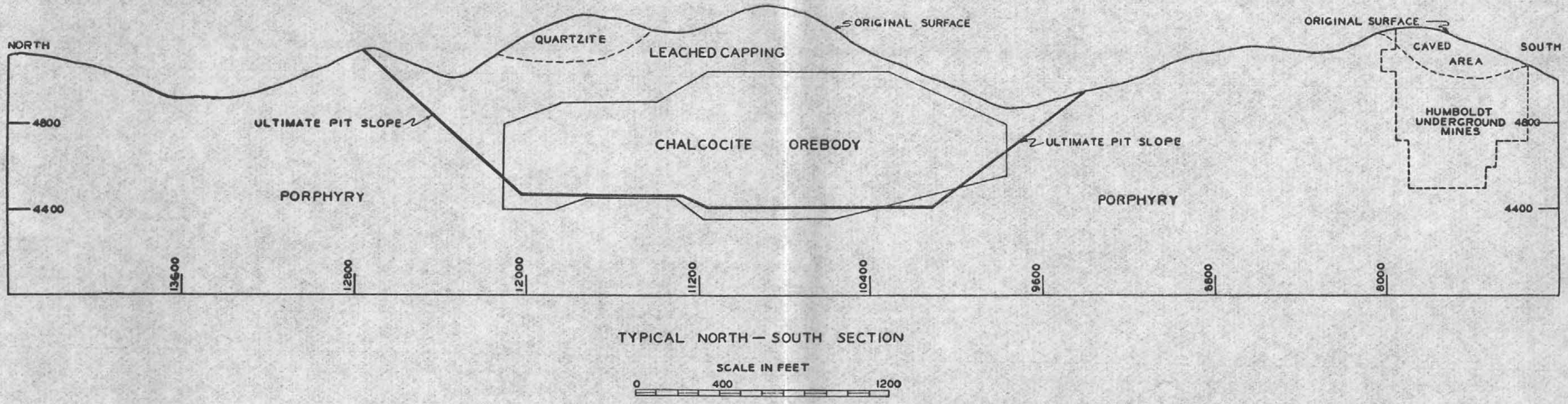


Plate XIX.—Typical north-south section through open-pit ore body.

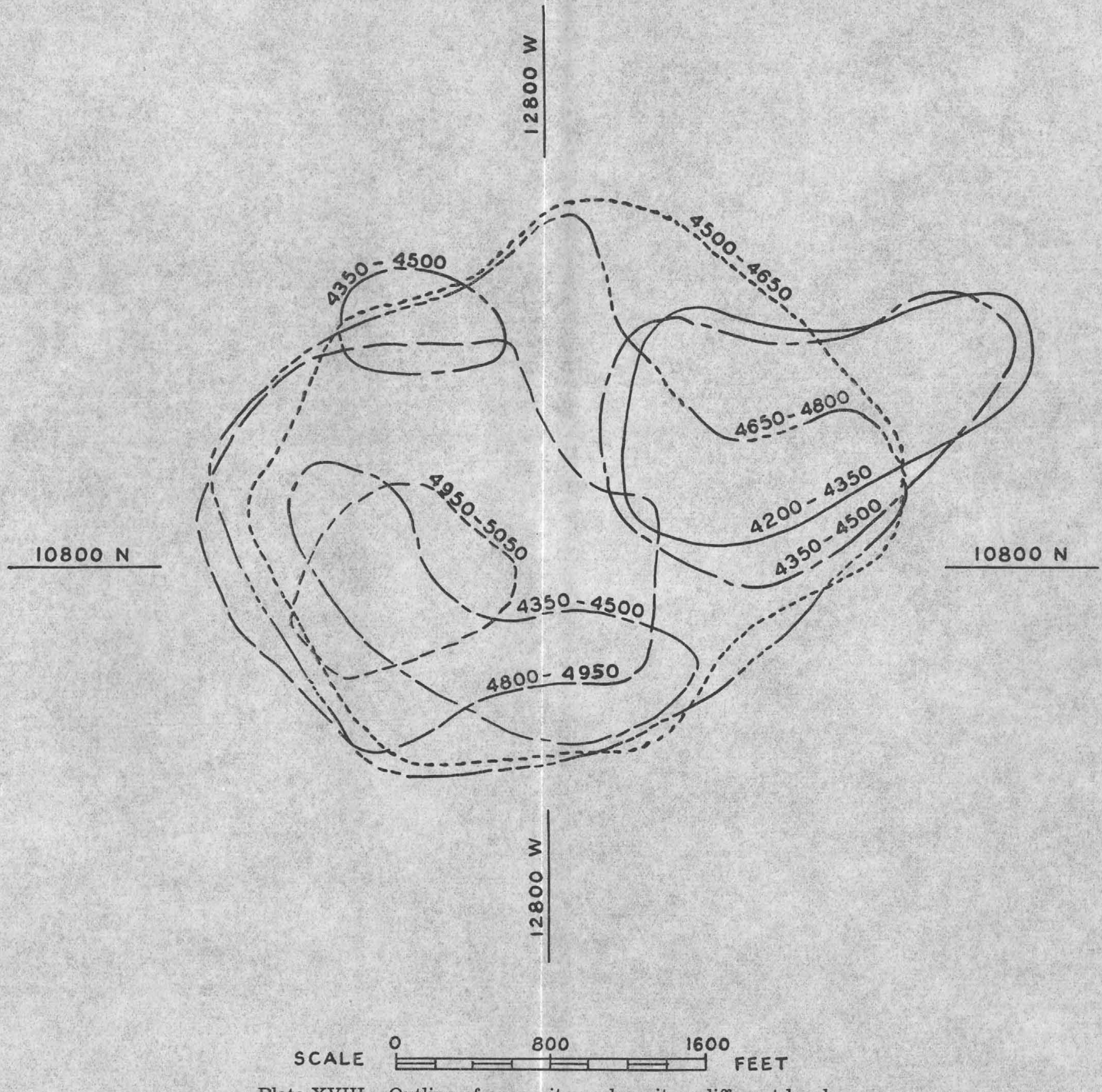


Plate XVIII.—Outline of open-pit ore deposit on different levels.

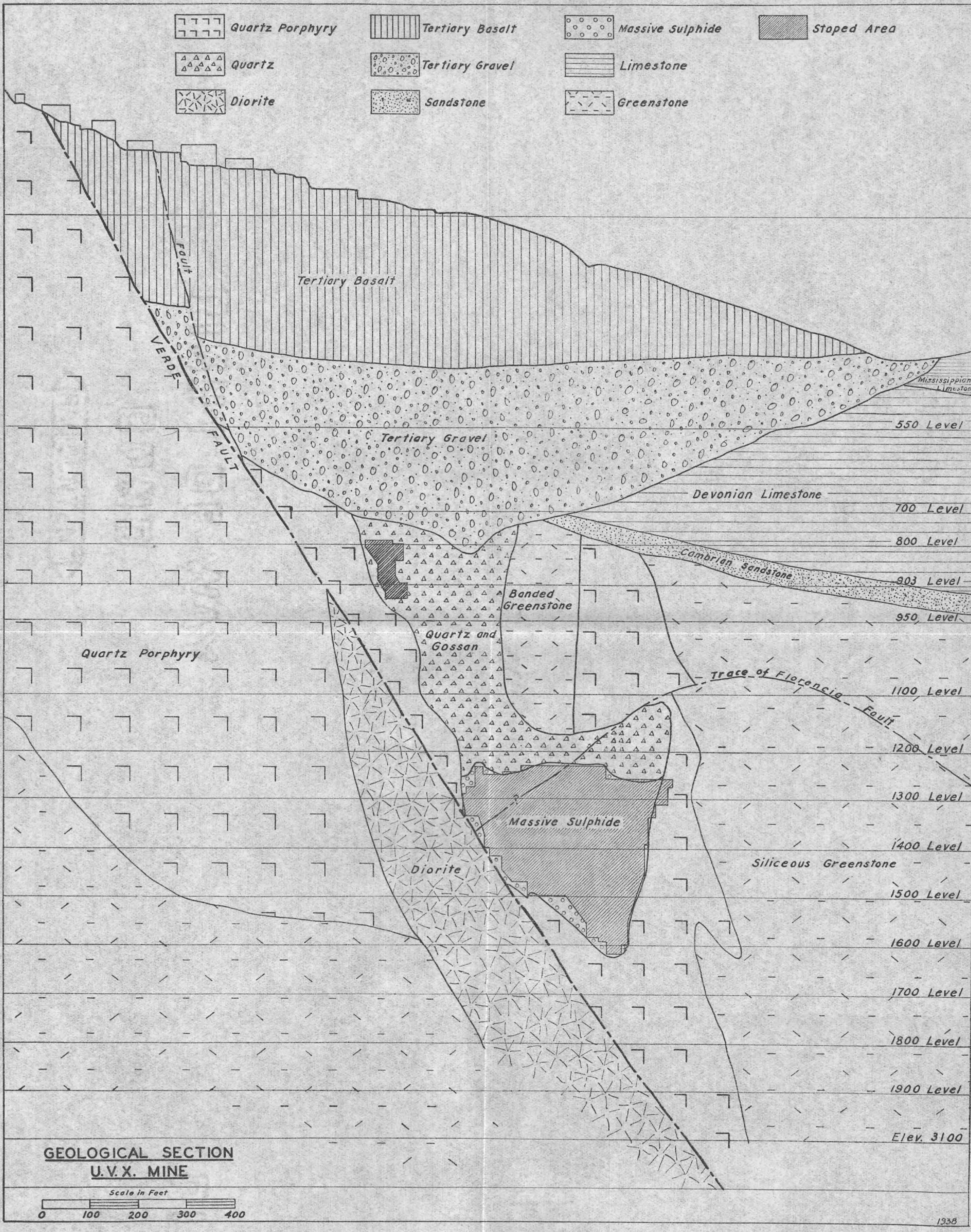


Plate XV.—Geologic section through U.V.X. ore zone along line B-B' of Plate XIII. Section trends about N. 67 degrees E. and passes through main ore body.

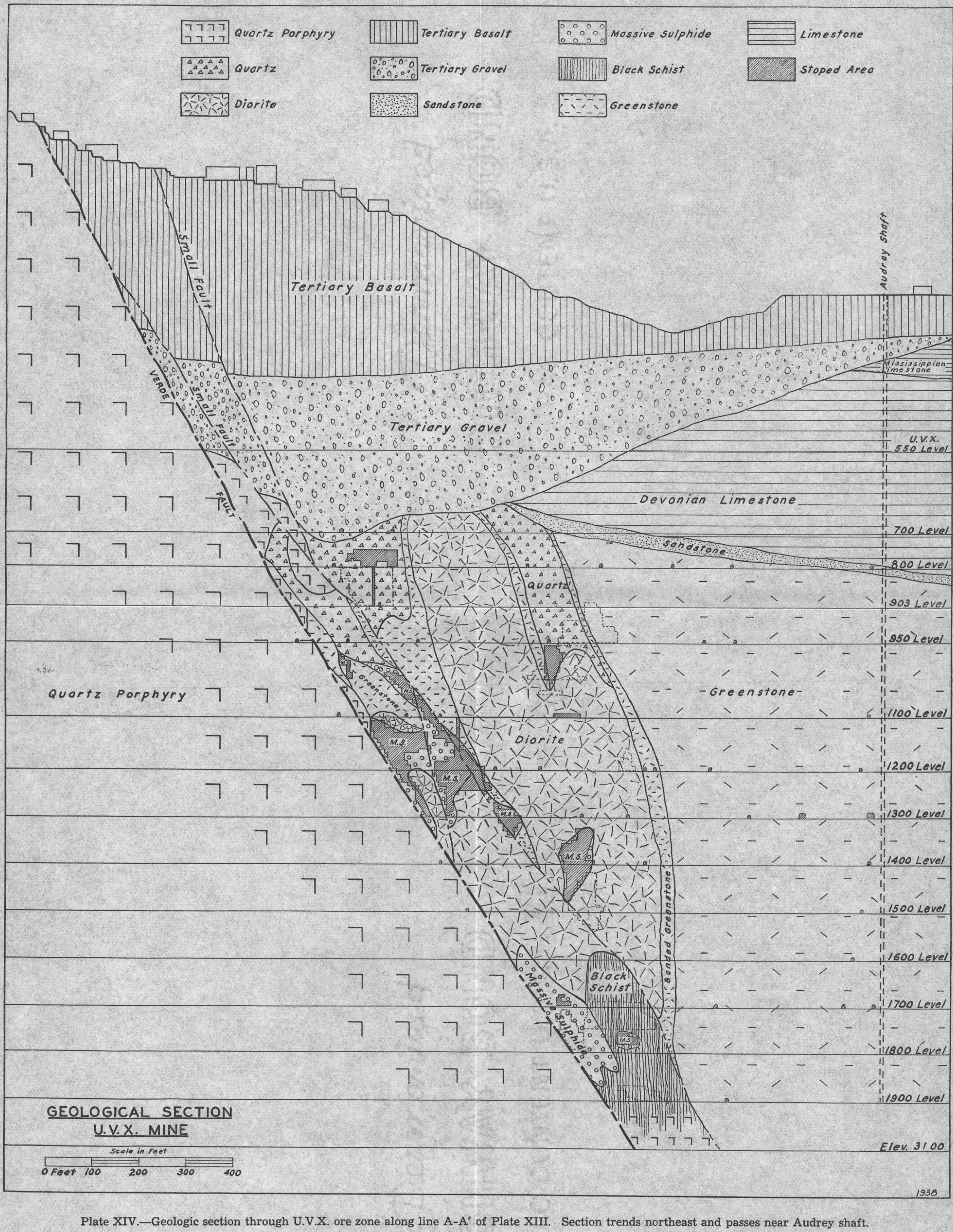


Plate XIV.—Geologic section through U.V.X. ore zone along line A-A' of Plate XIII. Section trends northeast and passes near Audrey shaft.

