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GEOLOGY AND ORE DEPOSITS OF THE COMET DISTRICT, LINCOLN COUNTY, NEVADA

Title

DAVID C. FITCH

Candidate

GEOLOGY

Department

Dean

Date

Committee

Lee A. Woodward

Chairman

R. M. Kudo

V. C. Kelley

GEOLOGY AND ORE DEPOSITS OF THE COMET DISTRICT LINCOLN COUNTY, NEVADA

By

DAVID C. FITCH

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Mountain Quartzite, as in the Comet mine, and bedded-replacement deposits in Cambrian limestone, as in the Pan American and Schodde mines. The largest lead-zinc-silver ore bodies are in the Combined Metals Member of the Pioche Shale, the lowermost exposed limestone unit in the region. The size and frequency of mineralized rock decreases stratigraphically upward. Nearly all the ore-bearing rocks are cut by lamprophyre dikes. Bedding faulting in the Combined Metals Member has displaced earlier dikes and faults, and has resulted in fracturing and folding of the unit, thus enhancing its favorability as a host rock. Similar favorable structural environments are present at other locations in the area and are suggested as exploration targets for large, low-grade, lead-zinc-silver deposits similar to those of the Pan American Mine.

INTRODUCTION

Location

The Comet mining district, about 9 square miles (Fig. 1), lies along the west side of the Highland Range, about 9 miles west-southwest of Pioche, Nevada. The Pan American mine near the south end of the district is 16 miles west of Caselton on Nevada highway 83, a gravel road. The mapped area, about 1 1/2 miles wide, extends from south of the Pan American mine to a point about 1 1/2 miles south of Stampede Gap (Fig. 1). Relief in the area is moderate, with elevations ranging from about 6,300 to 8,200 feet.

Previous Work

Previous reports on the stratigraphy of the Highland Range have been written by Walcott (1886, p. 33-35; 1888. p. 162; 1891, p. 317; 1908a; 1908b; 1912, p. 189-192; 1916a; 1916b), Mason (1938), Howel and Mason (1938), Deiss (1938), Wheeler and Lemmon (1939), and Wheeler (1940, 1948). A recent publication by Merriam (1964) summarizes the earlier work and provides a detailed description of the stratigraphy.

In 1932, Westgate and Knopf published a geologic map (1:62,500) and report covering the Highland, Bristol, and Ely Ranges following a less detailed report in 1927. An unpublished map by C.D. Campbell and J.A. Reinemund (1943) of the U.S. Geological Survey covers a strip from the Pan American mine to the Forlorn Hope mine (1 inch equals 500 feet); they

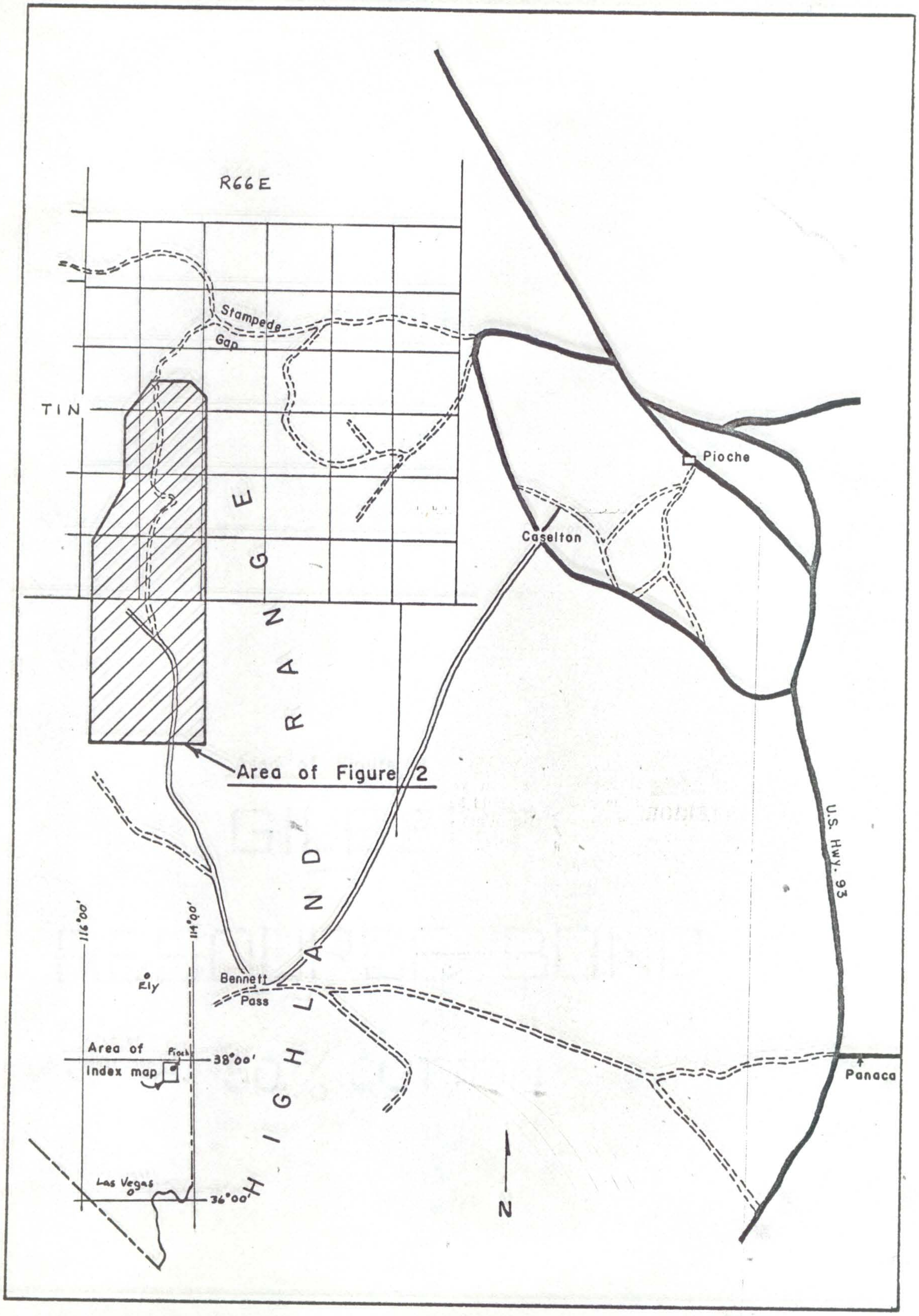

Figure 1. Index map showing location of the Comet mining district, Nevada

prepared a report for a subsequent drilling project by the U.S. Bureau of Mines (Trengove, 1949, p. 3118). A copy of this report was not obtained by this author. In 1947 Paul Gemmill mapped an area about 2,800 feet wide from the Pan American mine to a few hundred feet north of the Schodde mine at a scale of 1 inch equals 200 feet for the Combined Metals Reduction Company. Company geologic maps cover most of the underground workings in the area.

Field Work and Mapping Methods

In the summer of 1965 the author mapped parts of the Pan American mine and surface geology in the immediate vicinity at a scale of 1 inch equals 40 feet for the Grand Deposit Mining Company. Field work for the present study was begun in August, 1966 and was continued intermittently through 1966 and completed in April, 1967. Detailed geologic mapping was done on enlarged aerial photographs at a scale of 1 inch equals 500 feet and the geology transferred to a topographic base at that scale consisting of enlarged Highland Peak and Highland, Nevada quadrangle maps. All accessible mines in the area were mapped in detail with the exception of the Pan American mine which was studied with the use of the Grand Deposit Mining Company geologic map.

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STRATIGRAPHY

Cambrian System

Cambrian rocks comprise nearly all the western side of the Highland Range, and within the mapped area a thickness of about 3,000 feet is exposed. Formations exposed in the area range from the Prospect Mountain Quartzite at the western base of Highland Range to the Step Ridge Member of the Highland Peak Formation along the eastern border of the area (Fig. 4).. Stratigraphically higher Cambrian rocks of the Highland Peak and Mendha (?) Formations occur in fault contact with the Prospect Mountain Quartzite in the western part of the area. The Cambrian formations within the area correlate readily by lithology.

Hydrothermal fissure veins occur in the Prospect Mountain Quartzite. In the overlying strata, fissure veins are associated with replacement ore bodies in certain carbonate units. Replacement ore deposits of large tonnages are localized in the first limestone member above the Prospect Mountain Quartzite.

Prospect Mountain Quartzite

The Prospect Mountain Quartzite is the oldest formation exposed in the Comet district. This formation was named by Hague in 1883 from exposures in the Eureka mining district (Nolan, and others, 1956, p. 6-7), and recently has been described in the Pioche district by Merriam (1964, p. 9-13). The upper part of the formation is exposed along the western side of the area from the south border to south of One Wheel Canyon. Its western limit of outcrop is a fault contact with Middle Cambrian limestone and dolomite to the west.

The Prospect Mountain Quartizite consists predominantly of thin to medium-bedded, red to reddish-brown vitreous quartzite. Intercalated micaceous shale is present and increases in abundance toward the top of the formation. Grain size of the quartzite is commonly medium to coarse, but in places ranges to conglomeratic. Crossbedding occurs locally. Fresh surfaces are light gray to brown, generally with reddish tints. Weathered surfaces are commonly iron-stained to reddish brown or limonitic brown, but in places are light to dark gray.

The interbedded shale is characteristically micaceous, laminated, and ranges from reddish gray and light brown to green. Burrows, small mounds, and pits are common in places on wavy shale surfaces. Thicknesses of the shale interbeds ranges from less than one-quarter inch to 6 or 8 inches near the top of the formation.

As no marker beds are present in the formation, faults are difficult to recognize unless breccia zones are seen. Commonly the breccia zones in the quartzite show subtle signs of alteration such as slight bleaching, perhaps accompanied by pale-yellow jarosite staining. Only the upper 800 feet of the Prospect Mountain Quartzite is exposed in the area. Merriam (1964, p. 9) reports a partial measurement of 2,400 feet in the Pioche district.

The upper contact with the Pioche Shale is gradational, and for mapping purposes was placed a few feet below the uppermost quartzite layer. Topographically, this contact occurs in a slight saddle, with the Prospect Mountain Quartzite rising to small rounded hills to the west.

Pioche Shale

In the earliest investigation of Pioche, Nevada and vicinity, Gilbert (1875; p. 257-261) noted a unit corresponding to the Pioche Shale. Howell made similiar observations in 1875 (p. 259). Walcott named the formation in 1908, following a detailed study of the Highland Range section in 1886 (p. 35). Merriam (1964, p. 14) summarizes other publications on the Pioche Shale. Detailed subdivision of the formation into members and beds, which have economic significance, has been done by mining companies.

This formation has no type section, and Merriam (1964, p. 15) designates a reference section, faulted near the top, at Pioche Divide. A more complete section, however, is exposed near the Pan American mine (Fig. 2). Most outcrops of the formation north of Burrows Canyon are unsuitable for stratigraphic study because of strike or diagonal faulting.

The Pioche Shale, like overlying units, forms a nearly continuous outcrop band which extends from the southern border of the mapped area to the northern border. The formation contains several lithologic types, but the most common variety of rock is brown, micaceous siltstone and sandy shale. Several thin limestone beds, particularly common in the upper part of the formation, persist laterally throughout the area and are reliable marker beds. The formation has been subdivided into six lithologic members (Fig. 5) by mining companies in the region (Merriam, 1964, p. 19). The members are, from top to bottom: the A-Shale, B-Shale, Susan Duster Limestone, C-Shale, Combined Metals, and D-Shale.

The thickness of the Pioche Shale is 1,060 feet. Uniform thickness and lateral continuity are characteristic of the limestone beds and intercalated shales in the upper part of the formation. This fact, and results of mapping, indicate that the entire formation is relatively uniform in thickness in the area. Merriam (1964, Pl. 4 and p. 15) reports a thickness of 975 feet in a measured section at Lyndon Gulch and a thickness of 780 feet in a section at the Forlorn Hope mine. His section at the Forlorn Hope mine is shortened by strike faulting. The thickness from the top of the Pioche Shale to the top of the Combined Metals Member is 700 feet. This part of the section was measured along continuous exposures near the Pan American mine.

D-Shale Member

The D-Shale Member conformably overlies the Prospect Mountain Quartzite. This shale unit is poorly exposed in the mapped area, and forms saddles and low slopes which are generally covered by alluvium. Typically, this member consists of finely micaceous, greenish-gray shale and sandy shale. The color of weathered surfaces ranges from olive green in most of the fine-grained shale, to khaki in the sandy shale. Many of the micaceous bedding surfaces are uneven and contain numerous burrows, mounds, and tracks. Although some of the D-Shale is lithologically similiar to parts of the A- and C-Shale Members, its overall greenish aspect, and lack of limestone beds is distinctive.

The D-Shale is 270 feet thick as measured along a partially covered section in Lyndon Gulch. Although this figure is probably close to the true thickness, unrecognized strike faults may be present. The uppermost few feet of D-Shale in most places consists of laminated olive-green micaceous shale which is conformably overlain by the bottom sandstone bed of the Combined Metals Member.

Combined Metals Member

General Statement- The Combined Metals Member, consisting largely of limestone, is the host rock of ore bodies in the mapped area and in nearby Pioche. It has therefore received considerable study by mining companies.

This member is discontinuously exposed from the south end of the mapped area to about one-half mile north of the Forlorn Hope mine. Generally the middle part or lower contact is best exposed; the upper contact is nearly everywhere covered. The thickness of this unit generally ranges from 70 to 90 feet, and is about 80 feet near the Pan American mine. Merriam, however, reports a thickness of only 25 feet near the Pan American mine (1964, p. 18). This was probably obtained by measurements across the diagonal fault near the portal (Fig. 2) and along poor exposures.

A lower, medium-bedded part, and an upper, thin-bedded part comprise the Combined Metals Member. Subdivision into two parts is informal (Merriam, 1964, p. 19), although each is a mappable unit at large scales. The lower part, about 18 feet thick, consists of sandy limestone with calcareous sandstone at the top and bottom. The upper part consists of limestone and is 50 to 75 feet thick. Structural thickening in the upper part occurs in zones of disharmonic folding where dikes and faults have acted as barriers to bedding slippage.

Merriam (1964, Table 3) formally sudivides the Combined Metals Member into 5 subunits which generally correspond to mining company terms (Fig. 6). Subunits 1, 2, and 3 comprise the lower, medium-bedded part. Of these, only Subunit 3 (micaceous shale rib) can be recognized in the Highland Range. Subunits 4 and 5 of Merriam, comprising the upper, thin-bedded part cannot be distinguished in the Highland Range section. In fact, Merriam's (1964, p. 19) correlation of Subunit 4 to the "lower part of upper bed" (L.P.U.B.) and Subunit 5 to the "upper part of upper bed" (U.P.U.B.) does not agree with mining company usage. As used by the mining companies L.P.U.B. refers to those parts of the upper bed that are mineralized (H.E. Davenport, personal communication, 1967). Where unmineralized, the upper part of the Combined Metals Member is not subdivided.

Lower Part- The lower part of the Combined Metals Member is 18 feet thick and is medium bedded. It is divided into 3 informal lithologic units; a lower calcareous sandstone, a middle sandy limestone, and an upper, micaceous calcareous sandstone.

The lower calcareous sandstone, 3 to 3 1/2 feet thick, contains local lenses of quartize, and is fine to medium grained. On fresh surfaces this unit is medium gray to light brown. Weathered surfaces are medium to dark brown, and show a reddish hue in places.

The middle sandy limestone, 11 to 11 1/2 feet thick, is fine to medium grained, but contains varying amounts of sand.. This unit locally contains abundant trilobite fragments and

Figure 6. Stratigraphic subdivisions of the Combined Metals Member of the Pioche Shale at the Pan American mine showing equivalent terms used in the Pioche district

	Pan American mine section, this report: Subdivisions		Pan American mine section, this report: Lithology	Pioche Divide section, C. W. Merriam, 1964.		Mining Company terms (Pioche)
Combined Metals Member of Pioche Shale	Upper part (70 ft.)		Thin-bedded, fine-grained, dark-gray nodular limestone; carbonaceous, shale partings; locally silty.	Upper limestone (53ft)	Subunit 5 (40 ft)	Upper part of upper bed (U.P.U.B.) (35 ft.)
					Subunit 4 (10ft)	Lower part of upper bed (L.P.U.B.) (3 ft.)
	Lower part (18ft)	Upper calcareous sandstone (3½ ft.)	Medium-bedded, fine to medium-grained calcareous sandstone.	Lower calcareous sandstone and sandy limestone (17ft)	Subunit 3 (2½ft)	Micaceous shale rib (3 ft.)
		Middle sandy limestone (11½ ft.)	Medium-bedded, fine to medium-grained, medium to dark-gray arenaceous limestone; weathers brownish gray; brown sandy partings common in lower part.		Subunit 2 (4ft)	Lower bed (2 ft.)
						Siliceous shale rib (2 ft.)
					Subunit 1 (10 ft)	Footwall bed (1½ ft.)
						Siliceous footwall shale (10 ft.)
		Lower calcareous sandstone (3 ft.)	Medium-bedded, fine to medium-grained calcareous sandstone.			

Girvanella. Brown sandy partings are common in the lower part. Fresh surfaces of the sandy limestone range from medium to dark gray. Weathered surfaces range from brownish gray to bluish gray. Individual beds in this unit are more or less laterally persistent in the Pan American mine, but are not easily distinguished by lithology.

The upper calcareous sandstone with locally abundant mica is generally 3 1/2 feet thick (Subunit 3, Merriam, 1964, p. 19; "micaceous shale rib"). This unit is fine to medium grained and is separated from beds above and below by laterally persistent partings. Mica is locally abundant but in places is uncommon, or not easily seen.

Upper Part- The upper part of the Combined Metals Member, 50 to 75 feet thick, consists of thin-bedded limestone. The beds average 2 inches in thickness, are commonly nodular, and contain argillaceous partings. The limestone is dark gray, generally fine grained, and contains scattered angular quartz particles of silt size. Black, carbonaceous trilobite fragments are common in places. Weathered surfaces of the clay partings are pale red to medium gray. Surfaces of the thin beds in and near ore bodies are coated with thin layers of black, amorphous material. This material probably consists of fine-grained amorphous carbon and manganese oxides.

C-Shale Member

The C-Shale Member, 105 feet thick, conformably overlies the Combined Metals Member. This shale is characteristically pure, but in a few places it is sandy. Weathered surfaces are drab olive or greenish brown. Although parts of the D- and A-Shale Members have similiar lithology, the C-Shale is distinguished by its lack of abundant mica in hand specimen. Bedding of the C-Shale ranges from papery to laminated.

Susan Duster Limestone Member

This unit is named from the Susan Duster mine near Pioche. In the mapped area the Susan Duster consists mostly of medium light-gray aphanitic limestone, containing fossil fragments. It is thin bedded, and commonly becomes nodular in the upper half, with argillaceous partings between the uneven bedding surfaces. Thickness ranges from 10 to 17 feet and averages 15 feet.

B-Shale and A-Shale Members

Accurate separation of these members depends upon correct identification of a sandstone marker, which is present at the base of the A-Shale near Pioche (Merriam, 1964, p. 23). In the Highland Range section, however, this sandstone marker cannot be correlated with certainty. For purposes of description, the base of the A-Shale Member is placed at the bottom of a 4-foot calcareous sandstone which is overlain by a 7-foot limestone bed (Fig. 5). The base of the A-Shale, by this criterion, is 169 feet above the Susan Duster Limestone. Separation of the B-Shale and A-Shale Members is not practical for mapping purposes because of the stratigraphic uncertainty and because this part of the Pioche Shale is generally poorly exposed. Total thickness of the A- and B-Shale Members is 579 feet.

The B-Shale, 169 feet thick, conformably overlies the Susan Duster Limestone. It consists mostly of light-brown shale and siltstone. Limestone is absent except for a one-foot limestone bed and a thin calcareous sandstone bed in the upper half. Bedding surfaces of the shale and siltstone commonly are very micaceous and in places show pits and grooves that may be of organic origin.

