THE GEOLOGY AND ORE DEPOSITS

OF THE

MOUNTAIN QUEEN AREA

NORTHERN SWISSHELM MOUNTAINS

ARIZONA

by

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A Thesis

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INTRODUCTION

Scope of Investigation

With the approval of the faculty of the Geology Department of the University of Arizona, the writer chose the study of an area in the Swisshelm Mountains of southeastern Arizona as the subject of his thesis. This area centers in the Mountain Queen claim, the one from which has come most of the metal production from the area.

The field work was carried on from January to April, 1947. A part of the Pearce quadrangle topographic sheet, U. S. Geological Survey, was enlarged by photography and pantograph to the scale of 500 feet to the inch, and used in mapping; the contours were modified where necessary during the course of mapping.

Acknowledgements

The writer is indebted for advice and encouragement to every member of the staff of the Geology Department of the University of Arizona. Dr. F. W. Galbraith and Professor E. D. McKee visited the area; Dr. A. A. Stoyanow helped in the identification of fossils, and Dr. M. N. Short in the examination of polished sections. The writer assumes full responsibility for any errors in presentation or interpretation.

The writer is grateful to R. L. Brown, Douglas, Joe and Elmer Ridbaun, Elfrida, and Ben Heney, Tucson, mine

operators in the Mountain Queen area, who gave ready permission to examine and sample their workings. The plan of the Mountain Queen is based on a map loaned by R. L. Brown, operator of that property, which he received from Dr. C. A. Rasor of the Phoenix office of the Reconstruction Finance Corporation.

The history of mining has been compiled from information obtained from the above-mentioned mine operators and from Hawley and Hawley, Douglas assayers.

Previous Work

The Swisshelm range and isolated small peaks in the Sulphur Springs valley were mapped in 1922, on a scale of 2 miles to the inch, by C. J. Sarle, then of the University of Arizona. This map was incorporated in the State Geological Map. There was no report published.

The Reconstruction Finance Corporation examined the properties in the area under the direction of Dr. C. A. Rasor in 1946.

Location

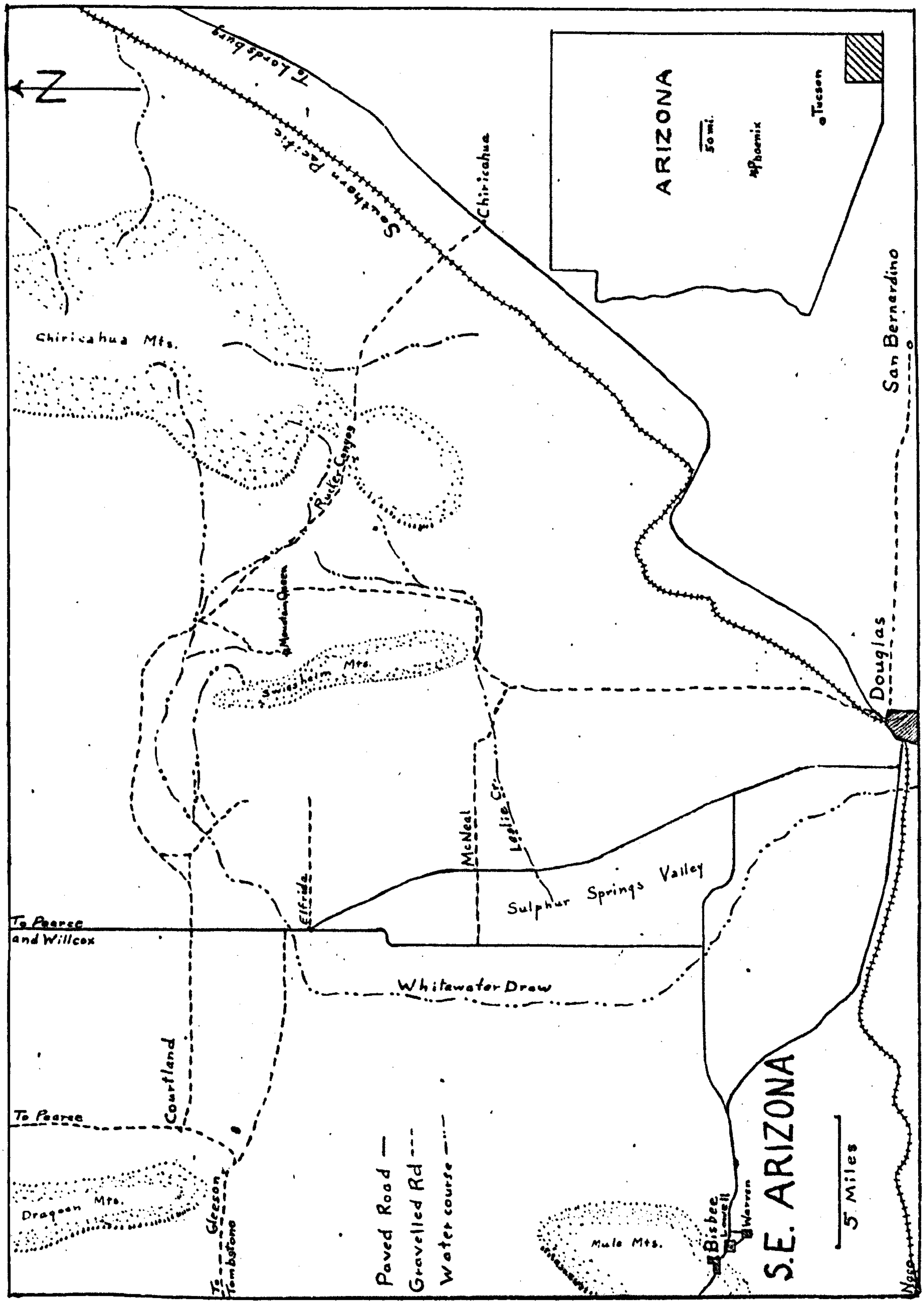
The area mapped in connection with this thesis comprises Sec. 12, the E. half of Sec. 11, the N. half of Sec. 13 and the N.E. quarter of Sec. 14, all in Twp. 20S., Range 27E., in southeastern Arizona. The Mountain Queen mine is located, approximately, at 31° 42' N. Lat. and 109° 33' E. Long. It is about twenty-five miles due north of Douglas, and is reached from there by 30 miles of pavement (the Douglas-Willcox highway), thirteen miles of graveled county road (the Rucker Canyon road), and five miles of narrow graveled mine road.

The closest store and post office are in the village of Elfrida, in the center of the Sulphur Springs valley, about ten miles west across the range, but twenty-four miles by the route described above. Tucson, via Tombstone and Benson, is one hundred and thirty-six miles to the northwest.

Climate

The climate is semi-arid, with a hot summer during which most of the rainfall occurs, a mild winter during which snow covers the ground for a week or two, a warm autumn, and a warm spring with strong westerly winds.

In Douglas, twenty-five miles south and 1300 feet lower, the average annual temperature is 78.0° maximum and 46.3° minimum, with a change in temperature between day and night of 30° or higher. The monthly figures for Douglas follow in Table I.



Map showing location of Mountain Queen Area

Table I[1]

Month	Precipitation Inches	Temperature Max. (degrees F.)	Temperature Min. (degrees F.)	Humidity,%
Jan.	0.58	60.7	29.4	44
Feb.	0.65	66.7	34.2	36
Mar.	0.37	72.5	38.4	30
April	0.22	77.9	42.9	22
May	0.17	86.4	49.9	16
June	0.43	95.2	59.3	20
July	3.14	93.7	66.2	26
Aug.	2.95	90.9	65.1	42
Sept.	1.31	88.4	59.5	37
Oct.	0.79	80.7	47.0	35
Nov.	0.72	69.6	36.0	33
Dec.	0.93	60.9	30.6	44

Flora and Fauna

The vegetation is that typical of the smaller ranges in southeastern Arizona. On sheltered northern slopes in the Swisshelm mountains, a half dozen or so small pines occur, and on most of the heights there are large pine stumps. Pinyon and juniper grow thickly in places where the soil holds a little water and on northern slopes. Scrub oaks are abundant, especially in clumps along arroyos. A few mesquite grow in the less accessible parts of the area; there are some catclaws. The low flats are covered with creosote bush. Ocotillo grows on sunny granite and quartzite slopes; agave ("century plant") stands on the lower hilltops. Cacti are fairly abundant and widespread. Chollas grow thickly on low hilltops and flat benches. Prickly pears are scattered over sunny slopes. Small cacti, such as rainbows and hedgehogs, are abundant on granite and on slopes of quartzite alluvium.

1, Information from U.S. Government records through Douglas Chamber of Commerce.

Grasses are rather abundant, but cropped short by cattle.

Animals seen during the course of field work include a few white-tailed deer, javelinas, jack-rabbits, cottontails and ground squirrels. The presence of pack rats is shown where they have made piles of cholla branches to protect their burrows. Quail are fairly abundant. A few vultures, hawks and ravens are among the common birds.

Flies are thick in the entrances of adits.

Cattle and horses belonging to the Sproule ranch graze over the area, and come to the overflow from the Chance shaft for water.

Topography and Drainage

The Swisshelm Mountains are a small, hull or keel-shaped range rising from the flat Sulphur Springs valley near its eastern edge. To the east, rolling country separates the Swisshelms from the larger mass of the Chiricahuas. A few miles east of Douglas, the axis of the range extends south into Mexico through isolated smaller peaks.

On the west side of the range, the alluvial fans merge rapidly into the flat valley floor. At the north end, the range breaks up into a few small ridges, and, beyond these, scattered low hills extend northwesterly across the valley.

Whitewater Draw, which comes westerly out of the Chiricahuas, turns southwesterly after skirting the north end of the small ridges which terminate the Swisshelm range. This draw crosses the international border and extends into Mexico just west of Douglas.

The crest of the range, near its north end, crosses the west side of the area mapped in this study, forming a series of round and elongated peaks separated by saddles. The east side of the area is crossed by a low, rather sinuous ridge, which has several western outliers. Between these high areas, and forming the central part of the area mapped, is a rather broad valley, drained by an arroyo which runs northerly along its eastern edge. A similar but broader valley is partly covered by the extreme eastern section of the map. A prominent hill in the north part ofthe area, just west of center, may be considered an outlier of the main range, but geologically it belongs to the eastern ridge.

Streams drain from the crest of the range, both easterly and westerly, notably from the saddles. At the south end of the area, one of these streams instead of turning north down the central valley, continues east, beheading this valley and terminating the eastern ridge.

All of the streams shown on the map drain into Whitewater Draw. Except for a trickle below the mine, all are dry throughout most of the year.

General Geology

The Swisshelm range is made up of Paleozoic and Cretaceous limestones, shales and quartzites, which have been folded and thrust faulted, and intruded by granite. Tertiary rhyolite, which probably once covered the whole range, remains as a capping on down-faulted blocks near its borders.

The mountains form a basin-range. Though offset slightly by cross-faulting, a single anticline forms the backbone of the range. This anticline strikes, roughly, north and south, dips more steeply to the west than to the east, plunges north at the north end and-- presumably-- south at the south end. Its granite core is exposed through the north half, but here the peaks are formed by the resistant Bolsa quartzite, of Middle Cambrian age.

The Mountain Queen area includes a part of the northern end of the crest of the anticline, and a section of the east limb up to and beyond a fault which separates the Paleozoic limestones from the Tertiary lavas.

An east-dipping thrust fault crops out across the center of the area. A diorite sill follows the main fault plane. Above the sill, lead-silver ore has replaced certain beds of limestone near minor faults, or localized in minor folds, in the overthrust block.

SEDIMENTARY ROCKS

General Statement

The consolidated sedimentary rocks in the Swisshelm mountains range in age from Cambrian to Cretaceous. They have been intruded by granite, of Laramide age, and are overlain by Tertiary rhyolite. They are correlated with the stratigraphic section at Bisbee, as described by Ransome[2] and Stoyanow[3].

The rocks of the northern part of the Swisshelm mountains were measured where best exposed, least metamorphosed and least interrupted by faulting (down the plunge of the anticline). The measured section starts at a point 2,000 feet north of the northwest corner of the area mapped, and ends about 2½ miles further north.

There was no angular unconformity observed between Paleozoic formations; the Cretaceous contact cuts across all the upper Paleozoic rocks.