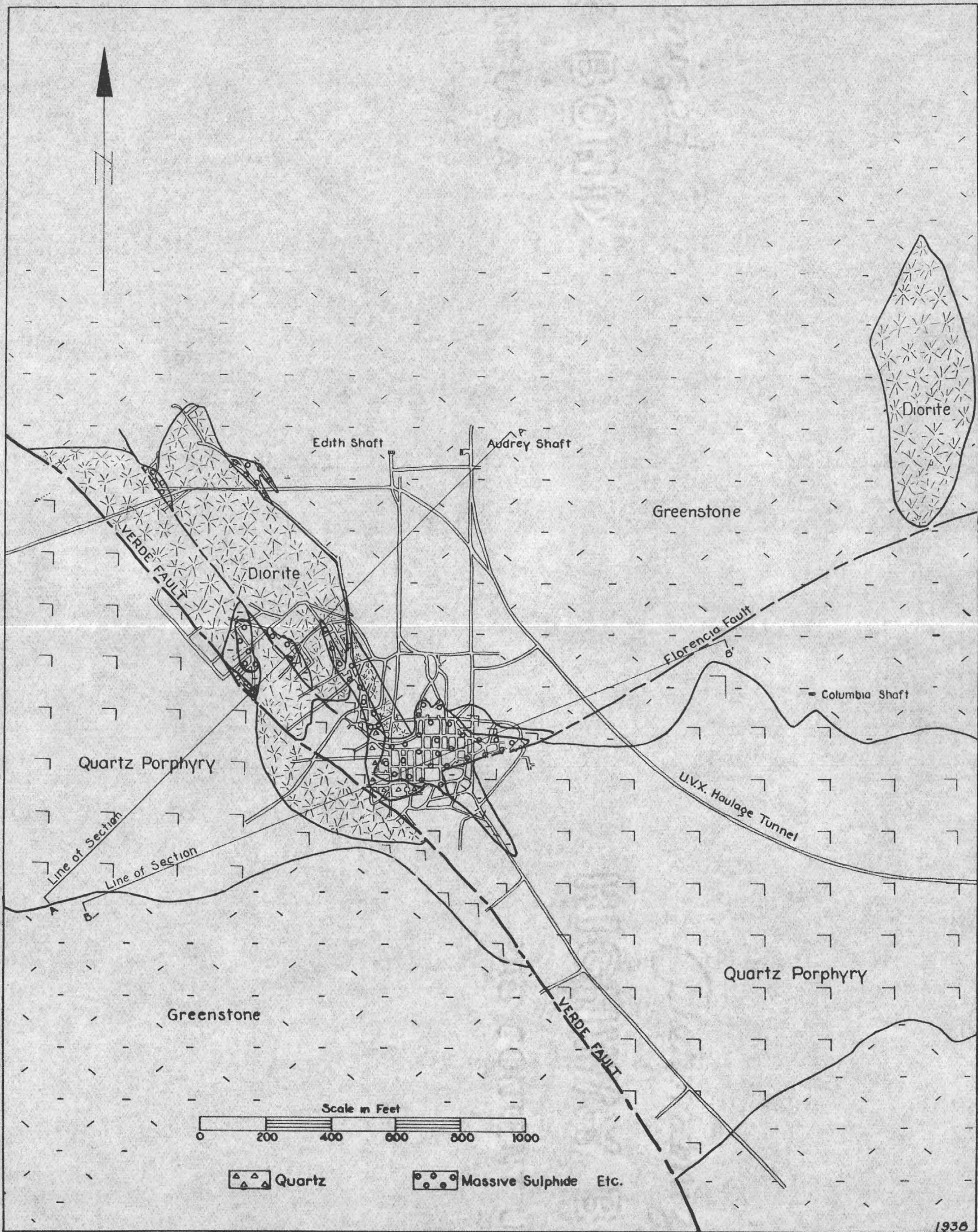


Plate XIII.—Generalized geologic map of United Verde Extension 1,300-foot level.

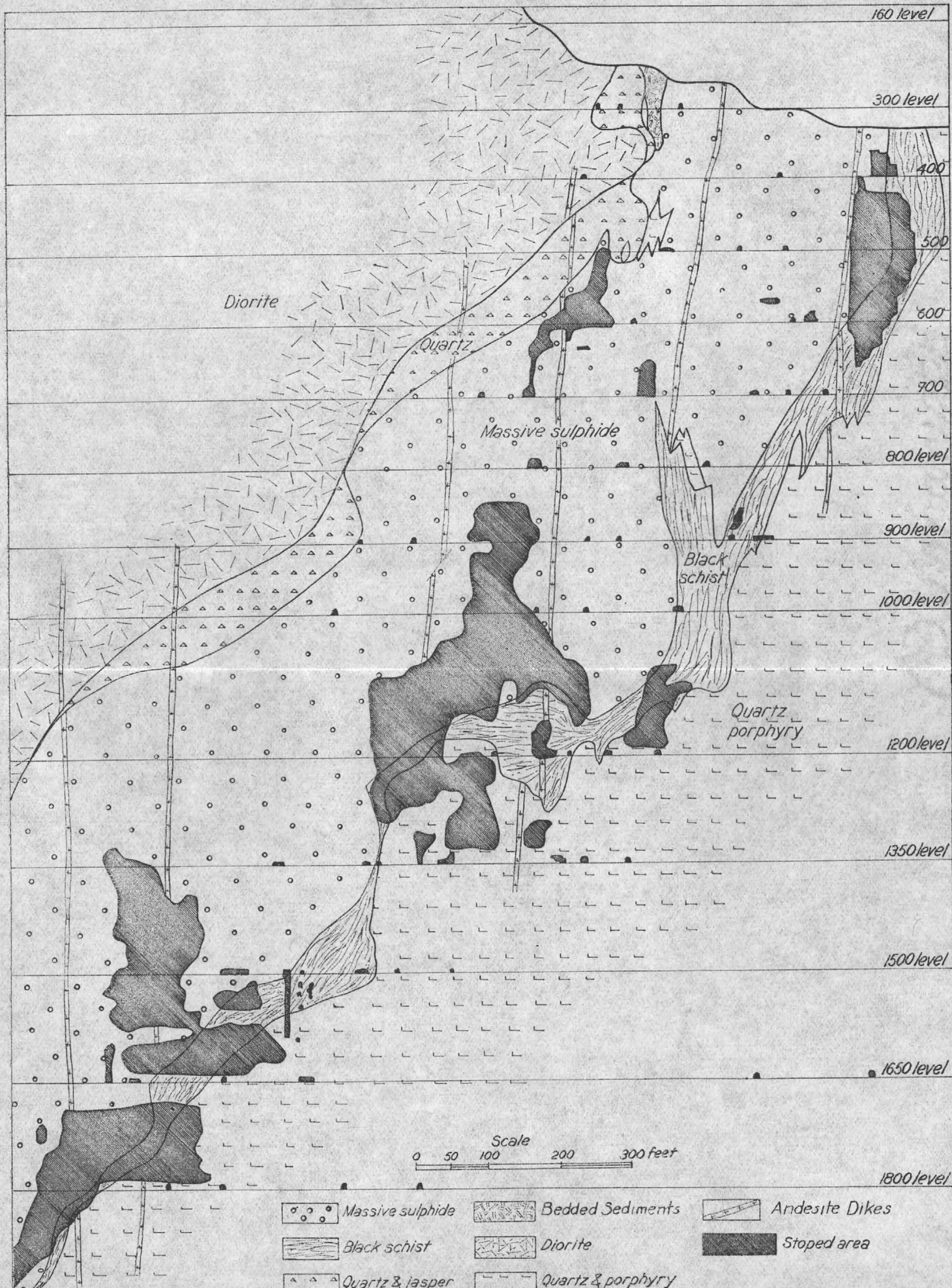


Plate XII.—Generalized geologic section through upper part of United Verde ore zone.

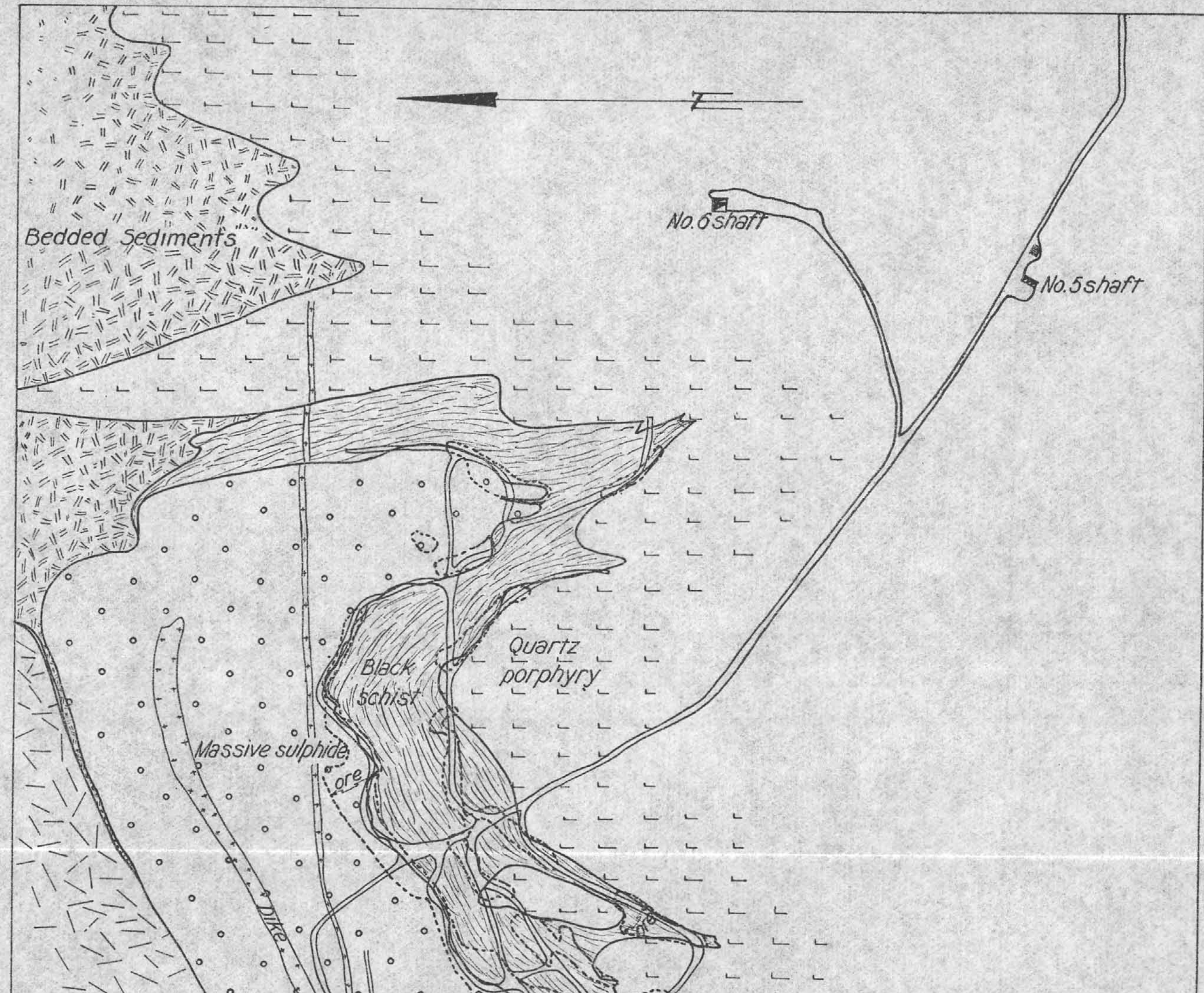


Plate XI.—Geologic map of United Verde 2,250-foot level, typical of lower part of developed ore zone.

