GEOLOGY OF THE CEDAR MOUNTAINS
TOOELE COUNTY, UTAH

By

Robert Eugene Maurer

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Robert E. Maurer

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ABSTRACT

The Cedar Mountains are in northwestern Utah in the northeastern part of the Basin and Range Province. The area mapped is about 60 miles west of Salt Lake City, Utah and includes an area of about 550 square miles.

Sedimentary strata exposed in the Cedar Mountains range in age from Late Mississippian to Recent. No Mesozoic beds outcrop in the Cedar Mountains. The sedimentary rocks have been divided into 10 different formations with a total thickness in excess of 20,775 feet.

The Paleozoic strata have a thickness of about 19,700 feet distributed amont the systems as follows: Mississippian 5790+, Pennsylvanian 5695, Permian 8190+. Thickness, in feet, of the series of Permo-Pennsylvanian age are: Guadalupian, 652+; Leonardian, 4772; Wolfcampian, 2772; Virgilian, 2390; Missourian (?) 487; Des Moinesian, 1473; Morrowan-Atokan, 1345. Quartzose sandstone, medium and dark gray limestone, black shale, and quartzite are typical of the Mississippian strata. Overlying beds of the Oquirrh and "Permian unnamed formation" are composed of sandy, cherty, and bioclastic limestones, sandstones and quartzites. Massive limestone, dark gray, thin-and medium-bedded dolostone, chert and phosphate beds succeeded upward by yellow-brown

and pink limestone constitute the highest units of the Paleozoic succession.

A basal red conglomerate and a sandy, tuffaceous formation constitute the early Tertiary sedimentary rocks and have an estimated minimum thickness of 1,100 feet.

Unconsolidated deposits of alluvial gravel, lacustrine clay and sand and gravel, and eolian sand comprise the latest Tertiary and Quaternary materials.

Folds, domal uplifts, thrust faults, high-angle reverse faults, strike-slip faults, transverse faults and block-faults constitute the more important structures recognized in the Cedar Mountains. Folds, thrust faults, high-angle reverse faults and a strike-slip fault developed during the Laramide Orogeny. Domal uplifts are probably related to intrusive activity and can only be dated as younger than folding of Early Laramide age. Transverse and block faults are features younger than early Tertiary basaltic andesite extrusives.

Rhyolites, of probable intrusive origin, a basaltic andesite series and basalt comprise the igneous rocks of the Cedar Mountains. The rhyolite and the basaltic andesite series are considered to be of early Tertiary age while the basalt is probably of Miocene or Pliocene age. Probable source areas for part or all of the extrusive rocks are located within the area of the investigation.

Vein deposits of aragonite, sand and gravel, and ground water have been of economic importance in the Cedar Mountains. Thin beds of phosphate rock in the west-central Cedar Mountains will not be of economic importance in the foreseeable future.

TABLE OF CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS - Continued

ILLUSTRATIONS - Continued

INTRODUCTION

PURPOSE OF THE STUDY

The purpose of the study was to distinguish the various stratigraphic and structural elements within the Cedar Mountains, to determine the interrelations of these elements, and to correlate their development with that of the surrounding region.

LOCATION AND ACCESSIBILITY

The Cedar Mountains Range is about 60 miles west of Salt Lake City, Utah mainly south of U. S. Highway 40 and Alternate 50. (Fig. 1). Secondary roads entering U. S. Highway 40 provide the easiest access to the northern part of the range while the central and southern sectors are reached easiest from the Dugway Proving Grounds road which joins U. S. Highway 40 at Timpie Junction. One can reach the foothills of any desired part of the range by means of dirt roads. A small four-wheel-drive vehicle can be used in the higher foothills and perhaps a little higher in some localities but most of the areas of bedrock exposure must be reached by means other than four-wheel vehicles. A pickup truck or four-wheel-drive vehicle provides the best transportation in this area for any off-highway driving. Even roads in the lowland