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2. Ransome, F. L., Geology and ore deposits of the Bisbee quadrangle, Arizona; U. S. Geol. Survey Prof. Paper 21 (1904)
3. Stoyanow, A. A., Correlation of Arizona Paleozoic formations: Bull. Geol. Soc. Amer., Vol. 47, pp. 459-540, 1936

Paleozoic Correlation Chart

	Swisshelm Mts.	Bisbee[4]	Dragoon[5] Mts.
Cretaceous	Maroon Shales	GLANCE Congl.	GLANCE Congl. (?)
Permian	Basal conglomerate, sandstone, interbedded shale and limestone, thin limestone 250' (+)	SNYDER HILL limestone 200' to 500' (Whet.) MANZANO ls. 1000' (Whetstones)	MANZANO or SNYDER HILL Thin limestone
Pennsylvanian	NACO limestone Thin, cherty, shaly ls., red shale at top, 2400', approx.	NACO limestone Thin, cherty, shaly ls. 1000' (±)	"NACO" ("Permian(?)") Thin, cherty, shaly ls. 1250' (total upper Carboniferous)
Lower Mississippian	ESCABROSA ls. Massive granular cliff-forming 328'	ESCABROSA ls. Massive granular cliff-forming 700'	ESCABROSA ls. Massive, granular, cliff-forming 300'
Upper Devonian	LOWER OURAY ls. MARTIN ls. Brown-gray, sandy total; 340'(+?) (400'?)	MARTIN ls. dark gray ls. pink calcareous shale 340'	MARTIN ls. brown and gray, sandy 355'

4. Stoyanow, A. A., op. cit., pp. 482, 486, 505, 508, and oral communication.
5. Cederstrom, D. J., Geology of the Central Dragoon Mountains; Ph. D. thesis, University of Arizona, pp. 13-33, 1946, and Structural Geology of the Dragoon Mountains, Arizona, Am. Jour. Science, Vol. 244, pp. 606-609, September, 1946

Paleozoic Correlation Chart, continued

	Swisshelm Mts.	Bisbee	Dragoon Mts.
Upper Cambrian	COPPER QUEEN limestone, gray, granular, arenaceous and cross-bedded 175'	COPPER QUEEN limestone, gray, granular limestone 81'	Parting quartzite? 8'
	ABRIGO Formation Thin cherty limestone and calcareous shale 228'	ABRIGO Formation Thin cherty dolomitic limestone 420'	ABRIGO Formation Thin limestone and chert 400'
Middle Cambrian	COCHISE Formation 194'	COCHISE Formation Thin dolomitic limestone 290'	COCHISE Formation Sandy shales 50'
	BOLSA Quartzite 180' (+)	BOLSA Quartzite 430'	BOLSA Quartzite 325'
Pre-Cambrian		PINAL Schist	Granite

Bolsa Quartzite

The Bolsa quartzite, of Middle Cambrian age, is the oldest formation in the area. It consists of a hard, fine grained, white quartzite. It is the most resistant to weathering of all the formations, and forms the peaks along the west side of the area. Here it forms a continuous outcrop, thinning (in the saddles) where it is embayed by granite, and in one place is cut out entirely by granite that intrudes into stratigraphically higher formations. This is near the north boundary of the map (see Plate I). Another outcrop, near the southwest corner of the area studied, belongs to the west limb of the Swisshelm anticline.

The average thickness of beds, in the Bolsa quartzite, is about 5 feet. Purple streaks in some of these give a dark color to the cliffs when seen from a distance.

The quartzite forms a blocky alluvium which covers much of the slopes below outcrops and obscures the overlying formations. A measured section of the Bolsa quartzite follows. This sequence is located just west of the center of Sec. 2, T. 20 S., R. 27 E.

Bolsa Quartzite Sequence

MIDDLE CAMBRIAN, Cochise formation

MIDDLE CAMBRIAN, Bolsa quartzite:

	Feet
9. Brown-gray, coarse sandstone, 1'-2' beds; forms ledge and weathers dusky brown	20

Bolsa Quartzite Sequence, continued

		Feet
8.	White, medium-grained quartzite, 5'-1' beds; forms cliff and weathers weak orange; worm casts between beds	20
7.	Light gray, coarse quartzite, 2' beds; forms cliff, and weathers dark gray; 50% 6 in. to 24 in. purple bands	13
6.	White, medium-grained quartzite, 2'-3' beds; forms cliff, and weathers reddish-gray	17
5.	Medium gray, coarse quartzite, 2'-4' beds; forms cliff, and weathers purple; hematite in joints ..	21
4.	White, fine-grained quartzite, massive; forms cliff, and weathers pale orange	36
3.	Pale pink, fine-grained quartzite, 4' beds; forms cliff, and weathers weak reddish brown ...	31
2.	Pale rose, coarse quartzite, 3"-2' beds; forms cliff, and weathers moderate brown; 6" purple streaks	13
1.	Pale flesh, medium-grained quartzite, 6"-2' beds; forms ledge, and weathers very pale brown; arkosic	7
	Total measured Bolsa quartzite	178

Intrusive contact

Laramide? Granite

Cochise Formation

Above the Bolsa quartzite, there are about 200 feet of the upper Middle Cambrian Cochise formation, consisting of soft slope-forming, thin-bedded sandstones, shales and limestones. Near the top is a conspicuous blue oolitic limestone. This oolitic limestone,[6] together with the presence of Obulus and Lingulella, and the distinctive lithology, indicate that these beds represent the Cochise formation.

6. Stoyanow, A. A., op. cit., p. 466

This formation consists of alternating thin beds of brown sandstone and shale in the lower part, grading upward into sandy limestone and shale and some pure bluish limestone. Above the oolitic limestone is a 10 foot series of gray limestones beneath the Abrigo formation.

Compared to the Abrigo, the Cochise formation has rusty brown, rather than olive brown shales, and massive, fine-grained, bluish limestone as opposed to coarse, gray thin-bedded limestone; but the only certain field guide appears to be the oolitic limestone.

The following section was measured in a saddle directly east of, and above, the measured Bolsa quartzite, that is, near the center of Sec. 2, T. 20S., R. 27E.

Cochise Formation Sequence

UPPER CAMBRIAN, Abrigo formation

MIDDLE CAMBRIAN, Cochise formation:

		Feet
12.	Medium gray, medium-grained limestone, thin beds; forms moderate slope, and weathers gray-buff	10
11.	Medium bluish gray, medium grained limestone, thin beds; forms ledge and weathers light brownish gray; it is oolitic at 162'-165', 175'-183'	25
10.	Medium gray, medium-grained limestone, thin beds; forms slope, and weathers yellowish brown; impure, arenaceous limestone grades into shaly limestone	76
9.	Medium gray, fine-grained limestone, massive; forms ledge, and weathers pale blue	3

Cochise Formation Sequence, continued

	Feet
8. Medium gray, fine-grained limestone, thin beds; forms slope, and weathers pale blue and brown; grades up from blue to brown, is shaly	9
7. Medium gray, fine-grained limestone, thin beds; forms slope, and weathers pale blue and brown; grades up from blue to brown and is shaly	12
6. Buff, fine-grained limestone, 2'-6" beds; forms ledge, and weathers reddish-brown; veined by chert	9
5. Blue-gray, coarse limestone, thin beds; forms ledge, and weathers gray-brown; arenaceous; <u>Lingulella</u>	10
4. Dark-brown, fine-grained shale, 5'-1' beds; forms slope, and weathers dark brown; calcareous, and has gnarly bedding planes	30
3. Brown, fine-grained shale, thin beds; forms slope, and weathers brown	8
2. Pale brown, coarse sandstone, massive; forms ledge, and weathers chocolate brown; calcareous	1½
1. Brown, coarse shale, thin beds; forms slope, and weathers brown	½
Total measured Cochise formation	194

MIDDLE CAMBRIAN, Bolsa quartzite

Abrigo Formation

The Cochise formation is overlain by the Upper Cambrian Abrigo formation; about 200 feet thick, it has lithologic characteristics similar to those of the Cochise formation. As at Bisbee,[7] the Abrigo formation contains trilobites of the

7. Stoyanow, A. A., op. cit., pp. 467-9

genus Hesperaspis, and the inarticulate brachiopods Lingulella and Obolus (?).

The thin shaly limestone beds of this formation are separated by thin partings of dark olive green shale; loose slabs are reminiscent of green-iced St. Patrick's day cake. The following section was measured on the lower part of a slope near the north central part of Sec. 2, T. 20S., R. 27E.

Abrigo Formation Sequence

UPPER CAMBRIAN, Copper Queen formation

UPPER CAMBRIAN, Abrigo formation:

	Feet
11. Gray-brown, medium-grained shale, thin beds; forms slope, and weathers light yellow-brown; contains some 1" and 2" beds of limestone and trilobites; Hesperaspis, at 204' with edgewise conglomerate	32
10. Medium gray, coarse limestone, thin beds; forms ledge, and weathers pale brown; has green shaly partings up to 1" thick; contains trilobites and Lingulella at 194'	16
9. Medium gray, coarse limestone, thin beds; forms ledge and weathers light yellowish brown; contains gnarly beds, green shale partings, and trilobites; Hesperaspis and Crepicephalus? at 170'	64
8. Not exposed, probably shale	6
7. Medium gray, medium to fine-grained limestone, 6"-2" beds; forms ledge, and weathers gray and brown	8
6. Not exposed, probably shale	72
5. Light olive gray, medium-grained shale, up to one inch in thickness; forms slope, and weathers a very pale brown; is arenaceous and calcareous	14

Abrigo Formation Sequence, continued

	Feet
4. Medium gray, medium-grained limestone, thin beds; forms ledge, and weathers yellow brown; is arenaceous	3
3. Reddish-gray, medium-grained shale, up to 2" thickness in beds; forms slope, and weathers light brownish gray; is calcareous	9
2. Yellowish gray, medium-grained shale, massive; forms ledge, and weathers light olive gray; has conchoidal fracture, is sandy and calcareous	1
1. Reddish-gray, coarse-grained sandstone and shale, ½" to 2" thickness; forms slope, weathers rusty brown, and is calcareous	3
Total measured Abrigo Formation	228

MIDDLE CAMBRIAN, Cochise formation

Copper Queen Limestone

The thin, shaly, green and brown Abrigo formation is overlain by 175 feet of the Upper Cambrian Copper Queen limestone-- a coarse-grained arenaceous, dark gray chocolate-weathering limestone that forms bold ledges.. It is lithologically similar to the Copper Queen limestone southeast of Warren near Bisbee, and is separated from the overlying Martin limestone, as at Warren, by the parting quartzite member.

At the Mountain Queen claim, because of its position above typical Abrigo beds, an outcrop of recrystallized, pale orange limestone has been correlated with the Copper Queen limestone.

The following section was measured up the slope of the hill from the top of the measured Abrigo formation, in the north central part of Sec. 2, T. 20S., R. 27E.

Copper Queen Limestone Sequence

DEVONIAN, Martin Limestone

Disconformity

UPPER CAMBRIAN, Copper Queen limestone:

	Feet
4. White, coarse-grained quartzite, massive; forms ledge, and weathers pale brown; "parting quartzite"	2
3. Reddish-gray, medium-grained limestone, 4"-2' beds; forms cliff, and weathers weak reddish-brown; is dark chocolate brown where longest exposed	23
2. Light reddish-gray, medium-grained limestone, massive; forms ledge, and weathers weak reddish-brown; slightly arenaceous	52
1. Reddish-gray, coarse-grained limestone, 6"-1' beds; forms weak ledge, and weathers dark yellowish brown; is arenaceous, cross-bedded	100
Total measured Copper Queen limestone	177

UPPER CAMBRIAN, Abrigo formation

Copper Queen Limestone-Martin Limestone Disconformity

The great time gap between the Upper Cambrian and the Upper Devonian was indicated in the field only through the changes in fossils. No erosion surface could be found.

Martin Limestone and Lower Ouray Limestone

The white, 4 foot thick "Parting quartzite", which marks the top of the Copper Queen limestone, is overlain by more than 300 feet of Martin limestone of Upper Devonian age, which is lithologically similar to the Copper Queen limestone.

Above the Martin limestone are at least 50 feet of thin, black, shaly, dolomitic limestones. The presence of a specimen of <u>Camarotoechia endlichi</u>, shows that these beds are the time equivalent of the Lower Ouray limestone of Colorado.[8] They are absent at Bisbee. The best exposure seen in the Swisshelm mountains is in the cirque-like valley in the north central part of the area mapped.

The Martin limestone is a gray, coarse-grained arenaceous limestone, and cross-bedded calcareous aandstone, with crinoids, and articulate brachiopods. The coral reef characteristic of the Martin limestone at Bisbee was not seen in the Swisshelm mountains, but <u>Atrypa reticularis</u>, a common brachiopod in the Bisbee section, was found.

In the measured section, the Lower Ouray limestone is not present, unless it is represented by the 10 feet of strata covered by Escabrosa limestone detritus. It has probably been faulted out. If this is true, at least 50 feet should be added to the measured 340 feet of Devonian age strata to attain the original thickness of this series.

Since in the area mapped exposures are not very good, no attempt has been made to separate the two formations, and they are mapped together as "Devonian".

In an attempt to distinguish between similar appearing calcareous sandstone of Cambrian and Devonian age, two samples of each were pulverized and leached with acid. The results, in percent loss, were: Lower bed in Copper Queen

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8. Stoyanow, A. A., op. cit., p. 489

limestone, 11%; upper bed, 23%; lower bed in Martin limestone, 9%; upper bed, 30%. These results indicate that the lower sandstone beds are, in both formations, less calcareous than are the upper beds.

The following section was measured, in Sec. 2, northeasterly from the top of the Copper Queen limestone.

Devonian Sequence

MISSISSIPPIAN, Escabrosa Limestone

Disconformity

DEVONIAN:

	Feet
11. Medium gray, medium-grained limestone, massive; forms slope, and weathers very pale brown; top 10' covered by Escabrosa float, may be Lower Ouray	25
10. Yellowish gray, coarse-grained limestone, massive; forms ledge, and weathers brown to chocolate; has some white chert, and is sandy	38
9. Medium gray, medium-grained limestone, thin beds; forms slope, and weathers yellowish white; is sandy	10
8. Gray, coarse-grained limestone, massive; forms ledge, and weathers reddish-gray; "Martin type"	3
7. Medium gray, medium-grained limestone, thin beds; forms ledge, and weathers pale brown; has pale purple seams	7
6. Medium gray, coarse-grained limestone, 2' beds; forms ledge, and weathers pale orange; contains crinoids and brachiopod fragments (Atrypa?)	27
5. Gray-green, fine-grained limestone, $\frac{1}{2}$" beds; forms slope, and weathers very pale brown; undulating shale between beds	12
4. Medium gray, medium-grained limestone, 2'-4' beds; forms ledge, and weathers pink; abundant crinoid and brachiopod fragments	10

Devonian Sequence, continued

	Feet
3. Gray, coarse-grained limestone, 1'-2' beds; forms ledge, and weathers pale reddish-brown; quite sandy	11
2. Pale pink, fine-grained quartzite, massive; forms ledge, and weathers reddish-gray	2
1. Gray, coarse-grained limestone, up to 2' beds; forms ledge, and weathers weak reddish brown; is arenaceous	18
Total measured Devonian	338

Disconformity

UPPER CAMBRIAN, Copper Queen limestone

Devonian-Mississippian Contact

The contact between the Devonian limestone and the Lower Mississippian Escabrosa limestone was covered-- faulted?-- in the measured section, and poorly exposed elsewhere in the Swisshelm mountains.