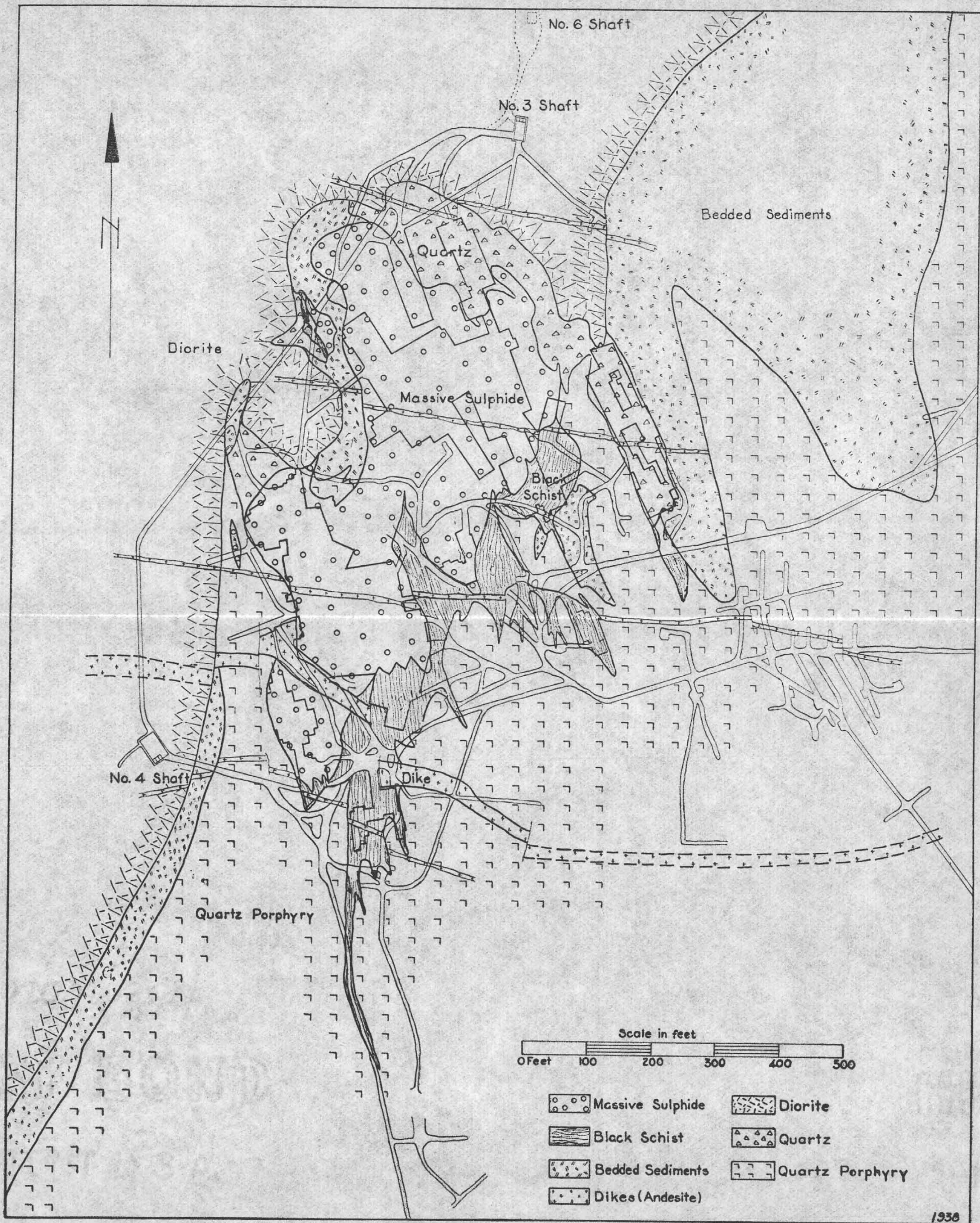


Plate X.—Geologic map of United Verde 300-foot level, typical of upper part of developed ore zone.

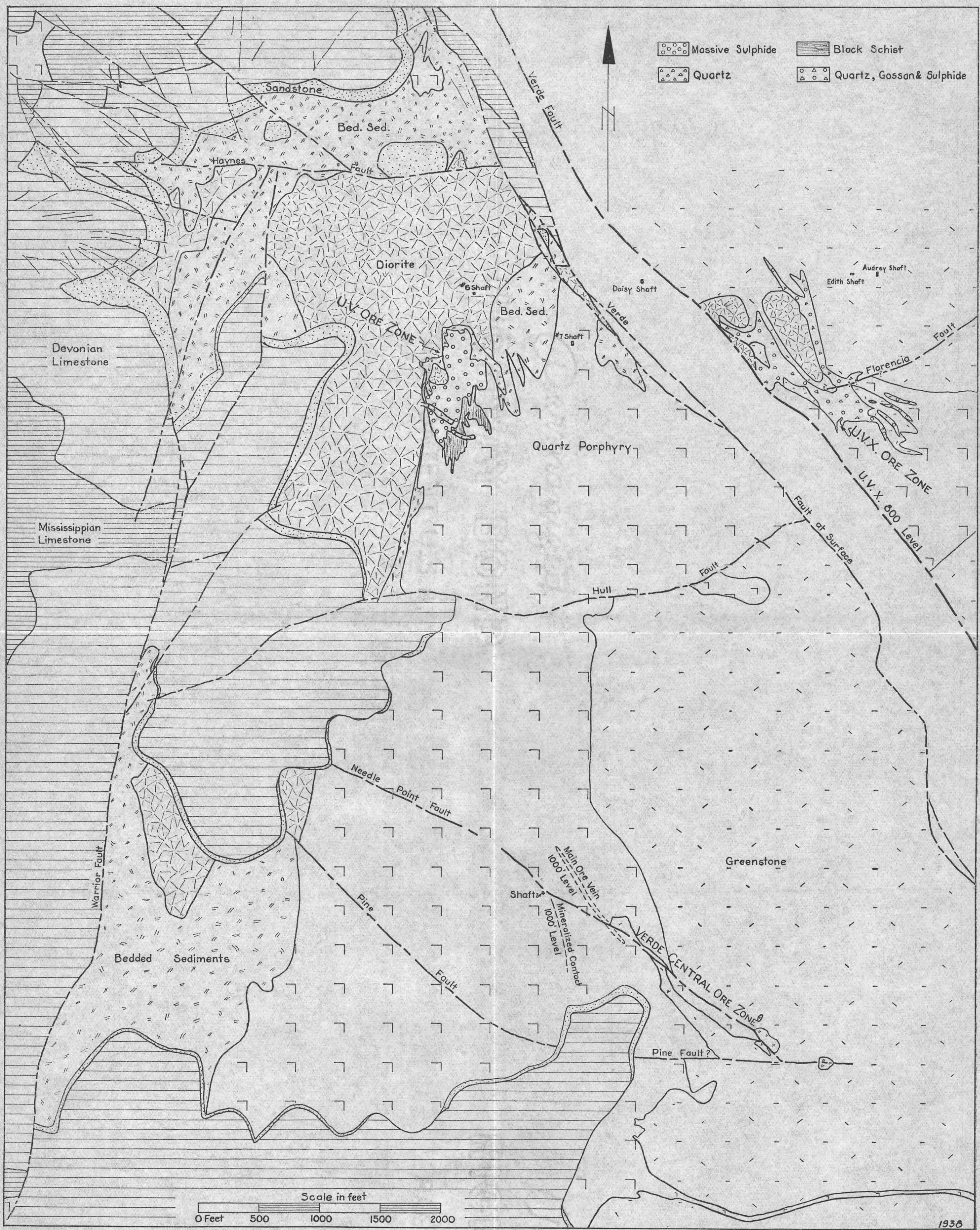


Plate IX.—Geologic map of northern part of Jerome District showing surface southwest of fault and U.V.X. 800-foot level northeast of fault.

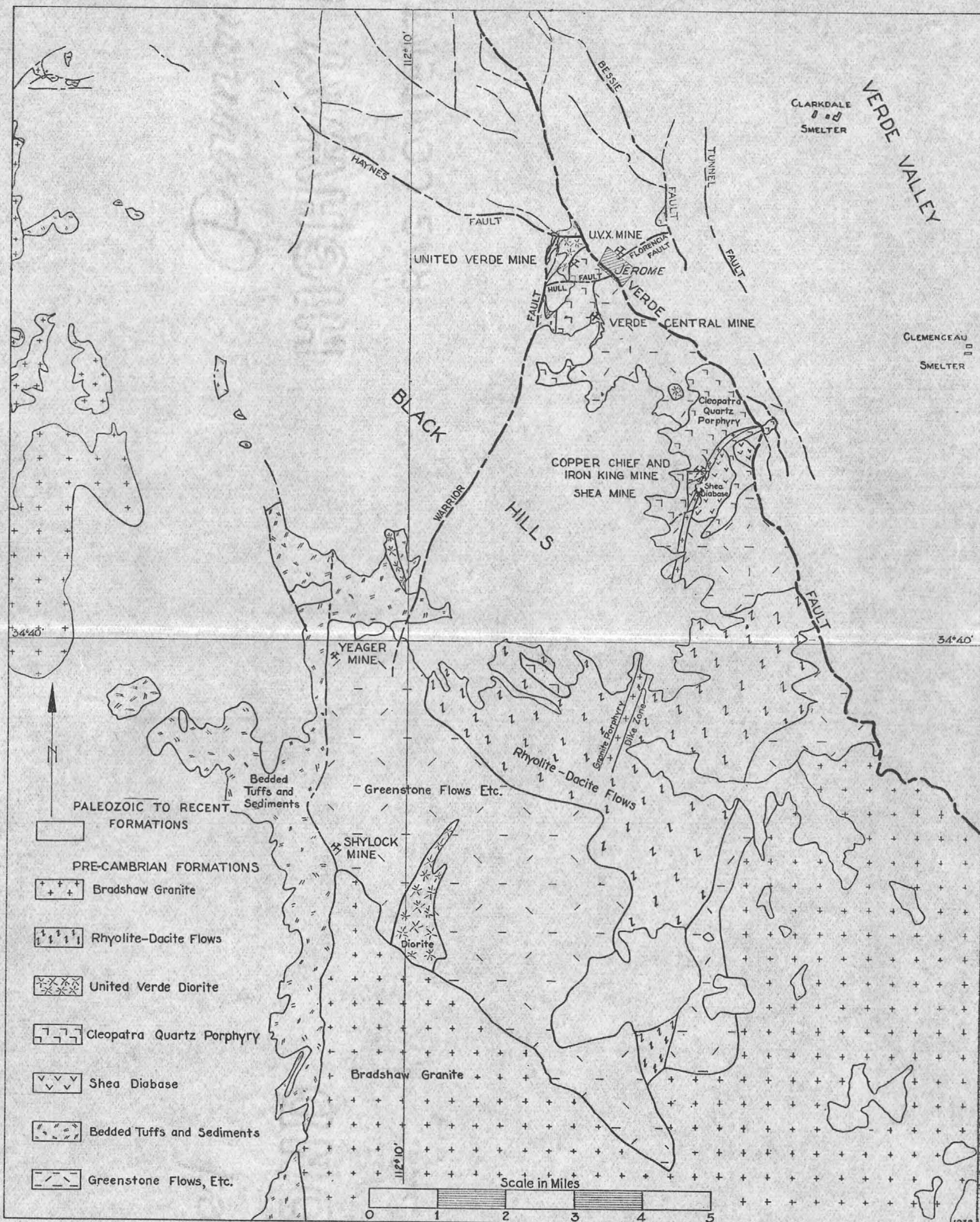


Plate VIII.—Generalized surface geologic map showing pre-Cambrian formations of Jerome district and surrounding area. Greenstone, bedded sediments, and rhyolite-dacite flows all part of Yavapai schist as mapped in Bradshaw Mountains quadrangle to south.