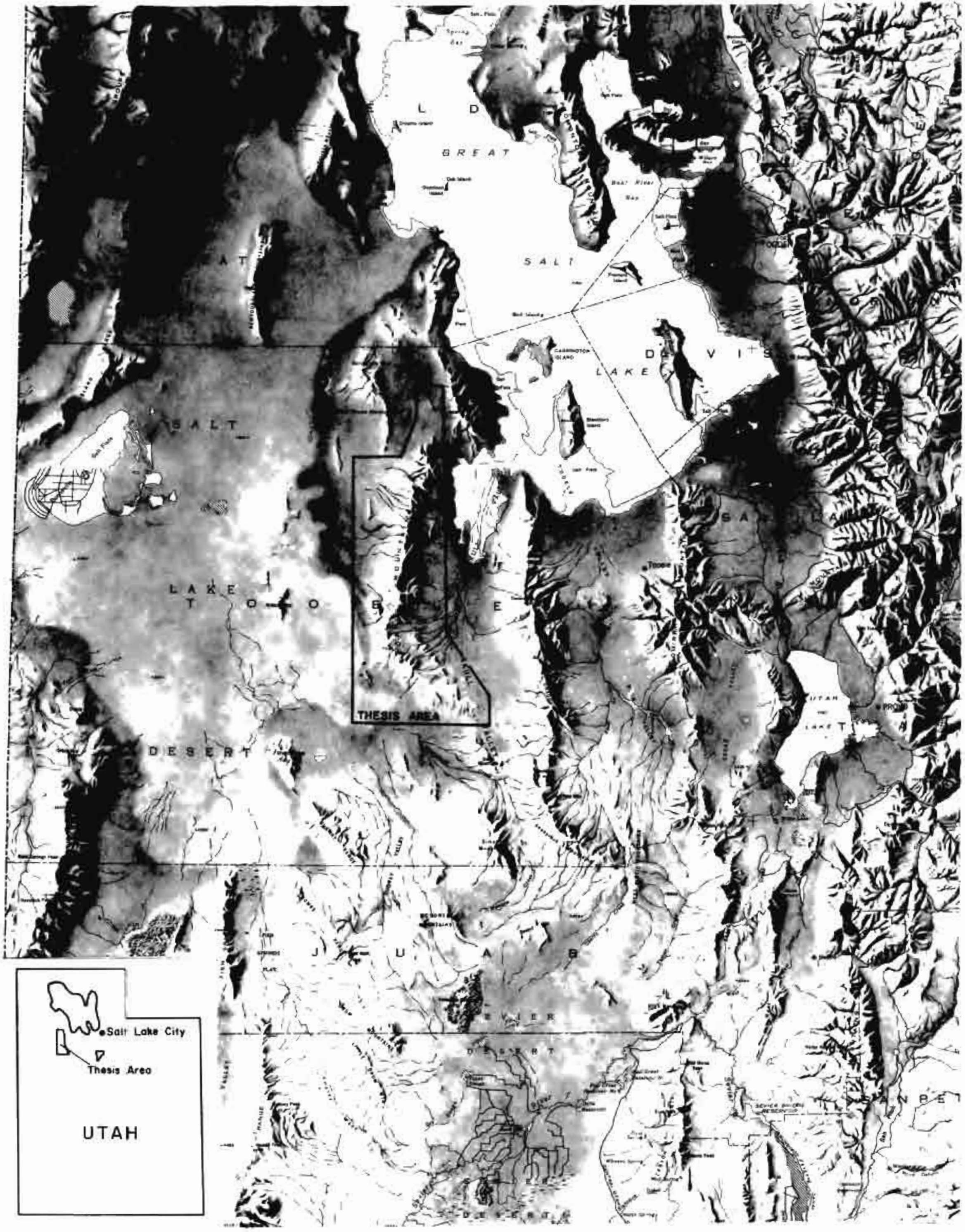

Fig. 1 - Index map to the Cedar Mountains, Tooele County, Utah

that appear to be easily passable have occasional deep ruts and soft sandy spots. Washouts from flash-floods, especially in late summer, can make the lower roads very difficult to traverse.

It is necessary to get permission to visit areas within the Dugway Proving Grounds at the headquarters in Dugway, Utah. The Army provides an escort for a visitor doing field work in the area. Also it is advisable to call at least a week in advance to arrange any visit to the Proving Grounds to learn whether the area of interest will be accessible at the time the trip is planned.