The A-Shale consists predominantly of gray-brown, sandy shale and siltstone. Sandstone is common, and limestone in beds from 0.5to 20 feet thick makes up about 20 percent of the member.

Most of the shale is very micaceous, and in places bedding surfaces show pits and grooves similar to those of the B-Shale. A thin zone of olive, papery shale, near the top of the A-Shale is similar to D-Shale or C-Shale. The A-Shale is, however, easily distinguished by its numerous limestone beds.

The limestone beds are persistent laterally, and the thicker ones, which are fairly well exposed, make good markers. The "20-foot limestone" marker (Blue Limestone Marker, Merriam, 1964, p. 23) is particularly well exposed and has been mapped in the present study. This limestone, which is 180 feet below the Lyndon Limestone, is generally 20 feet thick but reaches 35 feet at the north end of the mapped area. Fifty feet above this bed is another marker, the "10-foot limestone", which is generally well exposed. These two markers are lithologically similar, consisting of dark bluish-gray limestone that is aphanitic to fine grained. In places the "10-foot limestone" is coarsely crystalline. The markers are easily confused in areas of faulting or poor exposures, but may be distinguished by lithology of the underlying shale.

The sandstone beds of the A-Shale are fine to medium grained, quartzitic, and in places are calcareous. Weathered surfaces are generally medium brown. The A-Shale Member is 410 feet thick in the mapped area, but Merriam (1964, p. 23) reports a thickness of 310 feet in the Pioche area. The contact between the A-Shale Member and the overlying Lyndon Limestone is sharp but apparently conformable. Merriam, (1964, p. 29) suggests a possible disconformity at this contact, but bedding faults may explain the gently undulating surface which is seen in places. Locally the contact falls 10 feet above the base of a cliff whose upper part is formed by the Lyndon Limestone.

Lyndon Limestone

General

The Lyndon Limestone was named by Westgate and Knopf (1932, p. 10) from exposures in Lyndon Gulch. This formation typically forms ledges and cliffs and is about 360 feet thick in the mapped area. It has been subdivided into

3 members which are, in ascending order, A,B, and C Members (Merriam, 1964, p. 29). Corresponding mining company terms for these members are; the Black Prince Limestone, White Prince Limestone, and the Blue Prince Limestone or "Moonlight". The lower and upper members (A and C) are dark-gray limestone, and the middle member (B) is white and light-gray limestone.

Member A

Member A (Black Prince) consists mostly of very dark gray, fine-grained to aphanitic limestone. Oolites and Girvanella (?) are common in places. The lower 24 feet forms ledges and weathers massive, showing abundant brown silty partings. A thin-bedded zone of variable thickness commonly overlies the basal ledge former, and is overlain by medium-bedded limestone. The upper 20 feet of Member A is also generally thin bedded, and like other such zones, contains intercalated silty and argillaceous limestone. In general, the upper part of Member A is of lighter color and commonly has a light gray coating, probably derived from weathering of the overlying member. Member A is about 200 feet thick east of the Pan American mine, but generally ranges from 180 to 190 feet.

Member B

Member B (White Prince) consists of white and very light gray-weathering limestone which is generally massive. Its base is marked by a 4-inch laminated gray, sandy limestone.

Limestone below the base is medium to dark gray and finely crystalline, and limestone above the base is medium to light gray and aphanitic. Although thin-bedded zones occur in the lowermost part, most of Member B is massive and forms cliffs and ledges. Most of the white limestone is aphanitic and in places is lithographic. The medium- to light-gray limestone is generally fine- to very fine grained. Member B is about 145 feet thick in the mapped area.

Member C

Member C (Moonlight or Blue Prince) consists mostly of thin-bedded, dark-gray limestone, similar to Member A. It is finely crystalline, contains abundant ovoidal structures and locally anundant rods and blebs of white calcite. Weathered surfaces are dark bluish gray. This member is 15 feet thick east of the Pan American mine and ranges from 10 to 20 feet.

Chisholm Shale

The Chisholm Shale was named by Walcott (1916b, p. 409) from type exposures near Pioche. This formation is probably conformable with Member C of the Lyndon Limestone, but the contact is exposed in very few places. The Chisholm Shale consists of very fine grained tan shale and interbedded limestone. The shale is generally laminated and weathers into plates. Very fine grained mica is abundant in the shale but is not apparent without a lens. The lack of megascopically visible mica and the slightly pinkish tan color of the Chisholm distinguishes it from the Pioche Shale. The Chisholm contains numerous limestone beds that range in thickness from 1 inch to as much as 13 feet. They consist of fine-grained, medium- to dark-gray limestone and have abundant fossil fragments and <u>Girvanella</u> (?). Most of the limestone is thin bedded and contains shaly partings.

Thickness of the Chisholm north of Peasley Canyon is about 100 feet, but ranges from 80 to 135 feet in the mapped area. Most of the variation may be depositional. The Chisholm Shale is conformably overlain by the Peasley Member of the Highland Peak Formation.

Highland Peak Formation

The Highland Peak Limestone was described by Westgate and Knopf in 1932 (p. 11) from exposures in the Highland Range. Merriam (1964, p. 32) changed the name to Highland Peak Formation and classified its main stratigraphic units as members. Only the four lower members, or the lower 1,000 feet of the formation, are exposed in the mapped area. The members are, in ascending order; the Peasley, Burrows, Burnt Canyon, and Step Ridge Members. Total thickness of the Highland Peak Formation is 4,500 feet as measured in the Warm Springs section, northeast of Panaca, Nevada (Merriam, 1964, p. 33).

Peasley Member

The Peasley Member was originally described as the Peasley Limestone by Wheeler (1940, p. 17) from exposures south of Peasley Canyon. This member consists of medium- to medium dark-gray limestone that is fine to medium grained. It generally weathers bluish gray but in places shows alternating light- and dark-gray bands Oolites, Girvanella-like forms, and white calcite rods are common in parts of the Peasley. The lower one-third of the member is generally massive and forms ledges, whereas the upper two-thirds is mostly thin bedded with some medium-bedded limestone.

The upper contact is generally marked by an abrupt change to medium-gray dolomite of the overlying Burrows Member. In places, however, dolomite crosses this contact into the Peasley and closely resembles the Burrows. In several places, where the Peasley is entirely limestone, the lower part of the Burrows is also limestone. Thus, it is commonly difficult to distinguish the Peasley-Burrows contact, and for mapping purposes it was placed several feet above a thin-bedded zone and about 15 feet below a persistent dull-brown dolomite zone in the Burrows Member.

Where dolomitization of the lower part of the Peasley occurs, it is always associated with hydrothermal veins or fissure zones. The dolomitized rock extends laterally equal distances on both sides of the vein.

The Peasley ranges in thickness from 130 to 160 feet, and is 156 feet thick in a measured section north of Burrows Canyon. More variation in thickness occurs in the thin-bedded zones than in the thicker bedded zones. Some of the observed variation in thickness however, is probably related to irregularity of the upper contact.

Burrows Member

The Burrows Member, originally named the Burrows Dolomite (Wheeler, 1940, p. 27-29) in a type section south of Peasley Canyon, consists mostly of dolomite with local zones of limestone. The Burrows is characteristically medium light gray, exhibiting sugary texture and blocky, cliff-forming outcrops. Interbeds of darker gray dolomite, generally one inch thick, are common, giving a banded appearance to the rock. Medium-dark-gray, medium crystalline dolomite is also common in the Burrows, and generally contains one- to two-inch interbeds of medium light-gray dolomite. Girvanella-like forms are common in the lower part of the Burrows, especially near the Peasley contact. Near the middle and upper parts of the Burrows, small white rods and blebs are common, that usually consist of dolomite, but in a few places consist of calcite. In places sugary dolomite contains abundant white calcite-filled vugs. A generally persistent brownish-gray sugary dolomite occurs 20 to 30 feet above the base of the Burrows.

Very light gray, finely crystalline, massive limestone is present in places and comprises part of the Burrows south of Lyndon Gulch and the north part of the mapped area, east of the Mountain Lion mine. Locally this limestone resembles the light-gray member of the Lyndon Limestone and unit A of the Step Ridge Member. Lateral change in lithology in the Burrows is irregular; in places it is abrupt, and in other places gradational.

Marker beds are rare and nonpersistent laterally in the Burrows and thus it is often difficult to determine the displacement of faults that are restricted to this member.

Thickness of the Burrows ranges from 380 feet to 600 feet. North of Burrows Canyon, 508 feet was measured, which may be slightly excessive because of covered faults. However, any faults in this section would have minor displacement as faults in the Burrows with more than 15 feet of displacement are usually accompanied by breccia zones 10 to 20 feet wide. Merriam (1964, p. 37) reports a thickness of 370 feet. The Burrows Member is apparently conformably overlain by the Burnt Canyon Member.

Burnt Canyon Member

This member was designated the "Highland Peak C" by Wheeler and Lemmon (1939, p. 47) and later named the Burnt Canyon Limestone by Wheeler (1948, p. 36) from exposures between Peasley and Burnt Canyons. The east border of the area generally occurs in the upper part of the Burnt Canyon Member but in places cuts out the entire member. The Burnt Canyon Member and overlying units are mapped as undifferentiated Highland Peak Formation in the present study.

The Burnt Canyon Member consists mostly of thin-bedded to laminated, medium dark-gray to dark-gray, fine-crystalline limestone. Oolitic beds are present in parts of this member. Reddish-weathering, argillaceous intercalations are common in the lower and middle parts and the associated limestone interfaces are very pitted and bumpy. The argillaceous interbeds in places contain fossils. In a few places the Burnt Canyon has small amounts of interbedded, medium-gray dolomite. Parts of the dark-gray limestone are medium to coarsely crystalline and nearly all the dark-gray limestone phase gives a fetid odor when struck. This member forms slopes and saddles. The Burnt Canyon Member is 230 to 300 feet thick in the mapped area and is conformably overlain by unit A of the Step Ridge Member.

Step Ridge Member

This member was named by Merriam (1964, p. 43) from its type section at Step Ridge in the Ely Range and, as used by Merriam, includes the "Highland Peak D" and "E" of Wheeler and Lemmon (1939, p. 47). Merriam (1964, p. 43) divided the member into lithologic units a, b, and c. Only units a and the lower part of unit b fall within the area. The top of the member is exposed several hundred feet east of the area.

Unit a- Unit a, about 50 feet thick, consists of white to light-gray cryptocrystalline limestone which is oolitic in places. This unit is massive, cliff-forming, and closely resembles Member B of the Lyndon Limestone. It may be easily distinguished from Member B of the Lyndon by its oolitic phases, by the rare occurrence of white calcite rods and stringers, and by the beds above and below.

Unit Unit b- Unit b conformably overlies unit a and consists mostly of light- and dark-gray, fine-grained limestone. The lower part of this unit, being thin bedded to laminated, resembles the Burnt Canyon Member except for the lack of reddish-weathering argillaceous interbeds. Parts of unit b which are markedly oolitic, generally show light- and dark-gray nottling. Unit b is probably about 500 feet thick (Merriam, 1964, p. 43) but sections of this unit were not measured in the present study.

Upper Part(?) of Highland Peak Formation

The limestone in north-trending discontinuous exposures from west of the Pan American mine to the Comet mine is tentatively correlated with the upper part of the Highland Peak Formation. Designation of these beds as the Lyndon Limestone by Campbell and Reinemund (1943, unpublished U.S. Geological Survey map) is incorrect because chert is common locally. The lowest unit in which chert is common is the Condor Member of the Highland Peak Formation (Merriam, 1964, p. 46). However, the rocks here described are not lithologically similar to the Condor Member and thus probably correlate with higher units of the Highland Peak Formation.

These rocks consist mostly of dark- and medium-gray, fine- to medium-grained limestone. In places the limestone is medium dark gray, coarsely crystalline, and has oolites. Some interbedded medium dark-gray dolomite is present. Dark- to medium-gray chert is common locally, particularly in the small exposures west of the Pan American mine.

Stratigraphic relations of the unit are unclear because of faulting and erosion. Also the rocks are extensively brecciated in many places.

Cambrian and Ordovician Systems

Mendha (?) Formation

Rocks discontinously exposed in a fault-block along the western side of the area from the Comet mine to north of the Mountain Lion mine are tentatively correlated with the Mendha Formation as named by Westgate and Knopf (1932,p. 13). No fossils were found in this unit in the mapped area; the correlation is entirely by lithology and thus should be regarded as tentative. This writer is in general agreement with the distribution of the Mendha Formation mapped by Westgate and Knopf (1932, pl. 1) in this area.

The rocks, although lithologically diverse, consist mostly of limestone and minor amounts of dolomite. The most common variety of limestone is medium dark gray, fine to medium crystalline, and weathers to a sugary texture similar to the medium-dark-gray dolomite of the Burrows Member of the Highland Peak Formation. White to light-gray lithographic and finely crystalline limestone is present, commonly showing reddish-brown argillaceous fracture filling. Also present in minor amounts is light pinkish-brown and reddish-brown, medium-grained, detrital limestone. Oolites are common in places in the medium-crystalline dark gray limestone phases. Irregular white calcite blebs, although uncommon, occur in parts of the cryptocrystalline, medium dark-gray limestone.

Chert is abundant in places, particularly near the Mountain Lion mine, where it occurs in two- to three-inch beds in both the medium dark-gray and light medium-gray limestone. Most of the chert occurs in eleongate lenses and as nodules. However, west of the Mountain Lion mine, chert beds extend laterally for several hundred feet and in places are repeated every one to two feet in the section. The abundance and nature of chert is one of the main criteria for correlating these rocks with the Mendha Formation (Westgate and Knopf, 1932, p. 13-14; Merriam, 1964, p. 51-52).

Tertiary (?) System

Intrusive Rocks

General Statement

Lamprophyre dikes comprise the only intrusive igneous rocks exposed in the mapped area. However, a stock of quartz monzonite crops out 1.8 miles north of the mapped area. This stock is described by Westgate and Knopf (1932, p. 32-35) and a detailed study of the petrography is given by Gillison (1929, p. 76-86). Although the effects of contact metamorphism by this intrusion are seen in the extreme northern end of the area, none of the intrusive mass is exposed.

Lamprophyre

Numerous lamprophyre dikes ranging from 0.5 to 5 feet in width cut the sedimentary rocks in the area. Many of the dikes extend upward through the Pioche Shale and terminate in the Lyndon Limestone or Peasley Member of the Highland Peak Formation. A few extend into the Burnt Canyon Member. The dikes are persistent laterally as well as vertically and one or two may be traced for a distance of more than 1/2 mile.

Fragments of undoubted Prospect Mountain Quartzite occur in several of the dikes as high in the Cambrian section as the Burrows Member. This and the fact that many of the dikes terminate upward indicates that the source is below and that many, or all the dikes passed upward through the Prospect Mountain Quartzite. In spite of this evidence, no dikes were observed cutting Propsect Mountain Quartzite (Fig. 2), probably because the dikes are more easily weathered than the enclosing rock and the quartzite is particularly resistant to weathering.

Most of the dikes strike N. 60° E. and are nearly vertical; a few strike N. 70° W. and are vertical. The northeast set, spatially associated with mineralization, are more extensive laterally and vertically than the northwest set.

The dike rocks are commonly blackish green, even-grained, and microgranular. Some varieties are porphyritic and have phenocrysts of black augite and occasional specks of biotite. The rock weathers to pale green.

Under the microscope the rocks are panidiomorphic microgranular and consist of phenocrysts of diopsidic augite and biotite set in a microgranular groundmass of plagioclase. The plagioclase is uncertainly identified by the microlite method as An_{55}, labradorite. Extremely small crystals of apatite are present in minor amounts in most specimens. The rocks are greatly altered; augite and biotite have been altered to chlorite, and carbonate comprises up to 20 percent of some specimens. Magnetite, pyrite, galena, and sphalerite comprise as much as 30 percent of a specimen. These minerals replace pyroxene, and in places are cut by two ages of carbonate veinlets.

Because biotite and augite are present in nearly equal quantities, and plagioclase is the chief feldspar, these rocks are identified as either kersantite or spessartite. Westgate and Knopf (1932, p. 36) state that "there is some evidence to suggest that these rocks are minettes, but it appears best to call them biotitic augite lamprophyres". The rocks cannot be minette because the chief feldspar is not orthoclase or sanidine.

Extrusive Rocks

Two small exposures of red andesite and dark-gray obsidian one-half mile south of the Mountain Lion mine constitute the only volcanic rocks exposed in the mapped area

(Fig. 2). These exposures are remants of a larger area of flows that are well exposed west of the map border. A 3,000-foot section of andesite and dacite exposed in the Ely Springs Range, west of the Highland Range is described by Westgate and Knopf (1932, p. 30-31).

REGIONAL STRUCTURAL SETTING and HISTORY

The structural history of the earlier Precambrian crystalline complex in the easter Great Basin has not yet been adequately described. Exposures of these rocks are widely separated but seem to indicate that the region underwent metamorphism during earlier Precambrian time. Misch and Hazzard (1962), however, believe that in the northern Snake Range the rocks comprising the basement complex were formed during post-Paleozoic igneous and metamorphic activity.

During late Precambrian and Paleozoic time thick sequences of miogeosynclinal sediments were being deposited in the region with only minor periods of erosion or non-deposition. The late Paleozoic Antler orogeny (Roberts, 1949; Roberts and others, 1958) did not extend into this region (Misch, 1960, p. 33; Osmond, 1960, p. 36), but probably contributed clastic sediments during the Carboniferous and Permian (Misch, 1960, p. 33; Tschanz and Pampeyan, 1961).

Mesozoic sediments are present in only a very few scattered localities in the eastern Great Basin. With the exception of early Triassic marine beds, these are non-marine which indicates that the region was emergent during most of Mesozoic time (Stokes, 1960, p. 121).

Misch (1960, p. 33) and his colleagues have accumulated considerable evidence documenting an intense mid-Mesozoic orogeny in the region, characterized by large-scale thrusting. His east border of the region of décollement thrusting (1960, Pl. 1), if extended southwest along its trend, would pass to the west of the Highland Range area. The northwestern border of the frontal belt of Laramide thrusting (Misch, 1960, Pl. 1), if extended southwest passes to the east of the Highland Range area. The rocks of the Highland Range and surrounding area were probably not directly involved in the mid-Mesozoic décollement thrusting or strong Laramide orogenic activity.

During Oligocene and Miocene time thick sequences of ignimbrites accumulated in subsiding basins, apparently unrelated to those of the Basin-Range topography (Cook, 1965, Fig. 31-35). The ignimbrite basins trend northeast and east. Tertiary volcanism in the region was accompanied by, or followed by, intrusive activity in places. Potassium-argon ages of intrusive rocks in this region range from Cretaceous to Tertiary (Schilling, 1965, Pl. 1). The stock at Blind Mountain (Highland Range) has intruded and metamorphosed Tertiary lavas (Westgate and Knopf, 1932, p. 26) and thus may have been emplaced during middle or late Tertiary time.

Basin-Range faulting, the blocking out of ranges, occurred during Cenozoic time in the region (Nolan, 1943) after deposition of thick sequences of ignimbrites (Mackin, 1960; Cook, 1965). In east-central and southeastern Nevada, a late Miocene to pre-mid Pliocene age can be shown for Basin-Range faulting (Tschanz, 1960a, p. B295; 1960b, p. 208). In parts of the region block-faulting proably continued until the Recent, but in the Highland Range-Pioche area all faulting occurred before deposition of the mid-Pliocene Panaca Formation (Westgate and Knopf, 1932, p. 42).

Mention should be made of postulated post-volcanic thrusting in the region (Westgate and Knopf, 1932, p. 42-43; Tschanz, 1960, p. 206; Tschanz and Pampeyan, 1961). The interpretation of such thrusting hinges only on the fact that pre-Tertiary rocks rest upon Tertiary volcanic rock which could equally well be explained by gravity sliding as shown by Cook (1965, p. 55-56). Mackin (1960, p. 119-122) shows convincing evidence of gravity sliding in the Iron Mountain area, Utah, to explain the involvement of Tertiary volcanic rocks in horizontal movement. In any case the Cenozoic structural history of the eastern Great Basin is nearly everywhere characterized by normal faulting, indicating tensional rather than compressive forces.