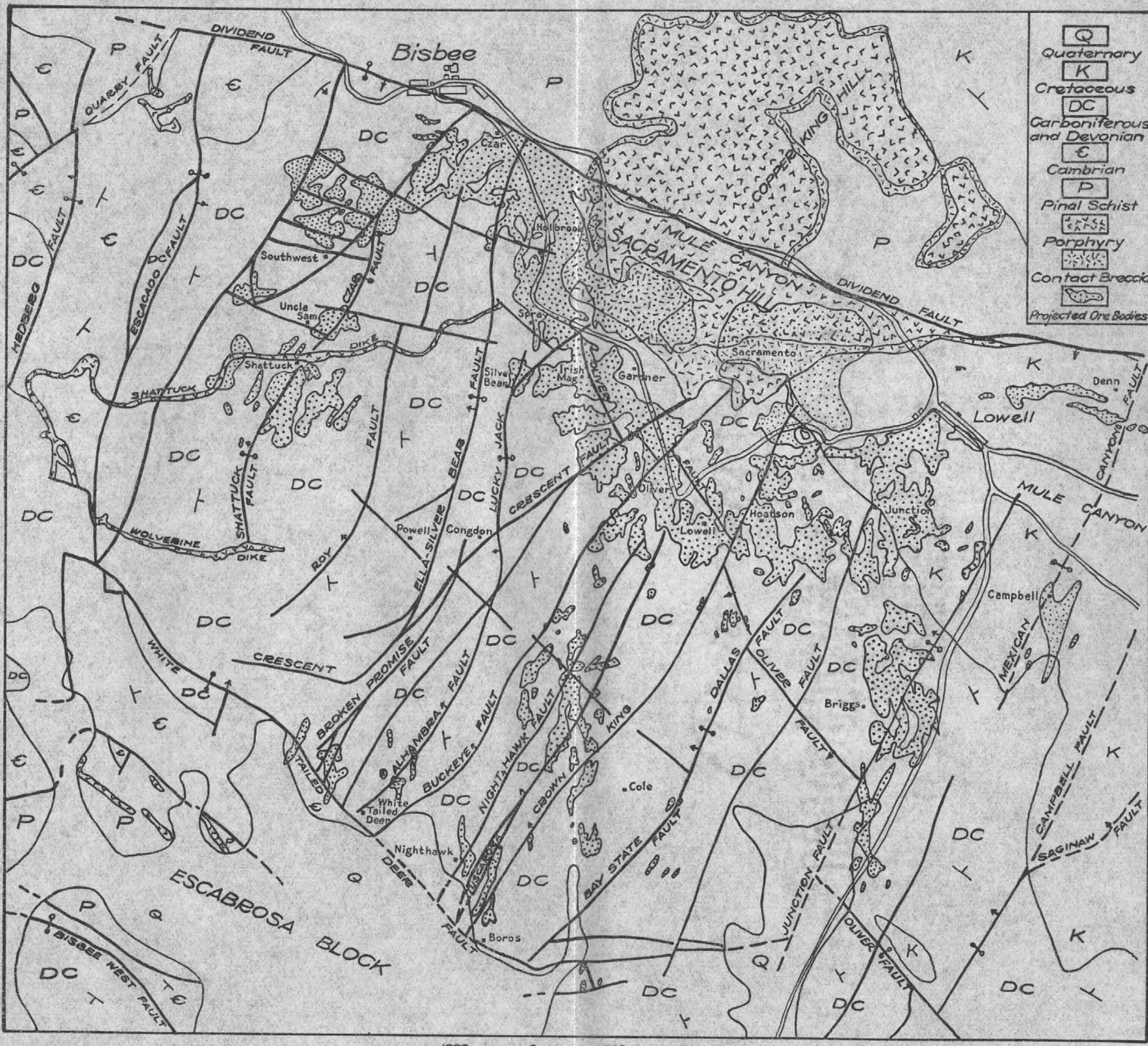


Plate VII.—Geologic map of Bisbee district.

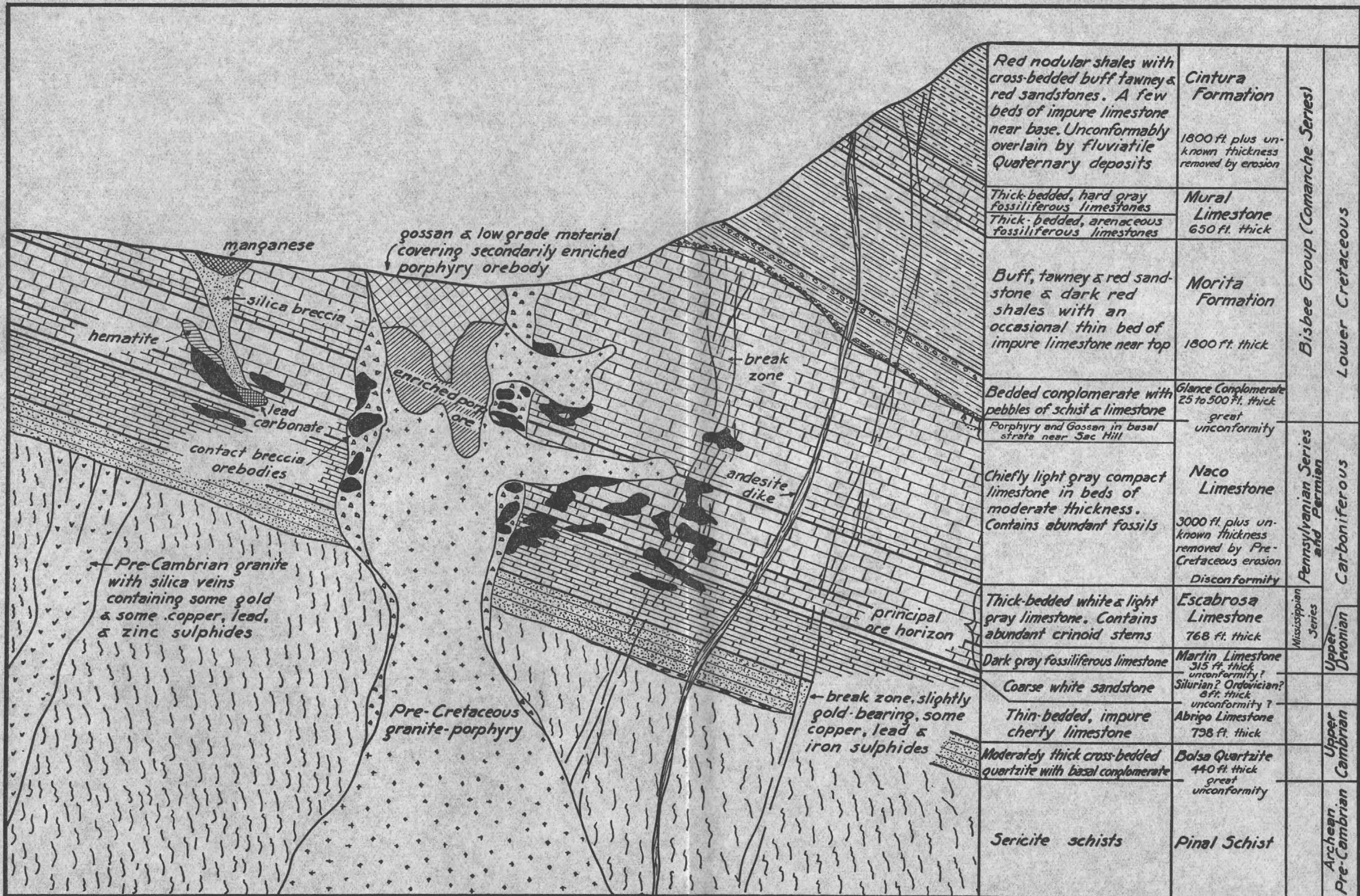
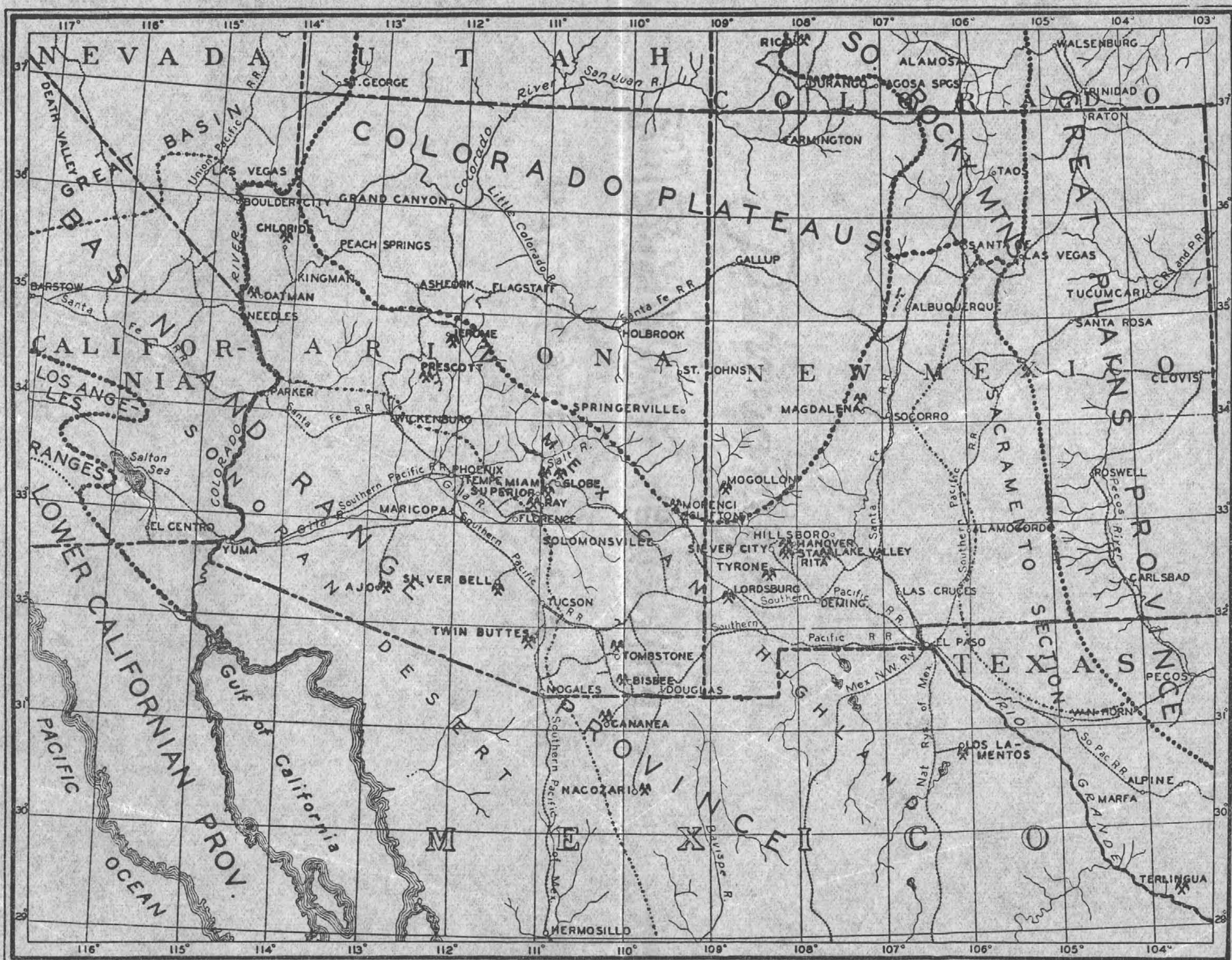


Plate V.—Bisbee columnar section.



MAP SHOWING GENERAL RELATION OF MINING DISTRICTS OF THE S.W. UNITED STATES TO MAIN PHYSICAL DIVISIONS

25 0 25 50 75 100 MILES

25 0 25 50 75 100 KILOMETERS

PHYSICAL DIVISIONS SLIGHTLY MODIFIED FROM N.M. FENNEMAN
PRINCIPAL METAL-MINING DISTRICTS INDICATED THUS: ⚒

AFTER F.L.RANSOME, XVI INT. GEOL. CONG. GUIDEBOOK 14

Plate I.—Map showing general relation of mining districts of the Southwest to main physical divisions.

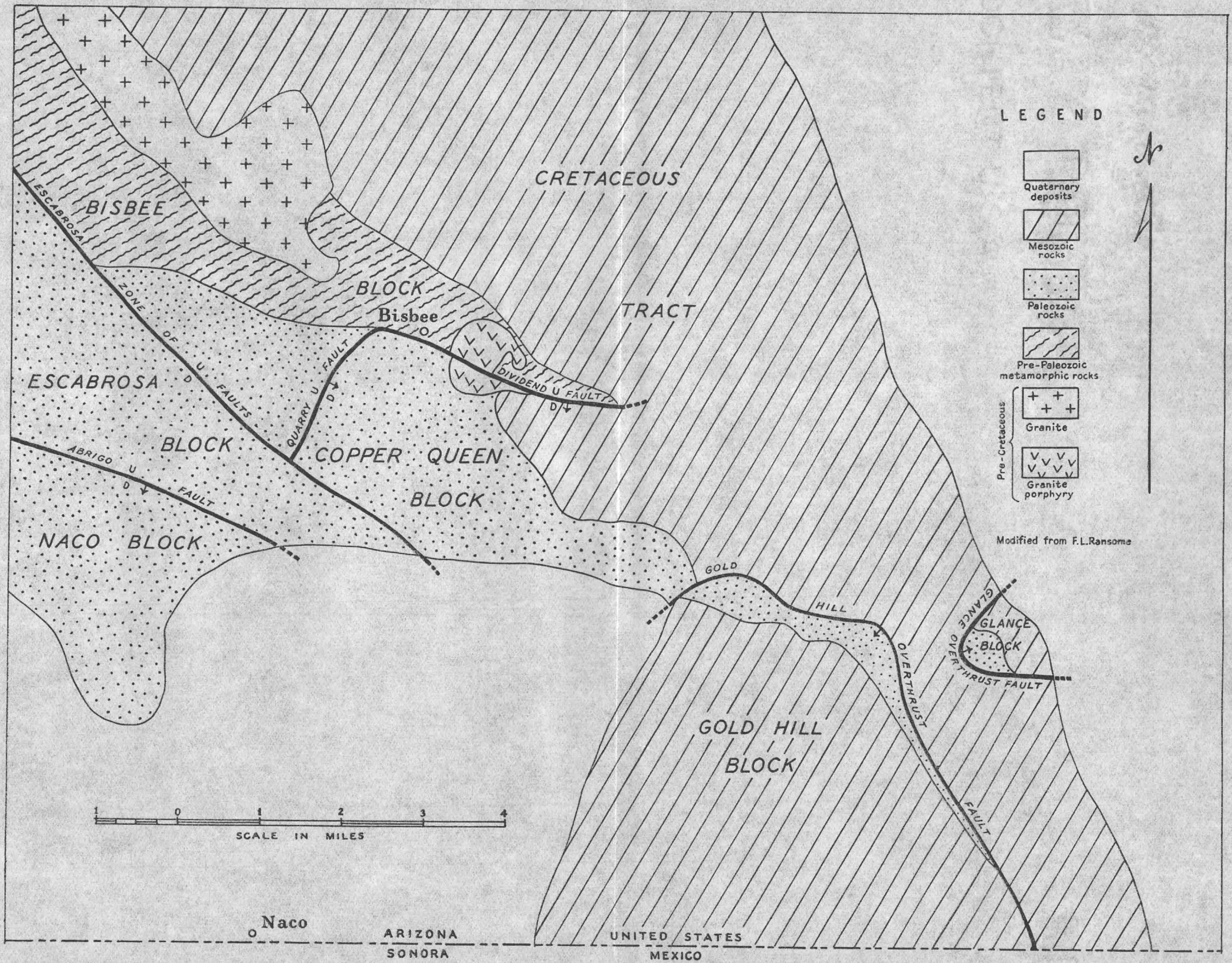


Plate VI.—Structural areas, Bisbee district.