The Cedar Mountains Range is about 45 miles long and 10 to 12 miles wide, the width estimated on the basis of bedrock outcrop area. It extends from Township 2 North into Township 7 South (Salt Lake City Base Line) and from Range 8 into 11 West. The area in which surface features have been mapped is about 550 square miles.

PREVIOUS GEOLOGIC INVESTIGATIONS

The earliest record of geological observations in the Cedar Mountains is recorded in the Wheeler Geographical and Geological Explorations and Surveys West of the 100th Meridian (Howell, 1875, p. 239-40). Howell recognized the anticlinal nature of the range a short distance south of

Sulphur Spring. He also appears to have recognized the en echelon anticline developed in the Great Blue Formation east of the Cochran Valley anticline in the southern Cedar Mountains.

King (1877, p. 462-65) described the unusual, grayish-white, rounded hill south of Cochran Spring, White Rock, as quartziferous trachyte and also recognized that the reddish volcanics in that area had been emplaced over a surface of some relief. He also commented on the basaltic lava in the vicinity of Hastings Canyon. He did not recognize the intra-range faulting north of Hastings Canyon, however, and surmised from the limited exposures he was able to observe that the structure north of Hastings Canyon constituted a syncline plunging northward.

Zirkel (1877, vol. 6) studied the igneous rocks collected as part of the Fortieth Parallel Survey. He described a thin section of the white rock rhyolite and one of reddish, andesitic flow-rock west of White Rock in considerable detail.

Woolley (1912) studied a small area in the vicinity of the Utah Calcium Company's aragonite mine in West Hastings Canyon. He mapped a total of five aragonite veins in the area and discussed the probable origin of the deposit.

Ives, (1946) described the volcanic neck known as

Moroni's Post Pile in the southwestern Cedar Mountains about 3 miles west of Cane Spring.

Johnson and Cook (1957) reported the results of a regional gravity survey of an area which included the southern part of the Cedar Mountains. About 60 gravity stations were occupied in or immediately adjacent to the mountain range. They found evidence of a major Basin and Range fault zone along the southeastern margin of the Cedar Mountains.

Bissell (1960, p. 1427) measured and described a composite section of the sedimentary units exposed in the Cedar Mountains as part of a comprehensive study of eastern Great Basin Permo-Pennsylvanian strata. He has referred to this Cedar Mountains section in more recent discussions (1962, 1964) of Permo-Pennsylvanian geology of the Great Basin.

FIELD WORK

The Field work was begun during the latter part of the summer of 1956. Most of the project was completed during the 1957, 1958, 1959, 1960 field seasons but occasional visits were made after 1960 and continued until August 24, 1966 when the writer made his final observations in the Cedar Mountains.

During the 1957 through 1960 field seasons the writer usually camped in the field four days per week. Most of the traverses into the mountainous areas had to be made on foot. The mapping was all done on air photos at an approximate scale of 1:20,000. The Oquirrh Formation section measured west from Cochran Spring and the Park City-Phosphoria-Gerster Formation sections were measured with a five-foot jacob staff and Brunton Compass. All other measured sections were made with a steel tape and Brunton Compass.

THE GEOLOGIC MAP

An acetate film base for the geologic map of the Northern Cedar Mountains was prepared by means of a radial line assembly using control points selected on the air photos. Geologic data were transferred to the base using an optical plotting device.

The base for the geologic map of the southern Cedar Mountains was drafted on acetate film base using topographic quadrangle maps published by the United States Geological Survey and geologic data was transferred from the photographs manually using topographic and cultural features as a guide in plotting.

STATIGRAPHY

General Statement

Rocks of Mississippian, Pennsylvanian, Permian, and Tertiary age and Quaternary sediments are exposed in the Cedar Mountains.

