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THE GEOLOGY OF SOUTHERN HOUSE RANGE MILLARD COUNTY, UTAH

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THE GEOLOGY

OF

SOUTHERN HOUSE RANGE

MILLARD COUNTY, UTAH

A Thesis

submitted to

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In partial fulfillment

of the requirements for the degree

Master of Science

by

D. Keith Powell

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ABSTRACT

The stratigraphic sequence of the southern House Range is composed of rock units of the lower Paleozoic and Cenozoic Eras. The Paleozoic rock units are approximately 6,800 feet thick and are Middle and Upper Cambrian, and Lower Ordovician in age. The Cambrian system is represented by the Marjum Limestone, Weeks and Orr Formations, Dunderberg Shale, and Notch Peak Limestone. The House Limestone and Fillmore Limestone comprise the units of the Lower Ordovician system. The Cenozoic Era is represented by Tertiary alluvium, Quaternary and recent sediments.

The Paleozoic beds were slightly folded and faulted during Mesozoic and early Cenozoic time. During this time, the Notch Peak intrusive invaded the Paleozoic rocks causing slight doming, fracturing and extensive metamorphism of the surrounding sedimentary rock. Later block-faulting produced the basin and range structure of the region. This block-faulting caused a displacement of approximately 10,000 feet along the White Valley fault on the western side of the House Range.

Mining is of little commercial importance in the area except for small deposits of tungsten ore around the periphery of the Notch Peak Limestone.

INTRODUCTION

PURPOSE AND SCOPE

The following thesis is the result of a study of the general geology of the Southern House Range area, Millard County, Utah. Special emphasis is given to geologic mapping, structural interpretation, lithologic description, and petrographic study of igneous and metamorphic rocks in the area. The boundaries of the stratigraphic units are based mostly on lithologic descriptions of Charles D. Walcott, 1908.

Previous work in the area has been limited to the description of stratigraphic units, publications of the faunal assembleges, and a detailed study of Notch Peak intrusive and surrounding metamorphic zone. The area is the type locality for the Marjum Limestone, Weeks and Orr Formations and the Notch Peak Limestone; and has not previously been mapped. It is the purpose of this thesis, therefore, to present an accurate geologic map and report of this area.

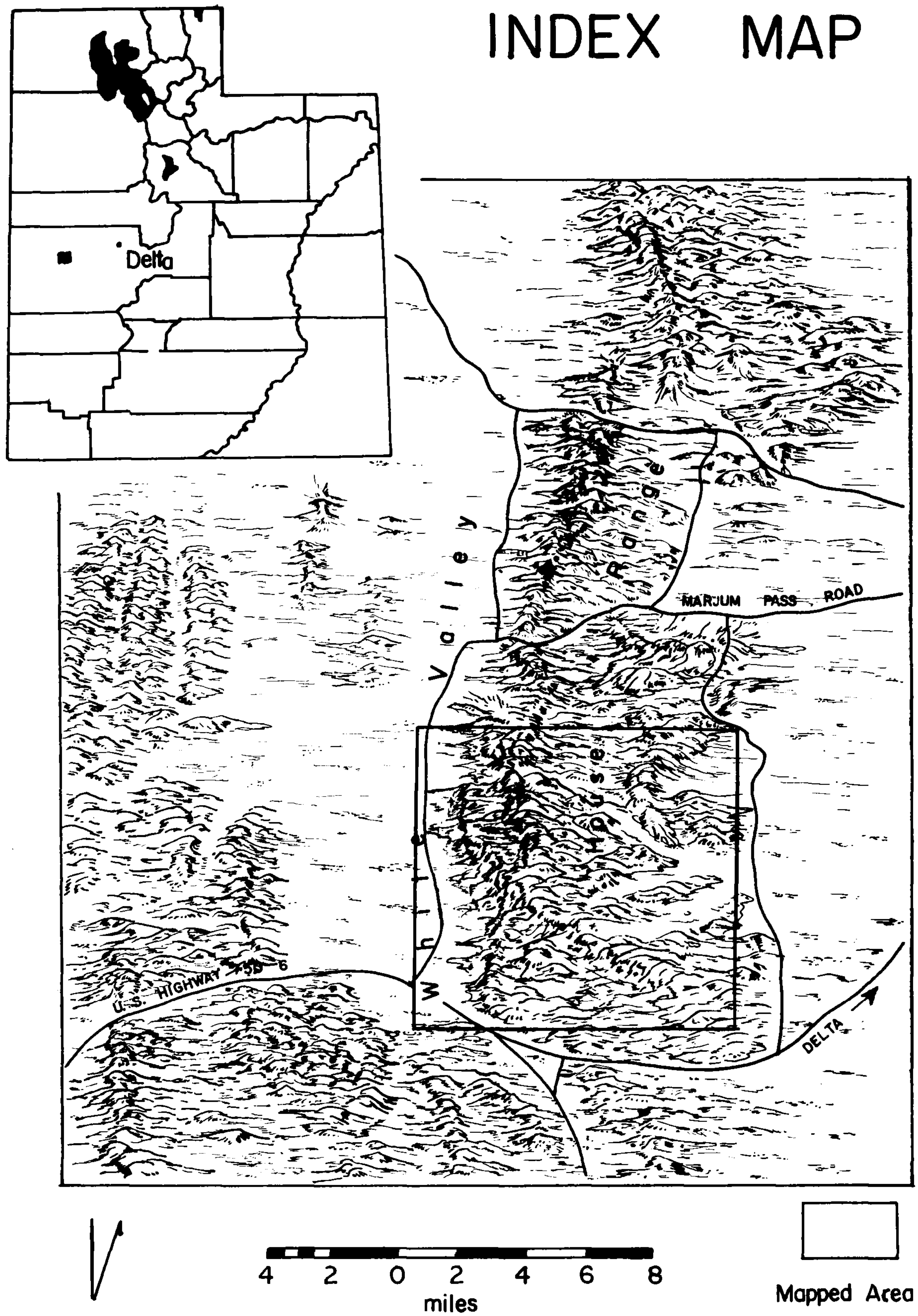
LOCATION AND ACCESSIBILITY

The mapped area is located in the southern part of the House Range in the vicinity of Notch Peak and the Notch Peak intrusive. The House Range is located in the west-central part of Millard County, Utah (Fig. 1). The mapped area is bounded on the west by White Valley and the Confusion Range, on the north by the Swasey Mountains of the House Range, on the east by Whirlwind Valley, and on the southeast by Sevier Lake playa.

The mapped area is bounded on the east and west by meridians 113° 15' and 113° 00' West Longitude, on the south and north by parallels 39° 00' and 39° 10' North Latitude. The Southern House Range area is approximately 14 miles long and 7 miles wide. The projected Township 19 south, and Ranges 13 and 14 west outlines the approximate boundaries of the area.

Fig. 1

INDEX MAP



The area is accessible by going west on U. S. Highway 50 and 6 via Delta, Utah, for approximately 60 miles or by turning off from U. S. Highway 50 and 6 about three miles west of Hinckley, Utah, and going northwest on the Marjum Pass road, the old U. S. Highway 6, for approximately 45 miles. Numerous improved roads, graded-dirt roads and trails afford good coverage of the area by car or jeep.

PHYSICAL FEATURES

The House Range is a northerly trending Basin and Range fault block consisting almost entirely of Cambrian strata. The range is approximately 40 miles long and averages 8 miles wide. The range is characterized on the western side by a steeply dissected fault scarp and a gently dipping dip slope on the east side of the range which has been partially covered by Lake Bonneville sediments.

Relief on the western side of the area is approximately 4,700 feet from the valley to the summit of Notch Peak. The most prominent features in the mapped area are the Notch Peak stock and associated sills, and the vertical cliffs of Notch Peak which reaches an elevation of 9,725 feet. The area is drained by intermittent streams. Only a few springs are found and these occur on the granitic stock and not in the surrounding sedimentary rocks. The area is sparsely covered by vegetation.

PREVIOUS WORK

The earliest geological literature on the House Range was written by Charles A. White and G. K. Gilbert. Their report was compiled and published in the United States Geographical and Geological Survey West of the 100th Meridian, 1874, under the direction of G. M. Wheeler. White was concerned with the collection and identification of fossils and Gilbert prepared a generalized section of the lower, and part of the middle, Cambrian strata. Gilbert, 1903, described the joints in the interbedded shales and limestones in Rainbow Canyon and in 1928 made a study of the Basin and Range structure in the area. In 1905, W. M. Davis described the physiographic features of the House Range.

Walcott, in 1886 and 1891, quoted Gilbert's House Range stratigraphic section and suggested correlation of its lithologic units with those in the Eureka and Highland Range sections of Nevada. In 1908, he published the first complete section of the Cambrian series in the area and defined the major formations. In 1939, Deiss remeasured and, in part, amended Walcott's Cambrian sections. Wheeler, 1948, as part of a regional synthesis of Cambrian stratigraphy in Western Utah, Nevada and Southeastern California, further revised the rock units within the lower and middle Cambrian series. He based his revision on recognition of regional distribution of lithologic units and priority of definition. In 1951, Wheeler and Grant Steele published an article on the Cambrian sequence of the House Range. Lehi F. Hintze, 1951, differentiated the Pogonip Group and proposed the formation names.

The most recent work in the area was done by Harry Gehman for his thesis at Cornell University. He described the igneous and metamorphic rocks of the Notch Peak intrusive.

FIELD AND LABORATORY STUDIES

The field work upon which this report and accompanying map are based commenced during June of 1957. The mapping of the area was accomplished by the use of vertical aerial photographs having an approximate scale of 1/20,000. The geological information was plotted directly on the photographs and then transferred to a photographic mosaic of the area.