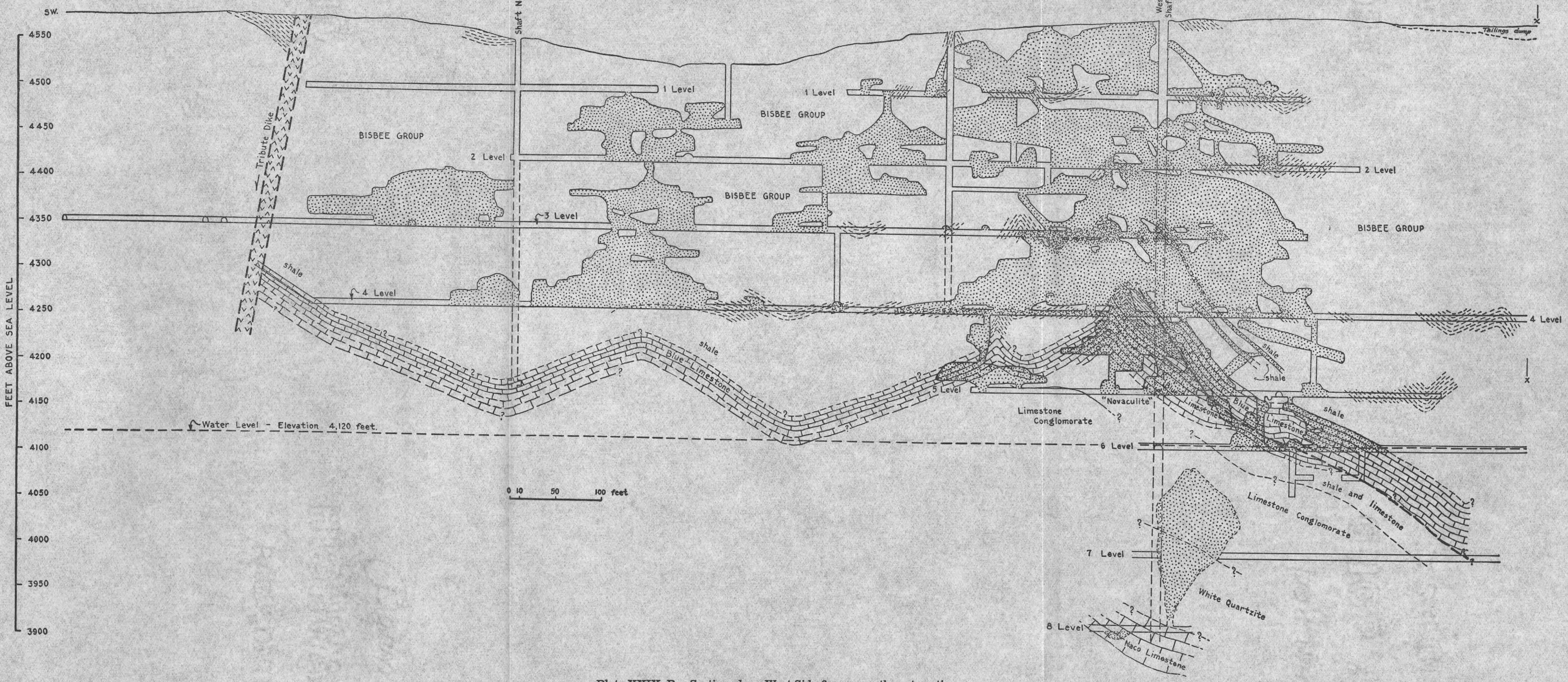


Plate XXIX, B.—Section along West Side fissure, southwest portion.

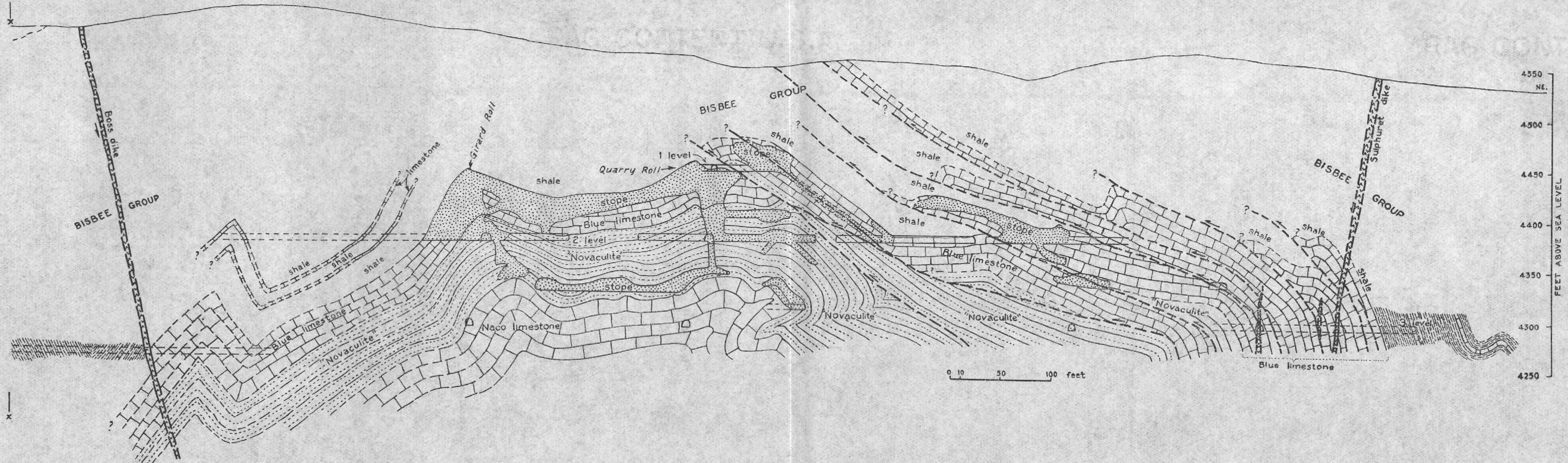


Plate XXIX, A.—Section along West Side fissure, northeast portion.

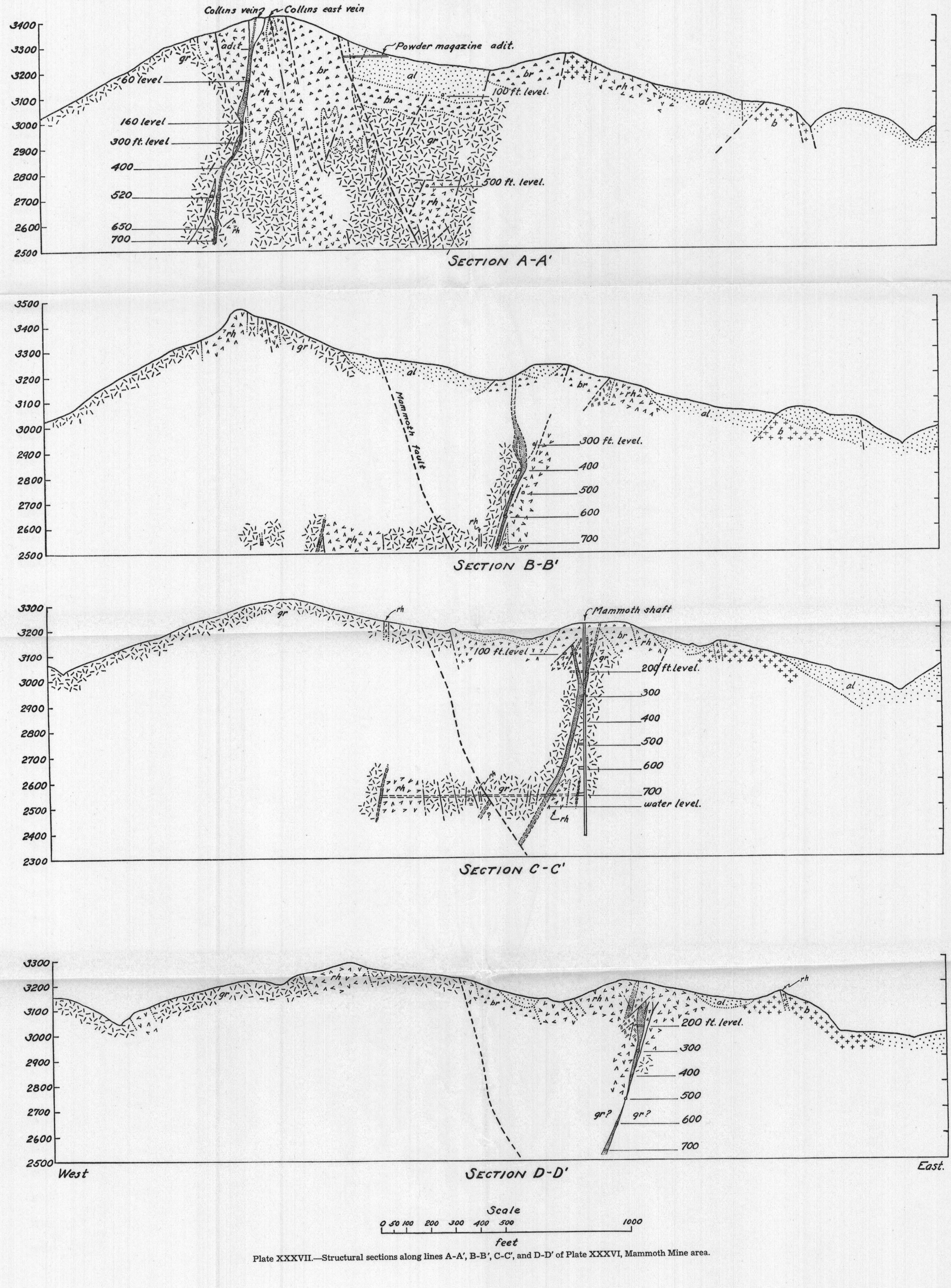


Plate XXXVII.—Structural sections along lines A-A', B-B', C-C', and D-D' of Plate XXXVI, Mammoth Mine area.