Escabrosa Limestone

Rising above the chocolate brown ledges of the Devonian are some 300 feet of cliff-forming, massive, granular, white limestones, lithologically similar to the Lower Mississippian Escabrosa limestone at Bisbee.[9] Where measured, perhaps because of the proximity of a possible fault which cut out the Lower Ouray limestone, it contains crinoid plates, but no identifiable fossils. Elsewhere it contains a few small cup corals.

9. Stoyanow, A. A., op. cit., p. 505

The top 100 feet has thinner beds, 2 to 4 feet thick, and contains chert, but no fossils. This is in contrast to the overlying fossiliferous Naco limestone.

In resistance to erosion, Escabrosa limestone is second to Bolsa quartzite. It caps the lesser peaks, as in the north central and southeastern parts of the area mapped.

The following section was measured at the center of the north side of Sec. 2, T. 20S., R. 27E., starting at the top of the Devonian limestone and ending at the Naco basal conglomerate at the top of the hill.

Escabrosa Limestone Sequence

PENNSYLVANIAN, Naco limestone

Disconformity

LOWER MISSISSIPPIAN, Escabrosa limestone:

		Feet
11.	Light gray, very fine-grained limestone, 1'-2' beds; forms ledge, and weather light gray ...	20
10.	Light gray, fine-grained limestone, 2' beds; forms ledge, and weathers light brownish gray; similar to (8), cherty	30
9.	Light gray, fine-grained limestone, 4'? beds; forms ledge, and weathers pale brown; fine chert, and colonial coral?	30
8.	Medium gray, fine-grained limestone, 4' beds; forms ledge, and weathers pale brown; contains much ropy lenticular chert	28
7.	Light gray, medium-grained limestone, 2' beds; forms ledge, and weathers light gray; pale purple tint	45

Escabrosa Limestone Sequence, continued

	Feet
6. Dirty white, coarse-grained limestone, massive; forms cliff, and weathers pale blue; is like (2); has rounded solution cavities	35
5. Light gray, coarse-grained limestone, massive; forms cliff, and weathers light brownish gray ..	10
4. Light gray, medium-grained limestone, massive; forms cliff, and weathers yellowish gray; similar to (2), has rounded solution cavities	76
3. Reddish-gray, fine-grained limestone, massive; forms ledge, and weathers pale brown	4
2. Grayish white, medium-grained limestone, 2'-5'? beds; forms cliff, and weathers pale brown; the bedding is indistinct; crystalline	35
1. Light gray, coarse-grained limestone, massive; forms ledge, and weathers dirty white; pitted; rusty ropy chert; crystalline	15
Total measured Escabrosa Limestone	328

Disconformity

DEVONIAN, Lower Ouray limestone

Escabrosa Limestone-Naco Limestone Disconformity

A conglomerate at the base of the Pennsylvanian Naco limestone, and resting on the top of the Escabrosa limestone, shows that there was a time lapse between the deposition of the two formations. This conglomerate is made up of fragments of the underlying Escabrosa limestone, and it contains numerous fish fragments and a specimen of Spirifer keokuk, a Lower Mississippian brachiopod.

Naco Limestone

A conglomerate marks the base of over 2000 feet of Pennsylvanian Naco limestone, overlying the Escabrosa limestone. This formation is made up of alternating beds of thin limestone and calcareous shale. It is full of such fossils as fusulinids, Chaetetes milleporaceous, Marginifera splendens (?), several species of Composita, Spirifer rockymontanus, Hustedia mormoni, Dictyoclostus semireticulatis, Linoproductus, Lopophyllum, and Campophyllum; and so is correlated with the Naco limestone sensu stricto of Bisbee.[10]

The Naco limestone is the host rock at the Mountain Queen and Chance mines; ore has preferentially replaced some of the purer limestone beds.

Where the Naco section was measured, the continuous outcrop ends at 2055 feet, where it is covered by alluvium. The nearest continuation of the section is a half mile to the east, and here the Naco limestone extends for an additional 326 feet to its contact with strata of Permian age.

The fauna and lithology at the two outcrops measured are similar but do not quite match. It is evident, therefore, that a slight stratigraphic gap exists between the two outcrops. In order to bring the sum of the 3 figures,-- lower Naco limestone, gap, and Naco limestone "extension"-- to a round figure, this gap has been estimated to be 19 feet. The total thickness of the Naco limestone is, thus, 2400 feet.

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10. Stoyanow, A. A., op. cit., pp. 521-523

In the area mapped, much of the surface is underlain by Naco limestone. Chaetetes and fusulinids are good guide fossils. The lithology,-- thin, alternating limestones and shales-- is a further aid.

The following section was measured from a point about the center of the south side of Sec. 35, T. 19S., R. 27E., to the end of the range at the center of Sec. 27, and from just west of the center of Sec. 26, to the Permian contact half-way up the hill to the north.

Naco Limestone Sequence

PERMIAN

Disconformity

PENNSYLVANIAN, Naco limestone

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
[11] 312	324	12	Marl	Medium	Pale red	Shaly	Pale red	Slope	46[11]	
306	312	6	Marl & limestone	Fine	Lavender	Thin	Gray	Slope	45	Productids
286	306	20	Marl & shale	Medium & fine	Brick red	Thin	Lt. reddish gray	Slope	44	Mostly mudstones & siltstones
282	286	4	Limestone	Fine	Black	Thin	Dark gray	Ledge	43	Gnarly, dolomitic
281	282	1	Limestone	Fine	Lavender	6"	Lt. buff	Ledge	42	
278	281	3	Shale & marl	Medium	Red	Thin	Pink	Slope	41	
276	278	2	Limestone	Fine	Gray	Massive	Lt. gray	Ledge	40	
260	276	16	Shale & marl	Medium	Red	Thin	Pink	Slope	39	
[11] 257	260	3	Limestone	Fine	Gray	6" rough	Lt. gray	Ledge	38[11]	

11. Naco limestone "Extension", measured from base of outcrop

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
[11] 252	257	5	Marl & shale	Med.	Pink	Thin	Pink	Slope	37[11]	
249	252	3	Limestone	Medium	Lt. gray	1'	Lt. gray	Ledge	36	Fine pink spots
245	249	4	Limestone	Fine	Lt. gray	Massive	Lt. gray	Ledge	35	Spines
230	245	15	Shale	Medium	Lavender	6"-1'	Lt. gray	Slope	34	
219	230	11	Shale					Slope	33	Covered
215	219	4	Limestone	Fine	Lavender	Massive	Lt. gray	Ledge	32	
198	215	17	Limestone	"	Gray	Thin	Gray	Slope	31	Gnarly limestone, mostly cov'd
194	198	4	Limestone	Fine	Mauve gray	Massive	Lt. gray	Ledge	30	
183	194	11	Marl & limestone	Medium	Pink & gray	Thin	Red gray	Slope	29	
180	183	3	Limestone	Fine	Gray	Massive	Lt. gray	Ledge	28	
177	180	3	Limestone	Medium	Mauve	Thin	Lt. mauve	Slope -	27	
169	177	8	Limestone	Fine	Lt. gray	2'	Lt. gray	Ledge	26	*Composita*, fusulinids
156	169	13	Shale	Medium	Mauve	Thin	Lt. mauve gray	Slope	25	
155	156	1	Conglomerate	Coarse	Dark gray	Massive	Med. gray	Ledge	24	Limestone with few small jasper pebbles, intraformational
146	155	9	Limestone	Fine	Dark gray	Thin	Gray white	Slope	23	Spines
141	146	5	Limestone	"	Lt. gray	Massive	Lt. gray	Ledge	22	Small *Composita*, crinoids, spines & plates, (Echinoid)
[11] 110	141	31	Limestone	Fine	Lt. gray	Thin	Buff	Slope	21[11]	Fusulinids (red)

11. Naco limestone "Extension", measured from base of outcrop

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
106[11]	110	4	Lime-stone	Fine	Dark laven-der	Mass-ive	Lt. gray	Ledge	20[11]	Echinoid spines, plates fine mottling
96	106	10	Lime-stone	Medi-um	Med. gray	$\frac{1}{2}$"-8"	Lt. gray	Slope	19	Fusulinids-long, abun-dant in thick-er beds; <u>Composita</u>, <u>Campophyllum</u>
85	96	11	Lime-stone	Fine	Dark gray	Thin	Gray buff	Slope	18	Mostly co-vered
82	85	3	Lime-stone	Very fine	Lt. gray	Mass-ive	Lt. gray	Ledge	17	
81	82	1	Lime-stone	Fine	Dk. gray	4"	Buff	Slope	16	
77	81	4							15	Covered, pro-bably marl
76	77	1	Lime-stone	Fine	Med-ium gray	Mass.	Lt. gray	Ledge	14	<u>Hustedia</u>
73	76	3	Marl	Medi-um	Mauve	Thin	Pale mauve	Slope	13	Mostly co-vered
72	73	1	Lime-stone	Fine	Gray	Mass-ive	Lt. gray	Ledge	12	
62	72	10	Lime-stone	Medi-um	Dark gray	Thin	Lt. gray	Slope	11	Soft, marly, fusulinids
60	62	2	Lime-stone	Fine	Laven-der	6"	Gray	Ledge	10	
54	60	6	Marl	Medi-um	Gray	Thin	Lt. gray pink	Slope	9	Mostly co-vered, marl showing
51	54	3	Lime-stone	Fine	Gray	6"-1'	Lt. gray	Ledge	8	Fusulinids, few flat small <u>Composita</u>
11	51	40	Lime-stone	Fine	Lt. gray	Thin	Lt. gray	Slope	7	Marly be-tween beds
8	11	3	Lime-stone	Medi-um	Dark gray	1'	Med. gray	Ledge	6	<u>Composita</u>
5	8	3	Lime-stone	Fine	Medi-um gray	Mass-ive	Lt. gray	Ledge	5	
4	5	1	Lime-stone	Fine	Medi-um gray	Thin	Lt. gray	Slope	4	Similar to (2) gnarly beds
1[11]	4	3	Lime-stone	Fine	Med. gray	Mass-ive	Lt. gray	Ledge	3[11]	Slight black chert, <u>Compo-sita</u>, <u>Linoproductus</u>, <u>Spiriferina</u>

11. Naco limestone "Extension", measured from base of outcrop.

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
0	1	1	Limestone	Medium	Lt. gray	Shaly	Lt. gray	Slope	2	Very fossiliferous, Derbya
[11]-2 ()	0	-2()	Limestone	Medium	Lt. gray	1'	Lt. gray	Ledge	1[11]	½ mi. E. of No. 154
2055	2074	19*							155*	Gap between outcrops, arbitrary thickness
2047	2055	8	Limestone	Fine	Lavender	Massive	Lt. gray	Ledge	154	Colonial corals; end of range, wash; fusulinids
2040	2047	7	Limestone	Medium	Lt. gray	Shaly	Lt. buff	Saddle	153	Some marl
2030	2040	10	Limestone	Fine	Medium gray	2' rough	Gray	Ledge	152	Fusulinids, Syringopora
2018	2030	12	Shale	Fine	Weak red	Thin	Pink	Slope	151	Mostly covered, some Composita, calcareous
2006	2018	12	Limestone	Fine	Med. gray	Massive	Lt. gray	Ledge	150	
2000	2006	6	Shale	Fine	Weak orange red	Thin	Buff	Slope	149	Mostly covered
1986	2000	14	Limestone	Fine	Med. gray	6" rough	Lt. gray	Ledge	148	Fusulinids
1980	1986	6	Shale	Fine	Weak red	Thin	Buff	Slope	147	
1958	1980	22	Limestone	Fine	Dark gray	6" rough	Lt. gray	Ledge	146	Fusulinids, Composita, Campophyllum
1949	1958	9	Shale	Fine	Dull brick	Thin	Buff-tan	Slope	145	Mostly covered
1947	1949	2	Limestone	Very fine	Lavender gray	4"	Lt. gray	Slope	144	Abundant Composita, bryozoa, spines
1945	1947	2	Limestone	Fine	Dark buff	Massive	Lt. buff	Ledge	143	
1924	1945	21	Limestone	Fine	Buff gray	4" rough	Gray	Ledge	142	Abundant fusulinids, esp. first 4'; Syringopora, productid fragments

11. Naco limestone "Extension", measured from base of outcrop.
* Measured from Escabrosa contact.

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
1920	1924	4	Limestone	Fine	Orange gray	Thin	Buff	Slope	141	Fusulinids, red; few bryozoa spines, <u>Campophyllum</u>, <u>Fenestella</u>, <u>Syringopora</u>
1890	1920	30	Limestone	Fine	Med. gray	6" rough	Lt. blue gray	Ledge	140	Fusulinids, base only; <u>Spiriferina</u>; <u>Composita</u>; <u>Campophyllum</u>
1881	1890	9	Limestone	Very fine	Dark gray	Massive	Lt. gray	Ledge	139	Fine chert
1867	1881	14	Limestone	Fine	Gray	Thin irregular	Lt. gray	Ledge	138	Fusulinids, long, abundant; <u>Syringopora</u>--large heads: <u>Campophyllum</u>
1862	1867	5	Limestone	Fine	Black	Massive?	Dk. gray	Slope	137	Mostly covered, mottled
1845	1862	17	Limestone	Very fine	Lt. gray	2'-4'	Very light gray	Ledge	136	Abundant <u>Composita</u> (fragmental)
1831	1845	14	Limestone	Fine	Dark to reddish gray	6" irreg.	Gray buff	Slope	135	Mottling
1830	1831	1	Shale	Medium	Gray pink	Thin	Lt. gray pink	Slope	134	Limestone fragments in arroyo
1795	1830	35	Limestone	Fine	Dark gray	1' irreg.	Lt. gray white	Ledge	133	Dip slope, fusulinids, <u>Composita</u>
1786	1795	9	Limestone	Fine	Lt. brown gray	Massive	Very light brownish gray	Slope	132	
1685	1786	101	Limestone	Fine	Lt. gray	1'-2' & 5'	Very light gray	Ledge	131	Abundant light colored chert; buff bed @ 1660, few large productids, 5' beds @ 1700 form crest; <u>Echinoconchus</u>