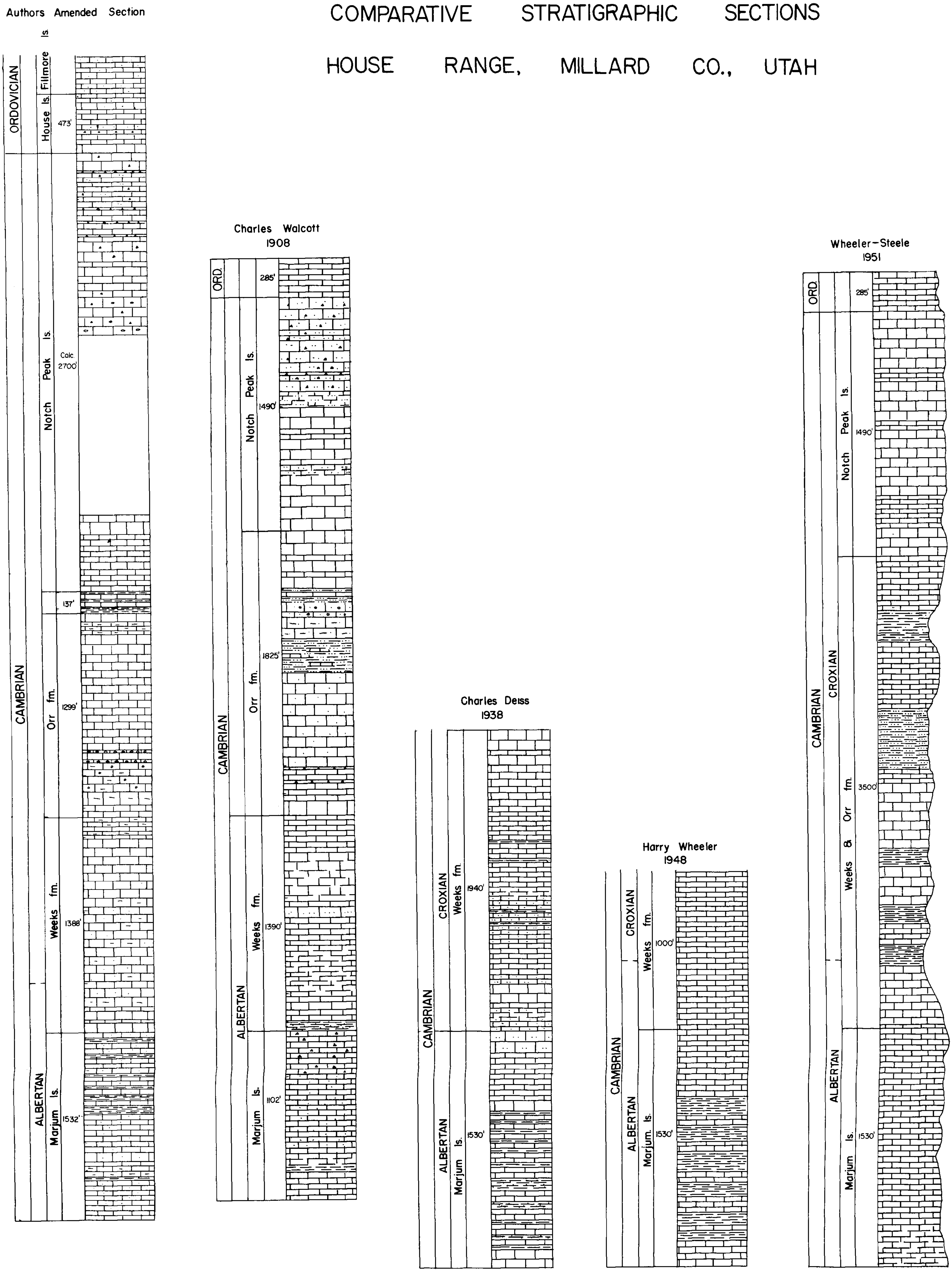
At present, no topographic map of the area is available. The writer used a prepared semi-controlled photographic mosaic compiled by Fairchild Aerial Surveys, Inc., Los Angeles and New York, for a base map.

A brunton compass, hand level, and a 200 foot steel tape were used in measuring the stratigraphic sections.

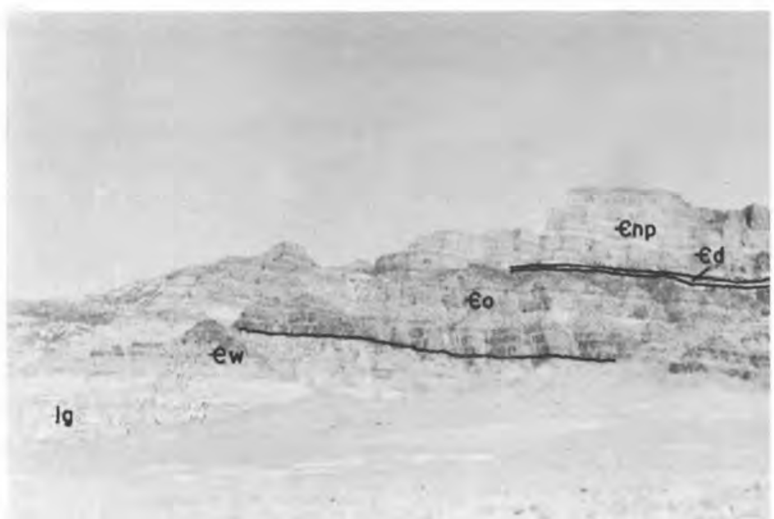
All thin-sections were made at the Brigham Young University. A petrographic microscope and mechanical stage were used in determining the mineralogical composition and percentage of each mineral present in the thin-sections.

COMPARATIVE STRATIGRAPHIC SECTIONS

HOUSE RANGE, MILLARD CO., UTAH



A. Contact of Notch Peak intrusive with Marjum ls. (Cm), Weeks fm. (Cw), and shows outcrops of Orr fm. (Co), Dunderberg sh. hidden from view, and Notch Peak ls. (Cnp).



B. Outcrops of Weeks fm. (Cw), Orr fm. (Co), Dunderberg sh. (Cd), and Notch Peak ls. (Cnp), on north side of Hanson Canyon.

A. Outcrop of the Orr formation, (Co) Dunderberg shale (Cd), and Notch Peak limestones (Cnp) in Granite Canyon.

B. Outcrop of the Notch Peak limestone (Cnp), House limestone (Oh), and Fillmore limestone (Of) in southeast corner of mapped area. One-fourth mile north of type locality for the House limestone.

STRATIGRAPHY

GENERAL STATEMENT

The stratigraphic sequence of the mapped area is composed of only rock units of the lower Paleozoic and Cenozoic Eras.

Cambrian and Ordovician strata of the House Range occupied a paleographic position near the central portion of the Paleozoic miogeosyncline. This is attested by great stratigraphic thickness, lithologic units, notable continuity of this formation along the northwest trending geosyncline, and by seemingly unbroken continuity of sedimentation through Cambrian to lower Ordovician times. In the mapped area the Paleozoic rocks consist of only rock units of the middle and upper Cambiran, and the lower Ordovician systems. The Cambrian system is represented by the Marjum Limestone, Weeks and Orr Formations, and Notch Peak Limestone. The House Limestone and Fillmore Limestone comprise the lower units of the Ordovician system.

Partially consolidated alluvium represent the Tertiary system, and Lake Bonneville and recent sediments represent the Quaternary system.

CAMBRIAN SYSTEM

Marjum Limestone:

The Marjum limestone is a medium to dark-gray, fine-grained, thin-bedded limestone irregularly interbedded with calcareous, fissile shale. The formation is 1532 feet thick in Rainbow Canyon, just north of the northwest corner of the mapped area and forms a steep brown, buff, orange-brown slope except for the upper 300 feet which forms a prominent brownish-gray cliff. The upper part of the formation is limestone with irregular interbedded shale, and the lower part is predominantly limestone with silty and clay partings with a few shale units. Shale varies in color from blue-gray, dark-gray, tan, buff, yellow to brown. The silt and clay partings of the limestone are buff, yellow, pink, orange-tan, purple, red-brown, and brown.

The formation crops out in the northwestern corner of the mapped area and forms the small hills beneath the granitic sill between Painter Springs Canyon and Notch Peak Canyon (Plate 1a). The formation has a general strike of north 10-30 degrees west and dips 8-18 degrees to the west. Only the upper 200-300 feet of the formation is exposed in the mapped area.

Marjum Limestone is conformably overlain by the Weeks Formation; however, the contact is either absent because of the intruding sill or can not be traced or determined because of the metamorphic effects. Some of the beds mapped as Marjum Limestone may possibly include the lower 20-50 feet of the Weeks Formation, but can not be differentiated due to the effect of contact metamorphism.

Type locality for the Marjum limestone is Marjum Pass, House Range, Millard County, Utah, which is approximately five miles north of the mapped area. The formation was defined and described as a formation unit by Charles Walcott (1908). He stated that the formation was 1102 feet thick, conformably overlain by the Weeks Formation and conformably overlies the Wheeler shale, and is Albertan in age. Charles Deiss (1938) remeasured and slightly amended Walcott's section. According to Deiss the revised Marjum Limestone section is 1540 feet thick and may contain some Upper Cambrian beds but the overlying Weeks Formation is strictly Upper Cambrian. Harry Wheeler, in 1948, making a lithologic and faunal zonation of the lower and middle Cambrian formations in southwestern Nevada and western Utah, measured 1540 feet of Marjum Limestone and raised the Middle-Upper Cambrian boundary to approximately 350 feet above the Marjum-Weeks contact. A comparison of Walcott's, Deiss', and Wheeler's, Wheeler-Steele's and the author's section of the Marjum Limestone is compiled on Fig. 2.

The Marjum Limestone has been dated as Albertan and may be correlated with the upper Burrows Dolomite and Highland Peak Limestone, Highland Range, Nevada; and Bloomington Formation, Bear River Range, Utah (Cambrian Subcommittee, 1944).

A complete stratigraphic section of the Marjum Limestone does not crop out in the mapped area, but the following section was measured in Rainbow Canyon, located just north of the northwest corner of the mapped area, by members of the 1957 Summer Field Camp, Geology Department, Brigham Young University.

Description	Thickness	Cumulative Thickness
Limestone and shale: Limestone is medium-gray, weathering dark-gray; very fine crystalline very thin-bedded; shale is tan, brown, and yellow; fissile (½ to 1"); cliff former. In the upper part of this unit is a 2 foot zone of pebbly limestone, and the upper part is very cherty	253'	1532'
Limestone and shale: Limestone is medium-gray, brown-gray and gray, fine crystalline, laminated to very thin bedded; shale is tan to pink-gray, weathering yellow to pink-yellow; fissile in lower part, ½ to 1" in upper part.	103'	1279'
Shale: Medium blue-gray; contains some silt partings; forms gray and grown shaley slopes	63'	1176'
Shale and limestone: Limestone is dark-gray, very fine crystalline, laminated to very thin bedded; ink and tan clay partings.	62'	1113'
Limestone and shale: Limestone is medium-gray shale, weathers brown and tan, limestone very fine crystalline, very thin bedded; ledge former weathers into angular fragments.	16'	1041'
Shale: Medium gray and brown, fissile, slope former, poorly exposed.	70'	1025'
Limestone and shale: Limestone brownish-gray to dark-gray, very fine crystalline, laminated to very thin bedded; upper section contains pink and tan shale partings.	11'	955'

Limestone: Gray at base becoming dark-gray toward center of unit, very fine crystalline, laminated to very thin bedded; lower part has red and brown silt partings; upper part has tan and purple silt partings; slope former.	172'	944'
Limestone: Medium-gray, very fine crystalline very thin-bedded; buff clay partings in lower part and pink clay partings in upper part resulting in buff and pink slopes; unit poorly exposed.	152'	772'
Limestone: Dark-gray, blue-gray, and gray weathers pale gray to blue-gray; some medium bedded horizons in lower part but mostly very thin bedded, laminated to very thin-bedded in upper part; portion of unit contains orange-tan silt-caly partings and forms orange-brown slope; upper part of unit has brown weathering silt partings and forms brown slope.	266'	620'
Limestone: Dark-gray, very fine crystalline, laminated; contains tan weathering wilt partings and limonite pseudomorphs.	26'	354'
Limestone: Dark-gray to black, very fine crystalline, laminated to medium bedded; becomes shaley in uppermost part; lower slope strewn with blocky talus; upper slope strewn with brown weathering shale.	297'	328'
Limestone: Light-gray, weathers light-gray very fine crystalline, very thin bedded, interbedded with brown fissile shale; contains limonite pseudomorphs, forms a slope.	21'	21-0'

The following fossils were collected from the Marjum Limestone in the mapped area. (Field collecting localities are shown on the geologic map.)