STRUCTURE OF MAP-AREA

General Statement

Faults dominate the area. Most are high-angle normal and an understanding of them may be economically important.

Folds are subordinant and generally related to faults. The economic significance of the structure follows in the section concerning ore deposits.

Folds

Beds of the Highland Range generally dip 10° to 12° E. (Fig. 2, 3). Large, well defined folds are absent. In the northern part of the area, east of the Mountain Lion mine (Fig. 2), the beds are arched in a north-trending asymmetric anticline. The west limb dips as much as 50° W. and the east limb dips 4° to 12° E. The anticlinal axis is poorly defined however, and the general nature of the fold is obscured by strike faults.

Minor folds and flexures are superimposed on rather uniformly dipping rocks. These folds are of low amplitude and not easily delineated. Most of the folds trend northerly, parallel to the average strike of beds in the area.

Small disharmonic folds occur in several places and are localized in thin-bedded limestone between medium-bedded limestone. The folds are related to bedding slippage and occur in the upper part of the Combined Metals Member of the Pioche Shale, the upper part of Member A of the Lyndon Limestone, and the upper part of the Peasley Member of the Highland Peak Formation.

Faults

Most of the faults in the area are high-angle normal

(Fig. 2). Next in order of abundance are low-angle bedding faults. Very few high-angle reverse faults are present in the area.

Displacement along high-angle normal faults is generally less than 15 or 20 feet, however several have displacements of 50 to 100 feet. The high-angle faults may be classified into three main sets; 1) northeast-trending, 2) northwest-trending, and 3) north-trending. A few east-trending faults are present but not common. Faults of the northeast- and northwest-trending sets are predominant in the southern half of the area, and those of the north-trending set are more abundant in the north part of the area.

Exceptions to the three main sets are the several high-angle faults showing an arcuate map pattern that are present in the central part of the map from Peasley Canyon north. The strike of each of these faults changes, going north, from northeast to north, to northwest. Most of these faults cut the Lyndon Limestone and in all of them the downthrown block is to the west. In all exposures of the fault surfaces the faults are high-angle and dip to the west indicating normal displacement. Stratigraphic separation of these faults ranges from less than 25 feet to about 200 feet.

Northeast-Trending Set

Most faults of the northeast-trending set have strikes ranging from N. 60° E. to N. 80° E., and normal stratigraphic separation ranging from 1 to about 30 feet. Many of the veins and nearly all the dikes have been emplaced along faults of the northeast set having less than 5 feet of displacement. Many of these faults are laterally continuous and some that have 5 to 10 feet of displacement may be traced about 1,200 feet.

Northwest-Trending Set

Most faults of the northwest-trending set are high-angle, normal and have strikes averaging N. 70° W. Many of them have displacement of 10 to 20 feet, but a few have as much as 50 or 80 feet of stratigraphic separation. Relatively few of the veins and dikes in the area are emplaced along faults of this set. Faults of this set are more abundant from One Wheel Canyon south and are uncommon in the north end of the area.

Among the larger members of this set are the Pan American fault and the Burrows fault, which both dip N.E. The Pan American fault has normal stratigraphic separation of about 50 feet and extends from the southeastern corner of the map to the Pan American mine portal (Fig. 2). It is offset by the north-trending Schodde fault. The Burrows fault is also normal and has about 50 to 80 feet of stratigraphic separation. It extends from east of Burrows Canyon to the Combined Metals Member outcrop south of Peasley Canyon and appears to cut the Schodde fault.

North-Trending Set

High-angle faults of the north-trending set dominate the structure in the northern part of the area, but are common throughout the area (Fig. 2). There are probably many more faults of this set than are mapped because they parallel the strike of the beds and cannot be seen in the relatively broad exposures of Pioche Shale. These faults are most conspicuous in such units as the Burrows Member because of breccia zones.

The strikes of faults in this set range 15° to 20° either side of north and displacements range from 5 to 100 feet. Nearly all these faults are high-angle and normal. However, one high-angle reverse fault with about 40 feet of displacement is present in the upper part of Burrows Canyon. The fault trace is northeastward..

Many of the north-striking faults have up to 30 or 40 feet of fault breccia. A number of the breccia zones have a 1- to 2-inch quartz vein in the middle which is barren of metals.

The largest fault of the north set is the Schodde fault which extends from the south border of the area northward where it merges with, or is truncated by, the Burrows fault. The east block is down on the Schodde fault and stratigraphic separation ranges from about 100 feet near the southern border of the area to about 80 feet on the ridge north of Burrows Canyon. Most exposures of the Schodde fault are accompanied by a breccia zone 20 to 30 feet wide.

Low-Angle Faults

Nearly all the low-angle faults are confined to rather narrow stratigraphic intervals and thus may be termed bedding faults. Bedding faults are common in the entire area and are most abundant in the shale beds of the Pioche Shale and Chisholm Shale, and in the thin-bedded parts of the Combined Metals Member of the Pioche Shale, Members B and C of the Lyndon Limestone, and the Peasley Member of the Highland Peak Formation.

The bedding faults are more common in the area from the Forlorn Hope mine southward. It is impossible to determine the slip of most of these faults. However, separation of a dike is about 100 feet near the Schodde mine, and about 90 feet in the Pan American mine. The separation in the Pan American mine is normal, the upper block having moved southeastward and downdip. The low-angle fault in the Chisholm Shale at the Schodde mine shows reverse separation of a dike. The upper block has moved northwest and updip along the fault surface. Two bedding faults are present in the Chisholm Shale about 1,000 feet south of the Schodde mine. The block between these faults shows an apparent movement of 100 feet northwest with respect to the underlying and overlying blocks. The fault surfaces are not exposed but their presence is conclusively determined by offset parts of a northeast-striking dike.

Bedding slippage has also occurred in the Chisholm Shale in the canyon north of Burrows Canyon. Two parallel southeast-striking veins are offset to the northeast in passing upward from the Lyndon Limestone to the Peasley

Member. A similar relationship occurs near the top of the Chisholm Shale in Peasley Canyon and a lamprophyre dike has been offset to the northwest in rocks overlying the fault. There are probably more bedding faults in the Chisholm Shale than were mapped, but lack of cross-cutting dikes or veins precludes their recognition.

Numerous low-angle faults of limited lateral extent are localized in the upper part of the Peasley Member of the Highland Peak Formation. Several of these are associated with alteration and mineralization as at the prospect north of the Forlorn Hope mine. North of the Forlorn Hope mine in the lower part of Member A of the Lyndon Limestone, a low-angle fault has formed a wide and relatively thick brecciated zone that has some altered and mineralized rock. Most of the low-angle faults in the Lyndon Limestone are in the upper, thin-bedded part of Member B or Member C.

Low-angle faults that cut the Combined Metals Member are present in the Pan American mine, and in the outcrop of this member east of the Comet mine. Low-angle faults are common in the Burrows Member of the Highland Peak Formation. They are of limited lateral extent and are not accompanied by breccia zones as are the high-angle faults cutting the Burrows.

West Border Fault

The largest fault in the area extends through the area along the western border (Fig. 2). Rocks of the Mendha (?) Formation on the west have been brought into juxtaposition with Prospect Mountain Quartzite and Pioche Shale on the east, indicating a stratigraphic separation of nearly 3,000 feet. The fault surface is not exposed in the area. The fault trace as outlined by rocks on either side of the fault is uniform in the area south of One Wheel Canyon, but irregular and sinuous north of the canyon. A dip of about 11° west is suggested by the fault trace across a ridge that is one mile north of One Wheel Canyon. However the fault trace in the south part of the area could be that of either a high-angle or low-angle fault.

In most places limestone and dolomite of the west block are intensely brecciated in the vicinity of the fault, and no features were seen to indicate direction of movement. The Prospect Mountain Quartzite and Pioche Shale of the east block show no deformation near the fault that could be attributed to the fault. Westgate and Knopf (1932, Pl. 1, p. 42-43) and Tschanz and Pampeyan (1961) have mapped this fault as the southern extension of a thrust in the Bristol Range. Exposures in the Bristol Range (Westgate and Knopf, 1932, p. 42) show Devonian rocks in fault contact with underlying Cambrian rocks. In the West Range, the same Devonian rocks comprise the upper block that overlies older Devonian rocks and in places, Tertiary volcanic rocks, indicating a post-volcanic age of the fault (Westgate and Knopf, 1932, p. 43). The relationship and the field relationship could be caused by either thrusting or gravity sliding. The author believes that gravity sliding is the more logical explanation because of lack of evidence of compressional forces in the Highland Range area during Tertiary and Cenozoic time. Mackin (1960, p. 119-122) convincingly shows gravity sliding as the mechanism for horizontal movement involving Tertiary volcanics in the Iron Mountain area, Utah.

Local Sequence of Structural Events

Detailed reliable evidence showing the relative ages of structures is common in the area. Lamprophyre dikes, and the faults along which they are emplaced, are probably the earliest structural features in the area and were followed by faults of the northwest set. Northwest-striking faults are cut and offset by most faults of the norteast and north sets, and by bedding faults. The B-fault (northwest set) is offset by a northeast-striking fault and by a bedding fault in the Pan American mine. (Fig. 8). The northwest-striking Pan American fault, exposed in the southeast part of the area (Fig. 2) is cut and offset by the Schodde fault (north set).

Bedding faulting occurred after faults of the northeast set. Northeast-trending dikes and faults are cut and offset by bedding faults in the Pan American mine and in the Chisholm Shale in Lyndon Gulch, Peasley Canyon, and other places. The northeast-striking A-fault in the Pan American mine (Fig. 8) which was formed after or during bedding faulting is an exception.

North-striking faults were formed after the northeast set and probably after bedding faulting. Some may have formed during Basin and Range deformation. The Schodde fault, for example, cuts all other faults and dikes and may have formed at relatively shallow depths because of its large brecciated zone.

The west border fault may be one of the youngest faults in the area because other structures cannot be traced across it.

The relative age of folding cannot be determined accurately but probably predates faulting in the area.

ORE DEPOSITS

History and Production

The Comet district was formed about 1895, 26 years after the nearby Pioche district, with production of small tonnages of high-grade, silver, lead, and gold ore from veins. From 1895 to 1913 about 106 tons of ore valued at $6,070 was produced (Couch and Carpenter, 1943, p. 84). From 1913 to 1919 no production is shown for the district by county records (Couch and Carpenter, 1943, p. 84) but Westgate and Knopf (1932,p.75) state that the Schodde mine produced about 1000 tons of silver-lead ore valued at $125,000 during World War 1.

During 1920 the district produced 69 tons of ore valued at $9,351 (Couch and Carpenter, 1943, p. 86). This ore was probably entirely from surface workings in the Stella vein or A-fault vein which cuts rocks in the Pan American mine. During 1921 and 1922 the Comet mine shipped an unknown amount of tungsten ore. From about 1924 to 1932 over 200 claims were staked in the area by Combined Metals

Reduction Company and geologic and engineering work was done. These claims comprised the Comet Coalition Mines group. In 1931, claims covering the Mountain Lion area were located and development work was later done. From 1925 to 1951 the Comet mine produced an estimated 15,700 tons of ore (Gemmill, 1968, Table 1). Most of this ore was produced from 1945 to 1951. During 1947 to 1964 about 10,000 feet of development work in shafts, inclines, and drifts was done on several parts of the Comet Coalition group. Most of this work was done by Combined Metals Reduction Company leasing from International Smelting and Refining Company which had acquired over 50 percent of the stock controlling the claims following the depression in the early thirties.

The first major production from the Comet district began in October, 1964 from the Pan American mine under the joint venture name Grand Panam Company, comprising the Grand Deposit Mining Company and the Combined Metals Reduction Company. The Pan American mine produced 186,000 tons of lead-zinc-silver ore from 1965 to 1966, and 311,363 tons from 1966 to 1967 (Eng. and Min. Journ., 1967, p. 89).

Ore Bodies

General Statement

Ore deposits of the Comet district are divided, for descriptive purposes, into two main classes: (1) vein deposits in the Prospect Mountain Quartzite, and (2) replacement and vein deposits in sedimentary rocks above the

Prospect Mountain Quartzite. Replacement deposits that are cut by veins in rocks above the quartzite are much more important by value of the ores produced than the vein deposits in the quartzite.

Deposits of the first class consist of fissure-filling along faults of small displacement in the Prospect Mountain Quartzite. No replacement deposits are known in the quartzite. Deposits of the second class consist of similar veins in shale, limestone, and dolomite above the Prospect Mountain Quartzite, with associated replacement deposits where the veins cut favorable limestone beds. The two classes of ore deposits are genetically related. Evidence in the district strongly suggests that the deposits were formed by ascending solutions which passed upward through the Prospect Mountain Quartzite and into the chemically reactive limestone beds above. Veins in rocks above the quartzite probably have downdip extensions in the quartzite. However, no veins in the area could be traced on the surface across the contact, probably because of poor exposures.

Vein Deposits in the Prospect Mountain Quartzite

Veins in the quartzite consist of fissure-filled faults of small displacement. Only seven veins are mapped in the quartzite in the area (Fig. 2). The veins are mostly quartz gangue with local concentrations of pyrite, chalcopyrite, galena, sphalerite, and hematite. Two of the veins, the Comet and the Murphy, contain wolframite. The Comet vein is the only one known to contain silver and gold, but data are lacking for the other veins. Ore at the Comet mine contains up to .26 oz. gold per ton, 10.5 oz. silver per ton, 5.0% lead, 14% zinc, and 0.5% WO_3. The veins are probably mesothermal by mineral content and mode of occurrence (Park and MacDiarmid, 1964, p. 289-311).

Most of the veins are nearly vertical and strike E. to N. 70° E. Few of the veins can be traced in outcrop more than a hundred feet, and only four have been explored to depths greater than 40 feet. Width of the veins in outcrop ranges from a fraction of an inch to less than one foot. Underground workings along the Comet vein, however, show a length of 2,000 feet and widths of 4 to 10 feet to a depth of 550 feet.

All the veins have sharp walls and many consist of numerous parallel veinlets that cut and replace quartz breccia. Locally, ore minerals fill voids in the brecciated rock and coat angular fragments in the vein. In a few places in the Comet mine, traces of pyrite and chalcopyrite occur outside the vein in shaly units of the Prospect Mountain Quartzite.

A careful search of outcrops did not disclose lamprophyre dikes in association with veins cutting the quartzite; dikes are commonly associated with veins that cut overlying rocks. None of the veins cutting the quartzite could be traced into the overlying rocks, and conversely, no veins cutting rocks above the quartzite could be traced into the Prospect Mountain Quartzite. It is likely that upper and lower parts of these veins have been offset by bedding faults in the D-Shale Member of the Pioche Shale.

Replacement and Vein Deposits in Rocks Above the Prospect Mountain Quartzite

The bedded replacement deposits contain larger tonnages of lead-zinc-silver ore and are therefore economically more important than the vein deposits in the Prospect Mountain Quartzite. Bedded replacement deposits above the quartzite are confined to limestone and dolomite beds and are spatially related to veins. The bedded replacement deposits are generally thickest where cut by veins and taper away from the veins. All bedded replacement deposits are cut by veins but the veins have not everywhere formed replacement deposits. Mineral content of the veins and replacement deposits is similar.

The veins are of two types; high-angle veins, and bedding veins. The steeply dipping veins are more abundant and generally occur along normal faults of three to five feet displacement. Most of the veins in the southern half of the Comet district strike about N. 65° E., and most in the northern part of the district strike N. Many of the veins have been more strongly mineralized in the lower-most limestone beds of the Pioche Shale and contain smaller amounts of economic minerals stratigraphically upward.

Some of the veins are emplaced along one or both sides of lamprophyre dikes. The dikes, where accompanied by veins, commonly contain trace amounts of galena.

The veins contain silver-bearing galena, pyrite, and some sphalerite and chalcopyrite in a gangue mostly of manganosiderite and manganocalcite with minor quartz. The veins are higher in grade than the replacement deposits and contain tens of ounces of silver per ton, a fraction of an ounce of gold per ton, and several percent lead and zinc. Most exposures are oxidized and show oxidized galena and maganese and iron oxides. The galena is commonly oxidized and coated by a residual of dark-gray limonite. Some of the veins, particularly in the northern part of the area, contain malachite and chrysocolla. The southernmost occurrence of a vein that contains oxidized copper minerals is on the ridge north of Lyndon Gulch.

Wall-rock alteration by the veins is common and the altered zone extends laterally a fraction of an inch to several hundred feet from the vein. Shale and limestone wall rock are generally silicified and in a few places limestone is dolomitized. Hairline veinlets and slightly mineralized fractures are most abundant near veins and decrease in abundance away from veins. Generally these are oxidized and consist of inconspicuous manganese oxide and goethite stains that commonly contain trace amounts of lead.

Ore bodies occur in breccia and gouge zones along bedding faults. Bedding faults are commonly localized at the contact of thin-bedded and massive units as at the Pan American mine. The bedding vein at the Pan American mine consists of 1 to 6 feet of strongly mineralized gouge. Mineralization extends through a greater thickness as replacement of the host rock. The minerals of the bedding veins are similar to those of the high-angle veins.

The lead-zinc-silver bedded replacement deposits are tabular and roughly parallel to the host rock beds. Most deposits of this type are in limestone; a few small deposits are localized in dolomite. The largest ore bodies of this group are in the Combined Metals Member of the Pioche Shale. The size and number of deposits decrease stratigraphically upward. Bedded replacement deposits are always associated with high-angle veins, but the converse is not true. The deposits are generally thickest where cut by veins and become thinner away from the veins. The long axes of ore bodies are parallel to the strike of associated high-angle veins.

The bedded replacement deposits are fine grained and contain silver-bearing galena, sphalerite, pyrite, small amounts of chalcopyrite, and trace amounts of gold in a gangue of fine-grained quartz and manganosiderite. No tungsten minerals have been found in the bedded deposits in contrast to the tungsten occurrence in veins cutting the Prospect Mountain Quartzite. The replacement ore has an average tenor of 1.75 oz. silver per ton, 1.25% lead, and 2.50% zinc. The mineral content and mode of occurrence of the replacement deposits indicates they are mesothermal (Park and MacDiarmid, 1964, p. 287-311).

Except for copper, no lateral zoning is evident for the metals in the bedded deposits. Copper appears to increase in abundance to the north but the evidence is not conclusive. Chalcopyrite is present in minor amounts at the Pan American mine and is more abundant in dump material from the Forlorn Hope mine.

Field evidence suggests that the vein and replacement deposits above the Prospect Mountain Quartzite were formed simultaneously. The veins are probably the plumbing system through which the mineralizing solutions passed, forming replacement deposits.

Ore-bearing limestone in the bedded deposits is highly silicified with finely crystalline quartz. The silicified envelope enclosing ore-bearing rock is generally not much larger than the deposit. Dolomitized, rather than silicified, envelopes enclose bedded deposits in places. The dolomitic zones are usually much larger than the ore-bearing rock they enclose.

Geologic Controls of Ore Deposits

Position of Ore Deposits in the Stratigraphic Column

From the size and distribution of ore bodies in the area it is evident that stratigraphy played an important role in localizing deposits. Limestone beds are the most favorable host rock. Although the ore deposits have a rather wide stratigraphic range, the largest deposits occur in the lowest limestone bed in the area, the Combined Metals Member of the Pioche Shale. Mine workings in the Combined Metals

Member include the Pan American mine, the Log Cabin incline, and the Forlorn Hope mine.

Thin limestone beds in the Pioche Shale above the Combined Metals Member have scattered prospect pits but no known economic replacement deposits. The Lyndon Limestone contains the Schodde mine and several other scattered mineral deposits. The Schodde orebody is not large but is of high grade. There are several small workings in thin limestone beds in the Chisholm Shale. Their favorabililty as a host rock was probably enhanced by impervious shales above and below. No significant mine workings are present in the Peasley Member of the Highland Peak Formation. The largest prospect workings in the Peasley are north of the Forlorn Hope mine (Fig. 2). The only workings that are in mineralized rock of the Burrows Member are in the extreme northern part of the area. These workings are along veins, and replacement of the Burrows Member dolomite is slight.