Approximately 19,700 feet of Paleozoic sedimentary rocks divisible into 8 different formations outcrop within the Cedar Mountains. Quartzose sandstone, medium and dark gray limestone, and black shale and quartzite are typical of the Mississippian strata. Overlying beds of the Oquirrh and"Permian unnamed formation"are composed of sandy, cherty, and bioclastic limestone, sandstone and quartzite. Massive limestone, dark gray dolostone, chert, and phosphatic beds succeeded upward by tan and pink limestone constitute the highest units of the Paleozoic succession.

No Mesozoic strata outcrop in the Cedar Mountains.

A basal, red conglomerate and a sandy, tuffaceous formation containing fossiliferous, white, lacustrine limestone constitute the early Tertiary sedimentary rocks in the Cedar Mountains. The minimum exposed thickness of these units is about 1,100 feet. A minimum of about 800 to 900 feet of early Tertiary basaltic andesitic volcanic strata outcrop in the southern Cedar Mountains.

Some of the alluvial sand and gravel deposits which cover the bedrock along the flanks of the northern Cedar Mountains are probably of late Tertiary age. The basalt in the Hastings Canyon area is also considered to be late Tertiary in age.

Clay and silt deposits of Pleistocene Lake Bonneville outcrop south of U. S. Highway 40 where it passes around the northern end of the Cedar Mountains. Gravel deposits of considerable magnitude are located at the north end and along the southeast margin of the range.

Recent sand dunes mask a large area underlain by Tertiary volcanics and Paleozoic strata in the southeastern Cedar Mountains from White Rock to Dugway.

Table 1. - Rocks of the Cedar Mountains Area.

SYSTEM	SERIES	FORMATION	THICKNESS (Feet)
Quaternary	Pleistocene to Recent	Unconsolidated deposits	?
	Miocene or Pliocene	Basalt	50-100
Tertiary	Early Tertiary	Basaltic andesite series	
		Upper mbr.	500+
		Middle mbr.	100-150
		Lower mbr.	250-300
		Rhyolite (intrusive)	
	Paloecene or Eocene	"Tertiary unnamed fm."	300+
		North Horn(?)Fm.	800+
		Total Tertiary	2,150+
Permian	Guadalupian (652+ ft)	Gerster Fm.	*511+
		Phosphoria Fm. Meade Peak Mbr.	*141
	Leonardian (4772 ft)	Park City Fm. Grandeur Mbr.	*419
		"Permian unnamed fm."	*3953
		Oquirrh Fm.	
		Unit 5	*1935+-2750 *340+
	Wolfcampian (2772 ft)	Unit 4	*2762-3000
		Total Permian	8,190

SYSTEM	SERIES	FORMATION	THICKNESS (Feet)
	Virgilian (2390 ft)		
	Missourian (487 ft)		
		Unit 3	*2556-3000+
Pennsylvanian	Des Moinesian (1473 ft)		
		Unit 2	*715-1400
	Morrowan-Atokan (1345 ft)		
		Unit 1	*434
		Total Pennsylvanian	5,695
Mississippian	Chesterian	Manning Canyon Fm.	1500-2000
		Great Blue Fm.	*2441+
	Meramecian	Humbug Fm.	*1014+
		Total Mississippian	5,790
	Estimated thickness of sedimentary rocks		20,775+
	Estimated thickness of volcanic rocks		1,050+

*Formation thicknesses measured in the field.

MISSISSIPPIAN SYSTEM

Humbug Formation

Distribution and Thickness

The Humbug Formation is exposed in the southeastern Cedar Mountains about a mile east of White Rock (Fig. 2). Outcrops occur discontinuously along a northwest-trending belt about three miles long. The Humbug is, in general, a poorly exposed unit which exhibits smooth slopes often mantled with its own talus. It appears at the surface along the eastern limb of an anticline cut obliquely on its western margin by the Cochran Spring Fault. The Humbug Formation is bounded on the north, east, and south by the overlying Great Blue Formation and along its western edge by the Cochran Spring Fault. The Humbug Formation is less resistant than the Great Blue Limestone and forms low hills and slopes along its western escarpment. The best exposures are just north of Wide Hollow where an incomplete section of 1,014 feet was measured. The base of the formation is not exposed in the Cedar Mountains.