Elrathia kingi	KP 60
Elrathia kingi	KP 77

Weeks Formation:

Weeks Formation is a 1388 foot thick, medium to dark-gray, fine grained, thin to thick-bedded, argillaceous and arenaceous limestone. The top 600 feet of the formation contains small cubes of pyrite, which give the brown color to the weathered surface of the limestone. The formation becomes more argillaceous toward top and color changes from reddish-brown to a dark yellowish-orange. The formation is generally a slope former but alternating ridges and slopes occur in the upper 130 feet and the lower 177 feet of the formation.

The Weeks Formation crops out only on the western slopes of Notch Peak, in Hansen Canyon, where it is terminated by a fault, trends north to Notch Peak Canyon and continues to the igneous intrusive. A complete section does not crop out in the mapped area because much of the Weeks Formation has been intruded by the Notch Peak intrusive and a large sill, or is metamorphosed. The formation has a general strike of north 30 to 50 degrees west and dips 9 to 15 degrees to the southwest.

Type locality for the Weeks Formation is found in Marjum Pass and Weeks Canyon in the House Range, Millard County, Utah. The Weeks Formation was defined and described as a formational unit by Charles D. Walcott in 1908. He measured 1390 feet and defined the formation as being Middle Cambrian, conformably overlain by the Orr Formation and conformably overlying the Marjum Limestone. In 1938, Charles Deiss amended Walcott's section. He measured 1940 feet of the Weeks Formation in Rainbow Canyon and lowered the Middle-Upper Cambrian boundary to the Marjum-Weeks contact. Wheeler, in 1948, measured only 1000 feet of the total thickness of the formation and raised the Middle-Upper Cambrian to approximately 400 feet above the Marjum-Weeks contact. Wheeler stated that possibly a part of the Weeks Formation below the Tricrepicephalus zone may belong to the Albertian series. In 1951, Wheeler and Grant Steele grouped the Weeks and Orr Formation together because they said the close similarity and intergradational character did not appear to justify their distinction as a separate formation, and used Walcott's measurement of 3500 feet of the Weeks and Orr Formation.

The Weeks Formation, as defined by the writer, is 1388 feet thick. It conformably overlies the Marjum Limestone and is conformably overlain by the Orr Formation. The writer is in agreement with Wheeler for the Middle-Upper Cambrian boundary. Walcott's, Deiss', Wheeler's, Wheeler-Steele's and the author's stratigraphic sections of the Weeks Formations may be compared on Fig. 2.

The Weeks Formation has been dated as lowermost Croxian, lower half of the Dresbachian stage, and may be correlated with the Lamb Dolomite of the Deep Creek Range, with approximately the lower half of the Opex Dolomite of central Utah, and with the lower half of the Hamburg Dolomite of Eureka, Nevada (Bentley, 1958).

A complete stratigraphic section of the Weeks Formation does not crop out in the mapped area, and the following section was measured from the cliffs on the southwest side of Marjum Pass to the massive brown limestone ledges on the south side of Weeks Canyon by Bentley and Robison (1958). Fauna identified by Richard Robison.

Description	Thickness	Cumulative Thickness
Argillaceous limestone: Medium-gray with small red iron specks, weathers tan to dark reddish brown, fine-grained, thin-bedded. Unit forms alternating ridges and slopes covered with ½ to 1" thick platy talus. Limestone becomes more argillaceous toward top and color grades to dark yellowish-orange.	130'	1388'

Fauna: <u>Cedaria minor</u> (Walcott)
<u>Deiracephalus multisegmentus</u> (Walcott)
<u>Holcacephalus tenerus</u> (Walcott)
<u>Tricrepicphalus coria</u> (Walcott)

This interval subject to error.

Limestone: Dark-gray, weathers in alternating bands of medium-gray and tan; fine grained, laminated but

weathers medium-bedded. Orange iron blotches found throughout unit. Toward top unit becomes argillaceous with tan color predominating over the gray, forming gradational contact with overlying unit, in which gray has completely disappeared. Unit forms a slope with poor outcrops.	475'	1258'

Fauna: Cedaria minor (Walcott)
Deiracephalus multisegmentus (Walcott)
Holcacephalus tenerus (Walcott)
Lonchocephalus plena (Walcott)
Oedorhachis typicalis (Resser)
Olenoides weeksi Robison
Tricrepicephalus coria (Walcott)

This interval subject to error.

Talus covered slope: Dark-gray limestone, talus similar to limestone of underlying unit. Unit forms gentle slope with no apparent outcrops.	461'	783'

Fauna: Cedaria minor (Walcott)
Tricrepicephalus coria (Walcott)
Weeksina multinodus Robison

This interval subject to error.

Limestone: Dark-gray, with alternating argillaceous beds, weathers alternating light olive-gray and medium gray, fine-grained, laminated, but thick bedded. Unit forms a cliff 50 5o 100 feet high with blocky and platy talus. Cliff is covered with white lichens giving it a white-washed effect.	151'	322'

Limestone: Dark-gray, weathers medium dark-gray fine grained, with

thin elongate wollastonite crystals 1/8 to 1/4 inches long throughout rock, thin to medium-bedded, with some argillaceous bands, wavy-bedded. Calcite stringers and vugs run irregularly through unit. Unit forms ledges and steep slopes with blocky talus.	171'	171-0'

The following fossils were collected from the Weeks Formation in the mapped area. (Field collecting localities are shown on the geologic map.)

Tricrepicephalus coria (Walcott)	KP 139
Olenoides sp.	KP 113, KP 140
Deiracephalus multisegmentus (Walcott)	KP 139
Agnostus sp.	KP 138
Crepicephalus buttsi (Walcott)	KP 139

Orr Formation:

Orr Formation is a light-gray to dark-gray, fine to medium-grained, thin to thick-bedded arenaceous limestone, which weathers to dark-gray and brown hues. The formation is locally argillaceous and has many oolitic beds throughout. It is generally a steep slope and ledge former, but a distinct 30 foot cliff occurs approximately 50 feet from the top of the formation. The top unit has been metamorphosed in the area and appears as a white case-hardened limestone which may be traced throughout the mapped area.

The Orr Formation crops out on the western and eastern slopes and ridges of Notch Peak. The formation crops out on the western slopes of Notch Peak where the formation trends northward from Notch Peak Cove fault dipping into Hansen Canyon and Notch Peak Canyon, continues north to Pine Peak, and then dips southward into Behunin Canyon, Granite Canyon, and Sheep Cove. The formation has a general strike of north 30 to 50 degrees to the east and dips 10 to 21 degrees to the southeast.

Walcott (1908) defined and measured 1826 feet of the Orr Formation from the section carried along the exposed strata two miles east to the west side of Orr Ridge, House Range, Millard County, Utah. The Orr Formation as defined by Walcott is conformably overlain by the Notch

Peak Limestone and conformably overlies the Weeks Formation. Wheeler and Steele (1951) measured 3500 feet of the Weeks and Orr Formation, and grouped the two formations together because of the close similarity, and intergradational character did not appear to justify them as a distinct and separate formation.

The writer has amended Walcott's and Wheeler-Steele's stratigraphic section because the Dunderberg Shale was traced into the area by Craig Bentley and Richard Robison during their lithologic and faunal zonation of the Upper Cambrian of Utah and eastern Nevada (1958). The amended Orr Formation is 1299 feet thick, conformably overlain by the Dunderberg Shale and conformably overlies the Weeks Formation. Walcott's, Wheeler-Steele's, and the author's amended stratigraphic sections may be compared on Fig. 2.

The Orr Formation has been dated as Croxian and may be correlated with the Hicks Formation in the Deep Creek Range, upper half of the Opex Dolomite in central Utah, upper half of the Nouman Limestone in northern Utah, and with the top of the Highland Peak Limestone and the base of the Mendha Limestone at Pioche, Nevada (Bentley, 1958).

The following stratigraphic section of the Orr Formation was measured by Craig Bentley and Richard Robison, during their lithologic and faunal zonation of the Upper Cambrian in Utah. The section was measured just north of the mapped area where the units were not metamorphosed.

Description	Thickness	Cumulative Thickness
Limestone: Light-gray, weathers same, fine-grained massive-bedded. Limestone powders easily to fine flour-like powder, appears case hardened. Unit forms alternating ledges and slopes with smooth to pitted weathered surface.	42'	1299'
Limestone: Dark-gray, weathers dark-gray with very light-gray argillaceous partings giving zebra bed effect, medium-grained, thin-bedded. Unit forms a		

meringue-weathered distinct 30 foot cliff (Marker unit).	65'	1257'
Limestone: Medium-gray, weathers tan to brownish-gray, fine-grained, massive-bedded. Units forms a steep slope with 4 feet ledge at base.	118'	1192'
Limestone: Dark olive-gray, weathers medium dark-gray, medium-grained, medium-bedded. Unit is highly weathered and porous with partially meringue weathered surface. Limestone is composed of approximately 25% fossil fragments. Unit forms a slope with foot-high ledges occurring approximately every 30 feet. (slope distance) in the lower half, with the upper half entirely covered.	334'	1074'

Fauna: Pseudagnostus communis (Hall & Whitfield)

Limestone: Medium dark-gray, weathers tan on surface to dark-gray on bedding planes, fine-grained, medium to thick-bedded, meringue weathered. Unit forms alternating ledges and slopes with a 31 foot brown arenaceous ledge forming interval at base.	145'	740'

Fauna: Tricrepicephalus coria (Walcott)

Limestone: Color and bedding similar to above unit, fine to medium-grained with 25 to 50% bioclastic. Silt-size particles of quartz make up 1% of rock. Thin oolite beds run through unit.	252'	595'

Fauna: Tricrepicephalus coria (Walcott)

Limestone: Medium-gray weathers medium-gray, light brown argillaceous banding, medium-grained. Oolites and fossil fragments make up to 25 to 50% of the rock. Unit forms thick-bedded cliff with sucrose meringue-weathered surface along bedding planes.	86'	343'

Fauna: Crepicephalus australis wahwahensis Robison

Limestone: Light brownish gray, weathers medium-gray on surface to light olive-gray through brownish-black on bedding planes, fine-grained with 5% limestone fragments 2 mm. in diameter, thin-bedded, but weathers as thick-bedded ledge-forming unit iwth good outcrops. Argillaceous on bedding planes.	66'	257'
Limestone: Medium light-gray with tan mottling, weathers medium-gray with tan mottling, medium-grained, massive-bedded. Quartz grains less than ½ mm. make up to 1 to 2% of rock. Unit forms alternating ledges and slopes with good outcrops.	25'	191'
Limestone: Medium-gray, weathers same, fine to medium-grained, thin-bedded, weathers massive, sucrose. Unit forms alternating ridges and slopes with cliff at top.	87'	166'

Fauna: Genevievella campbellina (Tasch)
Kormagnostus simplex (Resser)
Maryvillia arion (Walcott)
Syspacheilus camurus (Lochman)
Tricrepicephalus coria (Walcott)

Limestone: Light-tan to dark-reddish brown, weathers tan to

medium-gray, bioclastic partly recrystallized, thick-bedded. Unit weathers with sucrose surface and forms broken cliffs with good outcrops. Base of this unit taken as the base of the Orr Formation.	79'	79-0'

Fauna: Crepicephalus australis wahwahensis Robison
Genevievella campbellina (Tasch)
Holcacephalus tenerus (Walcott)

No fossils were collected from the Orr Formation in the mapped area.