In summary, most of the deposits were precipitated in a limestone host rock and particularly the lower limestone beds in the area. This strongly suggests that mineralizing solutions ascended through the rocks and were precipitated when they reached a favorable host rock. However, localization of patches of mineralization in a given limestone bed does not appear to be related to differences in the primary sedimentary texture and structure of that bed. Structure probably exerted more control than stratigraphy in localizing ore deposits.

Position of Ore Deposits in the Tectonic Framework

The is no apparent relationship of the ore deposits to large-scale tectonic features in the area. Most of the larger faults and the east dip of rocks in the area are post-mineralization and were formed during Basin-Range deformation. Large-scale folds do not appear to be related to mineralization and may be post-mineralization in age.

The Schodde fault, which has a displacement of 100 feet is thought by some geologists to be a "feeder vein" for deposits in the area, but field evidence disproves the hypothesis. Mine workings north of Lyndon Gulch cut several tens of feet of barren gouge material along the strike of the Schodde fault. A small adit on the south side of Burrows Canyon shows unmineralized Schodde fault breccia. In addition, surface exposures of the fault on a ridge south of Lyndon Gulch are unmineralized and there are no mineralized zones along the trace of the Schodde fault that are not extensions of northeast- or northwest-trending high-angle veins.

All the larger ore bodies are associated with northeast-trending faults and veins and are in the area extending from the south border of the map to the Forlorn Hope mine.

The abundance of lamprophyre dikes seems related to the intensity and abundance of mineralization. Dikes are most abundant in the area from Burrows Canyon south. This area contains the Pan American mine, the largest ore body in the district. The abundance of dikes may indicate proximity to a buried intrusive in the south part of the district, but conclusive evidence is lacking. The possibility that this part of the area is underlain by an intrusive body is suggested by the following: 1) a quartz monzonite stock is exposed 1.8 miles north of the area, 2) wolframite and specularite, generally regarded as high-temperature origin (Edwards, 1965, p. 160) occur in the Comet mine, and 3) the lamprophyre dikes passed upward with enough speed and force to carry unaltered fragments of Prospect Mountain Quartzite 2,000 feet up-section.

Structures That Localized Ore Deposits

The localization of ore deposits by small-scale structural features is probably even more important than stratigraphic control. Vein or fracture systems that allowed passage of ore-bearing solutions are the dominant control, followed in order of importance by structural preparation of the host rock.

Many of the deposits and nearly all the mines in the district are associated with lamprophyre dikes. The dikes are associated with a thickening of ore in the host rock as described in a later section on the Pan American mine. The dikes acted as semipermeable barriers to the flow of mineralizing fluids along conduits. Bedding plane faults are commonly mineralized in the area and acted as conduits for mineralizing solutions. Where bedding faults cut dikes, more intense fracturing of the host rock occurred and increased the permeability, porosity, and area of reactive surfaces. There is a relationship between ore and disharmonic folds in the host rock that occur near dikes cut by bedding faults. The folded zones are characterized by intense fracturing.

Mines and Prospects

Mines and Prospects in the Prospect Mountain Quartzite

Comet Mine

The Comet mine (Figs. 2 and 7), owned by the Comet Mines Company, is the largest ore body in the Prospect Mountain Quartzite in the area. The workings are accessible by a 550-foot vertical shaft and the hoist and head frame are still in working condition. There are four mining levels with drifts totaling about 3,500 feet.

The mine apparently has shipped very little ore (Couch and Carpenter, 1943, p. 84), although Gemmill, (1968, Table 1) reports an estimated production of about 16,000 tons from 1925 to 1950. The remains of a magnetic concentrator for tungsten ore are west of the shaft. Although no assays were made by this author, the ore is reported by Westgate and Knopf (1932, p. 75) to average about .20 oz. gold per ton, 5.8 oz. silver per ton, 2.8% lead, and .32% WO_3. Gemmill (1968, Table 1) reports average values of .04 to .26 oz. gold per ton, 5.0 to 10.5 oz. silver per ton, 3.0-5.0% lead, 14.0% zinc, and .40 to .50% WO_3. The ore is not nearly as high in grade as similar mines in the Prospect Mountain

Quartzite in the Pioche district (Westgate and Knopf, 1932, p. 48; Anderson, 1922, p. 283; and Pack, 1906, p. 312-318).

The ore at the Comet is in a steeply dipping quartz vein that cuts the Prospect Mountain Quartzite (Fig. 7). The beds strike about north and dip 5° to 12° E. the vein contains galena, sphalerite, wolframite, pyrite, and chalcopyrite. Most of the sphalerite is of the variety marmatite, and in places specularite is common. Traces of bornite and chalcocite are present on the 465 level. The vein strikes N. 63° E. and ranges from 1 to 10 feet in thickness. Slickensides on the walls of the vein dip about 9° N.E. on the 465 level, suggesting some strike-slip movement. The vein pinches and swells, and in most places consists of numerous anastomosing stringers of ore minerals and quartz that cuts and cements quartzite breccia. The vein is sharpwalled and shows crustification banding.

The ore is highly oxidized in the western part of the 160 level, moderately oxidized in the western part of the 465 level, and unoxidized on the 550 level. Oxidized material shows large cellular boxwork and is light and porous. The oxidized ore locally contains abundant malachite. Wolframite is abundant in places on the 160 level, particularly near the shaft. It occurs in aggregates of large tabular crystals up to 3 or 4 inches long. The mined-out stopes above the 160 level reportedly contained moderate amounts of large wolframite crystals. No wolframite was seen on the 465 or 550 levels.

No evidence of wall-rock alteration was seen; however, trace amounts of chalcopyrite are present in shaly partings in the quartzite wall rock on the 160 level. Slickensides and undulating partings between the beds are present in places, indicating bedding faults. However, the vein does not appear offset by bedding faults. Two well-defined sets of slickensides on bedding faults on the 465 level strike N. 40° W. and N. 15° W. The bedding faults are unmineralized and are cut by the vein.

Murphy Prospect

The Murphy prospect lies about 1,000 feet north of the Comet mine (Fig. 2) and consists of a 120-foot shaft and a 60-foot shaft along a vein in the Prospect Mountain Quartzite. Neither of the shafts were accessible during the field study. The vein strikes N. 85° W. and dips steeply south. The vein is about 1/2 to 1 foot wide and consists of quartz with minor amounts of pyrite, oxidized copper minerals, and wolframite. This and the Comet mine vein are the only veins in the area known to contain wolframite.

Miscellaneous Prospects

A 100-foot deep prospect shaft west of Lyndon Gulch cuts a quartz vein that strikes N. 65°E. and dips 88° N.W. The vein is poorly exposed, however, rock on the dump contains minor quantities of chalcopyrite and hematite with abundant manganese oxide stain.

A small prospect pit west of Burrows Canyon (Fig. 2) cuts a quartz vein 1 foot wide that contains some pyrite, chalcopyrite, hematite, limonite, and abundant manganese oxide stain.

A small prospect pit 1,500 feet north of the Murphy prospect cuts a thin, unmineralized white quartz vein that strikes N. 48° W. and dips 84° N.E.

Another prospect shaft that is 60 feet deep is located north of Peasley Canyon. The shaft is inaccessible but cuts a quartz vein that strikes N. 62° W. and dips 85° N.E. Limonite-bearing quartz is present on the dump.

Mines and Prospects in Rocks above the Prospect Mountain Quartzite

Pan American Mine

General- The Pan American mine (Figs. 2 and 8) is in the southern part of the area and is the largest mine in the district. Claim location and exploration work began near the mine in the 1920's. Development work was done at the mine from about 1947 to 1964 by Combined Metals Reduction Company, which has a continuing lease from Comet Coalition Mines Company, controlled by International Smelting and Refining Company (Eng. and Min. Journ., 1967, p. 87). The development work consisted of a 7- by 7-foot incline down 2,300 feet from the portal. Four levels were drifted from the incline; 1,270 feet of drifting was done on the 800 level, 300 feet on the 1,200 level, 1,100 feet on the 1,500 level, and 370 feet on the 2,000 level. Numerous short raises were driven to check ore thickness and grade. This work was done as a sampling project and resulted in reserves of 800,000 tons of proven ore having values of 1.75 oz. silver per ton, 1.25% lead, and 2.50% zinc. Several million tons of possible ore were also developed.

In October 1964 the mine was reopened by the Grand Panam Company, a joint venture comprising the Grand Deposit Mining Company and Combined Metals Reduction Company. The Pan American mine produced 186,000 tons of ore from 1965 to 1966, and 311,363 tons from 1966 to 1967 (Engineering and Mining Journal, 1967, p. 89). Tenor of the ore is similar to original estimates at start-up time. In addition to silver, lead, and zinc, the ore contains small amounts of copper and gold. The ore contains 9% manganese and 19% iron. Very small quantities of antimony are present in the ore and trace amounts of arsenic.

The mining method used is room-and-pillar, and trackless equipment is used to produce about 1,000 tons per day at a mining cost of $1.84 per ton (Engineering and Mining Journal, 1967, p. 90). The drifts are about 12 by 12 feet and about 1,000 feet of headings are completed each month. In 1965 ore reserves were being developed at the rate of two tons for every ton mined.

The ore body is in the Combined Metals Member of the Pioche Shale which dips about 10° E. Ore occurs in 3 zones; 1) the lower part of the Combined Metals Member of the Pioche

Shale, 2) the upper part, and 3) in the gouge zone along a bedding fault that is present between the upper and lower parts of the Combined Metals Member. The Combined Metals Member consists of limestone and is about 80 to 90 feet thick at the mine. The lower part of the Member is a medium-bedded unit about 20 feet thick, The upper part is thin-bedded, carbonaceous, and about 65 feet thick. Thickness of ore ranges from 1 to 15 feet in the lower unit and from 1 to 40 feet in the upper unit. Ore in the gouge zone of the bedding fault ranges from less than 1 foot to 6 feet thick.

Structure- Rocks in the mine dip 8° to 16° E. and average about 10° E. (Fig. 8). Minor flexures are present but large folds are lacking. Small-scale disharmonic intraformational folds are abundant and are generally related to steeply dipping dikes and faults. These folds are restricted to the upper thin-bedded unit and generally cause a tectonic thickening of the rock unit (Fig. 9).

Dominant structures in the mine are high-angle normal faults and bedding faults. The high-angle faults, dikes, and veins are of 2 sets. One set strikes N. 60° to 70° E. and the other set strikes about N. 70° W. Displacements on the faults range from 1 to 15 feet.

Examples of the northeast set of faults are the A-fault, the Bilyeu shear zone, the C-fault, and the D-fault (Fig. 8). Most of the northeast faults dip southeast in the south part of the mine, and dip northwest in the north part of the mine. The A-fault is sinuous and strikes about N.

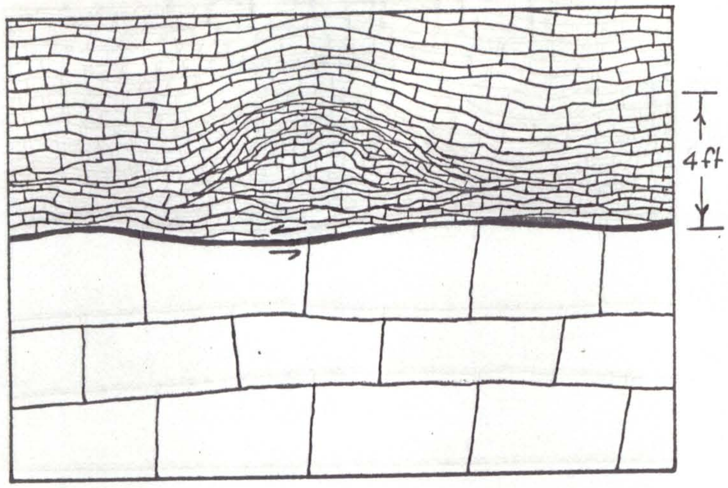

Figure 9. Diagram showing local structural thickening in the upper part of the Combined Metals Member. View southwest in the 51-south drift, Pan American mine

65°E. It dips 65° to 80° S.E. and the southeast block is down about 3 feet. The Bilyeu shear zone strikes N. 65°E. and dips 58° to 80° N.W.

Examples of the northwest set of faults are the B-fault and the E-fault (Fig. 8). The B-fault strikes N. 60° to 65°W. and dips about 70° N.E. The northeast block is down about 15 feet. The E-fault is parallel, dips 72° N.E., and is downthrown 3 feet on the northeast side.

Several lamprophyre dikes of two sets cut rocks in the mine (Fig. 8). The dikes are laterally persistent and range from 1/2 to 8 feet in width. The A-dike is nearly vertical, strikes N. 65° E., and is about 1 foot thick. The A-dike and A-fault have parallel strikes and are close at the portal and on the surface above the mine. However, the A-fault migrates south of the northwest-dipping A-dike in the lower workings of the mine because of its gentle southeast dip.

The Bilyeu dike in the north part of the mine strikes about N. 65°E. and dips 60° to 80° N.W. The Bilyeu dike is part of the Bilyeu shear zone and is about 6 feet thick.

The northwest-striking set of dikes do not show as strong a relationship to mineralization as the northeast set. Members of the northwest set are present in the northeastern part of the mine, and are particularly numerous in the 2,000-north level.

Manganosiderite veins generally are associated with the more extensive faults, and are parallel to them. The veins range from 1/2 inch to more than 1 foot in thickness and are emplaced along normal faults of small displacement. Veins of the northwest set are considerably more abundant than those of the northeast set. The northwest set of veins appears more abundant near the northwest-striking B-fault.

Bedding faults are abundant in the mine and commonly contain richly mineralized gouge material. The earliest description of mineralized bedding faults in the region was given by Pack in 1906 (p. 321) from occurrences near Pioche. The main bedding fault in the Pan American mine is localized at the contact of the lower and upper parts of the Combined Metals Member. Imbricate faults "peel" up from the main bedding fault into the upper thin-bedded unit. The bedding fault cuts and displaces all the dikes and all the northwest-striking faults. The apparent displacement of the A-dike and Bilyeu dike by the bedding fault is 90 feet. The apparent displacement of the B-fault by the bedding fault is 15 to 20 feet. The upper block moved about 90 feet S. 45°E. by comparing the A- and Bilyeu dikes and the B-fault in the upper block to their equivilents in the lower block (Fig.8).

Extensive crumpling and disharmonic folding of the thin-bedded unit has occurred on the northwest side of pre-fault structural barriers such as the Bilyeu dike, the A-dike, and numerous small faults (Fig. 10).

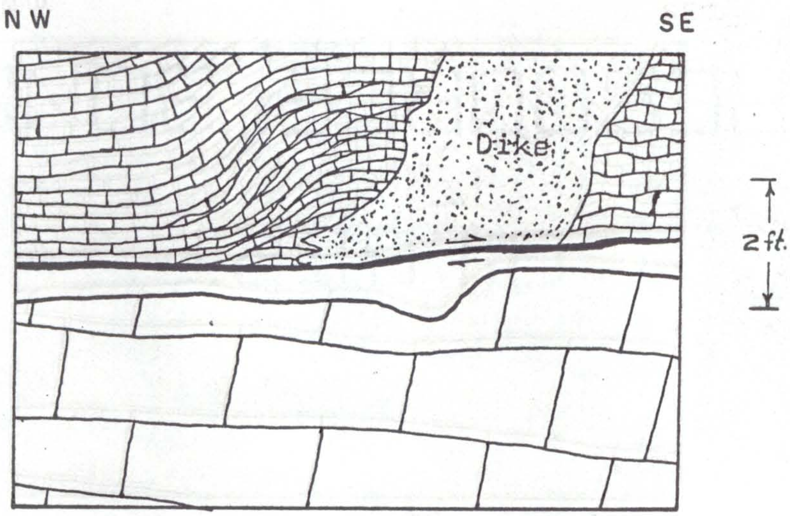

Figure 10. Diagram showing intense folding and fracturing of the upper thin-bedded unit caused by a dike that formed a structural barrier to bedding faulting. View northeast in the 55-north, and vent drifts in the Pan American mine

The gouge zone of the main bedding fault ranges from

1 to 8 feet thick. Displacement has generally occurred stepwise along several bedding faults. Thus, in a drift near 43-south and L-south, a section of a manganosiderite vein 1-foot thick lies on a bedding fault and extends upward 1 1/2 feet to a plane where it is cut by another bedding fault (Fig. 11). In the 1,500-south drift (Fig. 8) a 1.7-foot thick

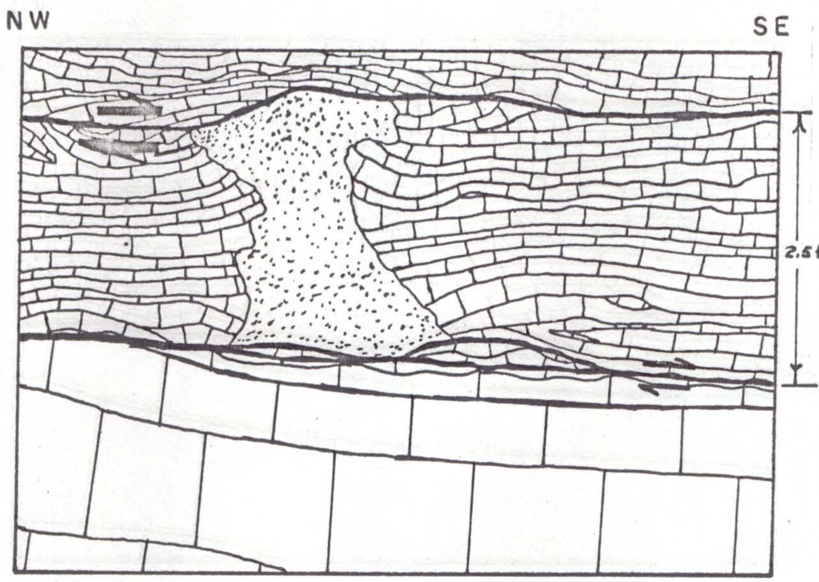

Figure 11. Drawing from photograph showing part of a manganosiderite vein cut above and below by bedding faults. View north 65 degrees east in the 43-south drift, Pan American mine

manganosiderite vein lies on a bedding fault and extends upward 1.3 feet where it is cut by another bedding fault and displaced 5 feet to the southeast. Above this point, another bedding fault cuts the vein and displaces it much farther.

Joints in the mine mostly strike either northeast or northwest. Most joints of these sets dip 70° to 80° N. Joints that strike east or north are present but less common. No relationship was found between the pattern or abundance of joints and mineralization.

Character of Ore- The ore consists of massive low-grade replacement by sulfides and carbonate minerals. The ore body is tabular and is parallel to the enclosing rock. Silica replacement of the limestone is extensive in ore-bearing rock and forms an envelope that is slightly larger than the ore body.

Ore thickness in the lower, medium-bedded part of the Combined Metals Member ranges from 1 to 15 feet. The ore extends downward from the bedding fault and is bounded on the bottom by an undulating ore-waste contact. The undulating contact forms "rolls" with apparent disregard to lithology. However, in some places, ore in the lower unit is bounded by minute, carbon-filled fractures. Thickest ore in the lower unit occurs where it is cut by the A-dike (Figs. 12 and 13). The surface on the bottom of ore in the lower part of the Combined Metals Member undulates gently in the area bounded by the B-fault, the A-fault, and a northeast line that is about 100 feet southeast of the Bilyeu shear zone. Northeast of the B-fault there are numerous sharp ore cut-offs in the lower part of the Member. These cut-offs delineate elongate ore "channels" or pods that are 30 to 70

ABSTRACT

The Comet mining district is on the west side of the Highland Range, about 9 miles west of Pioche, Nevada.

Sedimentary formations of Cambrian age are represented by more than 3,000 feet of carbonate and clastic beds ranging from the Prospect Mountain Quartzite to the Highland Peak Formation. Rocks of Cambrian-Ordovician age are represented by the Mendha (?) Formation. Lamprophyre dikes and andesite and obsidian flows are believed to be Tertiary (?).