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope Ledge	No.	Fossils, Remarks
1670	1685	15	Limestone	Med.	Med. gray	Massive	Lt. gray	Cliff	130	Crinoids
1652	1670	18	Shale	Med.	Mauve gray	Thin	Buff	Slope	129	Mostly covered
1645	1652	7	Limestone	Fine	Lt. gray	Massive	Lt. gray	Ledge	128	Cherty
1641	1645	4	Limestone	Medium	Med. gray	Massive	Lt. gray	Ledge	127	
1630	1641	11	Shale	Fine	Dark mauve	Thin	Buff	Slope	126	
1612	1630	4	Limestone	Coarse	Lt. gray	1' rough	Lt. gray	Cliff	125	Light colored chert; partings; <u>Composita</u> at top
1592	1612	20	Shale	Medium	Dark mauve	Thin rough	Buff	Slope	124	Shaly, abundant crinoids, <u>Linoproductus</u>
1590	1592	2	Limestone	Fine	Lt. gray	Massive	Very light gray	Ledge	123	<u>Composita</u>
1570	1590	20	Limestone	Medium	Mauve gray	6"	Buff	Ledge	122	Slight, ropy chert; <u>Meekela</u>; <u>Fenestella</u>; <u>Prismopora triangulata</u>; large crinoids; Derbya; fusulinids; <u>Echinoconchus</u>; <u>Linoproductus</u> to 3" diameter
1559	1570	11	Limestone	Fine	Lt. mauve gray	Thin	Lt. gray	Slope	121	
1548	1559	11	Limestone	Fine	Lt. gray	6"	Lt. gray	Ledge	120	Small black gastropods common; productids
1463	1548	85	Shale	Fine	Dark gray	Thin	Buff	Slope	119	Red and shaly at top
1445	1463	18	Limestone	Medium	Med. gray	1'	Lt. gray	Ledge	118	Slight ropy chert; <u>Dictyoclostus americanus</u>; <u>Campophyllum</u>
1436	1445	9	Shale	Fine	Black	Thin	Buff	Slope	117	Fish fragments

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
1426	1436	10	Limestone	Medium	Lt. gray	4'	Med. gray	Ledge	116	Slight ropy chert
1412	1426	14	Marl	Medium	Brownish gray	Thin	Mauve & buff	Saddle	115	Limy top 5' with abundant _Campophyllum_ and bryozoa
1407	1412	5	Limestone	Cse.	Dark gray	6"	Gray	Small ledge	114	Crystalline, like (112); _Composita_
1400	1407	7	Limestone	Fine	Lt. gray	1' rough	Lt. blue gray	Ledge	113	Ropy light chert
1394	1400	6	Shale	Fine	Black	Thin	Gray	Slope	112	Shaly, banded 1" black chert with crinoids
1390	1394	4	Limestone	Cse.	Dark gray	Massive	Gray	Ledge	111	Crystalline
1386	1390	4	Shale	Fine	Black	Thin	Buff	Slope	110	Covered, _Linoproductus_, _Spiriferina_
1370	1386	16	Limestone	Cse.	Gray	1'-4'	Gray	Ledge	109	Fragments of (108) in coarser mass; like (105) & (107) but more of a conglomerate, and less granular; _Linoproductus_; _Lopophyllum_, _Campophyllum_, _Spiriferina_
1364	1370	6	Limestone	Fine	Gray	1'	Lt. blue gray	Ledge	108	Slight ropy chert
1355	1364	9	Limestone	Cse.	Gray	Massive	Gray	Ledge	107	Like 105, but finer & lighter, gastropods, crinoid heads; _Campophyllum_, _Lopophyllum_, _Spirifer_
1352	1355	3	Limestone	Fine	Gray brown	6"	Lt. gray	Slope	106	

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
1345	1352	7	Limestone	Cse.	Black	Massive	Dark gray	Ledge	105	Crystalline, abundant fossil fragments; *Spirifer rockymontanus*, productids, *Composita*, crinoids
1340	1345	5	Limestone	Fine	Gray	Massive	Lt. blue gray	Ledge	104	
1339	1340	1	Limestone	Medium	Med. gray	Massive	Lt. gray	Ledge	103	Mottled, fish teeth, limestone conglomerate?
1330	1339	9	Limestone	Fine	Gray	6" rough	Lt. gray	Slope	102	Prominent ropy chert--10%; Bryozoa? *Lopophyllum*?
1326	1330	4	Limestone	Coarse	Lt. gray	Massive	Gray	Ledge	101	Crystalline, fusulinids
1324	1326	2	Limestone	Fine	Gray	Massive	Gray	Ledge	100	Fusulinids, in chert; triangular spicules?
1315	1324	9	Limestone	Coarse	Dk. gray	Massive	Gray	Ledge	99	Fair amount chert, some calcite veining; few brachiopod fragments
1308	1315	7	Shale	Fine	Dark gray	Thin	Buff	Slope	98	Productids
1298	1308	10	Limestone	Fine	Gray	Thin	Lt. gray	Slope	97	Fusulinids, abundant light chert, crinoids
1282	1298	16	Limestone	Fine	Gray	Massive	Lt. gray	Cliff	96	Fragmental at base; *Campophyllum*
1275	1282	7	Shale	Medium	Pink	Very thin	Pink	Slope	95	Crinoids
1255	1275	20	Limestone	Fine	Dark gray	1'-6'	Lt. gray	Cliff	94	Large chert (3'x4'x6") *Composita*? fragments at 1270'
1241	1255	14	Limestone	Fine	Gray	Thin		Slope	93	Covered

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
1240	1241	1	Limestone	Cse.	Gray	Massive	Lt. gray	Ledge	92	Crystalline
1225	1240	15	Limestone	Fine	Med. gray	1'-4'	Pale blue gray	Ledge	91	6" lenses of light chert, fusulinids? *Chaetetes*
1215	1225	10	Shale	Fine	Mauve	Thin	Lt. buff	Slope	90	
1195	1215	20	Limestone	Fine	Medium gray	2'	Light gray	Ledge	89	Chert, large cup corals, *Campophyllum*?
1085	1195	10	Shale	Fine	Brownish gray	Thin	Buff	Slope	88	Productids, *Spirifer cameratus*
1040	1085	45	Limestone	Fine	Light gray	3'	Light gray	Ledge	87	Lenticular and nodular chert, large cup corals; *Spirifer rockymontanus*
1016	1040	24	Limestone	Fine	Light gray	3'	Light gray	Ledge	86	Fusulinids, cup corals, *Chaetetes*, *Campophyllum*
1000	1016	16	Shale	Fine	Dark red	Thin	Pale red brown	Slope	85	
990	1000	10	Limestone	Fine	Light gray	1'-2'	Light gray	Crest	84	Fusulinids in gray chert, cup corals
976	990	14	Shale	Fine	Black	Thin	Buff	Slope	83	
970	976	6	Limestone	Fine	Medium gray	2'-3'	Lt. gray	Ledge	82	Fusulinids in gray chert, *Chaetetes*?
924	970	46	Limestone	Medium	Light gray	Massive	Lt. gray	Ledge	81	Productids, *Composita*, crinoids, *Spirifer rockymontanus*; colonial coral, beds 1" thick after 954'

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
912	924	12	Limestone	Fine	Dark gray	6" irreg.	Lt. gray	Slope	80	Nodular black chert, buff weathering
900	912	12	Limestone	Coarse	Lt. gray	1'	Lt. gray	Ledge	79	
885	900	5	Shale	Fine	Dark gray	Thin	Buff	Slope	78	Productids
860	885	25	Limestone	Fine	Medium gray	1'	Lt. gray	Ledge	77	Large ropy chert
850	860	10	Shale	Fine	Purple black	3"	Gray buff	Slope	76	<u>Composita</u>
835	850	15	Limestone	Fine	Light gray	1'-3'	Lt. gray	Ledge	75	Black chert
827	835	28	Shale	Fine	Purple black	Thin	Gray buff	Slope	74	
803	827	24	Limestone	Fine	Med. gray	Massive	Lt. blue gray	Ledge	73	Calcite veining
800	803	3	Shale	Fine	Mauve	Thin	Buff tan	Slope	72	
796	800	4	Limestone	Fine	Dark gray	1'-6"	Lt. gray	Crest	71	Fusulinids, <u>Chaetetes</u>, <u>Composita</u>
787	796	9	Shale	Fine	Dark mauve gray	Thin	Buff gray	Slope	70	
783	787	4	Limestone	Fine	Light gray	1'-2'	Lt. gray	Ledge	69	Few orange-colored joints, <u>Marginifera</u>?
780	783	3	Shale	Fine	Light red brown	Thin	Brick brown	Slope	68	
765	780	15	Limestone	Medium	Med. gray	1'-2'	Lt. gray	Ledge	67	
750	765	15	Shale	Fine	Mauve	Thin	Reddish gray	Slope	66	Mostly covered
728	750	22	Limestone	Fine	Med. gray	2'	Lt. gray	Ledge	65	<u>Marginifera</u>, <u>Composita</u>, few cup corals last 6", <u>Syringopora</u>

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
720	728	8	Limestone	Fine	Gray	Massive	Lt. gray	Ledge	64	Fusulinids, *Campophyllum*, *Chaetetes*, abundant cup corals, black chert, *Syringopora*, productids *Spirifer rockym.*
659	720	61	Limestone	Fine	Med. gray	2'-4'	Lt. gray	Ledge	63	Buff streaks, ropy chert, *S. rockym.*, *Marginifera*, *Chaetetes*
646	659	13	Shale	Fine	Med. mauve	Thin	Rusty brown	Slope	62	*Prismopora triangulata*, *Dictyoclostus insinuatus?*, *D. americanus*, *Marginifera fragil.*, crinoid, *Spiriferina*, *Chaetetes*, *Cleothyridina*
640	646	6	Limestone	Fine	Med. gray	Massive	Lt. gray	Ledge	61	Fusulinids, black chert, *Spirifer rockym.*, *Composita*
633	640	7	Shale	Fine	Deep mauve	Thin	Rusty brown	Slope	60	Small brachiopods, productids,
626	633	7	Limestone	Medium	Light gray	3'	Lt. gray	Ledge	59	Fusulinids? slight; *Spirifer rockym.*; *Chaetetes*; *Dictyoclostus nebraskensis*,
601	626	25	Shale	Fine	Dark mauve	Thin	Buff	Slope	58	*Prismopora triangulata*
598	601	3	Limestone	Fine	Lavender	Massive	Lt. gray	Ledge	57	Fusulinids, productids, slight chert, *Lopophyllum?*
592	598	6	Shale	Fine	Dark mauve	Thin	Buff	Slope	56	

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
588	591	4	Limestone	Medium	Light gray	Massive	Lt. gray	Ledge	55	Fusulinids, <u>Chaetetes</u>, slight dark chert
564	588	24	Shale	Fine	Mauve	Thin	Lt. brown	Slope	54	Mostly covered, many small brachiopod fragments including <u>Spirifer rockym</u>. <u>Cleothyridina</u>
560	564	4	Limestone	Fine	Dark gray	Massive	Gray	Ledge	53	<u>Chaetetes</u>, productids, fusulinids, <u>Syringopora</u>
547	560	13	Shale	Fine	Mauve red	Thin	Sandy buff	Slope	52	Mostly covered
544	547	3	Limestone	Medium	Light gray	Massive	Lt. gray	Ledge	51	<u>Composita</u> fragments
540	544	4	Limestone	Med. fine	Mauve gray	Massive	Lt. gray	Ledge	50	Fragmental
528	540	12	Shale	Fine	Toffee brown	Thin	Sandy brown	Slope	49	
516	528	12	Limestone	Cse.	Med. gray	Thin	Very pale brown	Slope	48	Crinoids & brachiopods, (fragments)
513	516	3	Limestone	Fine	Light gray	Massive	Pale orange gray	Ledge	47	<u>Chaetetes</u>, (slight) <u>Syringopora</u>, <u>Campophyllum</u>, fusulinids?
503	513	10	Limestone	Fine	Medium gray	Massive	Lt. gray	Ledge	46	
501	503	2	Conglomerate	Fine	Med. gray	Massive	Lt. gray	Ledge	45	Smaller fragments than (43), shell fragments, fish teeth, <u>Marginifera</u>?
450	501	51	Shale	Fine	Dark gray	Thin	Yellow buff	Slope	44	Mostly covered, <u>Spirifer occidentalis</u>, <u>Dictyoclostus nebraskensis</u>