Dunderberg Shale:

Dunderberg Shale consists of a 26 foot shale bed and a 111 foot interbedded shale and limestone unit. The shale unit is a fine to medium-grained, fissile shale which weathers to small olive-brown flakes 1/8 inches thick. Fresh samples are more blocky and thicker. The interbedded shale and limestone unit has a shale very similar to the shale unit below and occurs in beds 6 to 10 inches thick. The limestone is a medium-gray, fine-grained, thin-bedded limestone with argillaceous and pink mottling and weathers with a rough sandy surface. The limestone becomes dark-gray and thick-bedded with argillaceous banding near the top of the unit.

The formation crops out on the western slopes of Notch Peak where the formation trends northward from Notch Peak Cove fault dipping into Hansen and Notch Peak Canyons, continues north to Pink Peak and then dips southward into Behunin Canyon, Granite Canyon and Sheep Cove. The formation has a general strike of north 30 to 50 degrees to the east and dips 10 to 21 degrees to the southwest.

Hague (1833) originally defined the Dunderberg Shale as the same formation as the Hamburg Shale form exposures in the vicinity of the Hamburg and Dunderberg mines, Fish Creek Range, Eureka Mining District, Nevada. Charles Walcott (1908) differentiated the formations and proposed the name Dunderberg Shale for the younger unit. Type locality as proposed by Walcott extends from Shadow Canyon to the south end of Secret Canyon. The formation is described as equal thickness of shale and of interbedded shale with thin, nodular and lenticular limestone.

Wheeler and Lemmon (1939) measured 340 feet of Dunderberg Shale at the divide of Secret and Windfall Canyons; and T. B. Nolan, C. W. Merrian, and J. S. Williams (1956) measured 265 feet of the formation at the ridge in Windfall Canyon. Craig Bentley and Richard Robison (1958) traced the Dunderberg Shale into the area during their lithologic and faunal zonation of the Upper Cambrian. They measured 137 feet of the formation just north of the northeast boundary of the mapped area.

The Dunderberg Shale is dated as Croxian and may be correlated with part of the Mendha Formation, Pioche District, Nevada; upper part of the Hicks Formation and the Lower Chokecherry Dolomite (?), Gold Hills District, Utah (Nolan, Merrian and Williams, 1956).

The following stratigraphic section was measured by Craig Bentley and Richard Robison. The stratigraphic section was measured just north of the northeast corner of the mapped area on the slope south of Weeks Canyon.

Description	Thickness	Cumulative Thickness
Limestone and shale interbedded: Medium-gray limestone, weathers same with tan argillaceous and pink arenaceous mottling, fine to medium-grained, thin-bedded. Weathers with rough sucrose surface. Partially meringue-weathered. Shale identical to that in underlying unit.	111'	137'
Fauna: Cliffia lataegenae (Wilson) Irvingella major (Ulrich & Resser)		
Shale: Medium-gray, weathers light olive-brown, fine-grained, fissile, breaks in layers 1/8 inch thick. Forms covered slope with poor outcrops. Fresh samples are more blocky and thicker.	26'	26-0'

The following fossils were collected from the Dunderberg shale in the mapped area. (Field collecting localities are shown on the geologic map.)

Housia varro (Walcott)	KP 134
Elvinia roemeri (Shumard)	KP 134

Notch Peak Limestone:

The Notch Peak Limestone is a light to dark-gray, fine-grained, thin to thick-bedded, cherty arenaceous limestone. From a distance the formations appear as a cliff (Plate la). The formation is locally cherty with chert stringers or nodules but the upper part of the formation becomes very cherty with bands of dark-gray or brown chert one to three inches thick. These bands of dark-gray or brown chert give a brownish color to the whole unit upon weathering. Many algal heads with a diameter of 4 to 12 inches occur in the upper 650 feet of the formation.

The formation forms the vertical cliffs near the top of Notch Peak, and other outcrops are found on the eastern and southern slopes and ridges of the mapped area. Notch Peak limestone has a general strike of north 30 degrees east and dips 8 to 16 degrees to the southeast.

Type locality for the Notch Peak Limestone is Notch Peak, House Range, Millard County, Utah. The formation was defined and described as a formational unit by Charles D. Walcott (1908). The formation as defined by Walcottis 1490 feet thick and conformably overlies the Orr Formation (Fig. 2). Harry Wheeler and Grant Steele (1951) published a stratigraphic column in which they used the formational boundaries and measurement as defined by Walcott.

The writer has amended Walcott's and Wheeler-Steele's stratigraphic sections of the Notch Peak Limestone on the bases of lithology, fauna collected and the Cambrian-Ordovician contact defined by Lehi Hintze (1951). The amended Notch Peak Limestone is 1939 feet thick and is conformably overlain by the House Limestone and conformably overlies the Dunderberg Shale (Fig. 2). The Notch Peak-Dunderberg contact is taken where the massive cliff forming Notch Peak Limestone changes to the slope forming Dunderberg Shale (Plate lc). Notch Peak-House contact is just below the *Symphysurina* faunal zone where the slope and ledges forming units of the House Limestone change abruptly to the massive cliffs of the Notch Peak Limestone (Hintze, 1951) (Plate ld).

As illustrated on Fig. 2, the upper 304 feet of the Orr Formation as defined by Walcott has been included in the amended Notch Peak Limestone. The addition was based on the abrupt change from the 137 foot slope forming

Dunderberg Shale to the prominent 304 foot cliff former and the similarity of the 304 foot unit to the overlying cliff forming Notch Peak Limestone.

Walcott (1908) measured and defined the top 295 feet of Notch Peak as a thin-bedded, bluish-gray and purplish limestone and dated it as Lower Ordovician on the bases of fauna collected near the top of Notch Peak. He did not designate a specific name for the limestone unit. The following fauna was collected near the top of Notch Peak by Walcott (1908).

Obolus (Westonia) notchensis (Walcott)
Eoorthis coloradoensis (Meek)
Raphistoma sp.

In 1951, Harry Wheeler and Grant Steel described the top 285 feet of Notch Peak as Chokecherry, Ordovician in age. No fauna was described by the latter authors.

The fauna listed below was collected by the author near the summit of Notch Peak. On the basis of this distinct Upper Cambrian trilobite fauna and the Cambrian-Ordovician as defined by Lehi Hintze (1951), the author has classified Walcott's and Wheeler-Steele's Ordovician limestone unit as Upper Cambrian and not Ordovician in age. This unit is approximately 650 feet from the amended Notch Peak Limestone section.

Eurekia sp.	KP 209
Eoorthis sp.	KP 209

The Notch Peak Limestone has been dated as Croxian, Middle and Upper Franconian and Trempealeauan, and is correlated with the Ajax Limestone of central Utah; Windfall Formation, Eureka, Nevada; middle and upper part of the Mendha Limestone, Pioche, Nevada; and is equivalent to the St. Charles Formation above the Worm Creek Quartzite member of northern Utah.

The following stratigraphic section was measured by Craig Bentley and Richard Robison. The stratigraphic section was measured on the eastern slope of Notch Peak by Craig Bentley and Richard Robison in 1958.

Description	Thickness	Cumulative Thickness
Limestone: Light-gray, weathers medium light gray, fine-grained, medium-bedded. Chert bands 1 to 2 inches thick, 6 inches apart parallel bedding except for 30 feet		

interval 45 feet from base. Algal heads 8 to 10 inches in diameter occur 20 feet from top. Unit forms ledges with meringue-weathered surfaces.	124'	1939'
Limestone: Medium-gray, weathers medium dark-gray, fine-grained, thin-bedded but weathers thick. Cherty and arenaceous patches abundant throughout unit. Unit forms ledges with meringue-weathered surface.	168'	1815'
Limestone: Medium light-gray with brown tint, weathers tan and medium dark-gray with dark brown chert layers 1/8 to 1/4 inch thick, 1/2 inch apart, fine-grained and bioclastic (50% fossil frags.), thin bedded, cross-bedded in places. Unit forms ledges with sucrose, meringue-weathered surfaces.	239'	1647'
Limestone: Medium dark-gray, weathers same, fine-grained, thin- to medium-bedded. Unit forms a slope with good outcrops, surfaces meringue-weathered.	45'	1408'
Limestone: Light-gray, weathers medium light-gray, fine-grained, thick- to massive-bedded. Meringue-weathered cliff-forming unit, lower contact.	49'	1363'
Limestone: Medium light-gray, weathers medium gray, fine- to medium-grained, thick- to massive-bedded. Abundant chert nodules 1 to 3 inches by 1 inch and algal heads throughout unit. Meringue weathered, ledge-forming unit.	44'	1314'

Limestone: Medium dark-gray, weathers medium gray with red argillaceous material on bedding planes, fine- to medium-grained, thin-bedded, some chert nodules. Unit forms slope and breaks down into platy slabs.	16'	1270'
Fauna: <u>Eurekia</u> sp.		
Limestone: Same as dark in underlying unit. Intrafm. cg. bed just below top of unit.	21'	1254'
Limestone: Alternating light and dark; dark: Medium dark gray, weathers dark gray, fine- to medium-grained, massive-bedded; light: white, weathers very light gray with red streaks, fine- to medium-crystalline, appears highly altered. Alternating beds 2 to 10 feet thick. Unit forms a cliff.	18'	1233'
Limestone: Light-gray, weathers medium-gray, very fine-grained, but fine to medium grained at base, massive bedded. Abundant chert nodules in lower half, oolite beds in upper half. Algal heads abundant 40 to 50 feet from top of unit. Unit forms a cliff.	400'	1215'
Limestone: Medium dark-gray, weathers dark gray, very fine-grained, thin-bedded (wavy). Tan argil. material on bedding planes. Abundant chert nodules and calcite stringers throughout unit. Unit forms slope and weathers to meringue-weathered slabs. 15 foot thick unit 15 feet from base composed of very light-gray limestone, weathers mottled light-gray and medium gray, very fine-grained. Distinctive		

wavy chert bands 1 to 2 inches thick 1 foot apart. Forms sucrose, meringue-weathered ledge at base of unit.	137'	815'
Limestone: Identical to underlying unit, but forms a cliff. Breaks down into blocky frags.	197'	678'
Limestone: Same as underlying unit, but thin wavy-bedded. Alternates with massive-beds. Weathers with smooth undulating surface. Unit forms slope with poor outcrops.	162'	481'
Limestone: Medium dark-gray, weathers medium gray and light tan, sublithographic, thick-bedded--beds 5 feet thick with thin-bedded bands 8 to 24 inches thick in between often showing as white bands. Chert nodules in upper half. Meringue-weathered cliff-forming unit with ledges at top and slope at base.	319'	319-0'

The writer believes this measurement of the Notch Peak Limestone to be in error. By photographic methods, and comparison of Walcott's and Wheeler-Steele's stratigraphic sections, this stratigraphic thickness has been calculated to be 2700 feet thick and not 1939 as measured by Bentley and Robison. Amended section will be furnished upon request when climatic conditions permit.