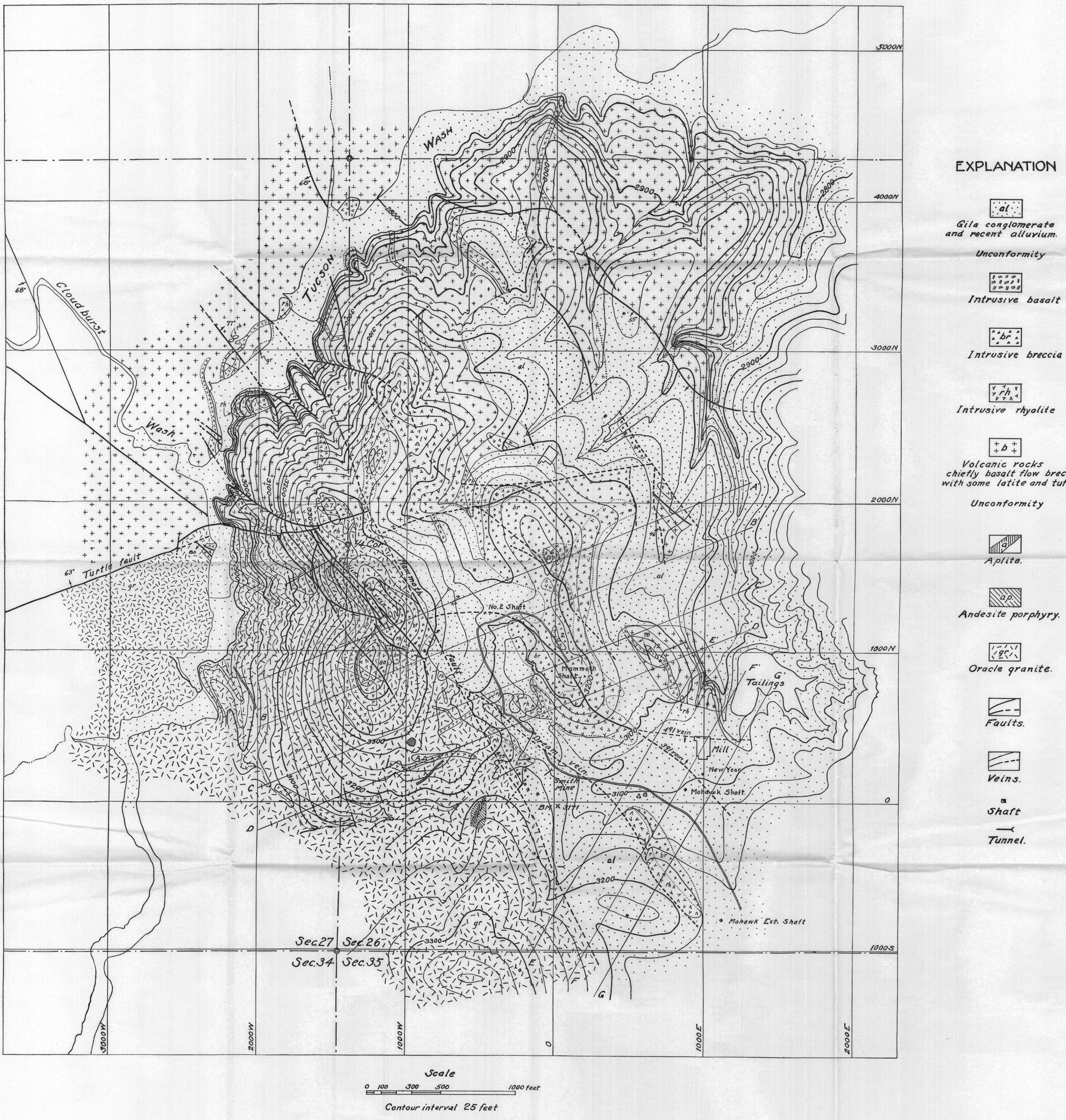


Plate XXXVI.—Geologic map of Mammoth mining camp area.

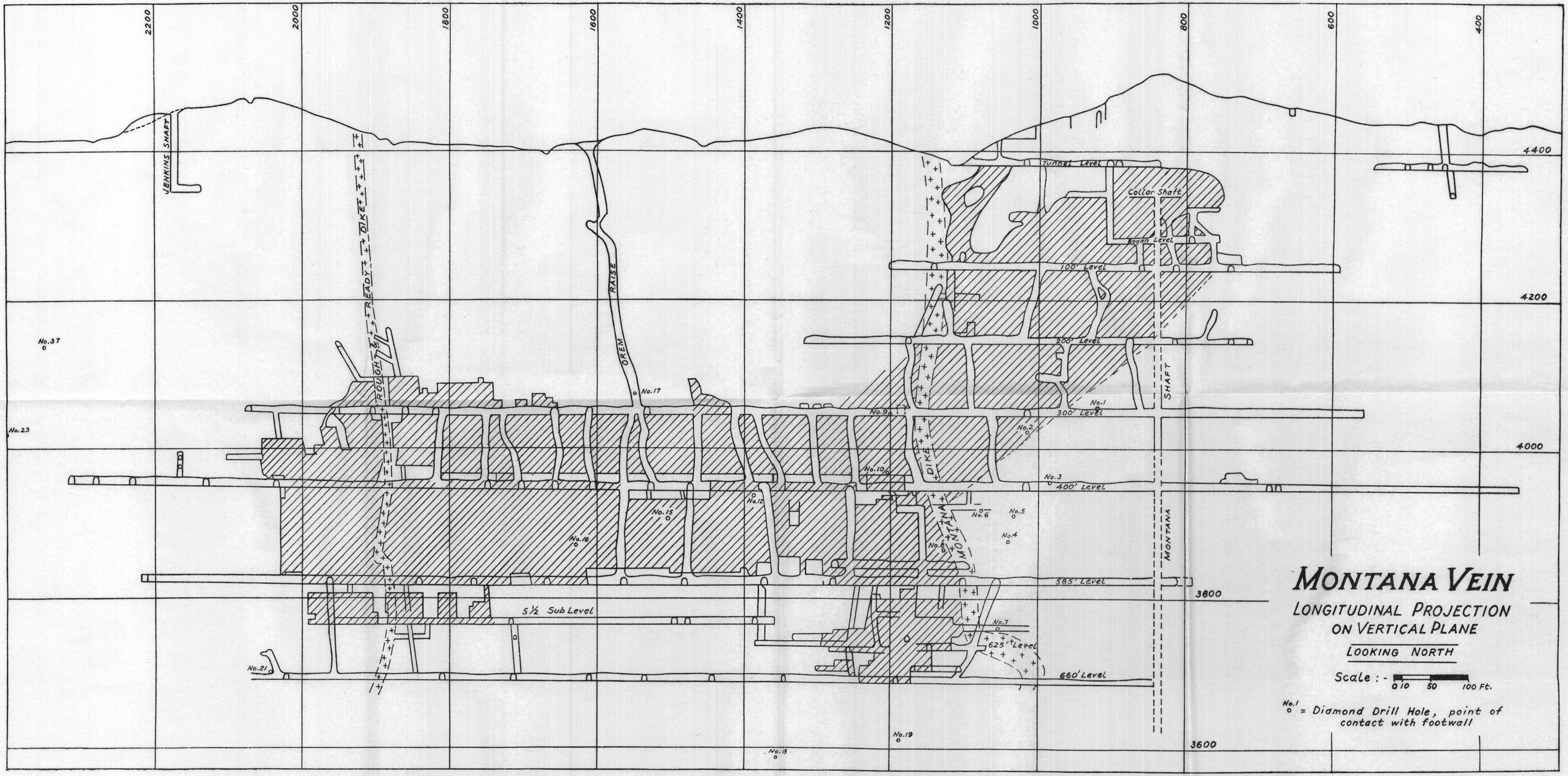


Plate XXXV.—Montana Mine, longitudinal projection, looking north.

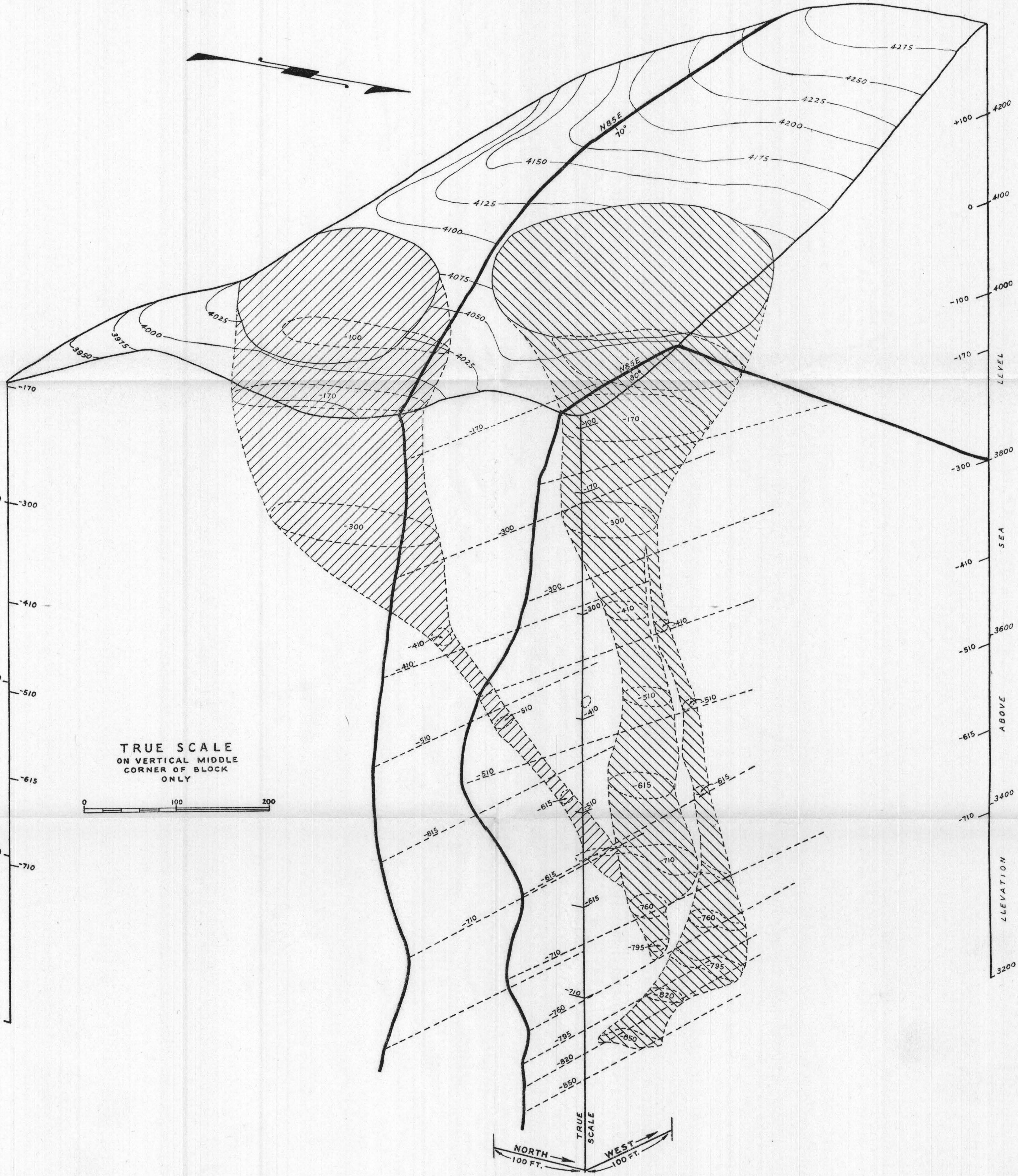


Plate XXXIX.—Stereogram showing principal relations at Childs-Aldwinkle Mine, Copper Creek.

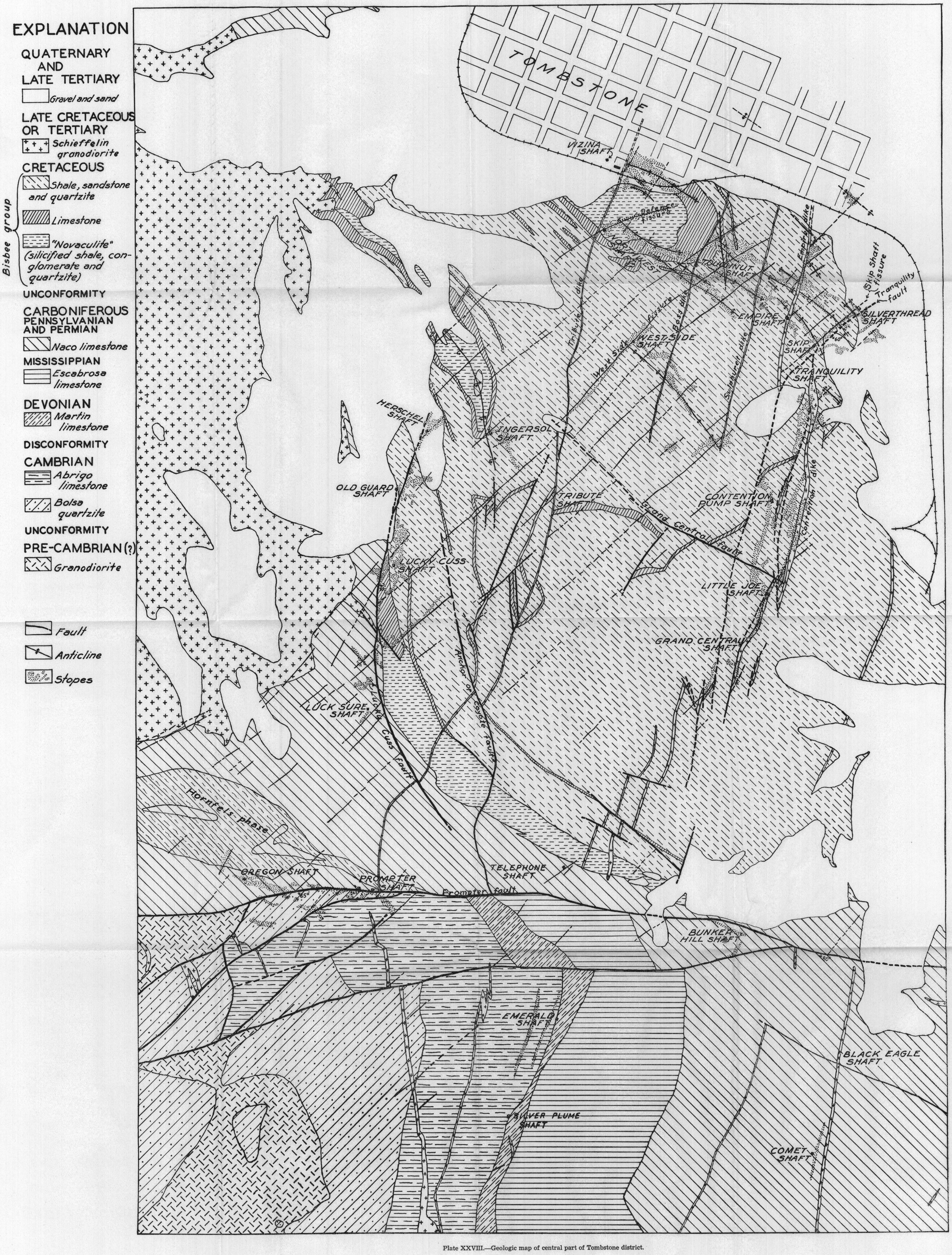


Plate XXVIII.—Geologic map of central part of Tombstone district.