During Paleozoic time thick sequences of miogeosynclinal sediment accumulated in the region. The Highland Range area was probably not involved in mid-Mesozoic thrusting, and the Laramide orogeny caused only gentle tilting of rocks in the region. During Oligocene and Miocene thick sequences of ignimbrites accumulated in the region. Basin-Range faulting, the blocking out of ranges, occurred during Cenozoic time.

Rocks of the Highland Range dip about 10 to 15 degrees east and large folds are rare. A north-striking, low-angle, normal fault in the western part of the area has about 3,000 feet of stratigraphic separation. High-angle normal faults are numerous and consist of an early northeast-striking set, a northwest-striking set of intermediate age, and a late north-striking set.

Mining in the Comet district began about 1895 and the district has produced about one-half million tons of lead-zinc-silver ore, mostly from the Pan American mine in 1965 and 1966. The ore deposits consist of veins in the Prospect

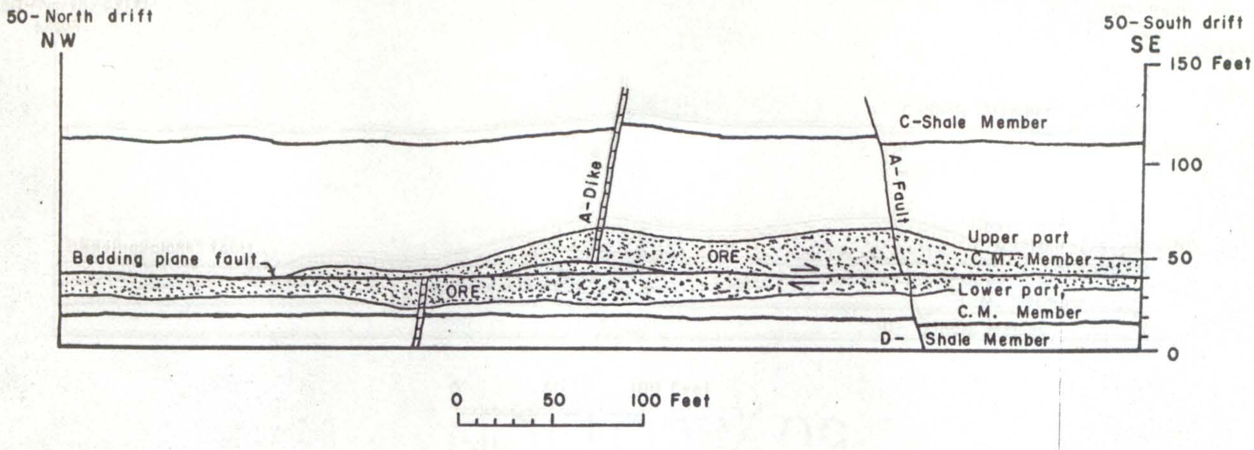

Figure 13. Idealized section from 50-north drift to 50-south drift in the Pan American mine, showing relation of ore thickness to dike and A-fault vein

feet wide and parallel to the B-fault and manganosiderite veins in the area.

Ore thickness in the upper part of the Combined Metals Member ranges from 1 to 40 feet thick. The ore extends up from the mineralized bedding fault and is bounded above by carbonaceous gouge zones along imbricate faults from the main bedding fault. Greatest thickness of ore in the upper part occurs along the A-dike and in the area bounded by the A-dike, B-fault, and A-fault (Figs. 13 and 14). Ore thickness in the upper thin-bedded part also increased where the upper unit is cut by the Bilyeu shear zone and dike, and along the B-fault. Lateral extent of thick ore zones is greatest near the intersection of two structures (Fig. 14).

A visual distinction between ore and waste in the Pan American mine can be made with some experience. The ore-grade material is somewhat "sparkly" and medium to dark gray. Waste is dull and dark gray.

The ore minerals present are silver-bearing galena, sphalerite, and minor amounts of pyrite which contain trace amounts of gold. Silver was not recognized in polished section and probably exists as ions in the galena crystal structure. Manganosiderite is common to abundant. It is identified by a siderite X-ray pattern and a high manganese content by assay. Minor amounts of chalcopyrite are present as small crystals in the ore. Minor amounts of black calcite are present near ore-waste contacts. The calcite contains manganese and anomalous amounts of silver (.26 to .40 oz. per ton). However, silver content of the manganoan calcite in samples checked is not as high as black calcite in other western mining districts described by Hewett and Radtke (1967, p. 1-21). Large, well-formed crystals of the ore minerals are uncommon; most of the ore is fine grained. The largest euhedral galena crystal found is about 6 mm in diameter. The largest euhedral sphalerite crystal noted is about 2mm in diameter, dodecahedral, and of the variety "ruby zinc".

Sooty carbonaceous and manganese oxide material is abundant in partings in the upper thin beds in and near ore. This material could not be identified by its X-ray pattern and probably consists of wad and amorphous carbon. The carbon content of the ore is not known by this author; however, a carbon flotation circuit at the mill was placed in operation on January 19, 1966 and resulted in higher grade lead concentrates (Eng. and Min. Journ., 1967, p. 91).

Alteration and replacement by quartz is pervasive in the ore body and extends for small distances beyond ore-bearing rock. Dikes of the northeast set, particularly the A-dike, are much altered by quartz. The A-dike in the 600-north level is light colored and has been almost completely replaced by fine-grained quartz.

No regular pattern of mineral zoning could be detected in the mine. However, chalcopyrite is more abundant on the 2,000 level than in other parts of the mine. Silica replacement extends for a small distance beyond the ore body. Also, black calcite is found near the ore-waste contact, commonly occurring in waste near the contact, rather than in ore.

Sequence of Mineralizing and Structural Events- The sequence of mineral deposition was tentatively established by study of several polished sections. Manganosiderite appears to have formed before galena; galena and quartz veins cut manganosiderite in places. Some sphalerite was deposited with galena because both sphalerite and galena replace manganosiderite along cleavage planes and at cleavage intersections. Some pyrite veins cut galena and therefore were formed later. One polished section shows crustification banding with manganosiderite (earliest) banded by the following: 1) galena-quartz-carbonate, 2) sphalerite-galena, 3) quartz-pyrite-sphalerite, and 4) sphalerite. It appears that manganosiderite, some quartz, and some white carbonate formed early, followed by galena, sphalerite, and pyrite.

Some quartz and carbonate may have formed along with the galena, sphalerite, and pyrite. The paragenetic sequence is shown in Fig. 15, and is based on the above textures (Bastin and others, 1931; Edwards, 1965).

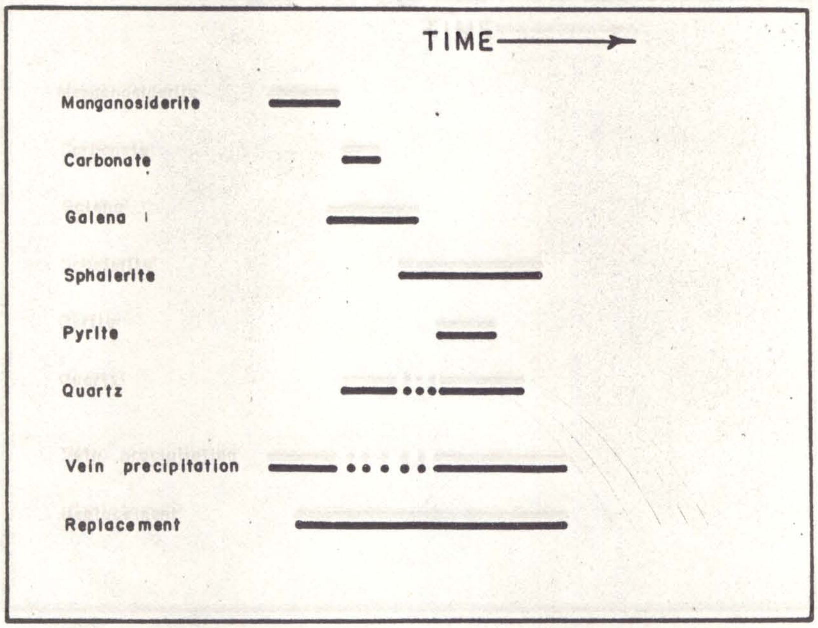

Figure 15. Paragenetic sequence of ore minerals in the Pan American mine

The sequence of structural events and mineralization at the Pan American mine is shown in Fig. 16. In general, this sequence of events holds true for the Comet district because of the similarity of structural features throughout the district and because these age relationships were verified at numerous localities in the area.

The intrusion of lamprophyre dikes is the earliest structural feature observed at the Pan American mine. There

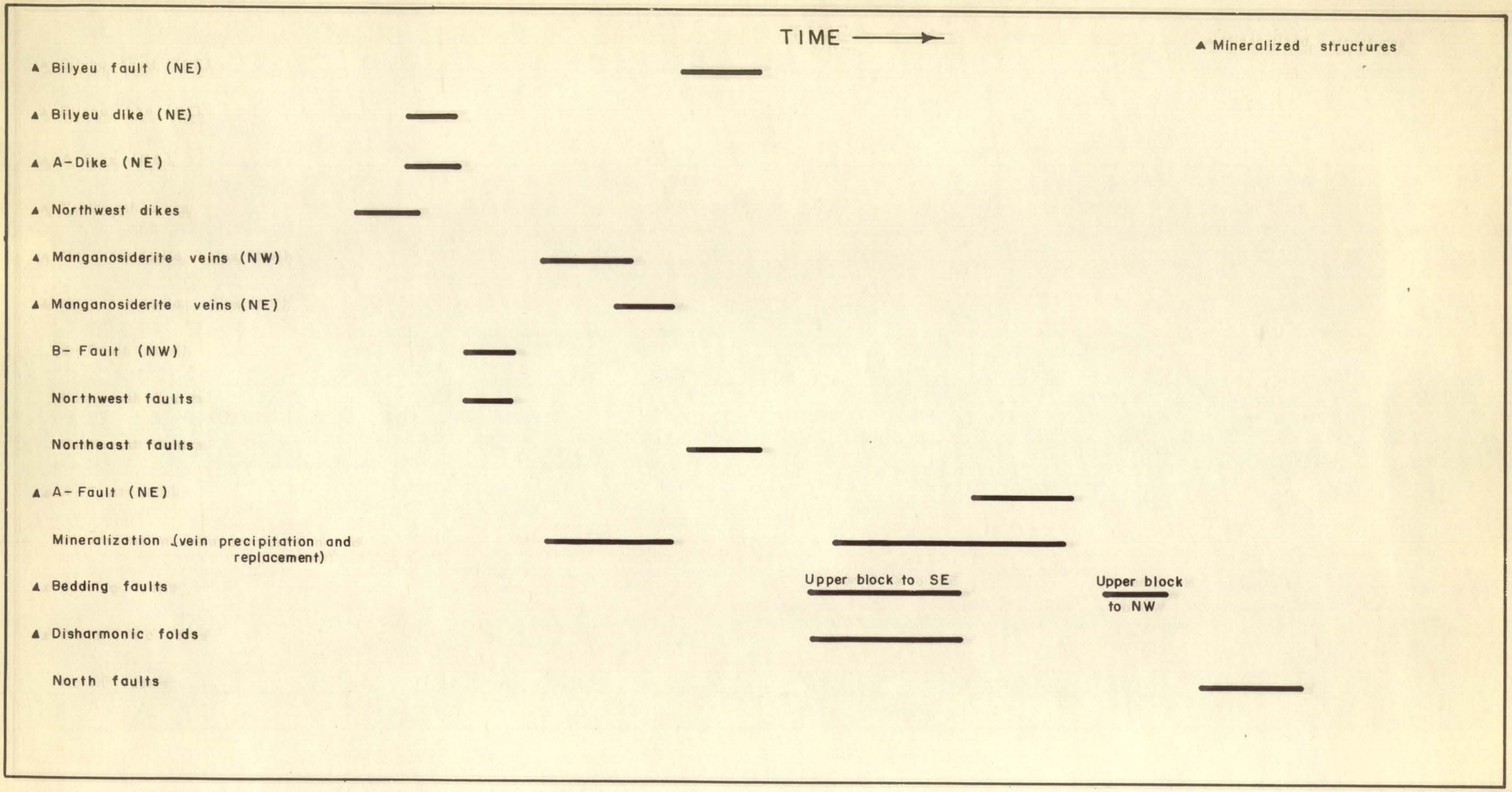

Figure 16. Sequence of structural and mineralizing events at the Pan American mine

is inconclusive evidence that dikes of the northwest set are older than dikes of the northeast set. The B-fault and others of the northwest set probably occurred, next. The B-fault cuts the A-dike in the 52-north drift (Fig. 8). Manganosiderite veins were emplaced and relatively weak, widespread mineralization occurred, after the B-fault. The manganosiderite veins cut dikes of both sets. This period of mineralization probably formed the ore "channels" in the lower part of the Combined Metals Member in the north part of the mine. The Bilyeu shear zone, consisting of parallel faults, was then formed. The Bilyeu fault cuts and offsets the B-fault to the left, and also appears to offset the ore "channels" in the lower part of the Member.

Bedding faulting occurred next and the upper thin-bedded part of the Combined Metals Member moved 90 feet S. 45°E. Pre-existing structural barriers such as dikes and faults caused extensive disharmonic folding in the upper thin-bedded unit during bedding movement. Strong mineralization occurred soon after, or possibly during, the bedding faulting. The bedding fault cuts and displaces all dikes, manganosiderite veins, and faults of the northeast set, except for the A-fault. There are numerous exposures in the mine of the bedding fault cutting dikes (Fig. 17), and of the fault cutting manganosiderite veins (Fig. 11). An exposure of the bedding fault cutting the B-fault can be seen in the Z-drift (Fig. 18).

Following bedding slippage, the A-fault was formed as

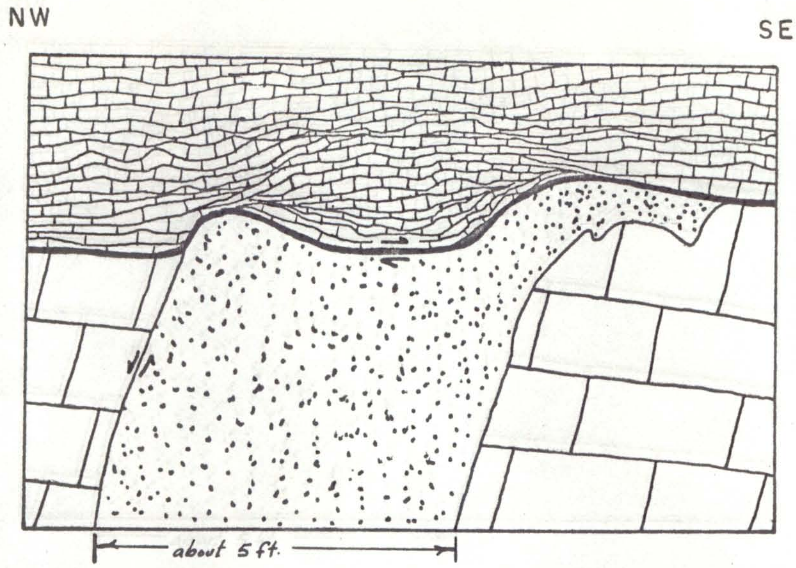

Figure 17. Sketch from photograph showing bedding fault cutting dike. Upper part of the dike moved right about 80 feet. View N. 65°E. in 53-north drift in Pan American mine

strong mineralization continued. The A-fault cuts and offsets the B-fault to the left. This feature is exposed in the 54-south drift. The A-fault appears to be slightly offset by renewed movement along the bedding fault to the northeast. Thus, in the I-south drift, the A-fault in the upper thin-bedded unit is 2 to 16 feet northwest of the A-fault in the lower medium-bedded unit. It is not known whether this apparent displacement is due to bedding faulting or refraction during formation of the A-fault.

The latest fault to form is the Schodde fault that strikes north. This structure is not exposed in the mine; however, the Schodde fault cuts and offsets two northeast-striking lamprophyre dikes and parallel veins north of Lyndon Gulch, and clearly was formed after mineralization in the area.

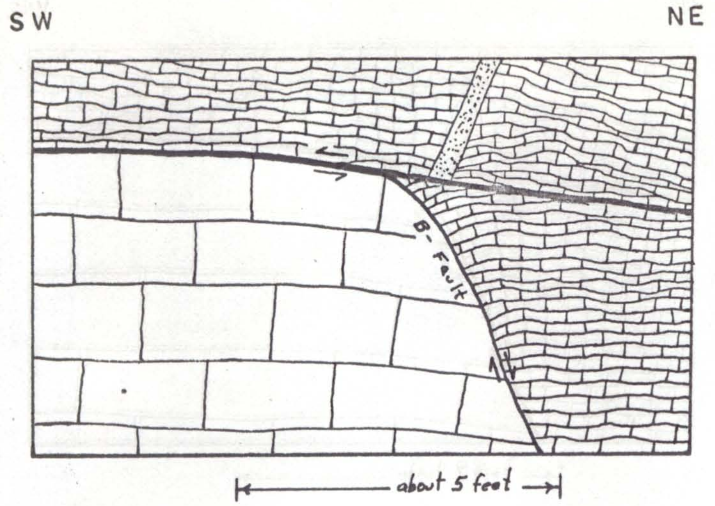

Figure 18. Diagram showing B-fault and dike cut by bedding fault. Dike oblique to plane of diagram. View about northwest in Z-drift, Pan American mine

Geologic Controls of Ore Deposition- Ore deposition in the Pan American ore body was controlled mainly by structural features. Lithology, and chemical reactivity of the host rock played an important, but secondary role in localizing ore.

The lamprophyre dikes predate mineralizing activity and acted as impounding structures during mineralization. The increase in ore thickness near dikes (Fig. 13) strongly suggests that they acted as relatively impermeable barriers. The northeast- and the northwest-striking dikes are followed by later manganosiderite veins that localized ore near vein concentrations. The predominant control of ore in the Pan American mine is the structural preparation of the host rock. Bedding faulting caused disharmonic folding and intense fracturing of the upper thin-bedded unit of the Combined Metals Member near structural barriers to rocks being displaced.

The structures are important in developing the necessary fractures to increase porosity, permeability and the area of reactive surfaces. Thus, for example, as the upper block was being displaced southeast the A-dike acted as a barrier to the movement of rocks in the upper block and deformation of the thin-bedded unit resulted. Thickness of the ore increases near all the dikes (Fig. 14). In addition, the dikes probably acted as ore impounding structures, a mechanism described by Mackay (1946). A number of high-angle faults also have acted as structural barriers to bedding faulting. Ore thickness increases in the vicinity of the B-fault which is displaced by the bedding fault (although the B-fault is not mineralized).

The northeast-striking A-fault exerted considerable influence on ore deposition and is related to an increase in ore thickness. However, this fault is unique among northeast-striking faults because it is not displaced significantly by the bedding fault. It therefore did not contribute to structural preparation of the thin-bedded host rock. It is likely that the A-fault was a conduit through which a major part of the ore-bearing solutions passed.

The lithology of the host rock exerted some control on ore deposition. It is significant that the Combined Metals Member consists of a lower medium-bedded unit and an upper thin-bedded unit that have contrasting mechanical properties. The upper thin-bedded unit responded to deformation by folding and fracturing, whereas the lower medium-bedded unit resisted intense deformation. The Combined Metals Member is a limestone which is a favorable host for base-metal deposits. There is much evidence in the district that ore was emplaced by ascending solutions, and the first favorable host rock encountered is the Combined Metals Member.

However, it is emphasized that the control exerted by composition of the host rock is of secondary importance to structural control. This contrasts with Park and MacDiarmid's (1964, p. 104-107) emphasis on chemical control for similar deposits in the nearby Pioche district.

Schodde Mine

The Schodde mine is on the north side of Lyndon Gulch (Fig. 2) and has reportedly produced over 1,000 tons of silver-lead ore with a value of $125,000 during World War I (Westgate and Knopf, 1932, p. 75). The mine is in the upper part of the Lyndon Limestone and has two accessible levels with about 600 feet of workings (Fig. 19). The upper level is accessible by several portals and has about 380 feet of workings. A 47-foot winze connects to the lower level which has about 220 feet of workings. There may be levels below this that are covered by stulls and lagging in the winze at the 47-foot level. Also an old company report states there are 1,200 feet of workings in the Schodde mine. The upper level was mapped by this author. The 47-foot level was mapped by H.E. Davenport and J.J. Crawford and inspected by the author.