The following fauna was collected from the Notch Peak Limestone in the mapped area. (Field collecting localities are shown on the geologic map.)

<u>Elvinia roemeri</u> (Shumard)	KP 210
<u>Eurekia</u> sp.	KP 209
<u>Eoorthis</u>	KP 209
<u>Litocephalus</u> sp.	KP 123

ORDOVICIAN SYSTEM

House Limestone:

The formation is a 475 foot thick, medium-gray, thin- to thick-bedded, cherty, silty, calcilutite with a few beds of calcisiltite. Most of the beds have chert nodules and stringers, but they are more prominent in the middle third of the formation. The House Limestone is a medium-gray in color, except for the lowest of two cliff-forming units and a slope-forming unit below the House-Fillmore contact which weathers to brownish-gray hues. A one foot intraformational conflomerate occurs 121 feet from the base of the formation. (Hintze, 1951).

The formation crops out on the southwestern end and the central part of the House Range just south of Notch Peak Cove. The stratigraphic sequence in both areas has been repeated many times by northwest trending, normal faults, which have a vertical displacement of approximately 50 to 100 feet.

House Limestone conformably overlies the Notch Peak Limestone and is conformably overlain by the Fillmore Limestone. The House-Notch Peak contact is just below the Symphysurina faunal zone where the slope and ledge forming units of the House Limestone change abruptly to the massive cliffs of the Notch Peak Limestone (Hintze, 1951). Twenty feet below the contact a 15 foot, massive, algal bed of limestone is used as an additional marker bed. The House-Fillmore contact is 475' from the base of the House Limestone at the top of a 9 foot ledge which has a reentrant with an abundance of small brachiopods.

Type locality for the House Limestone is in the south-western end of the House Range, on the north side of a small butte about ½ mile east of the White Valley Grazing Service road; and has been designated on the accompanying geologic map as B-B'. This area corresponds to Hintze (1951) Ibex Area A, Lower Ordovician Detailed Stratigraphic Section for Western Utah.

The House Limestone has been dated as Beekmantown on the basis of trilobite assemblege (Hintze, 1951) and may be correlated with the lower Garden City Formation in north Utah.

Hintze measured the following section of the House Limestone in the area designated as B-B' on the geologic map of this thesis.

Description	Thickness	Cumulative Thickness
Calcisiltite, medium, gray, silty, thin bedded indistinct bedding planes, for 8 foot ledge capping hilltop. Fossils abundant in reentrant under ledge.	9'	473'

Calcisiltite, brownish-gray, thin-bedded, slope frowming with slabby talus.	16'	466'
Paraplethopeltis genacurous Paraplethopeltis genaricius Hystricurus genalatus Synthrophina cf. S. campbellia		
Calcilutite and calcisiltite, medium gray to brownish gray, mostly thin-bedded, slope forming, but with occasional 1 foot or 2 foot ledges. Slope covered with platy talus with abundant fossils. Occasional small chert nodules in float slabs.	50'	450'
Hystricurus politus Bellefontia n. sp. Hystricurus genalatus Symphysurina c. sp.		
Calcisiltite, medium-gray, thin-bedded, chert nodules fairly common, slope forming with platy talus.	30'	400'
Hystricurus politus Bellefontia ibexensis		
Calcilutite, light to medium-gray thin-bedded slope forming.	15'	370'
Symphysurina cf. S. elogans Hystricurus genalatus Xenostegium franklinense Pseudokainella		
Calcisiltite and calsilutite, medium-gray thin-bedded to massive, cliff and ledge forming cherty, chert in thin bedding plane, layers up to 1 inch thick and in larger irregular nodules up to 4 inches thick mostly unfossiliferous. Fossils at top of cliff forming ledges.	65'	355'

Symphysurina cf. S. cleora
Hystricurus genalatus

Calcitites, silty to fine sand, thin-bedded slope forming	23'	290'
Calcilutite, medium gray, ledge forming, cherty in nodular lenses along bedding up to 1 1/2 inches thick	10'	267'
Covered, cherty calcilutite float covers slope.	17'	257'
Calcitites, weathering brownish-gray thin bedded, quartz silty, occasional cross-laminations up to 6 inches chert in thin bedding plane layers up to 2 inches thick, cliff and ledge forming.	75'	240'

Schizambon ? sp.

Calcilutite, medium to light-gray thin to medium bedded, with occasional thin beds of intraformational conflomerate and calcisilitite, 121' a one foot bed of intraformational conflomerate with pebbles up to 3 inches diameter.	65'	165'

Bellefontia
Sumphysurina brevispicata
Symphysurina
Hystricurus millarenois
Pseudokainella ? sp. indet.
Symphysurina sp. indet.

At 100' moved eastward from creek bed to follow ledges.

Calcilutite, medium-gray, medium to thin-bedded, cherty.	25'	100'
Calcilutite, medium-gray, medium-bedded cherty in bedding plane nodules.	10'	75'

Covered	8'	65'
Calcilutite, medium-gray, cherty, forms 2 foot ledge.	2'	57'
Covered, cherty calcilutite float	15'	55'
Calcilutite, medium-gray, medium-bedded, cherty, chert layers up to 2 inches. Forms ledges 2 to 5 feet high.	40'	40-0'

The following trilobites were collected from the House Limestone in the mapped area. (Field collecting localities are shown on the geologic map.)

<u>Symphysurina</u>	KP 107
<u>Symphysurina</u>	KP 109
<u>Hystricurus millarenois</u>	KP 109

Fillmore Limestone:

The Fillmore Limestone is a thin- to thick-bedded limestone and consists of interbedded, intraformational conglomerates, limy siltstone, muddy limestone, limy shales, with occasional thin layers of calculutite and calcarenites. Black chert is found on the bedding plane as thin layers or as stringers and irregular nodules cutting the bedding plane. The formation has occasional beds of pinkish-gray quartz sandstones, ripple marks, cross-laminated, and abundant beds of size sorted, badly worn silicified trilobites. The individual beds may thin or lense out or grade into other beds within short distance. The Fillmore Limestone has usually medium-gray to brownish-gray colors which weather to light-gray, brownish-gray, yellowish-orange, pale yellowish-brown or a yellowish-gray hues.

The formation crops out just west and south of Notch Peak Cove at the southwestern end of the House Range and generally dips 12 to 18 degrees to the south and strikes north 30 to 45 degrees east. Approximately one half of the 1500 foot thick formation outcrops in the mapped area.

Fillmore Limestone conformably overlies the House Limestone and is conformably overlain by the Wahwah Limestone. The formation has been defined by L. F. Hintze (1951) as consisting of all beds between the top of the House Limestone and the base of the Wahwah Limestone. Type locality for the Fillmore Limestone is just north of the lava dam on Yersin Ridge and Heckethorn Hills of the Ibex Area, and is located about four miles south of the southern boundary of the mapped area.

The Fillmore Limestone has been dated as Beekmantown and may be correlated with the middle part of the Garden City Formation in northern Utah.

TERTIARY SYSTEM

The Tertiary system is represented by a nonconsolidated to partially consolidated alluvium consisting of detrital material of the Eureka Quartzite, Fishhaven and Laketown Dolomite, unidentified limestone, and soil. The alluvium unconformably overlies portions of the Cambrian and Lower Ordovician formations in the area.

Alluvial deposits may occur as patches of isolated, angular to sub-rounded boulders of Eureka quartzite, Fishhaven and Laketown dolomite; or as partially consolidated alluvium consisting of Eureka Quartzite, Fishhaven and Laketown Dolomites, unidentified limestone, and soil. The detrital material of the latter deposit range in size from boulders to sand, which may either be angular or rounded depending on the mode of deposition.

Deposition of the Tertiary alluvium started shortly after the uplift of the area by the compressional forces of late Jurassic to early Tertiary. As the agents of erosion dessected and eroded the area the sediments were transported and deposited in other areas by streams, flash-floods, and landslides; or deposited in place by residual weathering (Fig. 3b). The deposition continued until the time of blocking vaulting which produced the Basin and Range structure of the area, late Tertiary to Recent (Fig. 3c).

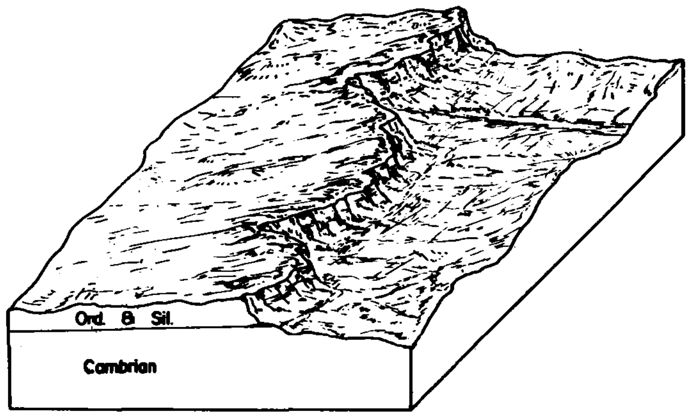
The alluvial deposits are found on the eastern dip-slope of the Sawtooth Mountains and in the eastern and southern hills of the Ibex Area just south of the mapped area. The alluvium contact has been observed in contact with only rock units older than the Eureka Quartzite, which is Upper Ordovician; and below, between and above the igneous flows in the Ibex Area which are thought to be Tertiary in age.

In the writer's opinion, the age of the Tertiary alluvium ranges from early Eocene to the time of block-faulting, which may range from Miocene to Pliocene. No attempt has been made to correlate this deposit to other Tertiary formations.