Plate XVI.—Geologic map of part of the Clifton-Morenci district, showing distribution of principal ore bodies. (Modified from Lindgren.)

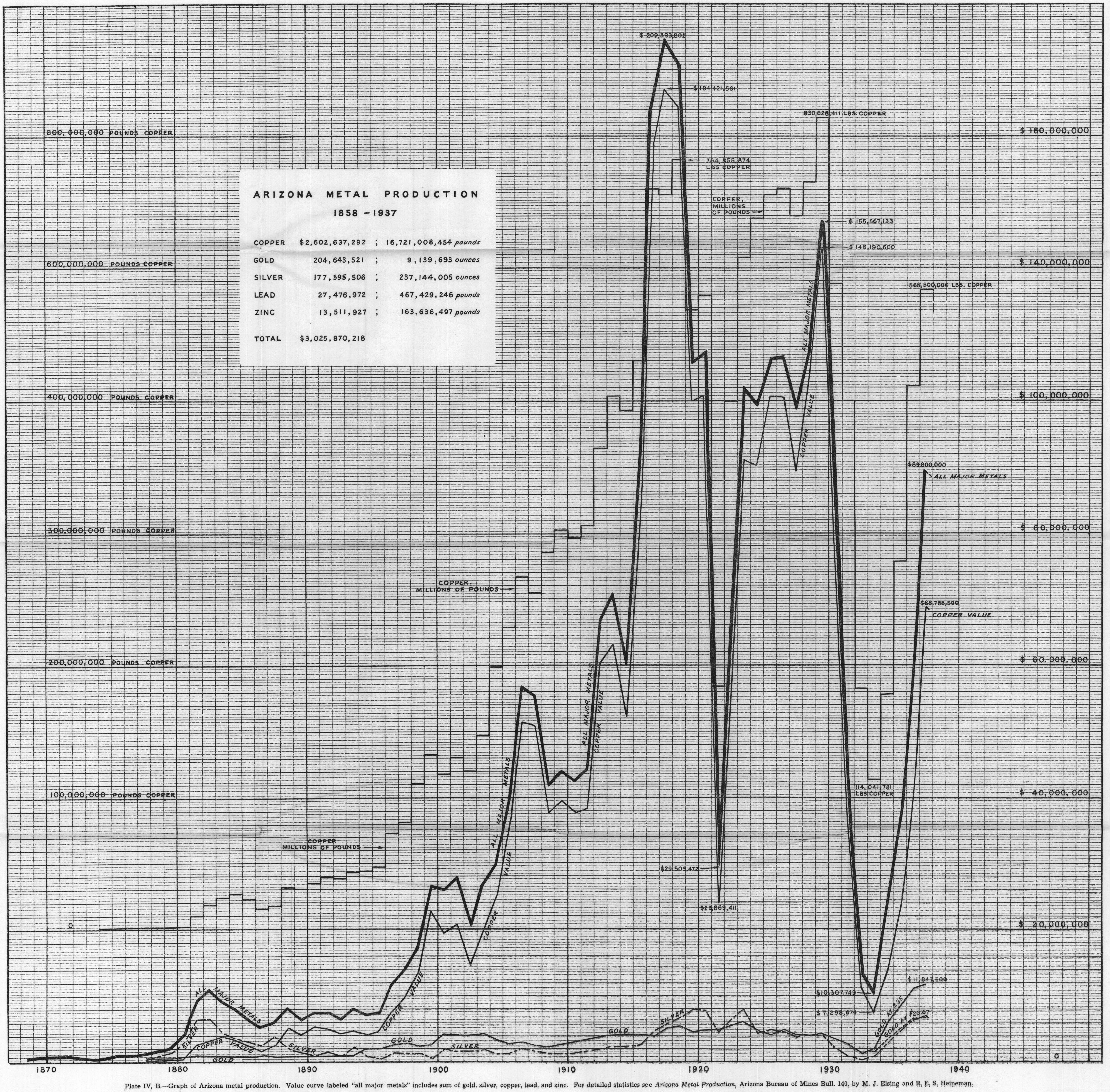


Plate IV, B.—Graph of Arizona metal production. Value curve labeled "all major metals" includes sum of gold, silver, copper, lead, and zinc. For detailed statistics see *Arizona Metal Production*, Arizona Bureau of Mines Bull. 140, by M. J. Elsing and R. E. S. Heineman.

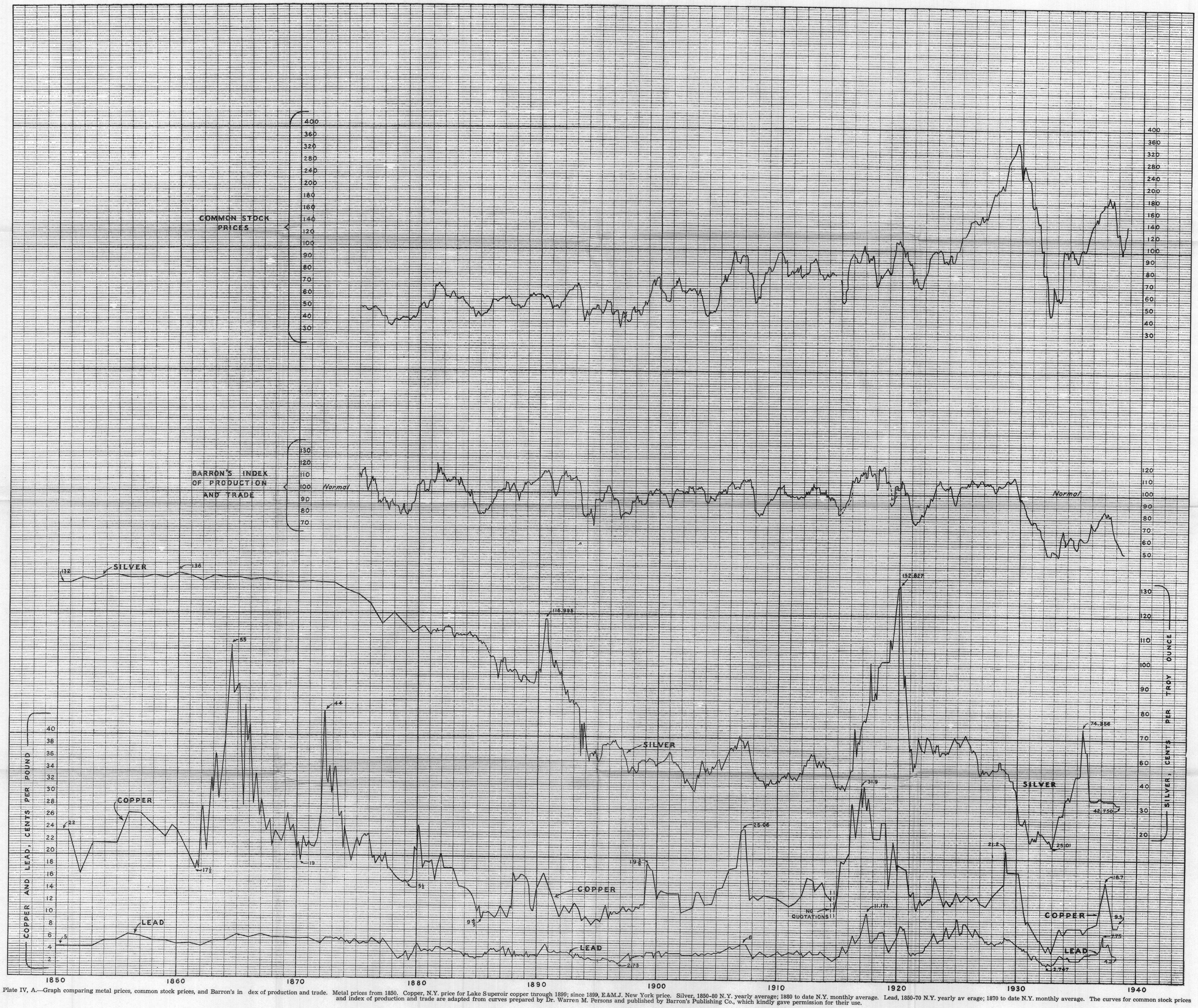


Plate IV, A.—Graph comparing metal prices, common stock prices, and Barron's in dex of production and trade. Metal prices from 1850. Copper, N.Y. price for Lake Superoir copper through 1899; since 1899, E.&M.J. New York price. Silver, 1850-80 N.Y. yearly average; 1880 to date N.Y. monthly average. Lead, 1850-70 N.Y. yearly av erage; 1870 to date N.Y. monthly average. The curves for common stock prices and index of production and trade are adapted from curves prepared by Dr. Warren M. Persons and published by Barron's Publishing Co., which kindly gave permission for their use.

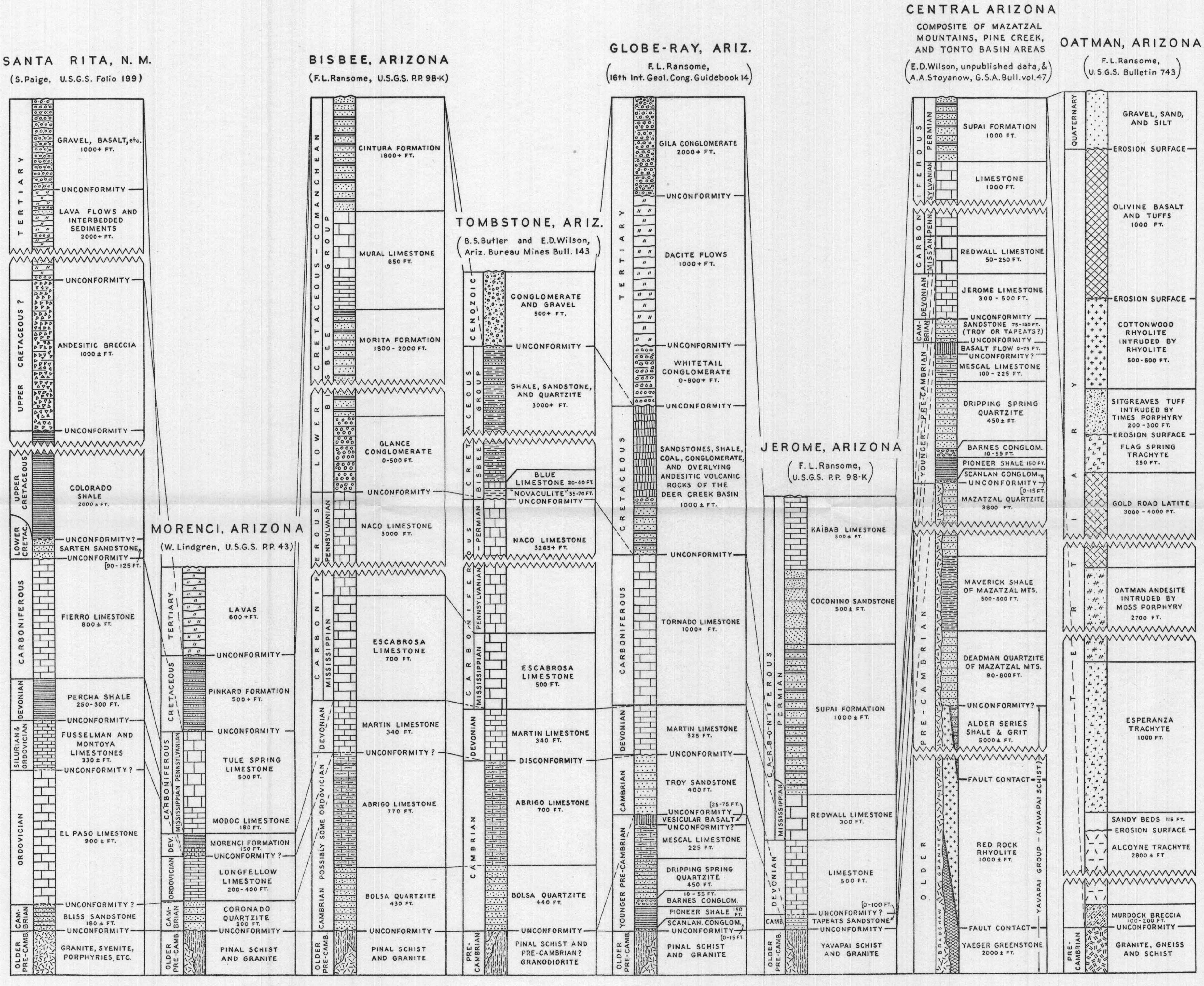


Plate III.—Generalized columnar sections.