Lithology

The Humbug Formation consists predominantly of fine- to medium-grained, thin-to medium-bedded, sandstones and ortho-quartzites. There are some medium and dark gray limestone beds in the middle part of the formation. Sand grains are sub-rounded and the sandstone units are cemented with calcite. The sandstone and quartzite beds are usually yellow-brown or gray on fresh surfaces but weather to shades of yellow-brown, brown, orange, and maroon.

Limestone beds occur mainly in the middle part of the formation and comprise one relatively resistant unit about 263 feet below the top of the formation. The thin-to medium-bedded limestone layers contain numerous thin horizontal black chert stringers. Corals and brachiopods are common in the limestone layers.

Three principal lithologic divisions are visible in Humbug Formation in the Cedar Mountains. The lower division, base not exposed, comprises thin-to medium-bedded sandstone and quartzite overlain by a medium-to thick-bedded, ledge-forming quartzite bed about 24 feet thick. The middle division comprises sandstone and quartzite beds with occasional medium-bedded layers of gray sublithographic limestone topped by a cherty limestone unit about 38 feet thick. The upper division is again sandstone and quartzite beds which grade into the overlying Great Blue Formation. The contact was chosen at the first medium gray, medium-bedded limestone characteristic of the Great Blue Formation.

The lower part of the Humbug Formation is not exposed in the Cedar Mountains so the following measured section represents a minimum thickness.

Measured section of the Humbug Formation; north side of Wide Hollow in sec. 10, T6S, R9W. (Township unsurveyed)

Conformable Contact

Unit	Description	Thickness (feet)
5	Quartzite and sandstone, yellow-brown and light-gray, fine to medium-grained, calcareous, weathers yellow-brown, orange, and maroon. Some sandy limestone beds in upper 70 feet. F549.	263
4	Limestone, dark gray, thin-bedded, weathers light-gray, black chert in thin stringers, ledge.	32
3	Sandstone and quartzite, yellow-brown, to gray, very fine to fine-grained, medium-bedded, calcareous, weathers yellow-brown and gray; medium gray aphanitic limestone layers near the top, slope.	355
2	Quartzite, brown-gray to gray, medium-grained, medium-to thick-bedded, weathers yellow-brown and pale-lavendar, ledge.	24
1	Sandstone and quartzite, yellow-brown, maroon, and purple, very fine to fine-grained, thin-to medium-bedded, brecciated in places, some fragments have concentrically-banded colors, forms a slope.	334
Base covered by Quaternary	Minimum Thickness	1014

Age and Correlation

Tower and Smith (1899, pp. 625-626) named the Humbug Formation for exposures in the Tintic Mining District and assigned it a late Carboniferous age. Morris (1958, p. 20) reported on the general geology of the East Tintic Mountains and indicated an upper Mississippian age for the Humbug Formation, "since it lies between formations that are well-dated as Late Mississippian." Fossils collected from the Humbug Formation in the Oquirrh Mountains are correlated with the "earlier faunas of the Brazer Limestone" (Gilluly, 1932, p. 28). The age of the Humbug Formation in the Cedar Mountains is inferred to be Meramecian on the basis of foraminifers so dated (Herman, personal communication) and collected in the lower 30 feet of the Great Blue Formation (p. 22).

The Humbug Formation has been recognized in the Lakeside Mountains (Doelling, 1964, p. 178-180), the Stansbury Mountains (Rigby, 1958, p. 45) and other nearby areas. The Humbug Formation of the Cedar Mountains is correlated with that formation in the Tintic Mining District and other nearby localities on the basis of similar age, lithology, and stratigraphic position.

Fig. 2 - Photograph of upper Humbug and lower Great Blue Formations in the southern Cedar Mountains looking east.

Great Blue Formation

Distribution and Thickness

There are about eight square miles of outcrops of the Great Blue Formation in the southeastern Cedar Mountains between Rydalch Canyon and Post Hollow where it forms a long, low, northwest-trending rampart facing Skull Valley. The eastern base of the exposures is covered by alluvium but geophysical data indicate that a border fault of as much as 6,750 feel displacement may interrupt the formation near the mountain front (Johnson and Cook, 1957, p. 53). The Great Blue Formation protects exposures of Humbug Formation which flank its western base near White Rock. The thick, essentially pure (97±% calcite) limestone beds of the Great Blue Formation resist erosion and form steep well-exposed outcrops.