The upper-level workings (Fig. 19) are along a mineralized bedding fault in Member C of the Lyndon Limestone. The gouge zone of the bedding fault ranges from 1 to more than 3 feet in thickness. Most of the mineralized gouge material has been mined out. A vertical lamprophyre dike that is 6 feet wide and strikes northeast is present in the upper workings. The dike is cut by the bedding fault in the back and the apparent displacement of the upper block is 180 feet northwest by surface exposures. The dike is also cut by several northwest-striking faults. The dike in the north part of the upper workings is correlated with the dike exposed in the east part, probably offset by a north- or northwest-striking fault.

The steeply-dipping vein that strikes northeast (Fig. 19) is 6 inches thick and consists of iron and manganese-rich oxidized material that contains some lead. This vein is displaced left by a northwest-striking fault. Several of the northwest-striking faults also displace the bedding fault.

Mineralized rock in the 47-foot level is less oxidized than in the upper level. The ore consists mostly of galena with trace amounts of sphalerite and oxidized copper minerals. Mananosiderite veins that strike northeast and northwest are more common in the upper level. The lamprophyre dike in the east part of the 47-foot level (Fig. 19) probably correlates across a bedding fault with the dike in the upper level.

Other workings in the Schodde area are the Mount Comet shaft on the saddle north of the Schodde mine, and an adit 500 feet southwest of the mine (Fig. 2). The Mount Comet shaft is about 50 feet deep and cuts a vein that strikes N. 70° W. and dips 84° N.E. The dump material contains abundant galena, manganoan-calcite, and manganese oxides. The adit southwest of the Schodde mine extends about 100 feet north and has an east-trending drift that cuts the Schodde fault. The workings are entirely in barren rock. The breccia zone of the Schodde fault is 10 to 20 feet wide and is barren of mimeralization. Samples of the brecciated rock were assayed to verify that the fault is barren (H.E. Davenport, personal communication).

Forlorn Hope Mine

The Forlorn Hope mine is on the north side of One Wheel Canyon (Fig. 2). The mine has not produced ore to the author's knowledge and has been a development prospect. The workings consist of a crosscut that has been driven 521 feet N. 20° E. in the Pioche Shale (Fig. 20). A vertical raise to the surface and a vertical winze to the Combined Metals Member is present 350 feet from the portal. The total length of the raise and winze is about 600 feet. An old company paper states that the Forlorn Hope mine has 2,500 feet of workings. The raise and the winze in the

Combined Metals Member are inaccessible; the water level in the winze is about 40 feet below the level of the crosscut.

Material on the dump consists of limestone replaced by galena, sphalerite, pyrite, and chalcopyrite. Chalcopyrite is more abundant here than in the Pan American mine. Ore bearing limestone is highly silicified with finely crystalline quartz. The crosscut traverses barren shale. A few calcite veins are present and iron-oxide staining is somewhat more abundant near the winze. Minor amounts of galena, chalcopyrite, and chalcocite are present in thin veinlets on the west rib near the winze. The crosscut and winze were developed to explore the Combined Metals Member where cut by a northeast-striking vein and dike. The dike was not observed in the workings.

Log Cabin Incline

The Log Cabin incline is located at the foot of Peasley Canyon and trends N. 82° E. (Fig. 2). The incline was driven as an exploration prospect by International Smelting and Refining Company for a length of 800 feet. The incline is caved 400 feet from the portal and the lower part is inaccessible. The workings are in the lower part of the Combined Metals Member which dips 8° E., and the sill is on the D-Shale Member (Fig. 21). Limestone of the Combined Metals Member is intensely silicified and contains abundant oxidized manganese and iron minerals. The manganese is contained in manganite, pyrolusite, and psilomelane. Goethite and lepidocrocite are abundant. No unoxidized ore minerals were found. Company assay results of rocks at the portal indicate concentrations of about 1.5 oz. silver per ton, .5% lead, 1.5% zinc. and 13 to 18% manganese.

Several small manganese oxide and calcite veins are present in the incline, but no lamprophyre dikes were mapped. An old company map shows a lamprophyre dike beyond the caved area. The caved area is at least 20 feet wide and occupies a fault zone that strikes N. 18° W. Displacement on the fault probably exceeds 40 feet judging from the width of the gouge zone. The fault is a strike fault and is not exposed on the surface where it cuts the C-Shale. However, the C-Shale section appears 30 or 40 feet thinner above the Log Cabin incline. Because of the fault, and the fact that the incline maintains an even grade to the end, the lower part of the incline cannot be in the Combined Metals Member. This fact is significant because it shows that the Combined Metals Member has not been explored beyond 400 feet from the outcrop. The workings are in highly oxidized material; unoxidized ore in the Combined Metals Member has not been reached for evaluation.

Mountain Lion Mine

The Mountain Lion mine is near the north border of the area and is in the Mendha (?) Formation (Fig. 2). Part or all of the claims covering this area were located by John Valente in May, 1931. The property is now controlled by Paul

Gemmill and brothers. It is reported that some work was done at the mine in 1936 (Roy Stewart, personal communication), however no production records are known.

The workings were inaccessible at the time of this study, but consist of two vertical shafts about 80 feet deep that are on a high-angle, northeast-striking vein. The vein is in the down-faulted west block of a Basin-Range fault having a stratigraphic separation in excess of 3,000 feet. The vein does not cross the fault into the Pioche Shale of the east block. The vein strikes N. 60° to 70° E., is vertical, and ranges from 2 to 8 feet in width. By inspection of the dump material, the vein consists of sugary, dark- to medium-gray dolomite breccia cemented by reddish-gray jasperoid. Trace amounts of galena are present in some samples. No rocks from the Pioche Shale are present on the dump although the Pioche Shale contact is 300 feet east. This indicates that the workings do not extend very far east.

Other workings on the Mountain Lion property are present north of the mine and 4,600 feet east of the mine. The workings north of the mine consist of two shallow prospect shafts in the Mendha (?) Formation. The prospects are on a vein that strikes N. 68° E. and dips 82° N.W. The mineralized zone is up to 6 feet wide and contains some lead and copper.

The workings 4,600 feet east of the Mountain Lion mine consist of the Valente shaft (Fig. 2) which is reported to be 300 feet deep. The shaft is on a vein that strikes N. 20°

E. and dips 58°E. The workings are inaccessible but are in the Burrows Member of the Highland Peak Formation. The dump contains silicified dolomite replaced by galena. Plumbojarosite is common in some of the specimens.

There are several other small prospects and unexplored veins in the vicinity of the Valente shaft. Most of the veins strike about north and are in the Burrows Member. A small adit 500 feet south of the Valente shaft (Fig. 2) exposes a gently-dipping vein and small replacement deposit. Limonite minerals are abundant in the replaced dolomite. A few specks of aurichalcite and minium are present in the vein. A small prospect pit 500 feet west of this point cuts a vein and small replacement mineral deposit. The vein strikes N. 10°E. and dips 65°E. The dump material contains locally abundant galena, some cerussite, plumbojarosite, malachite and minor amounts of melaconite and aurichalcite.

A small iron-replacement body is present on the ridge north of the Valente shaft. Apparently it is not associated with veins. The replaced zone is parallel to bedding, about 1 foot thick, and 100 feet long. It consists of massive goethite and hematite. Interbedded limestone has not been replaced as extensively as the dolomite.

Near the north border of the map (Fig.2) there is an area of jasperoid breccia "float" about 50 feet by 200 feet that occurs in the Chisholm Shale. The jasperoid appears barren. Although the jasperoid body is not exposed, it may represent a breccia pipe or perhaps fault breccia from the fault to the east.

Miscellaneous Prospects

The Iron Cap workings are located in the Combined Metals Member about 1,000 feet south of the map (Fig. 2). The workings consist of several prospect pits in highly altered limestone that contains abundant iron and manganese-oxides.

Several small workings lie on the A-fault in the Chisholm Shale near the Schodde fault (Fig. 2). Mineralized rock is more abundant where the A-fault vein cuts limestone beds in the Chisholm.

North of the Pan American mine several small prospect trenches occur along the C-dike and vein zone (Fig. 2). This vein is not as strongly mineralized as the A-vein. The vein and dike strike N. 63° E., the vein dips 83° N.W. and the dike is vertical. The vein is thin and contains abundant manganese and iron oxides, and some lead. The dikes and veins east of the Schodde fault may be the northeast continuations of the C-dike and vein zone that is offset to the right by the Schodde fault.

The workings east of the Schodde fault consist of several small prospect shafts and adits in the Lyndon Limestone and Chisholm Shale. The prospect shaft in Member B of the Lyndon Limestone cuts a vertical vein 4 inches thick that strikes N. 62° W. Galena, manganoan-calcite, and iron-manganese oxides are common in the vein material. Replacement of the limestone by mineralizing solutions extends 2 feet on each side of the vein.

Several prospect pits are on the D-dike and vein zone north of Lyndon Gulch (Fig. 2). The zone consists of two lamprophyre dikes and two parallel veins that strike N. 60° to 70° E. and cut the Pioche Shale and Lyndon Limestone. Only one dike is exposed in the Combined Metals Member, however, the limestone locally contains abundant iron and manganese oxide minerals. Both dikes and veins are exposed in the upper part of the Piochèd Shale and in the Lyndon Limestone. The two dikes are nearly vertical and are about 50 feet apart. The vein north of the dikes dips 76° N.W. and the vein south of the dikes dips steeply southeast. The north vein is thin but shows strongly mineralized rock, and some replacement of the limestone has occurred. Some lead is present, however no galena was found because the vein is greatly oxidized. The south vein is thin and contains abundant brown-gray and dark-gray, iron-manganese oxides and lead. Moderate quantities of brown, manganoan-calcite are also present.

East of the Comet mine there are several prospects in the Combined Metals Member, Pioche Shale, Lyndon Limestone, and Chisholm Shale.

The Combined Metals Member contains moderate quantities of iron and manganese for a strike distance of 300 feet and a thickness of 1 to 10 feet, 1,200 feet east of the Comet mine. The limestone is greatly altered to dark-gray to dark-brownish-gray, silicified rock. The rock locally contains .8 oz. silver per ton, .7 to 2% lead, 1.5 to 2.5% zinc, and 5 to 11% manganese by assay. Another strongly altered zone occurs 300 feet north of this outcrop. The mineralization extends for 60 feet along the strike of the beds and is confined to the lower part of the Combined Metals Member.

A 40-foot shaft and small adit cuts the Combined Metals Member 1,600 feet northeast of the Comet mine. The shaft exposes a lamprophyre dike that is 1 foot thick, strikes N. 78° W. and dips 87° N.E. Weak mineralization of the limestone is associated with the dike and consists of oxidized iron and manganese minerals.

Other prospects in the Comet area are located 3,600 feet N. 75° E. of the Comet mine, thence 600 feet north-northeast. The prospect east of the Comet consists of two adits , 90 and 20 feet long, at the top of the Lyndon Limestone. Ore is concentrated along a bedding-fault vein that ranges from 1 to 3 feet thick. Some of the rock contains abundant galena, with some cerussite. Several white calcite veins in the workings are cut by the bedding fault. Six hundred feet north of these workings are two parallel veins with moderate mineralization. Several small pits, adits, and shafts explore the veins. The vein to the south stikes N. 73° W., dips 87° N.E., and is about 5 feet thick. The vein cuts the upper part of Member B of the Lyndon Limestone and contains abundant limonite minerals, pyrolusite, and small galena crystals. This vein is cut and displaced left by two north-striking faults (Fig. 22). The other vein is 80 feet north-east, is vertical, and also cuts Member B of the Lyndon Limestone.

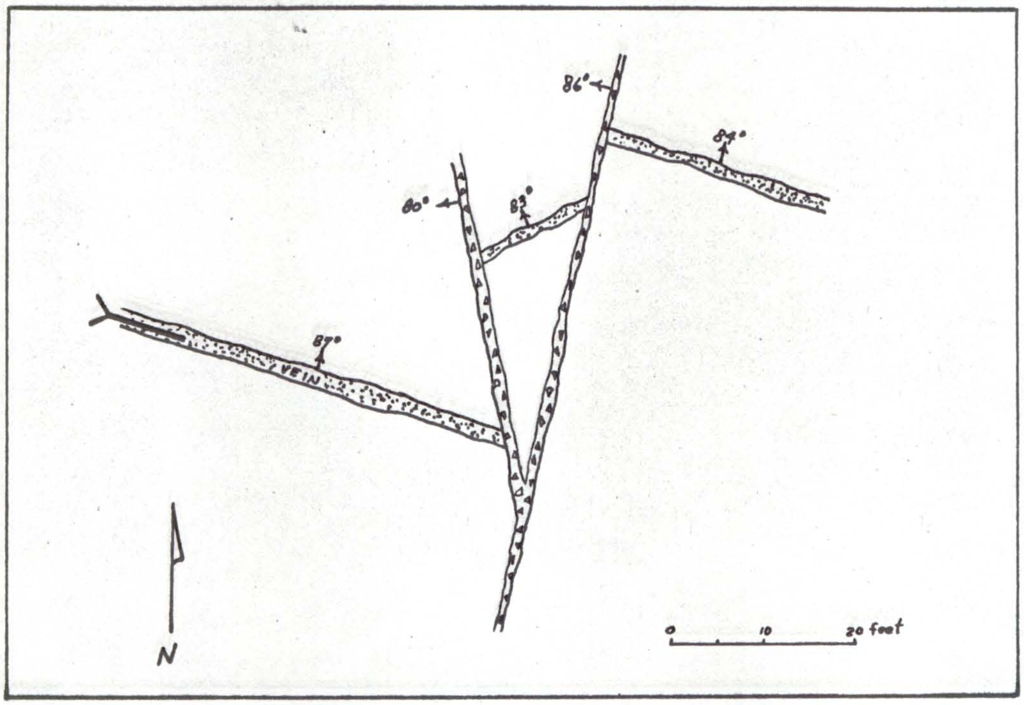

Figure 22. Detailed map of vein cut by two faults about 3,600 feet N. 75° E. of the Comet mine.

The vein consists of a zone 6 feet wide that has numerous parallel veinlets. Member C of the Lyndon Limestone is cut out by a bedding fault at this locality. Both of the veins extend up into the Peasley Member of the Highland Peak Formation but are not exposed in the intervening Chisholm Shale. By projection, they are offset along a bedding fault in the Chisholm Shale. The fault has an apparent displacement of 80 feet and the upper block has moved northeast. The north vein at the base of the Peasley Member contains moderate amounts of lead, and abundant iron-manganese oxide, and silica replacement. The south vein at the base of the Peasley is 1 foot wide and contains some lead.

Numerous prospects lie along the northwest and northeast-striking veins on the ridge north of the Comet mine (Fig 2). In attition, two adits are located in the mineralized Combined Metals Member on the lower part of this ridge. The mineralization consists of an oxidized, bedded replacement deposit that has a strike length of 300 feet and a thickness of 3 to 20 feet. A northeast-striking lamprophyre dike cuts the rocks at this outcrop. The mineralized rock consists of silicified limestone with abundant iron-manganese oxides. Old company surface assays of this outcrop show trace amounts of silver, .2% lead, 2.2% zinc, and about 9% manganese.

The Buckaroo workings are located in a limestone bed in the upper part of the Pioche Shale about 1,200 feet south of One Wheel Canyon. The adit bears N. 10° W. and reportedly extends 250 feet from the portal, although the workings are now caved 20 feet from the portal. Dump material shows quartz vein material at least 6 inches thick, containing galena, iron and manganese oxide minerals, and trace amounts of malachite. The vein is not exposed on the surface.

The Forlorn Hope dike and vein zone is one of the most continuous mineralized structures in the district (Fig. 2). The dike and vein have a discontinuously exposed strike length of 3,800 feet and cut rocks from the Pioche Shale to the

Burnt Canyon Member of the Highland Peak Formation. The dike and vein strike N. 60° to 70° E. and are steeply dipping. The vein is about 1 foot thick and locally is strongly mineralized. It contains galena, some sphalerite, and abundant iron-manganese oxides. A large bedded altered and mineralized zone occurs near the vein in Member A of the Lyndon Limestone. The altered and brecciated zone has a strike length of over 800 feet and is up to 100 feet thick (Fig. 2). The mineralized rock near the vein intersection contains moderate amounts of galena and is stained with iron-manganese oxides. Mineralization drops off sharply on the south side of the projected vein and tapers off within 20 feet on the north side of the projected vein. The remainder of the altered zone is spotted locally with limonite minerals and consists mostly of brecciated rock. The vein could not be traced into beds above the altered zone and it probably was displaced north by bedding faults in the upper thin-bedded part of Member A. The next exposure east of mineralization along the vein is in the Peasley Member of the Highland Peak Formation, about 400 feet north of mineralized exposures in the Lyndon Limestone. Although the vein is not exposed in the intervening units that consist of Member B and C of the Lyndon Limestone, and the Chisholm Shale, the vein probably was displaced north on bedding faults in these units. The mineralization in the Peasley Member is exposed by about 30 feet of workings. Mineralization forms a tabular bedded replacement body that has a strike length of about 250 feet and is 40 feet thick.

Mineralization is strongest near the center of the body and is markedly weaker 10 to 20 feet to either side. The remainder of the altered body consists of dolomitized limestone. Strongest alteration and mineralization is localized at the contact of the lower medium-bedded and the upper thin-bedded parts of the Peasley. The workings show locally abundant galena and some sphalerite. Trace amounts of dike rock are present on the dump but dikes were not seen in the workings. Numerous bedding faults cut the upper thin-bedded part of the Peasley Member. The dike and a weakly mineralized vein extend from the base of the Burrows Member into the Burnt Canyon Member of the Highland Peak Formation. A 30-foot prospect shaft is dug in the Burnt Canyon Member. The dike at this location is thin but the vein zone is about 3 feet wide. Dump material consists of strongly silicified limestone with abundant limonite minerals.

Another prospect pit lies about 4,500 feet north of One Wheel Canyon in the Mendha (?) Formation of the west fault block (Fig. 2). The prospect pit cuts a vein 1 foot thick that strikes N. 72° E. and dips 76° N.W. The vein contains abundant galena, some white calcite, and minor amounts of rhodochrosite.

Suggestions for Exploration

Large areas of favorable limestone of the Combined Metals Member in the Comet district are as yet unexplored. The possibility of large-tonnage, lead-zinc-silver ore bodies in stratigraphically higher rocks is very slight and serious exploration for million-plus ton ore deposits should be directed toward the Combined Metals Member. About half of the Comet area (Fig. 2) is underlain by this Member, yet it is exposed in only a thin discontinuous strip cutting the center of the area and only a very small part of the outcrop is mineralized. It is therefore necessary to apply techniques of finding ore at depth. Detailed knowledge of ore controls, and the sequence of mineralizing and structural events in the Pan American mine might be successfully applied to finding new ore bodies in the Comet district.

Many of the structures mapped underground in the Pan American mine are projected to the surface and similar structures occur at the surface throughout the area (Fig. 2). The A-dike, A-fault, Bilyeu dike and shear zone, and B-fault are mapped at the surface (Fig. 2). The A-fault is moderately mineralized at the surface where it cuts limestone beds in the Pioche Shale and becomes less mineralized stratigraphically higher. Above the Pioche Shale the A-fault appears insignificant. Knowledge that insignificant-looking northeast-striking veins high in the stratigraphic section may make ore in the Combined Metals Member is useful. The presence of dikes associated with the northeast-striking veins is important because the dikes have caused structural preparation of the Combined Metals Member where cut by bedding faults.

The largest tonnages of lead-zinc-silver ore in the Pan American mine are where the dike and A-fault vein separate because of different dips. The places where a vertical dike on the surface is associated with a vein which may migrate from the dike upon reaching the Combined Metals Member should be explored. The B-fault, although not a mineralized structure, has caused an increase in ore thickness in the Pan American mine. Similar northeast-striking structures occur in the area and increase the favorability of a target where associated with the northeast-striking dike and vein zones. The northwest-striking structures must, however, predate bedding faulting to be significant. In places, the careful observer may detect if northwest-striking faults are cut by bedding faults in beds above the Combined Metals Member.