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
448	450	2	Conglomerate	Fine	Med. gray	Massive	Lt. gray	Ledge	43	Intraformational limestone conglomerate--edgewise 424'-430'
420	448	28	Limestone	Fine	Med. gray	Massive	Weak orange	Ledge	42	Ropy chert, abundant fossils, <u>Composita</u>, large and small; <u>Wellerella</u>, or <u>Pugnax utah</u>, <u>Spirifer rockym.</u>, <u>Campophyllum</u>, <u>Dictyoclostus americanus</u>? <u>Hustedia mormoni</u>
400	420	20	Limestone	Cse.	Med. gray	6"	Lt. brown	Slope	41	
381	400	19	Shale	Fine	Med. gray	Thin	Yellow gray	Slope	40	
378	381	3	Limestone	Fine	Med. gray	Massive	Lt. gray	Ledge	39	Abundant fragments, <u>Composita</u>
362	378	16	Shale	Fine	Dark gray	Thin	Buff	Slope	38	Mostly covered
356	362	6	Limestone	Fine	Med. gray	6"	Gray	Slight ledge	37	Fusulinids, <u>Campophyllum</u>
347	356	9	Limestone	Fine	Med. gray	Massive	Lt. gray	Ledge	36	<u>Chaetetes</u>?
304	347	43	Limestone	Fine	Lt. gray	2'-6"	Lt. gray	Ledge	35	Cherty black lenses, <u>Spirifer cameratis</u>, <u>Linoproductus</u>, <u>Campophyllum</u>
291	304	13						Slope	34	Covered, probably similar to (32)
277	291	14	Limestone	Medium	Med. gray	Thin	Lt. gray	Ledge	33	<u>Chaetetes</u>, <u>Campophyllum</u>, fusulinids, <u>S. rockym.</u>
268	277	9	Shale	Fine	Lavender	Thin	Light buff	Slope	32	<u>Dictyoclostus americanus</u>

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
255	268	13	Limestone	Fine	Light gray	Massive	Very pale	Ledge	31	Prominent ropy chert, Spiriferina, crinoid heads, Syringopora, Lopophyllum
241	255	14	Shale	Fine	Purplish gray	Thin	Light buff	Slope	30	Prismopora triangulata
237	241	4	Limestone	Fine	Light gray	Massive	Buff	Ledge	29	Fusulinids, Chaetetes, productids, Campophyllum
230	237	7	Limestone	Medium	Lt. purplish gray	2'-6"	Dark gray	Slope	28	Chaetetes
219	230	11	Limestone	Cse.	Lavender	6"-2'	Med. gray	Slope	27	
204	219	15	Shale	Fine	Black	Thin	Pale brown	Slope	26	Abundant productid, leafy bryozoa, crinoids, Spirifer rockymontanus? Orbiculoidea, Cleiothyridina
195	204	9	Limestone	Cse.	Lavender gray	Thin	Light gray	Slope	25	Squamularia, Hustedia mormoni, Spirifer kentuckyensis
191	195	4	Limestone	Fine	Medium gray	Massive	Dark gray	Ledge	24	Chaetetes, fusulinids, chert, crinoid stems, Spirifer rockym., Syringopora, Hustedia mormoni, Marginifera, gastropods, Campophyllum
190	191	1	Limestone	Cse.	Lt. gray	Massive	Lt. gray	Ledge	23	Fetid odor, small gastropods
173	190	17	Limestone	Fine	Very light brownish gray	6"	Lt. gray	Slope	22	Crystalline, gastropods, productids, Spirifer, mostly covered

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
163	173	10	Limestone	Fine	Medium gray	Massive	Lt. blue gray	Ledge	21	Chaetetes, (white); fusulinids, Spirifer rockymontanus, Syringopora, Campophyllum
154	163	9	Shale	Fine	Lavender gray	Thin	Buff	Slope	20	Orbiculoidea, Spirifer occidentalis?, Dictyoclostus americanus
152	154	2	Limestone	Fine	Medium gray	Massive	Lt. gray	Ledge	19	Conical chert, Spirifer, Campophyllum, Lopophyllum
144	152	8	Shale	Fine	Pinkish gray	Thin	Buff	Slope	18	Prismopora triangulata, Dictyoclostus americanus, Spirifer occidentalis, S. rockym.?
138	144	6	Limestone	Medium	Dark purple gray	2'	Gray	Ledge	17	Many productids, Spirifer rockymontanus?
129	138	9	Limestone	Fine	Reddish gray	6"	Buff	Slope	16	Few Brachiopods, productids
107	129	22	Limestone	Fine	Medium gray	6"-4'	Lt. gray	Ledge	15	Large, light-colored chert
102	107	5	Limestone	Medium	Medium gray	2'	Lt. gray	Ledge	14	Chaetetes, S. rockymontanus?, fusulinida in chert, Lopophyllum, Campophyllum, Syringopora, crinoids, Stromatopora
81	102	21	Limestone	Fine	Purple gray	2'	Lt. gray	Ledge	13	Chert, crinoids, S. rockymontanus?
70	81	11	Limestone	Fine	Reddish gray	2"	Pale brown	Slope	12	Crinoidal
60	70	10	Limestone	Fine	Gray	4'	Pale blue gray	Ledge	11	Nodular white chert, rusty; small brachiopods

Naco Limestone Sequence, continued

From	To	Ft.	Rock	Text.	Color	Beds	Weathered Color	Slope, Ledge	No.	Fossils, Remarks
50	60	10	Limestone	Fine	Purplish gray	6"	Orange pink	Slope	10	*Prismopora triangulata*, productids
42	50	8	Shale	Medium	Gray black	Thin shaly	Pale brown	Slope	9	
33	42	9	Limestone	Fine	Light gray	2'	Pale blue gray	Ledge	8	
26	33	7	Limestone	Medium	Light gray	6"	Pale gray, orange streaks	Slope	7	Very fossiliferous; fish tooth, leafy bryozoa, *Marginifera splendens*, *Composita*, *Dictyoclostus americanus*, *Spirifer rockym*., *S. cameratus*
24	26	2	Limestone	Very fine	Light Brownish gray	Massive	Pale gray	Ledge	6	
20	24	4	Limestone	Fine	Brownish black	6"	Yellowish gray	Slope	5	
18	20	2	Conglomerate	Coarse	Med. gray	Massive	Gray brown	Ledge	4	Lighter color, smaller fragments, more fish plates than (1), *Hustedia*
10	18	8	Shale	Fine	Buff gray	Paper thin	Reddish gray	Slope	3	
2	10	8	Shale	Fine	Green black	$\frac{1}{2}$"-6'	Yellowish brown	Slope	2	Calcareous shale
0	2	2	Conglomerate	Coarse	Med. gray	Massive	Gray brown	Ledge	1	Elasmobranch fish plates and teeth, *Spirifer keokuk*, limestone pebbles

Disconformity

MISSISSIPPIAN, Escabrosa limestone

Range of Fauna in Naco Limestone

Since only one section was measured, few generalizations will be made. A close correlation of units would have been possible, the writer believes, had more than one section been measured.

Fusulinids occur all through the section, becoming larger toward the top. _Chaetetes_ begin a hundred feet above the base and extend about half way up. _Marginifera_ is restricted to the lower third. _Composita_ starts at about 400 feet and goes clear to the top. Echinoids begin about 500 feet from the top.

From the fauna present, it appears that the Naco limestone extends higher in the Pennsylvanian than it is known to go elsewhere in southern Arizona.

Cycles of Deposition

A definite grouping of units into some 60 cycles[12] is apparent. The ideal cycle, from shallow water deposition to deep sea to shallow would be approximately as follows: 1) calcareous shale; 2) coarse-grained limestone, with crinoids and cup corals; 3) fine-grained limestone, with chert and brachiopods; 4) fine-grained limestone, with fusulinids; 1) calcareous shale of the next cycle.

12. Weller, J. M., Cyclical Sedimentation of the Pennsylvanian Period and its Significance, Journal of Geology, Feb.-Mar., 1930, pp. 102,130

Pennsylvanian-Permian Disconformity

Above the highest known Pennsylvanian fossils;--fusulinids, of Upper Pennsylvanian age as identified by Dunbar,[13] in number (19) of the Naco limestone "extension" sequence-- about 200 feet of limestones and marls are followed by a conglomerate. Above the conglomerate, sandstones are followed by alternating red shales and non-fossiliferous limestones for about 200 feet before a continuous limestone series containing the lowest Permian fossils appears. In the absence of closer fossil evidence, it is possible, on the basis of the following field evidence that the above-mentioned conglomerate marks the Pennsylvanian-Permian boundary: 1) the presence below the conglomerate of fossil fragments, mostly of brachiopods, that resemble more closely the fossils found in the underlying Pennsylvanian beds than they do those found in the overlying Permian beds (these fossils occur in beds which are 5 feet, 75 feet, and 135 feet below the conglomerate); 2) the presence for more than 250 feet below the conglomerate, of marly beds, and the absence of these beds above the conglomerate; 3) the widespread occurrence of the conglomerate (it was found 2 mi. southeast, and also 2 miles south of the measured outcrop); 4) the lack of so abrupt a change in the character of beds anywhere

13. Dunbar, Carl O., Personal communication to E. D. McKee

else in this 400 foot thickness of strata. The fact that the distinctive lithologic character of the conglomerate (red-stained, rather small pebbles of quartz in sandy matrix) makes it a good marker bed, was a consideration in its choice.

If, therefore, this conglomerate marks the base of the Permian beds, it shows the presence of an hiatus during which the Pennsylvanian seas, which had been becoming shallow, finally disappeared, allowing erosion to set in. Gravel then accumulated, sand was deposited and, with the deepening of the basin, or the lowering of adjacent highlands, or both, the Permian shales and limestones were laid down.

Permian

Resting on the red marly beds which form the top of the Naco limestone is a 4 foot thick, pink-stained quartz conglomerate. Above the conglomerate are about 30 feet of thin sandstones and red shales. Shales alternate with limestones through the next 40 feet. From 75 feet above the conglomerate to the recent erosion surface at about 250 feet are limestones, which, in the upper beds, contain typical Permian fossils. Among these are Dictyoclostus (bassi?) and Strophalosia; also such gastropods as Euomphalus. These beds are correlated by Stoyanow[14] with those that contain Manzano fauna in

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14. Stoyanow, A. A., oral communication

New Mexico.

The gypsum beds which mark the base of the Permian in other sections in southern Arizona are missing in the area studied. It may be that, 1) their place is taken by conglomerate and sandstones,--continental or littoral deposits in place of lagoonal-- 2) that they are represented by the unconformity beneath the conglomerate; 3) that the gypsum is represented by the marly beds, which are therefore Permian.

In the Mountain Queen area, there is one outcrop of Permian rocks. This outcrop lies in the north central part of the area, and consists largely of the conglomerate.

Permian Sequence

Recent Erosion Surface

PERMIAN

	Feet
7. Medium-gray, fine-grained limestone, thin beds; forms slope, and weathers light gray; contains abundant fossils: Euomphalus, Derbya, Camarophoria deloi?	25
6. Medium-gray, fine-grained limestone, thin beds; forms slope, and weathers light gray; includes some pink impure shaly limestone beds, contains abundant fossils: Strophalosia (spines intact), Composita, small snails	15
5. Light gray, fine-grained limestone, 3' beds; forms ledge, and weathers light gray; some pink shaly beds, and beds of red sandstone, echinoid spines	95
4. Medium gray, fine-grained limestone, 1' beds; forms slope and weathers light gray	40

Permian Sequence, continued

	Feet
3. Medium gray, fine-grained limestone, beds 3' to 1', forms cliff, and weathers light gray; contains some pink shaly beds	40
2. Brick red shales and sandstones; forms slope, and weathers pale reddish brown	32
1. Red-stained conglomerate; forms ledge; contains pebbles, mostly quartz, ¼" to ½", sandy matrix ..	4
Total measured Permian	251

Disconformity

PENNSYLVANIAN, Naco limestone

Cretaceous

Cretaceous sediments were laid down on an eroded surface of Paleozoic rocks, Devonian to Permian in age.

There is a series of beds consisting of fine-grained, maroon-colored shales, coarse conglomerate made up of quartzite and limestone gravels, sandy shales, and rusty quartzite, totalling over 900 feet.

There is no outcrop within the mapped area; the closest, a part of the west limb of the Swisshelm anticline, is a half mile to the west.

The basal conglomerate, known as Glance conglomerate at Bisbee, is not represented here.

Recent

A mantle of alluvium covers many of the lower outcrops and forms the floor of the valleys. The valley fill contains some locally derived limestone, but is comprised mostly of Bolsa quartzite, ranging from sand size to 2-foot boulders. Bedding is rather indistinct. The alluvium is compact enough to stand in stream banks four feet high.

Caliche is present, but in minor amounts.

IGNEOUS ROCKS

General Statement

An intrusive mass of granite, small diorite dikes in the granite, a sill of diorite porphyry, and a series of rhyolite flows make up the igneous rocks of the Mountain Queen area.

Granite

Granite crops out as the exposed core of the Swisshelm anticline along the west side of the area. It has an intrusive contact with the Bolsa quartzite, and in one place-- the northwest corner (see Plate I)-- it extends into the Cochise limestone.

The granite weathers rapidly except where protected by closely spaced quartz veinlets or by overlying quartzite. Detrital fragments from it usually are no larger than a cubic inch, and in places are a coarse sand. The outcrop surface of the rock is typically "rotten" and crumbly.

Where freshly exposed, the granite is rusty orange in color, or, rarely, a mottled olive tan. The weathered color is a gray-brown.

A thin section shows the composition to be: muscovite, 10%; orthoclase, 35%; oligoclase, 10%; microline, 10%; quartz, 30%. The texture is granitoid, average grain size being 0.2 mm. to 1.0 mm. The feldspars are all partly altered, forming sericite and kaolin.

Since the granite forms the intrusive core of the Swisshelm anticline, its age is younger than that of the youngest of the folded rocks and older than that of the oldest of the post folding rocks. It comes, therefore, between the Upper Cretaceous sediments and the Tertiary lavas, and is quite possibly Laramide.

Diorite

Intruding the granite in a series of small northeast striking dikes is a fine-grained green-weathering rock. Since these dikes are small-- 50 feet in maximum traceable length and 5 feet in width-- and not very numerous, no attempt has been made to show them on the map.

A thin-section showed: a feldspar, probably andesine but highly altered to sericite, about 4 mm. by 0.75 mm., 10%; andesine (?) laths under 0.1 mm. in an interwoven mat, 50%; green flakes, probably chlorite, up to 0.05 mm., 30%; small (0.02 mm.) black grains, probably magnetite, 10%.