The Great Blue Formation is estimated to be at least 2,441 feet thick in the southern Cedar Mountains. The basal 522 feet of a composite section were measured on the west side of the mountain in sec. 32, 33; T5S, R9W (Fig.2). The horizon of the highest bed measured at that locality was followed northward and estimated to be about 300 feet below the base of the overlying strata whose measurement began in SW 1/4, sec. 13, T5S, R10W (unsurveyed) and proceeded northward to the highest exposed beds of the

Great Blue Formation. This upper measured sequence totaled 1,619 feet. The Great Blue-Manning Canyon Formation contact is not clearly exposed but the topography and occasional exposures suggest that the contact is near the highest measured outcrop of the Great Blue Formation.

Lithology

Limestone comprises the Great Blue Formation almost to the exclusion of other lithologies in the Cedar Mountains. Every unit in the measured section is designated limestone. Color ranges from medium to dark gray and the texture is usually finely crystalline or bioclastic. Crinoid and bryozoan fragments commonly form the majority of clasts in the detrital units. Many strata of the Great Blue Formation are medium-and thick-bedded and on weathering produce a rugged, ledgy topography. Gray and black chert in stringers and nodules are common in some beds in the upper part of the formation. Samples of five different beds in the upper third of the Great Blue Formation were collected by the writer for Morgan Peterson Enterprises of Sale Lake City, Utah. Chemical analyses of these samples indicated an average $CaCO_3$ content of 96.9%. No true shale beds, i.e., laminated, pelitic strata, were found in the Great Blue Formation in the Cedar Mountains in spite of the fact that they occur in the formation in more easterly and southerly locations (Rigby, 1958; Gilluly, 1932; Cohenour, 1959; Morris, 1957). Three zones that contain significant amounts of sand, one with well-differentiated sandstone beds, were observed in the southern Cedar Mountains. These beds constitute Units 7, 8, 16, and 19 (see measured section). Doelling (1964) found no shale in the Great Blue Formation in the Northern Lakeside Mountains but reports a "middle member" of slabby, sandy limestone, 574 feet thick with sandstone at the top.

The lower boundary of the Great Blue Formation is transitional into the Humbug Formation and is placed at the base of the first gray limestone characteristic of those in the Great Blue Formation. The upper contact with the Manning Canyon Formation is not exposed in the Cedar Mountains.

Composite Measured Section of the Great Blue Formation in Southern Cedar Mountains (See p. 15 for discussion of location)

Manning Canyon Formation
Conformable (?) Contact

Unit	Description	Feet
34	Limestone, medium gray, weathers same, finely crystalline, medium to thick-bedded.	11
33	Covered.	206

Unit	Description	Feet
32	Limestone, medium gray, weathers same, medium-to thick-bedded, few black chert nodules, cliff-former.	69
31	Limestone, medium to dark gray, weathers medium gray, finely crystalline to detrital, medium-bedded, occasional chert nodules, slope with small ledges.	87
30	Limestone, medium to dark gray, weathers medium gray, detrital to finely crystalline, medium-bedded to massive, about 25% chert, bedded, maroon, gray, and black. Makes one steep cliff undercut by a one-foot, shaly limestone bed.	28
29	Limestone, medium gray, weathers medium gray, clastic to finely crystalline, thin to thick-bedded, thin-bedded weathers to platy slopes, much gray to black chert in discontinuous layers, steep slope.	159
28	Limestone, medium gray, weathers medium blue-gray, finely crystalline, medium-to thick bedded, numerous fractures filled with white calcite, numerous corals, steep, ledgy slope.	227
27	Limestone, dark gray, weathers medium to dark gray, medium to thick-bedded, very finely crystalline, dark gray to black chert nodules.	84
26	Limestone, dark gray, weathers medium to dark-gray, finely crystalline, medium-bedded, small crinoid and bryozoan fragments, occasional horn coral, partly covered slope.	478
25	Limestone, dark gray, weathers medium to dark gray, medium-bedded, slope.	23
24	Limestone, dark gray, weathers medium to dark gray, horizontally-elongated brown chert nodules, numerous horn corals, forms ledges.	16