North-striking unmineralized faults should be disregarded as ore-making structures in the Combined Metals Member, but their effect on mining operations should be considered. Silicification of ore-bearing rocks in the Pan American mine can be uncertainly traced to the surface. Shale in the A- and B-Shale Members of the Pioche Shale is silicified above the Pan American mine. This shale is resistant to weathering and stands out slightly in ledges. However, it is difficult to determine whether silicified shale outcrops have been formed by mineralization or by sedimentary processes.

A well-planned exploration drilling program in the area should begin by testing intercepts of the more strongly mineralized dike and vein zones with the Combined Metals Member. It is difficult to predict these intercepts in drill holes collared above the Lyndon Limestone because of the possibility of intervening bedding faults.

The following structures and areas show the best potential for low-grade, lead-zinc-silver ore bodies in the Combined Metals Member: 1) D-dike and vein zone, 2) C-dike and vein zone, 3) Comet mine area, 4) Log Cabin mine area, and 5) Forlorn Hope area (Fig. 2).

The D-dike and vein zone north of Lyndon Gulch (Fig. 2) is one of the most favorable structures in the map area. Surface exposures of the vein are among the most strongly mineralized in the area. The north vein dips north and the south dike dips to the south; thus, the area between these structures in the Combined Metals Member may be large. Mineralization in the Combined Metals Member in this area extends across the Schodde fault as indicated by the Bureau of Mines diamond-drill hole no. 2 (Fig. 2; Trengove, 1949, Fig. 7) which cut 12 feet of mineralization in the Combined Metals Member. The mineralized interval includes 5 feet of ore that assayed 3.0 oz. silver per ton, 0.2% lead, 2.8% zinc, and 12.8% manganese. The ore-bearing zone is thin because it is probably 150 to 200 feet south of a dike in the Combined Metals Member.

The C-dike and vein zone has good potential and probably cuts thick ore in the Combined Metals Member. This structure could be explored by relatively shallow drilling and perhaps could be reached by mining in ore-bearing rock from the Pan American mine workings 1,100 feet south. The

U.S. Bureau of Mines dimond-drill hole no. 3 (Fig. 2) cut 15 1/2 feet of ore-grade mineralization, consisting of 2.76 oz. silver per ton, 2.4% lead, 4.9% zinc, and 8.7% manganese in the Combined Metals Member (Trengove, 1949, Fig. 3, p. 5) near its intersection with the C-dike and vein zone.

Good potential in the Comet area is indicated by mineralized exposures of the Combined Metals Member east of the Comet mine. However, further mapping is required in this area to accurately define drill targets. The dike and vein zones common in other parts of the area are not adequately exposed in this area and must be mapped by other methods, perhaps by geochemical techniques. Another problem is that the Schodde fault is 1,200 feet east of the mineralized outcrop. The east block is down 80 feet and drilling depths become greater.

The Log Cabin mine area could be explored by relatively shallow drilling. The Combined Metals Member has been tested only 400 feet down the Log Cabin incline where it is cut by a fault. None of the workings past this point cut the Combined Metals Member and the limestone mineralization that has been tested is greatly oxidized. Some old drilling may have been done in the vicinity of the Log Cabin incline (H.E. Davenport, personal communication), however the location and results of the drilling are not known.

The Forlorn Hope dike and vein zone has excellent potential for ore in the Combined Metals Member. This vein has a greater stratigraphic range than any vein in the district. If mineralization in the Combined Metals Member is continuous along the structure, the ore body could be greater than 3,000 feet long. In addition, the Forlorn Hope dike and vein zone is cut by a mineralized north-striking vein at the top of the Burrows Member (Fig. 2).

It is again emphasized that successful drill tests are entirely dependent upon accurate projection of surface structures to the Combined Metals Member. If the target is missed by one or two hundred feet because of intervening bedding faults, the results could be either a thin ore zone or the waste that occurs between ore "channels".

Geochemical mapping of exposed veins and tracing unexposed veins would be a useful method in exploring the area. Thus, the potential of the dike and vein zones could be rated by the intensity of their metal concentration. This was done in a qualitative way during the present study by the potassium iodide lead-determination method described by Jerome (1950, p. 358-362). This author tested almost all mineralized or altered outcrops by this method and found that most occurrences of iron-manganese oxide staining gave a positive lead test.

In summary, the Comet district has very good potential for containing additional very large, low- to medium-grade lead-zinc-silver ore bodies. It is possible, but not likely, that the district contains undiscovered high-grade ore-bodies similar to the nearby Pioche district. The Pan American mine may represent an outlying low-grade area, high in manganese content, that is similar to the zoning in the Pioche district.

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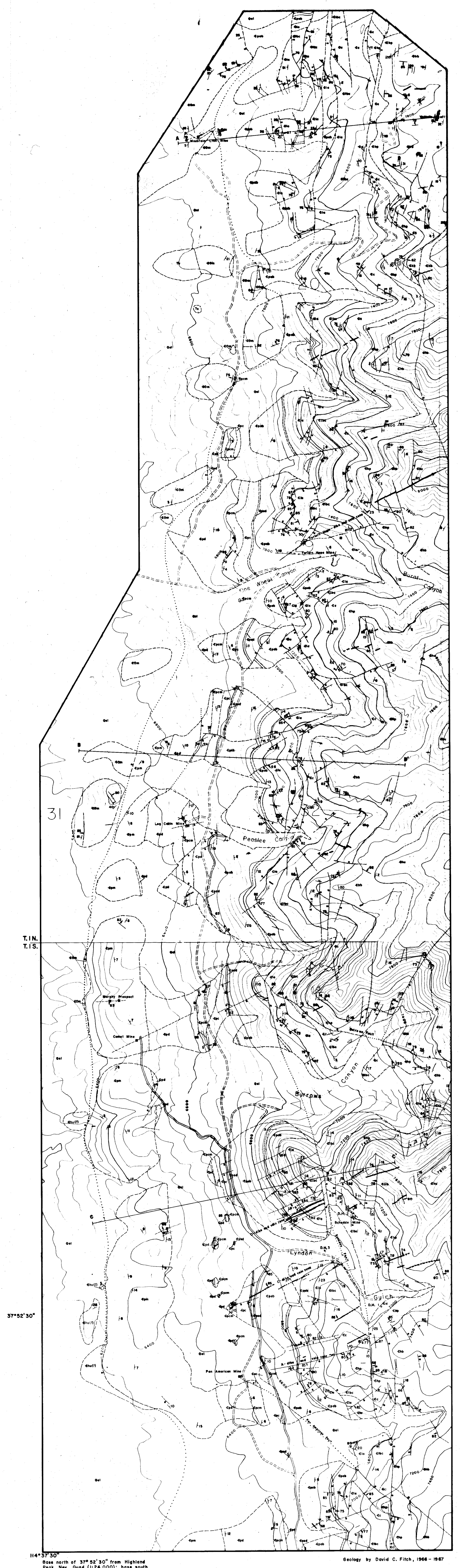
Figure 2



Base north of 37° 52' 30" from Highland Peak, Nev., Quad. (1:24,000); base south of 37° 52' 30" from Highland, Nev., Quad. (1:62,500)

Geology by David C. Fitch, 1966 - 1967

EXPLANATION

QUATERNARY

Qal — Alluvium

TERTIARY

Tv — Volcanics

Lamprophyre dikes

CAMBRIAN AND ORDOVICIAN (*Upper Cambrian and Lower Ordovician*)

€Om — Mendha(?) Formation

CAMBRIAN

Middle Cambrian

€hu(?) — Upper Part (?) of the Highland Peak Formation

Lower Part of the Highland Peak Formation:

€hu — Highland Peak Formation Undifferentiated
Consists of Burnt Canyon and Step Ridge Members

€hb — Burrows Member

€hp — Peasley Member

€c — Chisholm Shale

€lbc, €la — Lyndon Limestone
€lc, Member C
€lb, Member B
€la, Member A

Lower Cambrian

€pab, €psd, €pc, €pcm, €pd — Pioche Shale
€pab, A- and B-Shale Members, with 20-foot limestone bed
€psd, Susan Duster Limestone Member
€pc, C-Shale Member
€pcm, Combined Metals Member
€pd, D-Shale Member

€pm — Prospect Mountain Quartzite

Contact
Dashed where approximately located

76
Fault, showing dip
Dashed where approximately located, dotted where concealed, half dumbell on downthrown side

12
Strike and dip of beds

84
Vein, showing dip
Dashed where approximately located

Mineralized or altered outcrop

Vertical shaft

Inclined shaft

Adit

D.H. 5
U.S. Bureau of Mines diamond-drill hole

GEOLOGIC MAP OF THE COMET MINING DISTRICT, LINCOLN COUNTY, NEVADA

SCALE
1:12,000

1,000 0 5,000 Feet

16°30'
True North
Magnetic North

By DAVID C. FITCH, 1969

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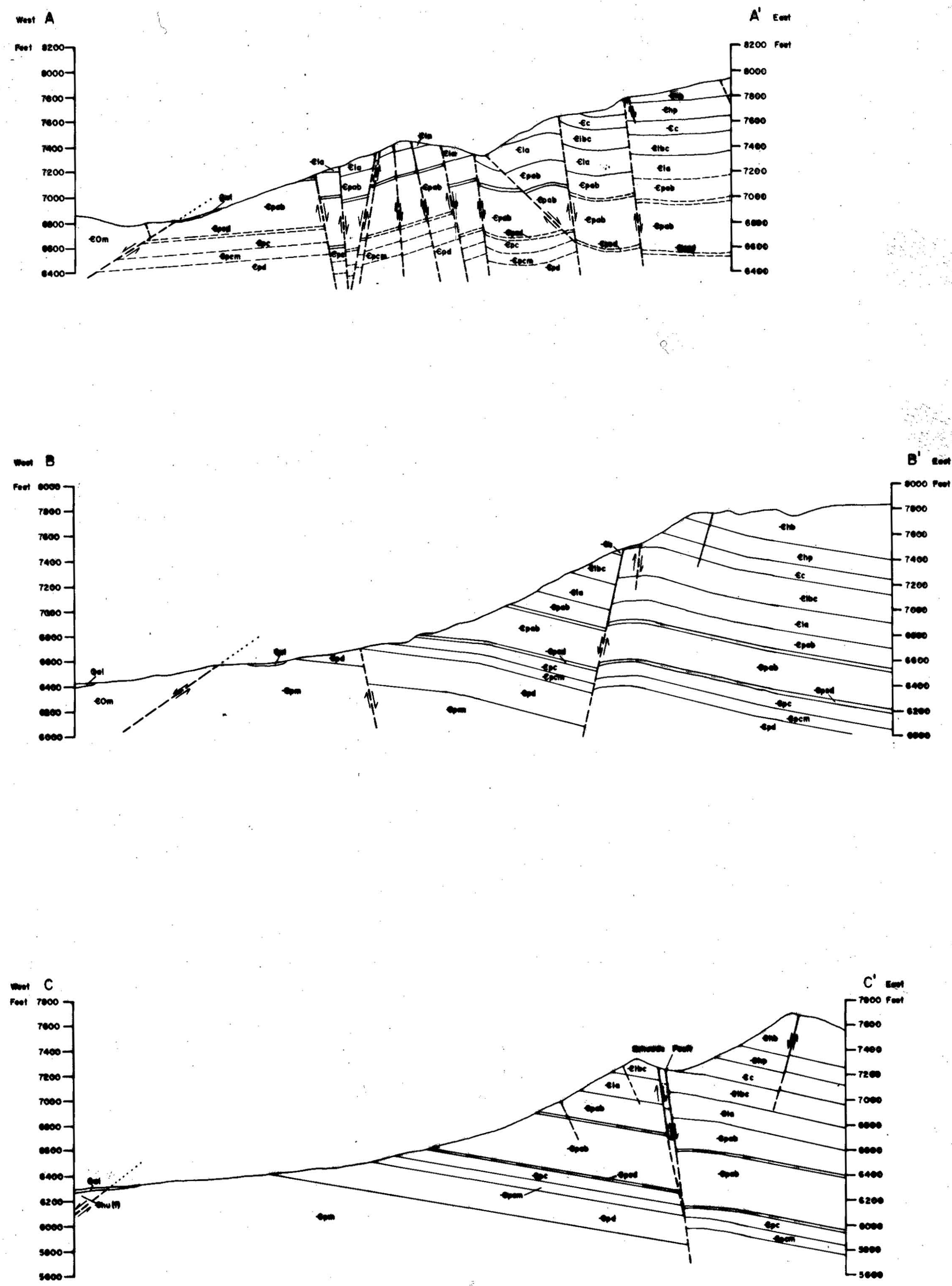
Figure 3



STRUCTURE SECTIONS OF THE COMET MINING DISTRICT, LINCOLN COUNTY, NEVADA

SCALE

Vertical and horizontal

1:12,000

1,000 0 5,000 Feet

By DAVID C. FITCH, 1969

Figure 4. Generalized columnar section of Cambrian and Ordovician rocks of the Comet District, Lincoln County, Nevada (scale 1 inch = 200 feet)

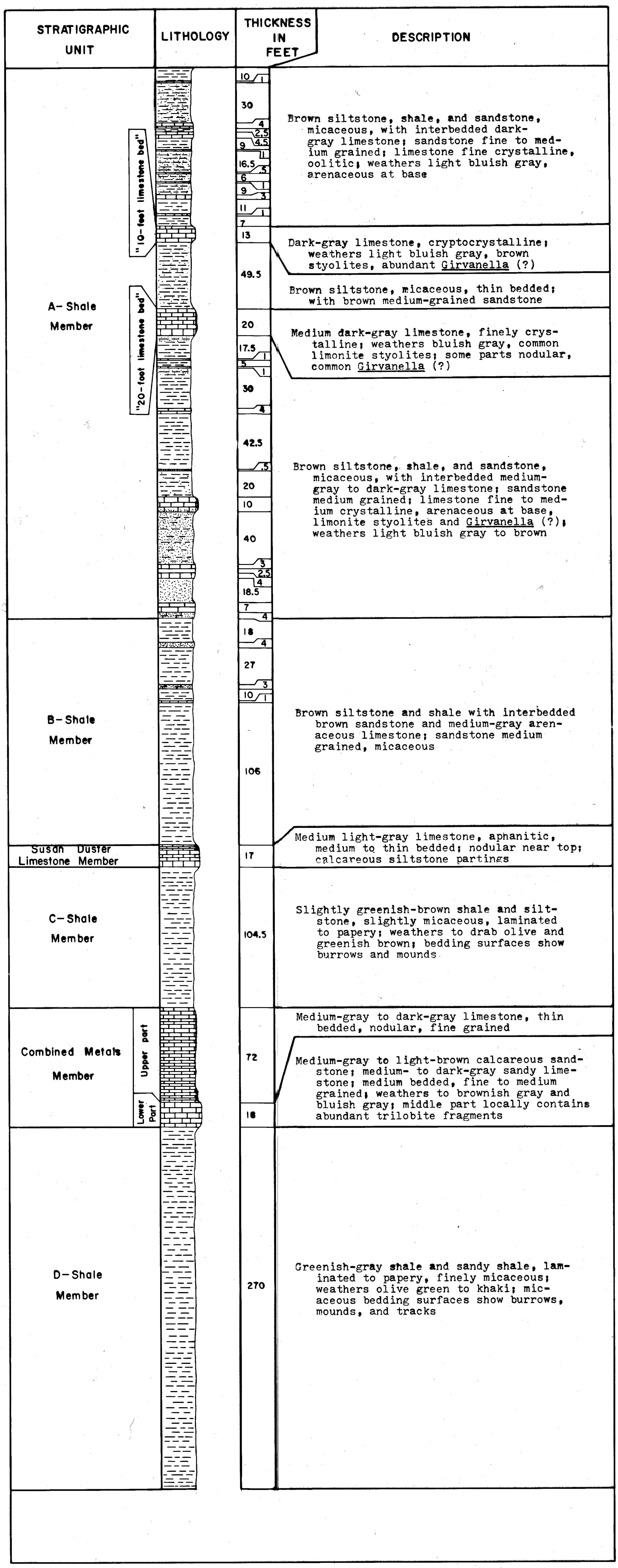


Figure 5. Detailed columnar section of the Pioche Shale in the Comet District, Lincoln County, Nevada (scale 1 inch = 50 feet)

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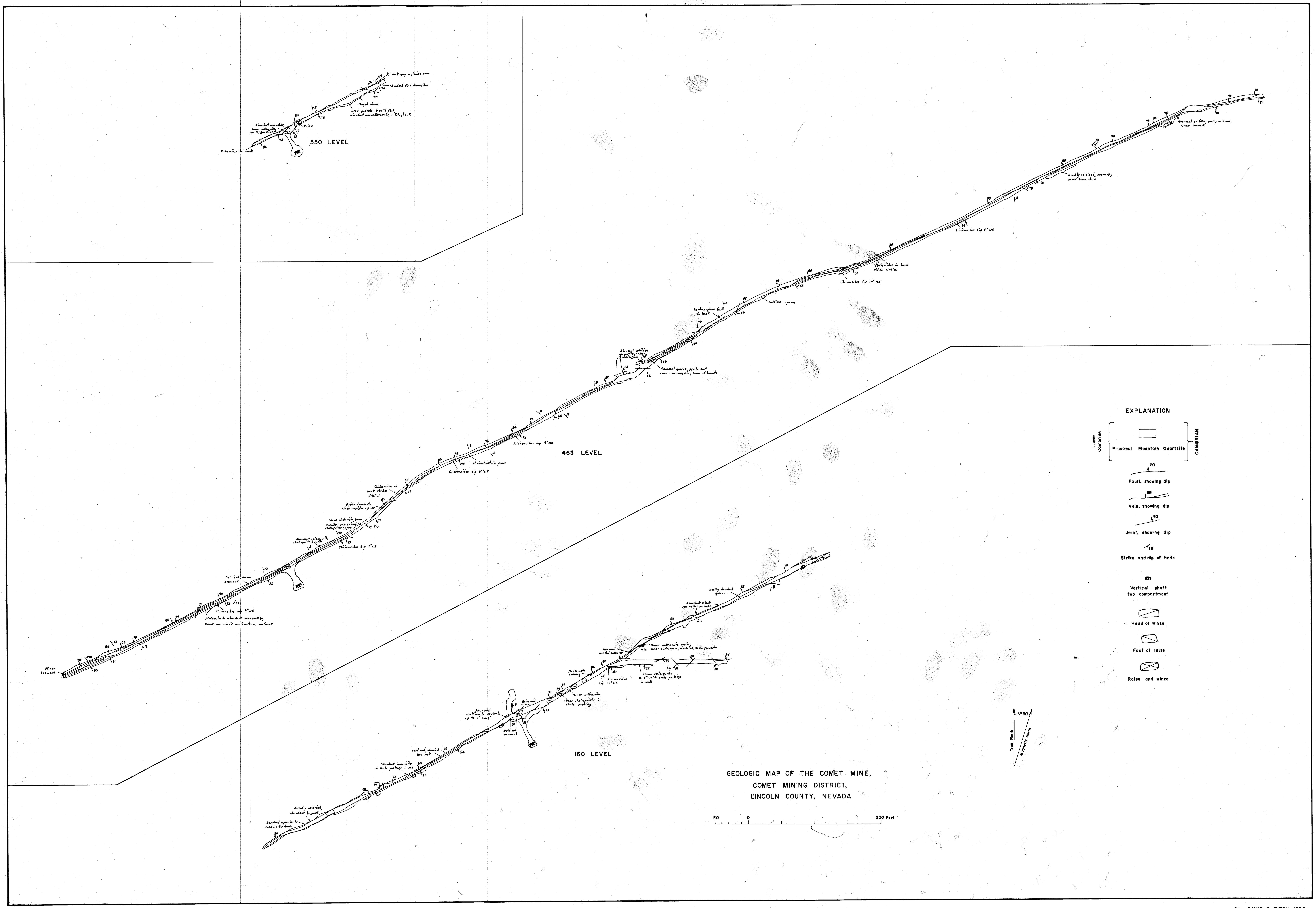
Figure 7