These dikes are restricted to the granite. They appear to occupy tension cracks developed during the last stage of compression. They are possibly early Tertiary in age.

Diorite Porphyry

Outcropping irregularly throughout the central part of the mapped area is a much altered basic sill, ranging in thickness from 4 to over 60 feet. It follows one plane of the east-dipping fault.

Depending on the degree of metamorphism, the sill is colored bluish gray, maroon, brownish red, or brick red. Its outcrops are slope-forming, and are exposed beneath cappings of limestone or alluvium.

A thin section was taken from the freshest looking of the bluish-gray outcrops along the arroyo north of Chance No. 2 claim. This showed: a much kaolinized feldspar, probably andesine, 0.85 mm. by 0. 2 mm., 40%, in a ground mass of, probably, clay minerals.

A half mile north of this location, off the map, a grayish brown porphyritic fresher-looking rock outcrops near the road. A thin section of this showed: andesine, 2 by 0.5 mm., 25%, 0.3 by 0.1 mm., 30%; biotite 2 mm. by 2 mm., 10%; hornblende, 15 by 5 mm., 10%, fine -grained, ground mass 25%.

The sill as a whole was probably closer in composition to the second slide than to the first before alteration, and, therefore, is classed as "diorite porphyry" on the map. In age, it is probably late Cretaceous or early Tertiary. Its fractured nature suggests that it was involved in the dying stage of movement along the thrust fault.

Rhyolite

The northeast part of the mapped area, the downthrown side of an east-dipping normal fault, is underlain by rhyolite flows.

Topographically, the rhyolite forms rounded knobs which, rising 500 feet above their base, show the total thickness to be at least that great.

The color is a lavender or pale purplish red on the fresh surface and a grayish red on the weathered.

A thin section shows: orthoclase, 0.6 mm. by 0.5 mm., 25%; oligoclase, 0.6 mm. by 0.4 mm, 10%; quartz 1.5 mm. by 1.5 mm. to 0.25 mm. by 0.25 mm., 15%; biotite, 6%; magnetite, 4%; ground mass, light colored, heavily peppered with red hematite, 40%.

Because it is later than the thrust faulting which accompanied the folding, because of its fresh appearance, and by analogy with other areas in southeastern Arizona-- and in the whole Basin Range province-- this rhyolite is considered to be Tertiary in age.

STRUCTURE

General Statement

Structurally, the Swisshelms are a Basin range. The Paleozoic and Cretaceous sedimentary rocks, under compression, were folded and thrust faulted; later, after an outpouring of lava, block faulting took place.

The Mountain Queen area contains an anticline, a complex thrust fault, a normal fault, and minor folds and faults.

In bringing the west limb of one anticline close to the east limb of another, the thrust fault has created a pseudo-syncline down the center of the area.

Folds

The eroded crest of the Swisshelm anticline occupies the western part of the map area (sec. C-C'); here its plunge is some 15° to the N.N.E.

From the attitude and stratigraphic position of the rocks immediately to the west of the steep fault in the eastern part of the area,--that is, between the rhyolite and a line drawn roughly north-south through the center of the map-- the writer believes they form a part of the west limb of a parallel anticline, also plunging to the north, which has been brought south-west by the thrust fault and then sliced off near its axis by the normal fault.

Attendant on the thrust faulting was the development of local folds in the overthrust block, especially in the less competent formations. One area of such faulting lies between Chance No. 2 claim and the north boundary of the map (Plate I); another occurs on the Mountain Queen claim and here minor"rolls" have helped localize the ore.

Faults

The most prominent fault in the area is the one which, in this text, frequently been referred to as "the" thrust fault. It outcrops across the center of the area (see Plate I); it dips to the east or northeast at a variable angle, averaging perhaps 10° to 15°. It is a composite fault, broken in the North into an imbricate pattern of at least five distinct planes, which come together in the lc South into a narrow zone separating the Cambrian from the Pennsylvanian. Underground, the fault appears as a zone of minor, rather haphazard, slip planes. The diorite porphyry sill follows a major plane of this fault. Judging by the northeasterly strike of several vertical faults of slight, apparently horizontal movement,--probably tear faults, one of the major directions of movement was from the northeast. Striae on a thrust plane exposure near where the road lc crosses the South boundary of the Mammoth claim support this view. Displacement was probably from a half mile to a mile.

There are many minor high-angle faults accompanying the major thrust. Those parallel to the supposed direction of movement are considered to be tear faults; the others to be due to shearing and to the settling of parts of the over-thrust block on an uneven surface.

The thrust fault is believed to follow the bedding in places.

As already mentioned, there is a normal fault across the northeast section of the area. This fault has brought the Tertiary rhyolite down against the Paleozoic sediments. Where exposed, in a drift of the N. Mammoth claim, it dips north-east at 60°; here it has about 3 feet of gouge. Vertical displacement was probably about 500 feet.

Age of Folding and Faulting

The fact that Cretaceous sediments were involved in the folding, whereas Tertiary rhyolite flows--shown by their nearly horizontal attitude-- were not, sets the time of folding and attendant thrust faulting at the close of the Cretaceous period or the beginning of the Tertiary; that is to say, during the Laramide Revolution.

The normal fault is patently post Tertiary rhyolite, probably late Tertiary in age, as was the block faulting that shaped all the Basin Ranges.

Causes of Folding and Faulting

No local causes can be assigned to the results of either orogeny; both were parts of widespread movements.

The fact that the over-thrust block moved at an acute angle to the axis of the anticline instead of perpendicular to it indicates a rotation in the direction of application of the compressive forces.

Localization of the normal fault may have been governed by a boundary of the underlying granite.

GEOLOGIC HISTORY

General Statement

From the study of the stratigraphy and structures, the following tabulation of events has been compiled.

Pre-Cambrian:

No rocks exposed

Cambrian:

Lower Cambrian: Land under erosion

Middle Cambrian: sinking, advance of shallow seas, inarticulate brachiopods

Upper Cambrian: seas still shallow, scant fossil-forming life,-- trilobites, inarticulate brachiopods; retreat of seas at close

Ordovician:

Land above sea, no deposition-- or else deposition followed by erosion

Silurian:

Land above sea, no deposition

Devonian:

Lower Devonian: land still above sea

Upper Devonian: return of seas, bringing articulate brachiopods, crinoids, and fishes

Mississippian:

Lower Mississippian: clear shallow seas, adjacent lands low

Upper Mississippian: retreat of seas, setting in of erosion

Pennsylvanian:

Alternate sinking and rising (60 times) of land beneath shallow inland seas, attendant migration and dying out of fauna,-- brachiopods, reef and cup corals, fusulinids, bryozoa; evaporation near close of period causes deposition of marly beds

Permian:

Deposition of basal conglomerate, followed by sandstones and shales; then advance of shallow seas with some cyclic deposition; coming of abundant marine life,-- brachiopods, various gastropods; uplift at close

Triassic:

Land above sea, erosion

Jurassic:

Land above sea, erosion

Cretaceous:

Continental deposition; folding and thrust-faulting and granitic intrusion at close, ore deposition?

Tertiary:

Further movement along thrust planes; outpouring of lavas, block-faulting

Recent:

Erosion, deposition of valley fill, intrenchment of these valleys

ECONOMIC GEOLOGY

General Statement

The mines in the Copper Queen area are producers of direct-smelting lead ore. The primary ore mineral is galena, oxidized, above the water table, to cerussite. With the lead, there are variable amounts of silver and traces of gold. Individual ore bodies are small, but they are numerous.

Occurrence of Ore

The ore occurs as the replacement, by galena, of favorable beds which are immediately above the diorite porphyry sill and adjacent to minor faults and fractures. The host formation is the Naco limestone, which is made up of alternating shaly and pure beds-- see "Naco Sequence" above--; the purer limestone beds are the ones that were replaced by the ore.

Source of Ore

The ore solutions must have come up along the same channel as the sill,-- the thrust fault. They then moved up into the broken-up ground at the base of the overthrust block.

Age of Ore

The thrust fault was formed during the Laramide revolution, so the ore must be Laramide or younger. If it is younger than Laramide, it must have accompanied the only post-Laramide structural event,-- the late Tertiary block-faulting. In that case, there should be ore along the normal fault; however, mine workings on the North Mammoth claim have not disclosed any there; if the solutions had come up the normal fault and been tapped off when they reached the thrust fault, the ore should be below, not above, the sill which follows that fault. Therefore, it seems likely that the ore was of Laramide age.

Polished specimens, taken from orebodies in the Mountain Queen and Chance mines, show the sulphides to be predominately galena, with a little pyrite. The galena is, in even the freshest of the specimens, in the process of alteration into cerussite. The cerussite forms first along cleavage planes, or crystal boundaries, within the galena, and at the galena-pyrite borders.

Although silver is an important metal in the ore, no silver minerals were seen in the sections. The occurrence, therefore must be as an argentiferous galena. One speck of gold was seen in a specimen taken 2 feet above the sill at the east end of the North cross-cut on the 250 foot level of the Chance Mine.

History of Mining

A prospector, John (?) Scribner, of Tombstone, made the first discovery in the area in 1885 when he located the Mountain Queen claim. Oxidized ore probably was exposed at the site of some of the subsequent surface workings. He carried on a small production until about 1913, shipping by wagon to Webb, about 4 miles north of Elfrida. Webb was a station on the now abandoned Douglas-Courtland branch of the El Paso and Southwestern railway. The Mountain Queen claim has produced most of the ore from the Swisshelm district.

Jacob Sherrer, who owned a saw-mill in the Chiricahua mountains, located claims adjacent to the Mountain Queen shortly after Scribner made his discovery. Sherrer's claims were probably on the site of the present Chance group.

About 1898, John Swisshelm, a native of Ohio, came into the new district. He located the Mammoth and Whale group.

The next event was the acquisition, in 1922, of the Mammoth-Whale group of claims by the Swisshelm Development Company. They sank an incline shaft, and did some lateral development work.

In 1913, R. N. Reynolds leased the Mountain Queen claim. He continued a small-tonnage, near-surface production until 1926. He then retired to Tucson with, reputedly, a million dollars.

Cole and Ford, of Alabama, in 1915, sank a shallow incline shaft in the north part of the Chance group.

In 1935, a well drilled in search of water cut 20 feet of ore on the Mountain Queen claim, near the Chance boundary. Interest in the area was immediately revived; Ether Hayne leased the Mountain Queen; the No Name and Trophy claims were located by Parker. A 116 foot shaft (now used as a manway) was sunk by Hayne on the Chance side of the boundary line; from it he ran a drift over to the new ore-body.

A cave-in in 1941 covered his drilling equipment and caused Hayne to cease operations. It is reported that he produced $80,000 worth of ore in the years 1939 to 1941.

The current activity in the district began in 1945. R. L. Brown, from Tombstone, leased the Mountain Queen claim, and the Ridbaun brothers leased the Chance group. They jointly sank a 250 foot shaft on the Chance No. 1 claim. Drifting was financed by the Reconstruction Finance Corporation. Production got underway from the 160 foot level on the Mountain Queen by Brown, and by the Ridbaun brothers on the 250 foot level on the Chance No. 1. The ore is taken by truck to Douglas, and from there sent by train to the smelter at El Paso.

In 1947, the Swisshelm Mountain Gold and Silver Mining Co., incorporated by Ben Heney of Tucson, started production in a small way on the N. Mammoth - North Whale group. The ore is being stock-piled.

The Mountain Queen Mine

The Mountain Queen claim extends north from the center of the south side of Section 12 (see Plate I). It is a patented claim, belonging to the Emily C. Scribner estate. R. L. Brown, of Douglas (formerly of Tombstone) has the lease. In March, 1947, Brown took into partnership Corzelius, of El Paso, who is financing a development program.

The low ridge in the western half of the property is underlain by a catacomb of old workings, which reach the open in a half-dozen adits. The present workings consist of close to a thousand feet of drifts and cross-cuts, all on the 160 foot level of the Chance hoisting shaft. This shaft and manway, which is also on the Chance property, are the only means of access to the underground workings of the Mountain Queen; these are used in common, each outfit having the use of the shaft for one shift per day. At present, the underground work consists in the raising of a shaft. This shaft will follow the course of the drill hole which found ore when drilling for water in 1935.

There are 4 stopes (see Plate II) averaging about 75 by 40 by 20 feet high in the center, which cover a northwest-southeast area 250 feet long and 100 feet wide. The one farthest northwest was worked by Brown. An examination of ore remaining in this stope, and in the wall of one of the other stopes shows a foot or two of galena grading above and below into cerussite, quartz and then shale. The ore boundaries were apparently the arching shale above, and one plane of the thrust fault below. Production, prior to the transferance of operations to shaft raising, was of the order of 200 tons a month, of ore averaging about 25 percent lead and with a sulphide-carbonate ratio of around one to four.

The management plans to sink the new shaft to the sill, a distance of about 75 feet below the present level, and explore for ore there. The underground crew consists of about 4 men at the time of writing, and the surface crew of about 8. Surface work consists in the erection of a head-frame, a hoist-house, and a change house, and the removal of overburden from the shaft site. The shaft will have two compartments.

The Chance Mine

The Chance group consists of 4 claims, lying immediately east and north of the Mountain Queen claim. The claims are owned jointly by W. R. Schupback, of Elfrida, and D. H. Taylor, of Laveen, Arizona-- near Phoenix. The lessees are: Joe and Elmer Ridbaun and Earl Bryant, all of Elfrida.

Mining operations are confined to the number one claim, which adjoins the Mountain Queen. The shaft (one compartment) is 250 feet deep, plus a sump; a raise connects with the manway at the 160 foot level. The workings on the 160 foot level are for access to the Mountain Queen claim--see Plate II; on the 250 foot level, there are some 400 feet of drifting and cross-cutting--Plate III.