Unit	Description	Feet
23	Limestone, dark gray, weathers medium to dark gray, aphanitic to finely crystalline, medium- to thick-bedded, horn corals, forms slope.	33
22	Limestone, dark gray, weathers medium gray aphanitic to finely crystalline, medium to very-thick-bedded, fractured, ledge.	6
21	Limestone, dark gray, weathers medium gray medium-bedded, many white calcite seams, slope.	38
20	Limestone, medium gray, weathers same, aphanitic to medium-crystalline, mostly aphanitic, many solitary and colonial corals, ledgy slope.	35
19	Limestone, medium gray, weathers medium gray, fine to coarsely crystalline medium to thick-bedded, partly encrinal, has thin interlayers of sandstone, very-fine grained, tan, calcareous, froms a slope.	33
18	Limestone, medium gray, weathers medium gray, medium-to thick-bedded, partly encrinal, ledgy slope	16
17	Limestone, medium gray, weathers medium gray, very-thick-bedded, becomes medium- to thin-bedded in the top quarter, encrinal, frew thin layers of maroon sandstone.	45
16	Limestone, medium gray, weathers medium gray, medium-to thin-bedded, sandy laminations, slope weathers in places to yellow-brown platy fragments.	23
15	Limestone, medium gray, weathers medium gray medium to coarsely crystalline, medium-bedded, encrinal, forms a ledge.	2
		1619

Unit	Description	Feet
	Unmeasured interval	300
14	Limestone, medium gray, weathers medium dark gray, medium to coarsely crystalline, medium-bedded, forms strong ledges, weathers to a very finely irregular surface.	19
13	Limestone, dark gray, weathers medium gray, fine crystalline, thin-to medium-bedded, slope, F553-13,14 from units 13 and 14.	56
12	Limestone, medium gray, fine crystalline to calcarenitic, medium-bedded, makes small ledges.	53
11	Limestone, dark gray, weathers medium gray, fine crystalline, forms ledges, fetid odor from fresh break.	37
10	Limestone, medium gray, fine-crystalline, medium-to thin-bedded, many solitary corals, cherty, forms a slope.	39
9	Limestone, medium gray, weathers dove-gray, arenitic and fine-crystalline, medium-to thick-bedded, makes ledges, several lenticular chert zones, cross-bedded.	164
8	Limestone, medium gray, fine-crystalline some layers silty, medium-bedded, horn corals, forms a slope.	31
7	Limestone, medium gray, weathers medium gray, detrital, sandy (fine), cross-bedded.	11
6	Limestone, medium gray, fine-crystalline, thin to medium-bedded, forms a slope.	40
5	Limestone, medium gray, weathers dove-gray medium-to thick-bedded, much crinoid debris, makes double ledge.	5
4	Limestone, gray, weathers medium gray, detrital and fine-crystalline, thin-bedded, horn corals, forms slope F553-4.	17

Unit	Description	Feet
3	Limestone, medium gray, weathers medium gray, numerous beds sandy, small ledges (about 3 feet) separated by short slopes, sandy beds makes slopes, small horn corals and crinoid debris, F55303.	18
2	Limestone, gray, weathers medium gray, thin-bedded, sandy toward top, forms a slope, F553 from units 1 and 2. F674-1, F674-2, F674-3 from units 1 and 2.	27
1	Limestone, gray, weathers medium gray, sandy, detrital, thick-bedded, forms a ledge.	5
		522
	Conformable contact Minimum Total Humbug Formation	244;