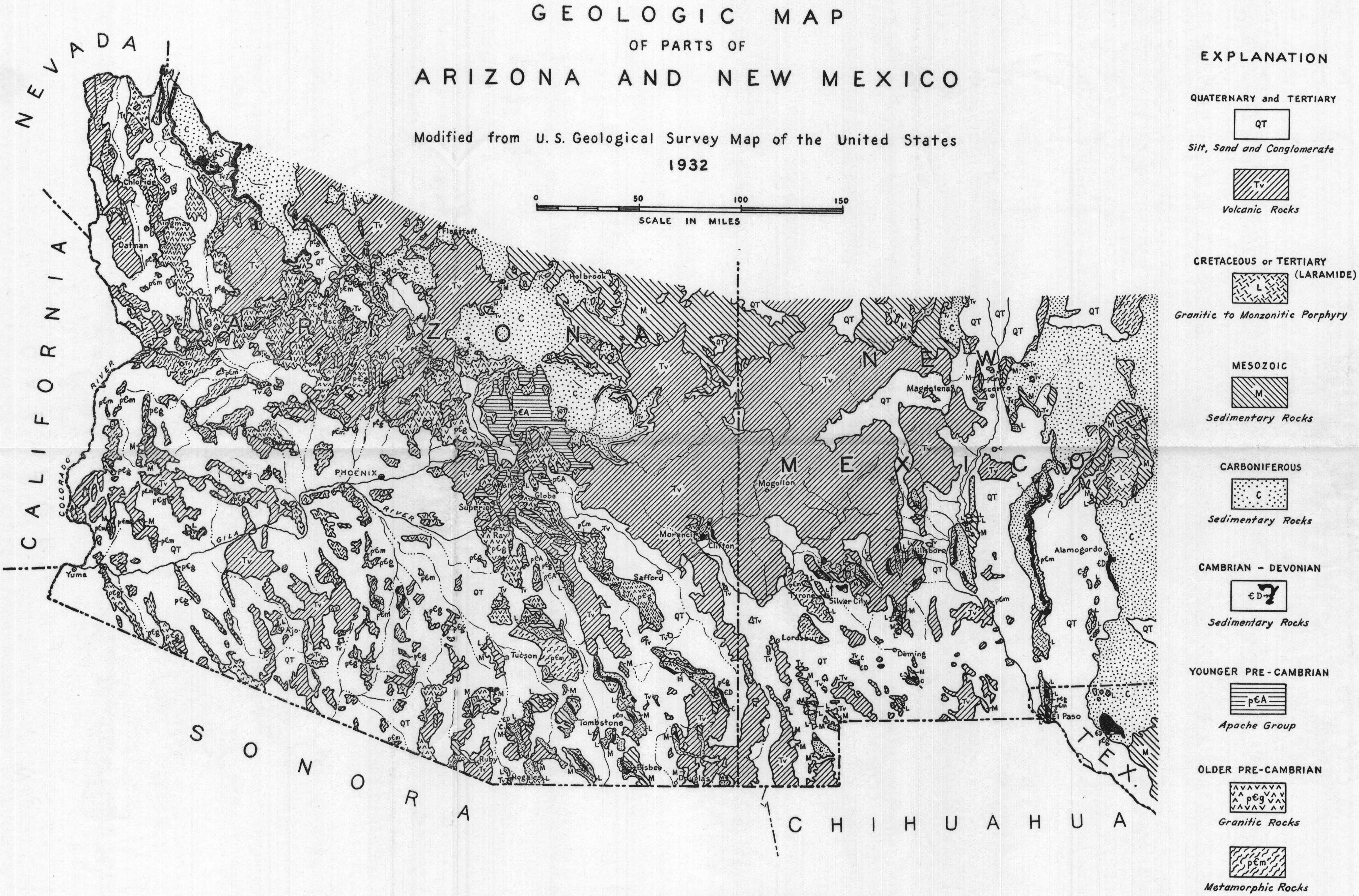


Plate II.—Geologic map of parts of Arizona and New Mexico.

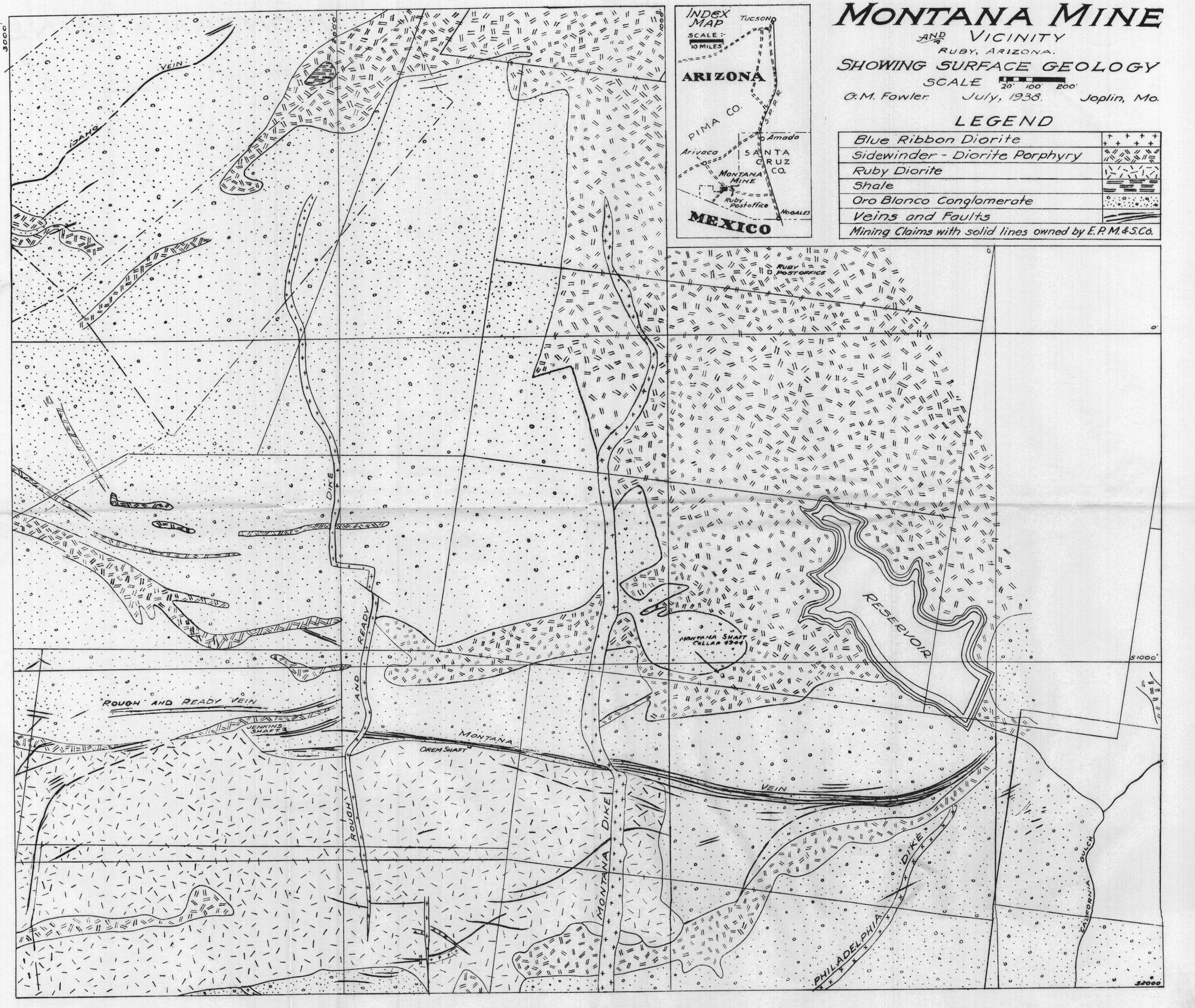


Plate XXXII.—Geologic map Montana Mine and vicinity.

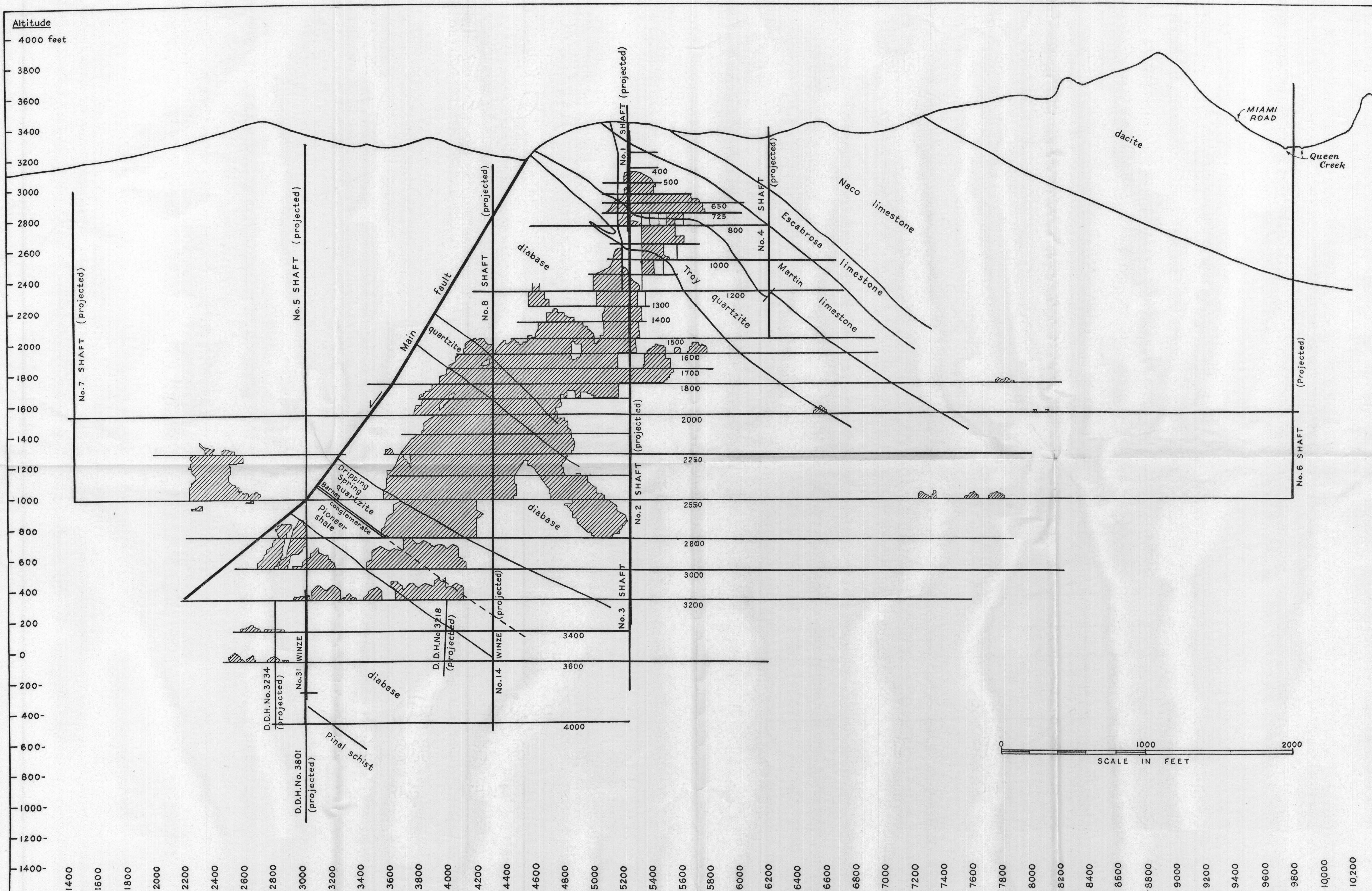


Plate XXIII.—East-west vertical section of Magma Mine through No. 3 shaft with projection of stoped ore bodies, showing geology of south wall of Magma vein. Compiled by M. N. Short from maps of Magma Copper Company.