Four ore-bodies have been found. Stoping is still in progress on the 3 farthest from the shaft; the mined-out orebody is about 50 feet by 20 feet by 30 feet high.

The ore occurs, where Naco limestone, striking N.N.E. and dipping steeply has been replaced close to tear faults striking northeast. The ore begins a few feet above the sill, and is cut out at the top by faulting. The purer limestone beds were the ones replaced; the diorite porphyry sill can be seen in the sump and in the lower parts of drift walls.

The ore is: argentiferous galena, about 70%; cerussite, about 25%; and pyrite, about 5%. One speck of gold was seen in a polished section. There is very little quartz.

The grade of ore shipped runs about 25% lead; a high silver streak gives, in addition to lead, assays of 28 ounces of silver and two tenths of an ounce of gold per ton.

The crew consists of 5 men underground and one hoist-deckman. Production has varied from 200 to 500 tons a month. Surface building includes: headframe, loading pocket, hoist-house, combination change-room and blacksmith shop.

The mine makes a little water, about 3,000 gallons a day; at one place, a steady drip was noticed from the upper contact of the sill.

The Swisshelm Mountain Gold and Silver Mining Company

This company, controlled by Ben Heney of Tucson, owns the following claims: N. Mammoth, Little Tree, New Hillside, N. Whale, Nos. 1-4. There is, on the N. Mammoth claim, a 300 foot, 30° incline shaft with two levels. On the bottom level, there is a 300-foot cross-cut and 125 feet of drifting. The first level, at 75 feet, reaches the surface in an adit, through which the present work is being done; there are some 300 feet of drifting, and a 275 foot cross-cut.

The shaft follows a mineralized bed of the E.-W. striking Naco limestone. The mineralization consists of quartz and calcite, a little pyrite, and scattered values in gold and silver. Ore is being taken out from stopes above the first level, and stock-piled. The first level cross-cut follows the normal fault, showing no ore.

There is a 4-man crew on the property.

Future of the District

Other claims in the area include: the Mammoth and Whale, located by R. L. Brown; the Tomboy, owned by D. H. Taylor and Grover Wease; the No Name and Trophy, owned by R. H. Parker, O. Reynolds and H. Bates, and leased by Frank and Lawrence Moore. Recent locating has extended the staked area in all directions, and indicates that production from the district is still only in its early stages.

The properties that have ore developed will find the most favorable conditions for ore, beyond the limits of their stoped areas, wherever easily replacable limestone beds have been faulted and brecciated. The other properties, if underlain by the sill, have good chances of finding ore above it in favorable beds near minor faults.

The under-side of the sill has not been explored for ore, If, in accordance with one theory of ore deposition, the ore solutions moved vertically through the sill and deposited ore above it, some ore could have been deposited below the sill. This ore might be directly below the above-sill ore; or it might be at other places, where the rising ore solutions could not break through the sill.

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PLATE IV

Southern part of a relief map of Cochise county. San Pedro Valley on left, Sulphur Springs Valley in center, Willcox Playa in north center.

C: Chiricahua Mountains

D: Dragoon Mountains

DC: Doz Cabezos Mountains

M: Mule Mountains

S: Swisshelm Mountains

PLATE IV

PLATE V

A - View of Swisshelm range looking southeast from Rucker Canyon road. Peak to right of center formed by west-dipping Bolsa quartzite.

B - View looking south from the top of Permian hills at north end of range.

B and B: peaks formed by Bolsa quartzite

PLATE V

A

B

PLATE VI

A - View of Swisshelm mountains looking east from Elfrida. McPherson's store in center foreground.

B - Elfrida from the south

PLATE VI

A

B

PLATE VII

A - View looking northeast, Mountain Queen area, showing typical vegetation. Buildings of Mountain Queen mine in center

B - Horses at Chance water tank

PLATE VII

A

B

PLATE VIII

A - Looking northeast from near southwest corner of Mountain Queen area. Mine road visible across center; Chiricahua mountains right skyline.

R: rhyolite hill near northeast corner of mapped area

B - View south from Escabrosa-capped hill in north central part of Mountain Queen area. Trace of thrust fault shown by inked line.

B: Bolsa quartzite, hill in center background shifted left by E.-W. fault.

C: Chance shaft

Q: Old workings of Mountain Queen

PLATE VIII

A

B

PLATE IX

A - Granite (left) - Bolsa quartzite contact, measured section.

B - Oolitic limestone near top of Cochise formation, Measured section; note book is 7 inches long

PLATE IX

A

B

PLATE X

A - Abrigo formation, measured section.

B - Devonian (Martin limestone) weathered outcrop, measured section.

PLATE X

A

B

PLATE XI

A - Escabrosa limestone in foreground, Naco limestone in middle distance; measured section.

B - Bed with *Chaetetes*, Naco limestone; measured section.

PLATE XI

B

A

PLATE XII

A - View looking north from north end of Swisshelm mountains. Isolated hills in background (beyond road) are of rhyolite

B - Foreground of (A), lines indicate contacts

G: granite

€b: Bolsa quartzite

€c: Cochise formation

€a: Abrigo formation

€cq: Copper Queen limestone

D: Devonian limestone

Ce: Escabrosa limestone

PLATE XII

A

B

PLATE XIII

A and B - Views looking north at north end of range, include upper part of measured section

Ce: Escabrosa limestone

Cn: Naco limestone

D: Devonian

P: Permian

Tr: Tertiary rhyolite

PLATE XIII

B

A

PLATE XIV

A - Devonian limestones (below) - Escabrosa limestone contact, measured section.

B - Escabrosa limestone (left) - Naco limestone contact, about 1 mile north of northwest corner of Mountain Queen area

PLATE XIV

A

B

PLATE XV

A - *Chactetes* in Naco limestone

B - Chert in Naco limestone

PLATE XV

A

B

PLATE XVI

A - Naco (below) - Permian contact, measured section.

B. Permian limestone beds, fossiliferous above X. measured section.

PLATE XVI

A

B

PLATE XVII

A - Permian conglomerate resting on marly beds (Naco?), measured section.

B - Close-up of Permian conglomerate

PLATE XVII

B

A

PLATE XVIII

A - Granite - Cochise formation contact, near northwest corner of mapped area

C: Cochise formation

G: Granite

B - Granite - Bolsa quartzite contact, near west center of mapped area.

B: Bolsa quartzite

G: Granite

PLATE XVIII

A

B

PLATE XIX

A - Looking southeast at rhyolite hill near northeast corner of Mountain Queen area

B - Rhyolite hills in Sulphur Springs valley, north of Swisshelm range

PLATE XIX

A

B

PLATE XX

Looking south from hill in northwest corner of Mountain Queen area; Bolsa quartzite (B) resting on granite core of anticline.

PLATE XX

PLATE XXI

View looking north, showing section A - A' (Plate I)

€a: Abrigo formation

€b: Bolsa quartzite

€c: Cochise formation

Ce: Escabrosa limestone

Cn: Naco limestone

D: Devonian limestones

G: granite

Tr: Tertiary rhyolite

PLATE XXI

PLATE XXIII

View looking north from near southwest corner of mapped area. Includes west part of section B - B' (Plate I)

-Єb: Bolsa quartzite

G: granite

PLATE XXII

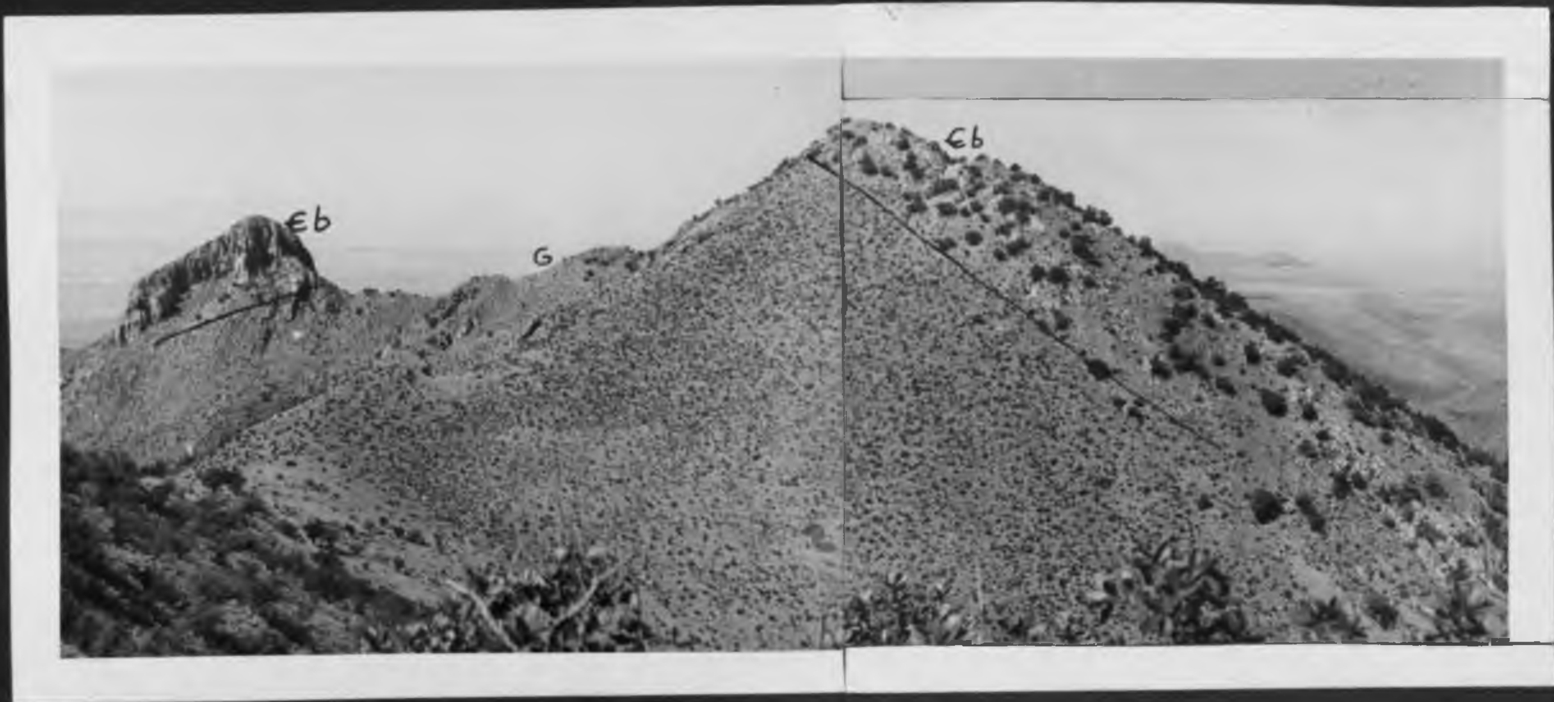


PLATE XXIII

View looking north from southeast corner of mapped area; includes east end of section C - C' (Plate I)

Ce: Escabrosa limestone

D: Devonian limestones

Tr: Tertiary rhyolite

PLATE XXIII

PLATE XXIV

A - Chance manway (foreground) and shaft, looking southeast.

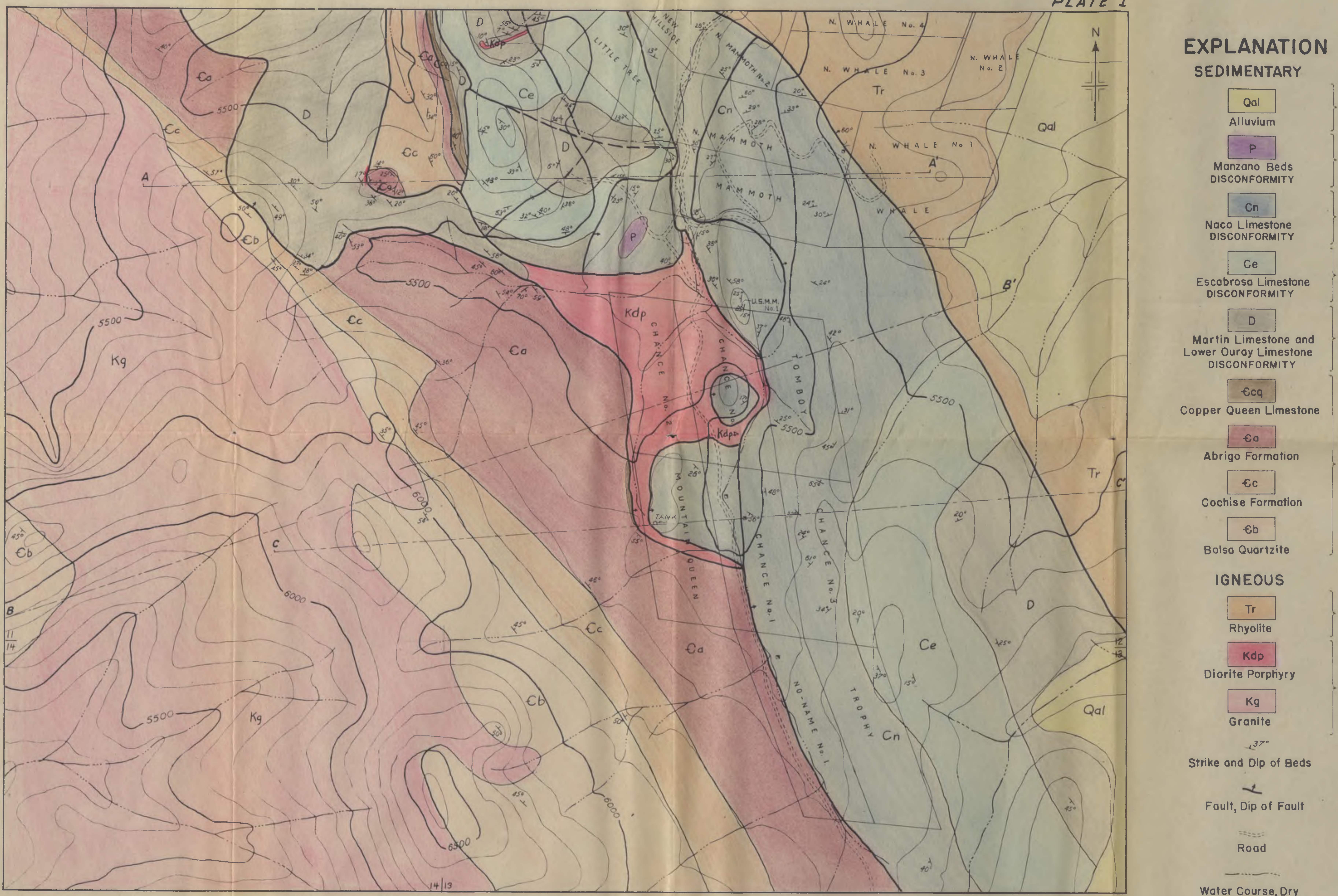
B - Chance shaft and loading pocket, looking southeast.