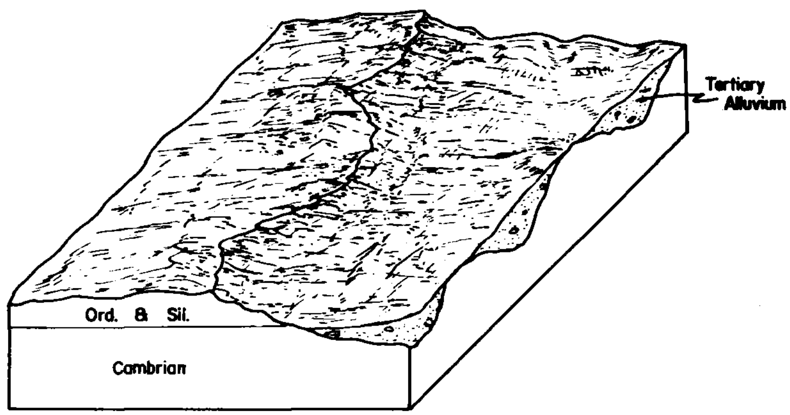
Plate 3.

Tertiary Alluvium in Behunin Canyon.

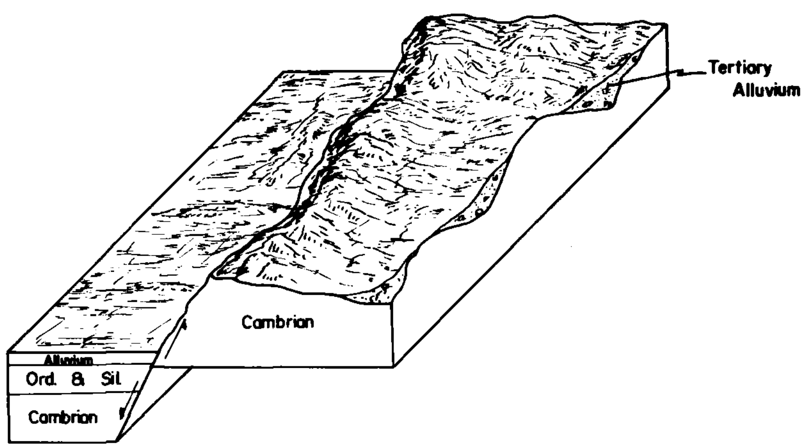
Fig. 3.



A. Uplift and erosion of the Paleozoic strata



B. Deposition of the Tertiary alluvium



C. Down faulting of source area by block-faulting

Basin and Range
Structure

QUATERNARY SYSTEM

Lake Bonneville sediments and recent alluvial deposits represent the Quaternary System.

Lake Bonneville sediments are exposed on the western side of the mapped area. These sediments have been mapped as the Bonneville and Alpine Formations on the basis of fossil assemblege of the Alpine Formation, stratigraphic position, and composition of the two formations. The Bonneville is represented by sands and gravels, which are rounded and exhibit good grading and cross-bedding. The Alpine Formation is represented by light-gray, very calcareous, diatomaceous marl. These sediments range in grain size from clay to silt, and have well preserved laminae. A sample of the Alpine Formation was dissolved in HCl and 1/5 of the volume was noted to be composed of residual material, mostly quartz fragments, diatom tests, and glass shards of volcanic origin.

Recent alluvium is represented by reworked Tertiary alluvium, Lake Bonneville sediments, and recent stream alluvium deposited by intermittent streams. Much of the sediments of the Bonneville and Alpine Formations have been reworked or covered by recent alluvium; therefore, the writer has designated and mapped this material as recent alluvium except where terraces or fans are still preserved or where the exposures of light-gray diatomous marl is exposed.

IGNEOUS ROCKS

The Notch Peak intrusive crops out in an elliptical area at the northern portion of the mapped area. The long axis of the stock is perpendicular to the trend of the range. Several large granitic sills project from the main stock into the surrounding country rock along the western base of the range, extending from Pierces Canyon southward to Notch Peak and Hansen Canyon. Many small dikes and sills, showing a wide variation in color, grain size, and composition, cut both the intrusive and the surrounding country rock. Small tabular pegmatities bodies are associated with the large sills and the granitic stock.

The Notch Peak intrusive is an ortho-magmatic stock measuring four and one-half miles by two and one-half miles and is composed of grayish-orange pink, porphyritic granite. In the mapped area, the intrusive crops out in Behunin, Granite, Pierces, and Notch Peak Canyons. As illustrated on Plate 4, the igneous-country rock contact is very sharp, weathers to rounded outcrops and has a well defined system of joints due to the cooling of the magma. The strong orientation of joints which are very apparent in the field and on the photo may be divided into four main systems which are: North 80 West to South 80 West; South 45 West; North 45 West; and generally North-South dipping almost vertically.

Megascopically the granite of the Notch Peak intrusive is a crystalline porphyritic rock with phenocrysts about 2 cm. long and 1 cm. wide, and the ground mass averages about 5 mm. in diameter. The euhedral phenocrysts of orange-pink orthoclase give the orange pink tone to the intrusive. The ground mass consists of white plagioclase, orange-pink orthoclase, gray quartz, and biotite.

Petrographically the granite samples were identified as having the following suite of minerals present:

Orthoclase: As both phenocrysts and as grains in the ground mass. The othroclase crystals may be slightly pherthitic and have inclusion of plagioclase, quartz and biotite. Sericite and kaolonite are common.

Quartz: Variable in size and are interstitial to the feldspars. Some of the quartz show a faint pattern of light and dark bands resembling microcline twining. Some phenocrysts present.

Plate 4

Sharp contact of the intrusive and metamorphic rocks.

Shows rounded outcrop and joint systems of the intrusive.

Aplite dike cutting the Notch Peak intrusive.
Sharp contact.

Plagioclase: The plagioclase is of oligoclase composition which was determined by the extinction angle, which is from 5 to 12 degrees. Albite twinning is most common with many crystals exhibiting good zoning. Sericite and kaolonite common.

Biotite: Strongly pleochroic from dark brown to almost colorless. Biotite occurs as anhedral grains interstitial to and penetrating the plagioclase and included in the quartz and orthoclase. Inclusion of apatite, zircon, and magnetitie. Replaced partly by a green weakly birefringent chlorite.

Other accessory minerals are: Sphene, apatite, zircon, and magnetite.

The following petrographic analysis are of three samples taken from the Notch Peak intrusive. (Field collecting localities may be observed on the geologic map.)

No.	Orth.	MicroPerth.	Plagio.	Quartz	Biotite
100	36	25	15	20	4
5	33	18	18	28	3
185	31	28	14	24	3

Sample KP 100 was chemically analyized by the United States Bureau of Mines, Salt Lake Division, for the writer and the following minerals and mineral percentages were reported.

Na_2O	K_2O	CaO	MgO	SiO_2	Fe_2O_3	Al_2O_3
4.05	3.65	2.25	0.50	71.0	4.15	14.2

On the bases of the petrographic and chemical analysis, the writer has with the use of Whalstorms' book Igneous Minerals and Rocks classified the Notch Peak intrusive as a porphyritic granite. Gehman classified the intrusive as a quartz monzonite.

Tabular bodies of fine- to coarse-grained igneous dikes and sills cut the stock and sedimentary rocks and are located on the geologic map. The dikes cutting the stock are generally a foot or two thick and do not maintain a constant strike throughout their length, but pinch out abruptly and may have numerous branches. Their contact with the granite stock is very sharp and has a greater resistance to erosion; therefore stand out sharply in relief (Plate 5).

The following is a petrographic analysis of two of the granular dikes that cut the stock:

No.	Orth.	Plag.	Quartz	Muscovite	Pherthite
3b	66.18	2.68	30.34	.8	
4	50.00	9.23	34.20	.2	6.00

The samples were severely altered, with sericite and small flakes of muscovite present. Small euhedral crystals of apatite and quartz.

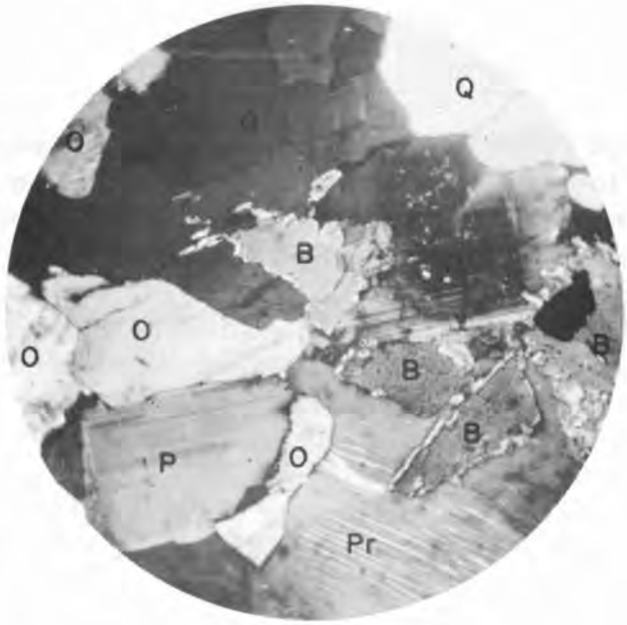
The dikes and sills in the sedimentary rocks vary from a few feet in thickness to 15 to 20 feet, but usually keep a constant strike and dip. They may change in texture and composition with an individual sill or dike. In many of the slides of the dikes and sills quartz has replaced much of the feldspars. The following samples were analized by the writer and were found to have the following minerals present and percentages as listed below.

	Plag.	Ortho.	Quartz	Pherthite	Biotite
KP 28	45.00	20.00	35.00		
KP 31	42.00	19.00	24.80	3.00	1.20
KP 33	46.00	22.00	30.00		2.00
KP 45	32.88	29.01	33.46	3.67	.98

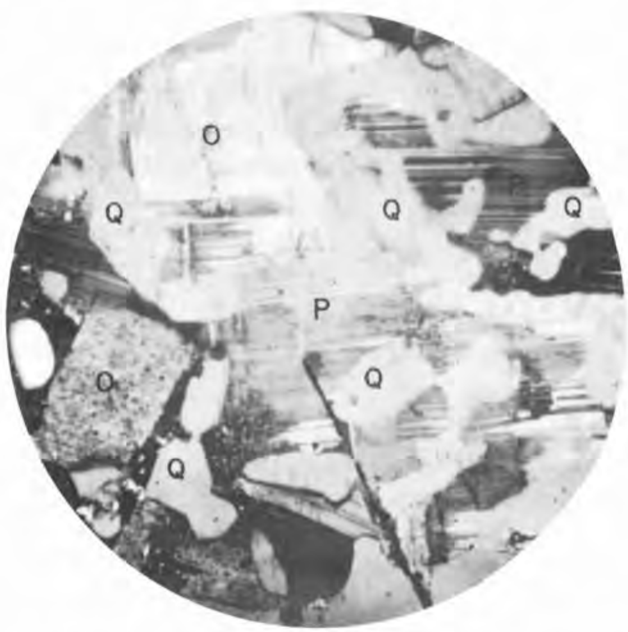
Small tabular pegmatites are found within the stock and the two large sills on the western base of the range. The mineral assemblege is feldspars, quartz, biotite, muscovite, tourmaline and pyrite.

The Notch Peak intrusive, dikes, and sills can only be dated as post Cambrian by the stratigraphic units present; and pre-Basin and Range structure (Miocene-Recent) by structural means. Noland (1943) considers that most of the small stocks common to eastern Nevada and western Utah to probably be early Tertiary in age. Lindgren (1915) states that the small stock common to the same area may range in age from Late Jurassic to Tertiary.