By DAVID C. FITCH, 1969

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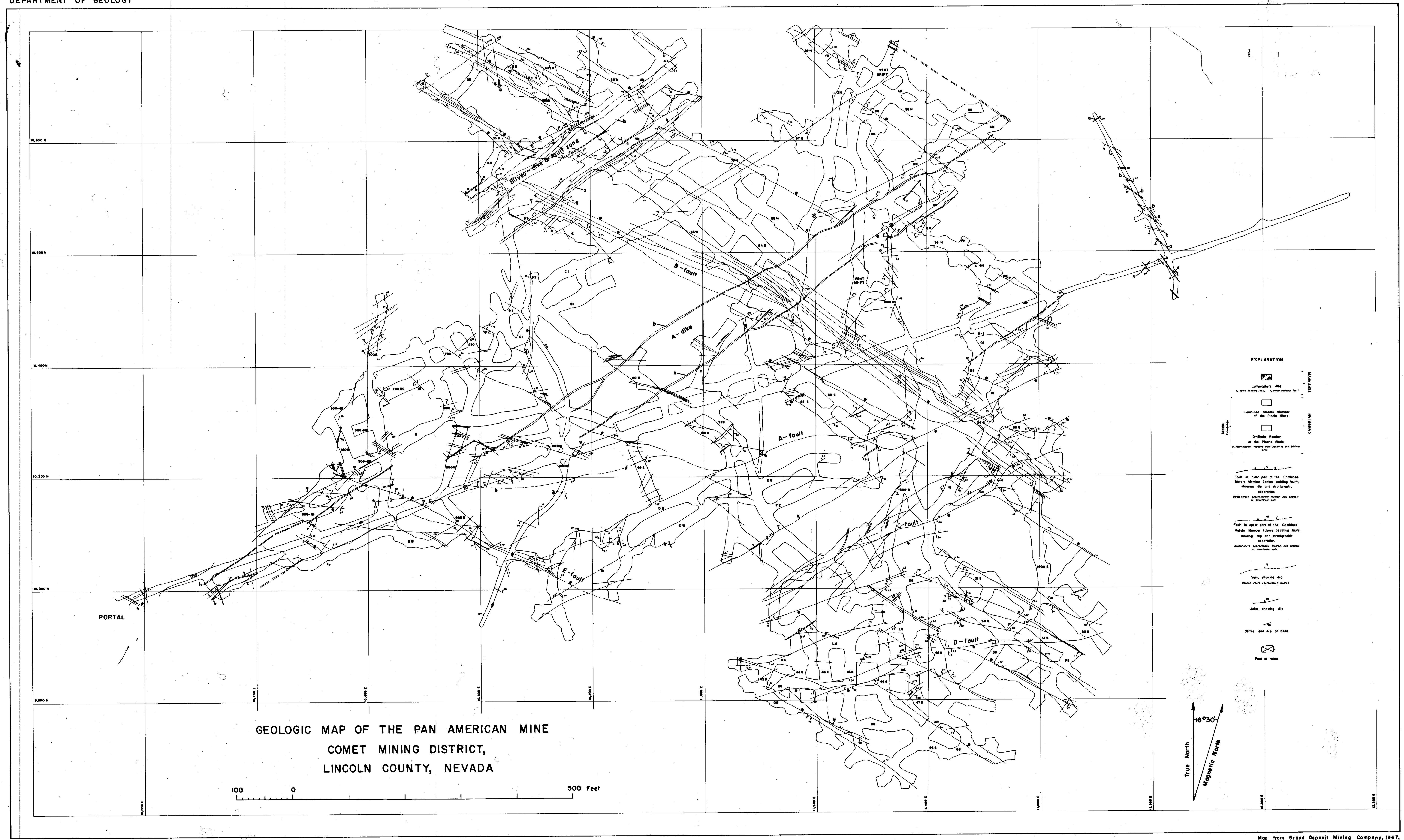
Figure 8



GEOLOGIC MAP OF THE PAN AMERICAN MINE
COMET MINING DISTRICT,
LINCOLN COUNTY, NEVADA

Map from Grand Deposit Mining Company, 1967, with minor modifications by David C. Fitch, 1967. Published with permission

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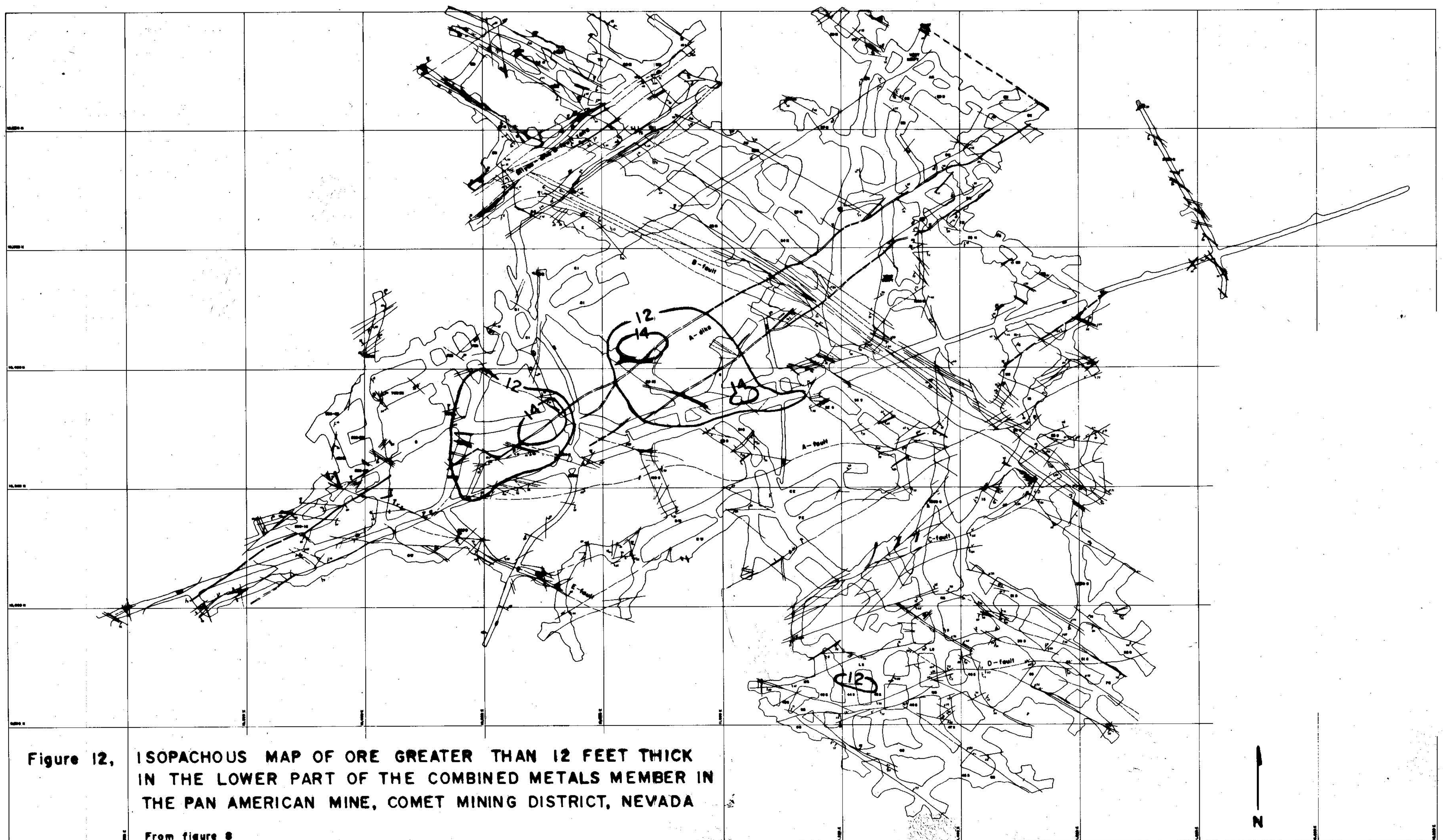

Figure 12, ISOPACHOUS MAP OF ORE GREATER THAN 12 FEET THICK IN THE LOWER PART OF THE COMBINED METALS MEMBER IN THE PAN AMERICAN MINE, COMET MINING DISTRICT, NEVADA

From figure 8

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Figure 14

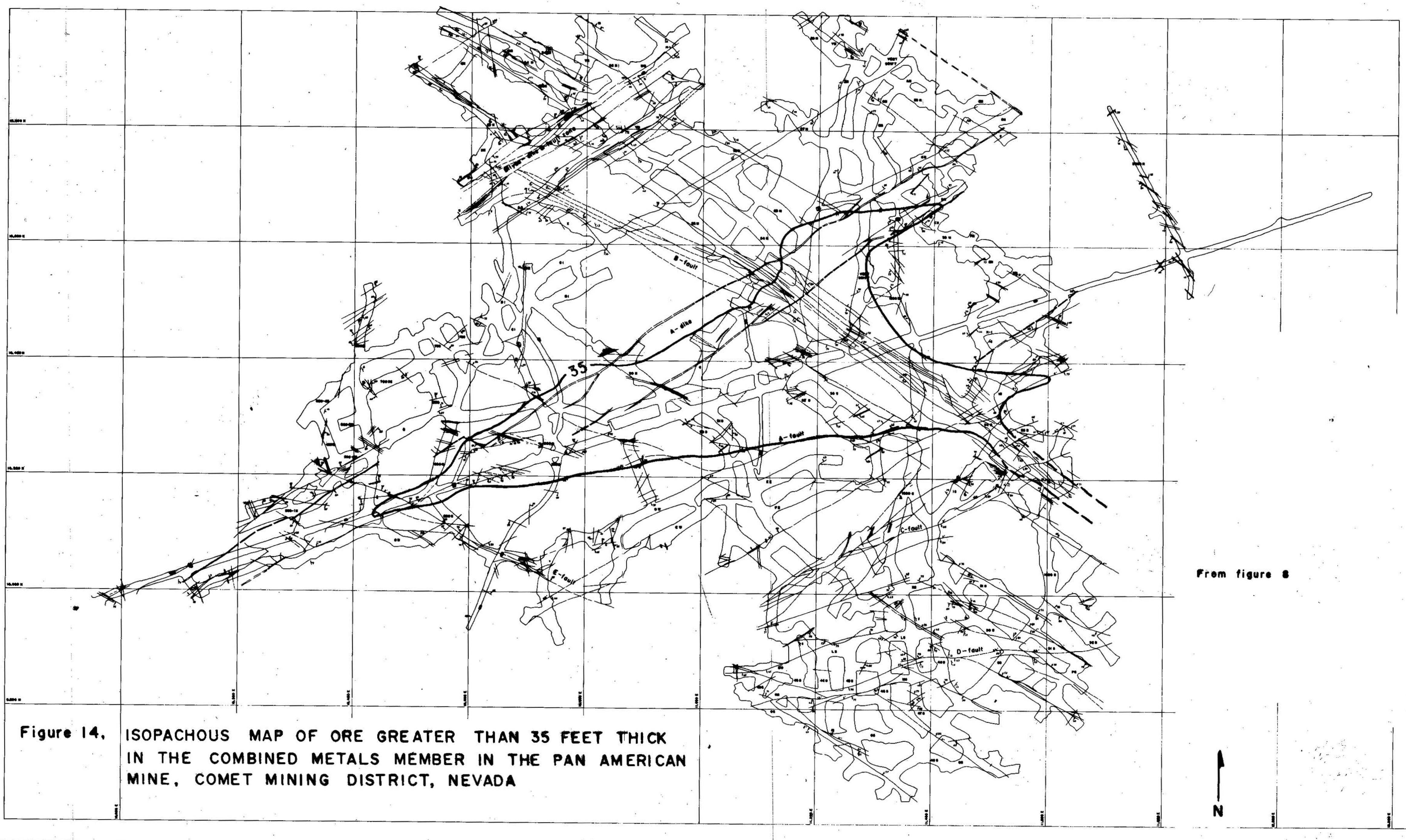

Figure 14, ISOPACHOUS MAP OF ORE GREATER THAN 35 FEET THICK IN THE COMBINED METALS MEMBER IN THE PAN AMERICAN MINE, COMET MINING DISTRICT, NEVADA

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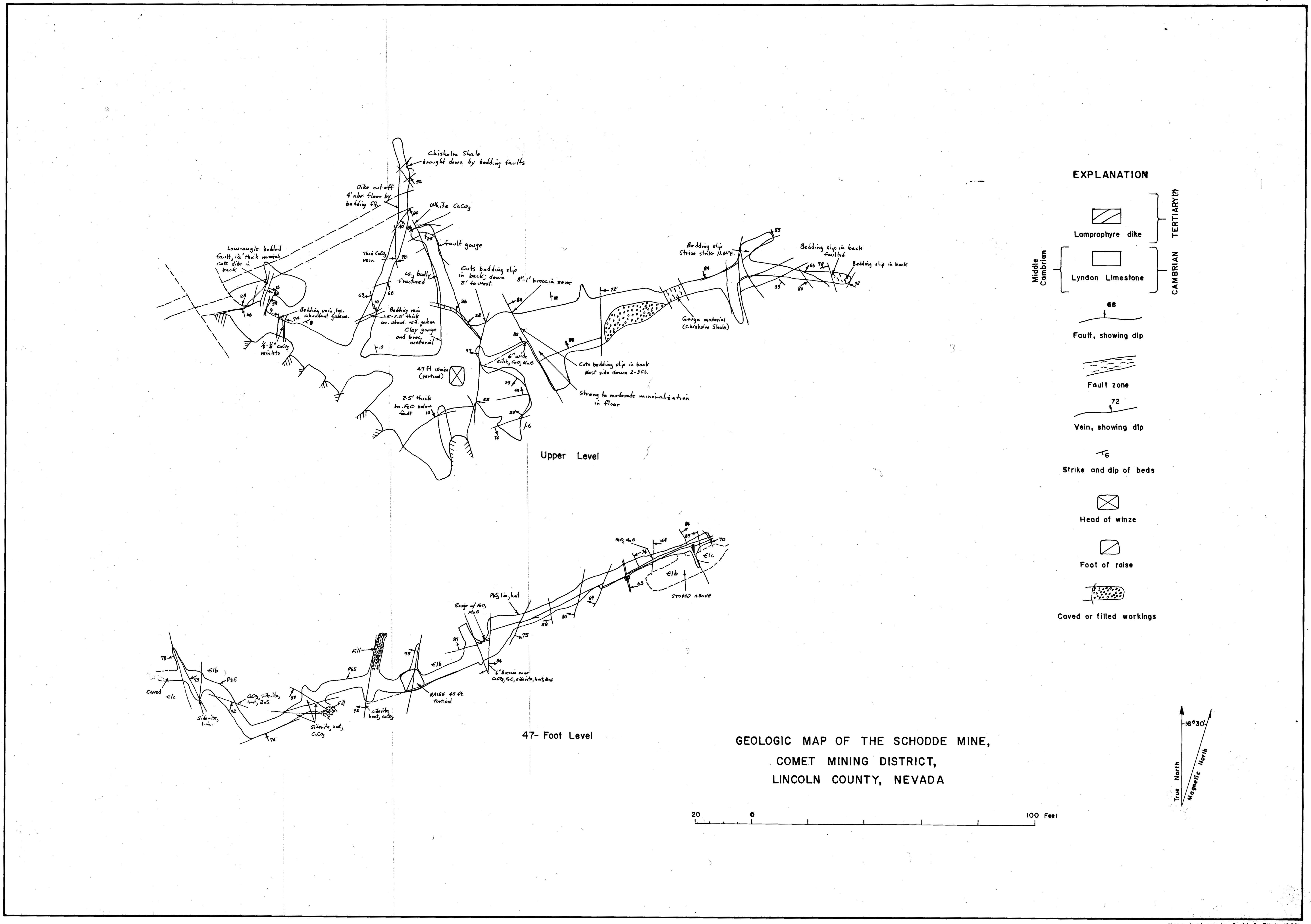
Figure 19



GEOLOGIC MAP OF THE SCHODDE MINE, COMET MINING DISTRICT, LINCOLN COUNTY, NEVADA

Upper level map by David C. Fitch, 1966; 47-foot level by Howard E. Davenport, 1966, slightly modified by David C. Fitch

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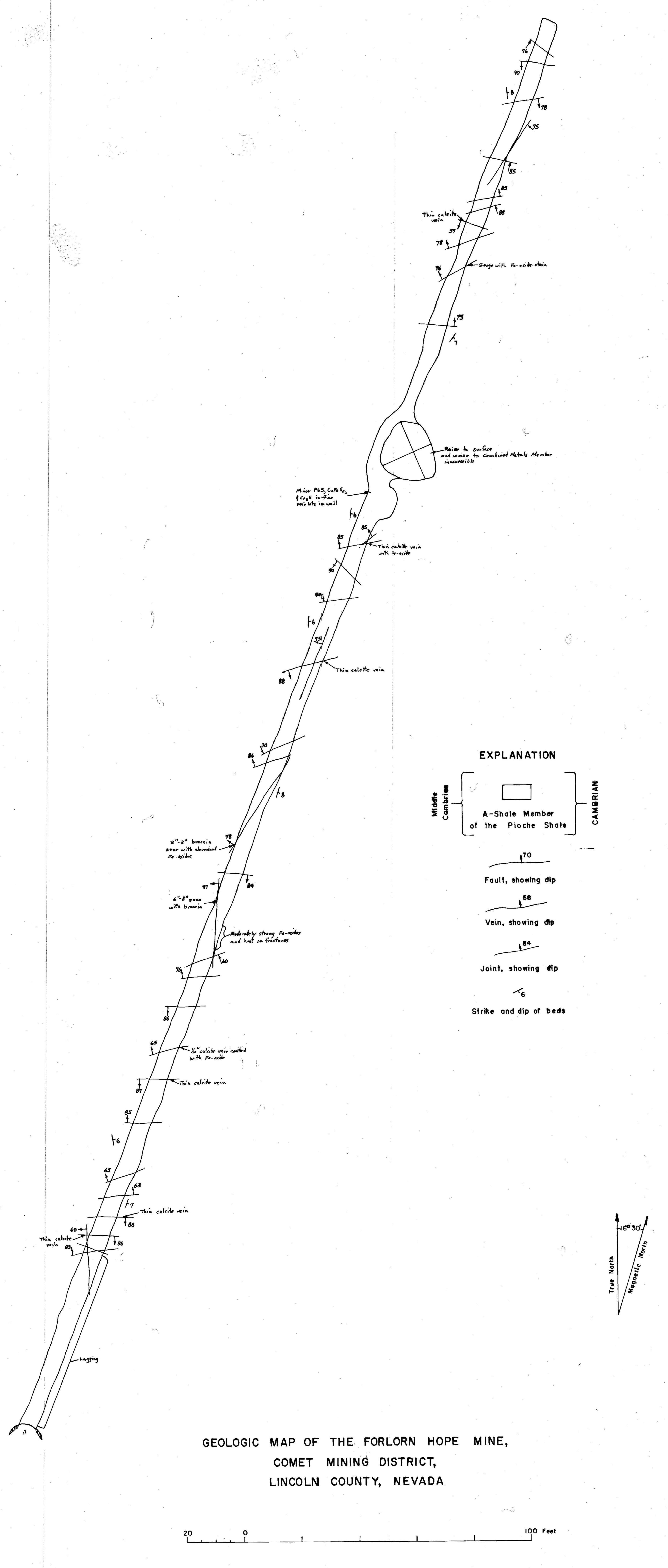
Figure 20



GEOLOGIC MAP OF THE FORLORN HOPE MINE,
COMET MINING DISTRICT,
LINCOLN COUNTY, NEVADA

By DAVID C. FITCH, 1969

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Figure 21

GEOLOGIC MAP OF THE LOG CABIN MINE
COMET MINING DISTRICT,
LINCOLN COUNTY, NEVADA

By DAVID C. FITCH, 1969