PLATE XXIV

A

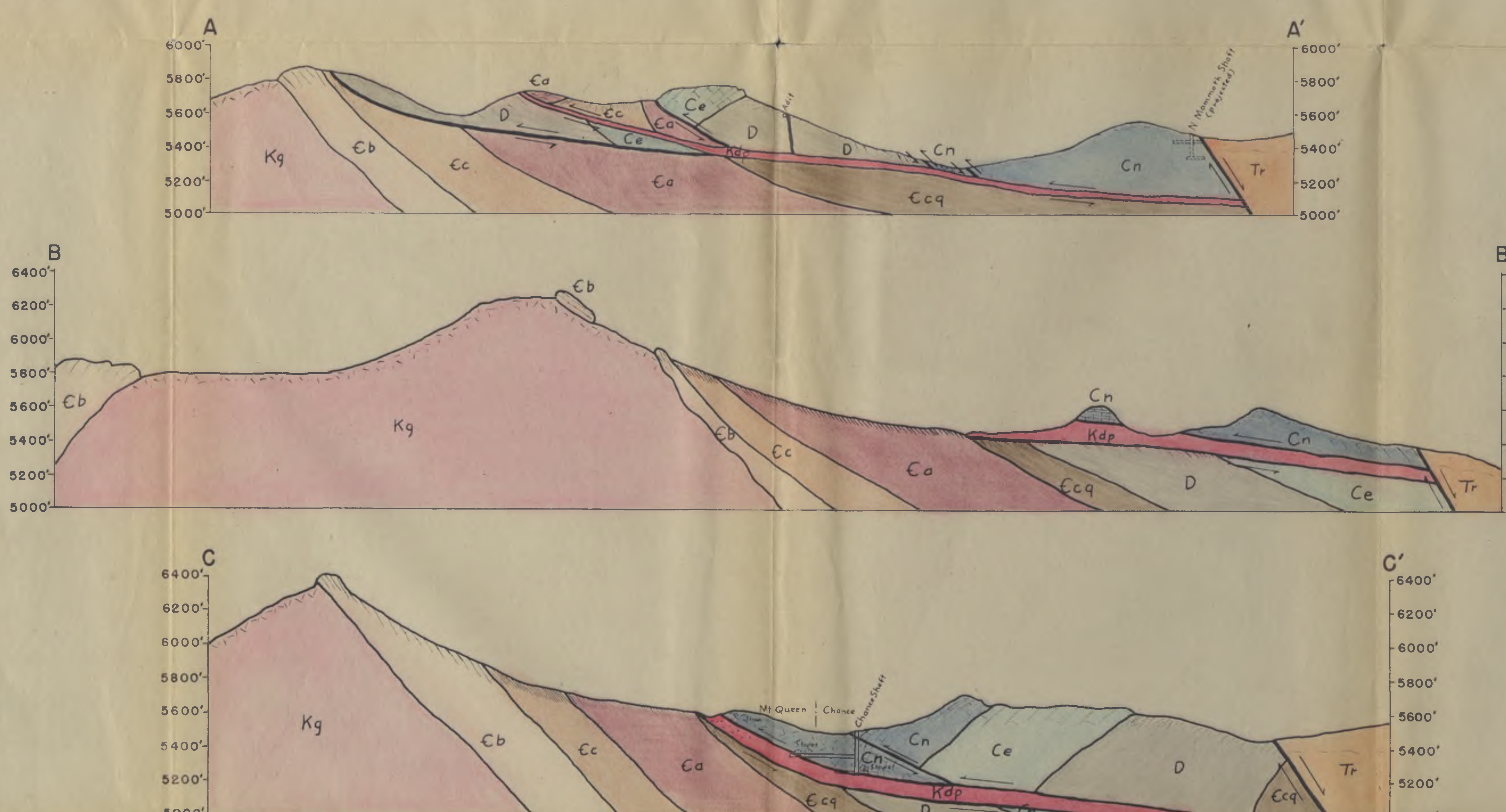
B

PLATE 1



TOPOGRAPHY BY US GEOLOGICAL SURVEY

GEOLOGY BY W B LORING, 1947



GEOLOGIC MAP AND SECTIONS OF THE MOUNTAIN QUEEN AREA

SWISSHELM MOUNTAINS, COCHISE COUNTY, ARIZONA

SCALE: 1 IN = 500 FT

500' 0 500 1000 2000 2500'

CONTOUR INTERVAL: 100 FT

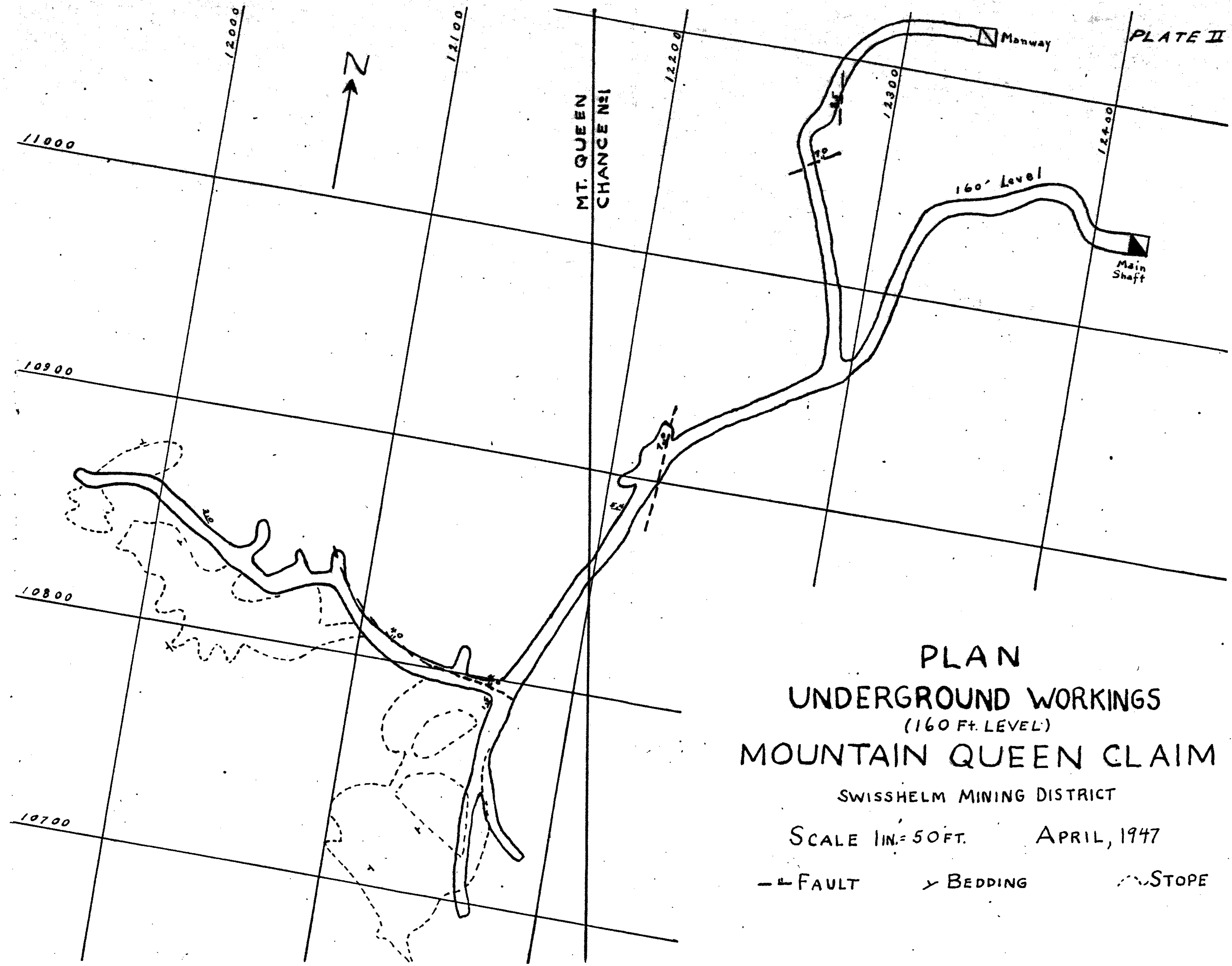


PLATE II
N
Manway
Main Shaft
160' Level
MT. QUEEN
CHANCE No. 1
12000
12100
12200
12300
12400
11000
10900
10800
10700
PLAN
UNDERGROUND WORKINGS
(160 Ft. LEVEL)
MOUNTAIN QUEEN CLAIM
SWISSHELM MINING DISTRICT
SCALE 1 IN. = 50 FT.
APRIL, 1947
FAULT
BEDDING
STOPE

Plate 2

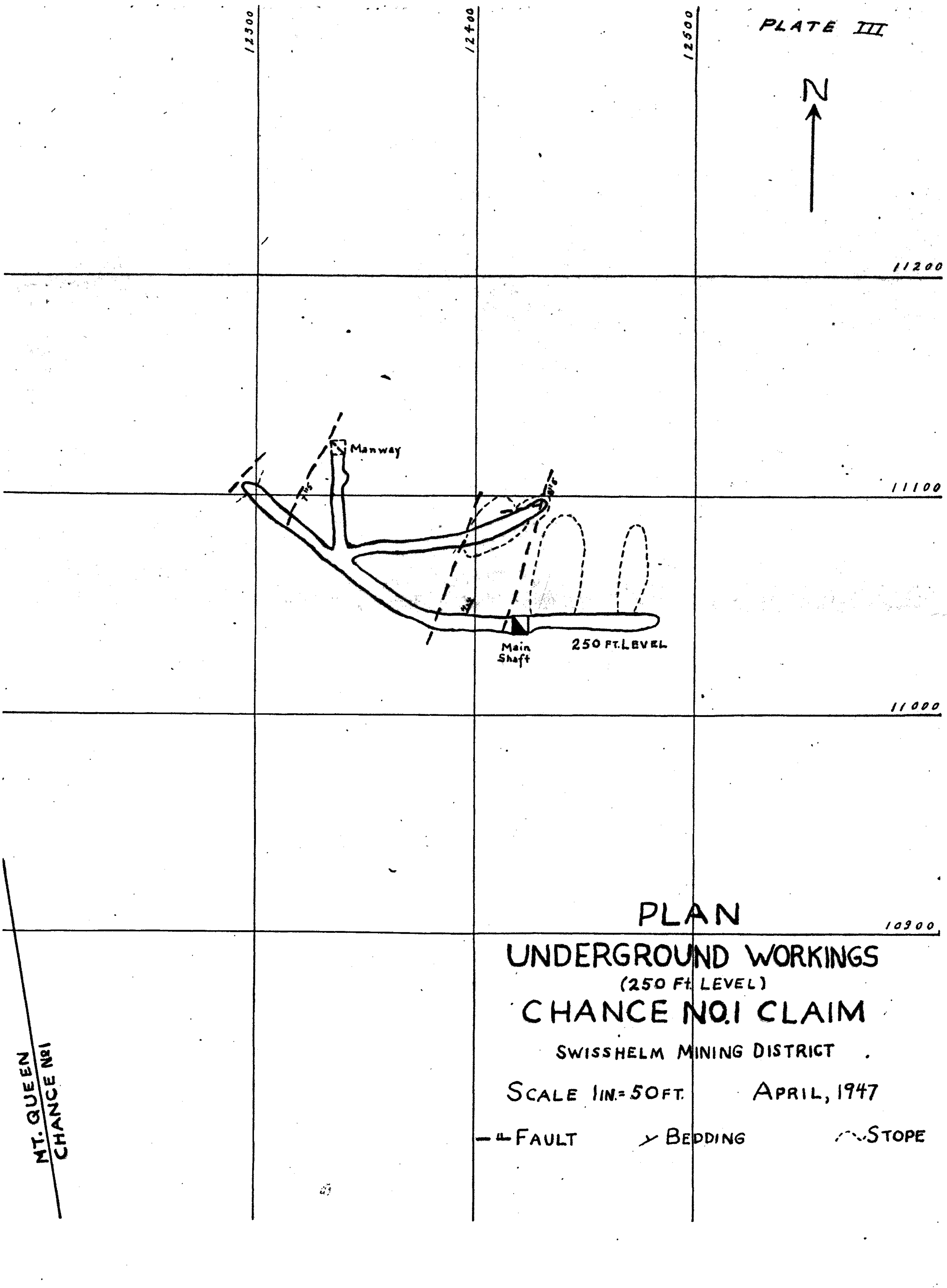


PLATE III
N
12300
12400
12500
11200
11100
11000
10900
Manway
Main Shaft
250 FT. LEVEL
MT. QUEEN
CHANCE No1
PLAN
UNDERGROUND WORKINGS
(250 Ft. LEVEL)
CHANCE NO.1 CLAIM
SWISSHELM MINING DISTRICT
SCALE 1IN.=50FT.
APRIL, 1947
FAULT
BEDDING
STOPE