Plate 6.



A. Slide 100. Photomicrograph of Plagioclase (P), Orthoclase (O), Quartz (Q), Perthite (Pr), Biotite with outer edges altered to chlorite (B), and Magnetite (M). (X150).



B Slide 45. Photomicrograph of typical dike rock. Plagioclase (P), Orthoclase (O), and Quartz (Q). (X150)

METAMORPHIC ROCKS

The metamorphic aureole around the Painter Springs intrusive ranges approximately one to two miles from the periphery of the intrusive. The metamorphic rocks have been divided into four main zones which are the tactite, silicatization, silicification, and recrystallization.

The tactitic zone is composed almost entirely of andradite garnet, with small amounts of quartz, tremolite, epodite, tourmaline, scheelite, molybdenite, and calcite. The tactite zone ranges in width from a coating on some of the joints to deposits approximately 50 feet by 150 feet around the igneous contact. The zone of silicatization is approximately one mile wide and is constituted of such metamorphic rocks as biotite-anorthite hornfels, banded biotite marble, banded idocrase marble, wollastonite, and gray limestone with microscopic metamorphic minerals. Silicification zone extends for a varying distance around the zone of silicatization. Rocks in this zone have been mostly hardened by the thermal metamorphism with some addition of free silica. Recrystallization has occurred in some selected beds for a distance of two to three miles from the intrusive. An example of this selective recrystallization is examplified by the top limestone unit of the Orr Formation which has been recrystallized for a distance of three miles from the intrusive. Many beds which constitute the units of Notch Peak have also been recrystallized. This selective recrystallization of these beds is due to hydrothermal and pneumatolytic alteration.

According to Gehman (1954) the metamorphism of the area was a result of wide spread isochemical-thermal metamorphism and silica metasomatism, and localized iron-silica metasomatism of the surrounding sedimentary rocks.

The main mineral assemblege of the metamorphic rocks are idocrase, garnet, biotite, plagioclase, diopside, woolastonite, tremolite and epiodite which have generally developed parallel to the bedding plane of the sedimentary rocks.

The following is the classification of the three distinct types of metamorphism and type of rocks produced by the alternation of the original sedimentary rocks as defined by Gehman.

Isochemical-Thermal Metamorphism:

1. Biotite-anorthite hornfels.

2. Gray limestone with microscopic metamorphic minerals of wollastonite, diopside, and oligoclase.
3. Banded biotite marble which consist of alternating layers an inch or so thick of biotite-anorthite hornfels and calcite marble.

Silica Metasomatism:

1. Banded idocrase marble consisting of idocrase, diopside, grossularite, and small amounts of calcite, albite, and rarely epidote.
2. Massive idocrase marble -- same minerals present as in the banded idocrase marble.
3. Wollastonite rock.

Iron-Silica Metasomatism:

1. Tactite in banded idocrase.
2. Tactite in aplite.
3. Tactite in gray limestone.

Samples of the tactite zone were analyized by the writer and the following minerals were identified: Andradite, scheelite, mobybdenite, diopside, calcite, quartz, pyrite, tourmaline, and epidote. Two samples of the tactite zone were spectrographicly analyized by the United States Bureau of Mines, Salt Lake Division, for the writer and the following approximate percentages were reported.

A: Probably 10%	D: Probably 0.01 to 0.1%
B: Probably 1 to 10%	E: Probably 0.001 to 9.01%
C: Probably 0.1 to 1%	F: Probably 0.0001 to 0.001%

Li: D	Sr: C	Zr: D	V: D	Cr: E
Ca: A	Ti: C	Co: D	Ni: D	Mg: B
Pb: E	Fe: A	Rb: E	Be: F	Si: A
Mn: C	K: C	Al: B	Ga: E	Mo: D
Na: C	Ba: D			

The metamorphism is related to the intrusion of the igneous bodies. The isochemical-thermal metamorphism occurred during and shortly after the intrusion of Notch Peak magma and was followed by the silica metasomatism. The silica metasomatism was dated as post aplite intrusion by Gehman because of the following factors:

"1. The dike contact, which later served as controlling channels for the tungsten- and molybdenite-bearing fluids, has no controlling effect on the silica metasomatism.

"2. Blocks of metamorphic rock within the large sills have the mineralogy and textural characteristics as the country rock from which they were detached. These blocks should have been effectively sealed off by the relatively impermeable aplite from the solutions causing the metasomatism, if the aplite intrusions preceded metasomatism.

"3. A reaction zone might be expected between the silica- and aluminum rich aplite and the calcite, if the aplites had been present before the metasomatism. No change is noted in either the texture or composition of the limestones or marbles in contact with aplites, that no such reaction took place."

The iron-silica metasomatism that formed the tactitites zone followed the intrusion of the aplite dikes and is late in the time sequence. Gehman states that the tungsten and molybdenum followed the aplite intrusion because of the presence of molybdenite replacing the igneous minerals, and development of andradite at the expense of the igneous minerals.

N-S - compression

STRUCTURE

A traverse from Sand Pass, House Range, to Steam Boat Pass of the Ibex Area, a distance of about 15 miles, forms a broad, low amplitude anticline and syncline (Fig. 4). The anticline and syncline are thought to be the result of the north-south compressional forces of Late Jurassic to Tertiary. The writer is cognizant that the House Range is thought to be the south-eastern slope of a north-south trending anticline, because of the north-south trending folds in the Confusion Range and the gentle eastward dip of strata in the House Range. The dip of the strata in the House Range is low enough that it would be difficult to determine whether the dip of the beds are a result of a north-south anticline or due to the uptilted block-faulting of the Basin and Range structure and the east-west trending anticline. It is possible that all of the forces have helped determine the attitude of the beds, but it is the opinion of the writer that the latter forces are responsible for the present structure of the House Range.

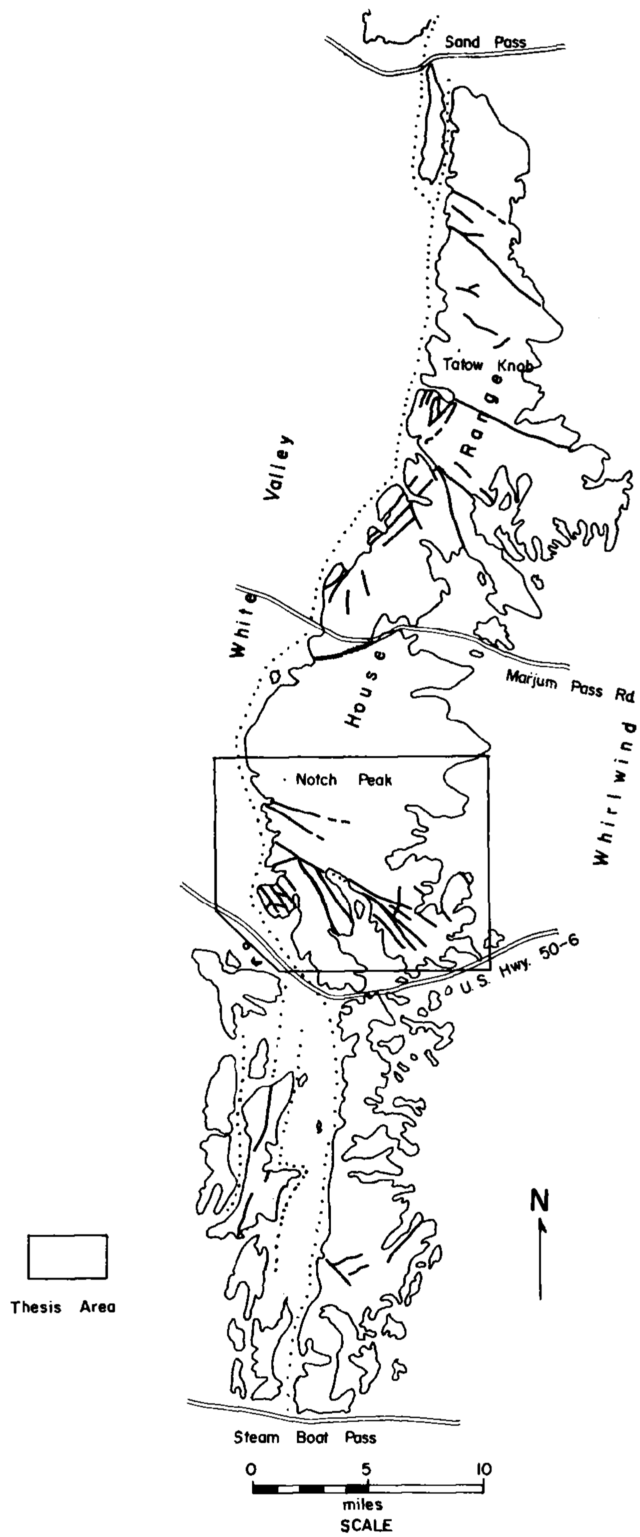
As illustrated on Fig. 4, the House Range has two major fault systems, which are those resulting from forces from Late Jurassic to Tertiary which generally trend north 50 to 80 degrees west and the faults resulting from the Basin and Range structure which generally trend north-south. The major fault of the range is the White Valley Fault, Basin and Range structure, which formed the steep fault scarp along the western side of the House Range. The vertical displacement along the range from Sand Pass to Notch Peak is estimated as approximately 9,000 to 10,000 feet, but gradually dies out in the Ibex Area, just north of Steam Boat Pass.

The mapped area is located on the south limb of the anticline and the beds generally strike north 30 to 50 degrees east and dip 8 to 13 degrees to the south. The area has two major fault systems which are the result of the forces of Late Jurassic to Early Tertiary and the block-faulting, Basin and Range structure, Late Tertiary. The two main faults which are dated as post block-faulting are the Hansen Canyon fault and the Notch Peak Cove fault, which generally trend north 70 degrees west and have a vertical displacement of approximately 500 to 1000 feet. Faults resulting from the block-faulting usually parallel the White Valley fault which generally trends north-south.

Hansen Canyon fault is located in Hansen Canyon just south of Notch Peak. The fault strikes north 70 degrees west and dips 80 to 85 degrees to the south and may be traced for approximately two miles. The fault zone is narrow, has very little breccia and has been cemented by calcite. The

Fig. 4

Structural map of House Range and Ibex Area showing fault systems.



south side has been faulted down and placed the Notch Peak Limestone, Dunderberg Shale and Orr Formation opposite the Dunderberg Shale, Orr and Weeks Formations respectively.

Notch Peak Cove fault is located in the southern portion of the mapped area. The fault generally strikes north 70 degrees west and dips approximately 80 to 85 degrees to the south and may be traced for approximately 6 miles. At the east end of the fault it divides into a few minor faults with an approximate displacement of 20 to 100 feet. Where the fault is not covered, the zone of brecciation is narrow, has very little fault breccia and has been cemented by calcite. The south side has been faulted down approximately 1000 feet placing the Notch Peak Limestone opposite the Dunderberg Shale, Orr Formation and House Limestone.

White Valley fault is a high-angle normal gravity fault which was formed by block-faulting. The fault has been covered by valley fill and Lake Bonneville sediments. The approximate location of the fault has been estimated on the bases of the fault scarp along the western side of the House Range. The general strike is north-south but in the southwestern corner of the mapped area the strike changes to north 45 degrees west. Small outcrops of the Eureka Quartzite are found in the valley between the House and Confusion Range, thus it is presumed that the Upper Ordovician is faulted down opposite the Lower Cambrian strata along the White Valley fault. In the vicinity of Notch Peak, the vertical displacement has been estimated to be 9,000 feet and in the southwestern corner of the mapped area the vertical displacement has been estimated to be approximately 3,000 feet. Many faults with small vertical displacement are found in the area south of Notch Peak Cove fault. The faults strike vary from north-south to north 45 degrees west. In the opinion of the writer the faults are probably not due to the compressional forces of post-block-faulting but due to the isostatic adjustment of the block-faulting in the area.

The Notch Peak intrusive caused the doming and fracturing of the surrounding beds. The intrusive can only be dated as post-Cambrian by the stratigraphic units present but is probably Tertiary in age. The doming of the beds has changed the magnitude of the dip of the beds 5 to 10 degrees. The strike of the beds are generally tangent to the oval contact of the stock. Beds in the south and east keep their general dip and strike but the beds on the western flank of the intrusive has been strongly deformed and dip 8 to 20 degrees to the west.

SUMMARY OF GEOLOGIC HISTORY

The Cambrian and Ordovician strata of the House Range occupied a paleographic position near the central portion of the Paleozoic miogeosyncline. This is attested by great stratigraphic thickness, lithologic units, notable continuity of its formation along the northeast trending geosyncline, and by seemingly unbroken continuity of sedimentation through Cambrian to Lower Ordovician times. This general process of subsidence in the shallow Paleozoic seas was interrupted many times by local uplifts that usually bordered the sites of this, relatively complete sedimentary accumulation, such as in the House Range area. These uplifts caused deposition of large blankets of clastic sediments such as the Eureka Quartzite and Swan Peak Quartzite in the Confusion Range.

During late Jurassic to early Tertiary, compressional forces folded, faulted, and uplifted most of the area of the Cordillerian Geosyncline. In the House Range the compressional forces produced a gently folded anticline and syncline from Sand Pass to the southern end of the Ibex Area, which has an east-west axis. The faults in the area are normal gravity faults which generally trend northwest and have an approximate displacement of 500 to 1000 feet.

The Notch Peak intrusive can only be dated as post-Cambrian by the stratigraphic units present, but Nolan (1943) considers that most of the small stocks common to eastern Nevada and western Utah to be early Tertiary in age. The igneous intrusive caused the doming, fracturing and metamorphism of the surrounding strata.

Deposition of the Tertiary alluvium started shortly after the uplift of the area. The agents of erosion dessected and eroded the area and the sediments were transported and deposited in other areas by streams, flashfloods, and landslides; or deposited in place by residual weathering. The deposition continued until the time of blocking faulting which produced the Basin and Range structure in the area, Miocene to Recent.

During late Tertiary, the block faulting produced the Basin and Range structure in the area. This faulting produced the fault scarp along the western side of the House Range which has an approximate displacement of 9, 000 feet. Alluvial fans formed along the fault scarp and were later cut or covered by the Lake Bonneville and recent sediments.

ECONOMIC GEOLOGY

MINES

Mining is of little importance in the area except for small deposits of tungsten ore around the periphery of the Notch Peak intrusive. The tungsten ore occurs in small tactite zones and the main mineral assemblege of the ore is scheelite, molybdenite, pyrite, andradite, epidote, and quartz. The tungsten ore in the area has an average grade of 0.9 per cent WO_3. Mining of the ore is accomplished by open pit, shafts, and adits. Cold placer claims are found at the apex of the North and East Forks of Granite Canyon. No production records of these placer claims were found. Small deposits of disseminated molybdenite are found in some of the aplite dikes radiating from the intrusive and in the tactite zones.

The main mines in the area are the South Pit and Pine Peak mines of the Treasure Mountains Mining and Milling Company; and the New Klondike mine of the Mid-States Development Company. The following production records of these mines were secured from the U. S. Bureau of Mines, Salt Lake City.

Treasure Mountain and Milling Company: 4,300 tons crude ore, average grade 0.8 per cent WO_3, recovered 2,384.16 units which netted $146,842. Company records state 2,431.6 units valued at $143,167.42. The Rainbow Mine yielded 3,000 tons of this ore and the remainder came from the Horseshoe, Sidesprings, South and Mt. Baldy Mines. Pinke Peak Mine recovered 175 tons, $2,633. Three hundred tons remain stockpiled.

Mid-States Development Company: New Klondike Mine: 366 units recovered which netted $31,231.

The mines are now closed due to the low price per unit of WO_3.

WATER SUPPLY

The water supply of the area is derived from springs located on the granitic stock or by intermittent streams during early spring. Main water supply is a reservoir near the Mid-States Development Dompany buildings in Granite Canyon. Other main water reservoirs are located just north of the mapped area at Painter Springs, a water tank at the intersection of the White Valley Grazing road and the Painter Springs road, and the Moody Reservoir at the east end of Amasa Valley. The lack of water has been a main factor controlling the expansion of mining operations and the concentration of the tungsten ore for shipment.

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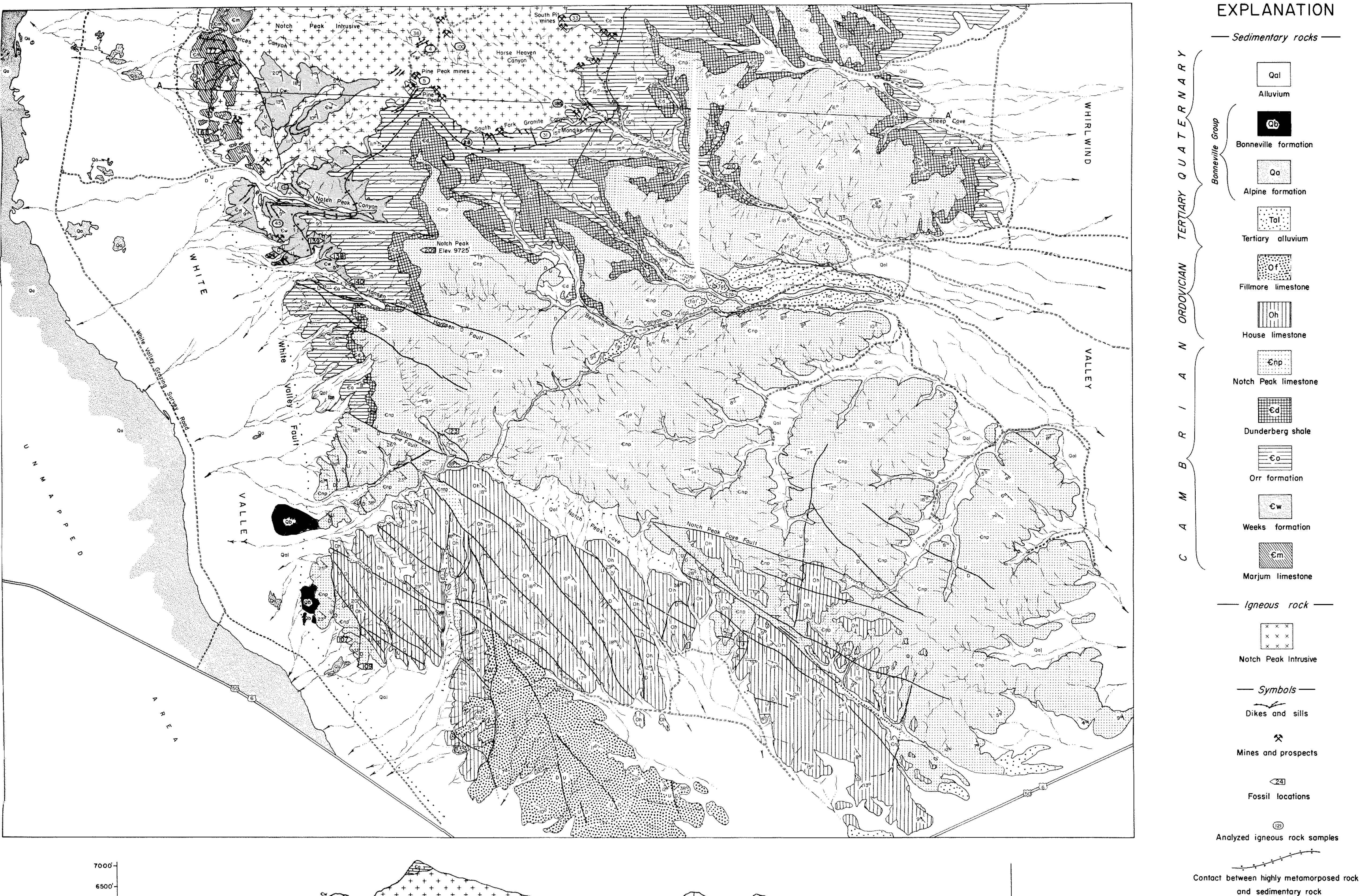

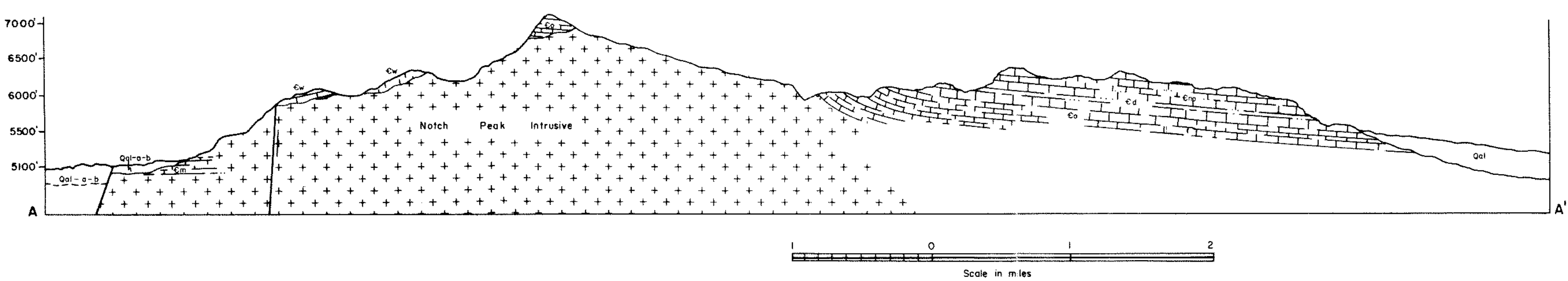

GEOLOGIC MAP AND CROSS SECTIONS OF THE SOUTHERN HOUSE RANGE, MILLARD CO., UTAH

By

D. KEITH POWELL