Age and Correlation

Spurr (1895, p. 375) named the Great Blue Formation for exposures in the Mercur District of the Oquirrh Mountains. At that time its age was established on faunal evidence merely as Carboniferous. Gilluly (1932, p. 31) in his study of the Stockton and Fairfield Quadrangles in the Oquirrh Mountains collected faunal evidence supporting a Late Mississippian age for the formation. Since that time, it has been recognized at several localities in the vicinity of the type section and Girty (Nolan, 1935, p. 30) suggested the Great Blue Formation as the unit most nearly correlative with the Ochre Mountain Formation in the Deep Creek Mountains. Cohenour (1959, p. 93) mapped the Great Blue Formation in the Sheeprock Mountains and cited faunal evidence for a "basal Upper Mississippian (Chester) age." Doelling (1964, p. 183) made fossil collections from the lower and upper Great Blue in the Northern Lakeside Mountains indicative of Late Mississippian age. Rigby (1958, p. 38) suggested a maximum thickness of 1,300 feet for the incomplete section of Great Blue Formation in the Stansbury Mountains.

Sadlick (personal communication, see measured section) examined five fossil collections from the lower Great Blue Formation in the Cedar Mountains and reported as follows:

F549	*Lithostrotion* sp. (Collected 68 feet below top of Humbug Formation.)
F553	*Ovatia* sp. *Brachythyris* (?) sp. *Triplophyllites* sp.
F553-3 Unit	No. 3 *Striatifera brazerianus*
F553-4 Unit	No. 4 *Torynifera* sp.
F553-13/14 Units	No. 13-14 *Faberophyllum* sp. *Ovatia* sp. *Spirifer* sp. *Brachythyris* (?) aff. *ozarkensis*

"Late Visean, no younger than Mid-Chester."

Herman examined three limestone specimens from the lower thirty feet of the Great Blue Formation and reported as follows (personal communication):

(upper)	674-3	*Endothyra* *symmetrica*
		Endothyra *hamula*
		Plectogyra *irregularis*
		Plectogyra sp.
		Hyperammina sp.
		Hyperammina *tourniayella*
		Tetataxis *howchenia*
	674-2	*Endothyra* *symmetrica*
		Plectogyra sp.
		Plectogyra *irregularis*
		Hyperammina sp.
		Hyperammina *tourniayella* (?)
		Tetra-taxis *howchenia*
(lower)	674-1	*Endothyra* *symmetrica*
		Endothyra aff. *hamula*
		Endothyra sp.

Mr. Herman reported that these foraminiferal collections indicate late Meramec Age.

The Great Blue Formation of the Cedar Mountains is correlated with that unit in the nearby ranges on the bases of similar lithology, stratigraphic position, and age. Data now available regarding the occurrence of shale and quartzites in the Great Blue Formation suggest that both these lithologies decline in abundance northward and westward from the East Tintic Mountains, shale disappearing at some point east of the Cedar Mountains. The sandstone beds and sandy limestone of the Cedar Mountains section are in approximately the same stratigraphic position as the Chiulos shale of the East Tintic and Sheeprock Mountains.

Manning Canyon Formation

Distribution and Thickness

The Manning Canyon Formation is sparsely exposed in the Cedar Mountains, the total area of outcrop being estimated at about two square miles. Exposures are confined almost completely to the southeastern Cedar Mountains and the largest ones are in Cochran Valley about a mile southeast of Cochran Spring where black shale, sparse limestone, and underlying iron-stained quartzite rise to the surface along the crest of the Cochran Valley Anticline. The second most extensive exposure is near the mouth of east Rydalch Canyon. The pediment along the base of the central Cedar Mountains broadens across the easily-eroded Manning Canyon Formation and produces the prominent topographic reentrant which surrounds the narrow entrance to Rydalch Canyon. There are other small outcrops of the Manning Canyon Formation along the valley which trends southeast from White Rock, near Sulphur Spring, in west Rydalch Canyon, and east Hastings Canyon.

The writer has found no surface exposures in the Cedar Mountains which would allow a reliable thickness measurement of the Manning Canyon Formation. At the most obvious location, between the Great Blue Formation and the lower Oquirrh in east Rydalch Canyon, the formation is cut by

Rydalch Canyon fault. Additional faulting is indicated because Oquirrh units 1 and 2 do not appear at the base of the Oquirrh exposures. Furthermore, adequate lithologic description would be unavailable in this area because the Manning Canyon is almost completely covered. Moyle (1959, p. 66) has prepared an isopachous map for the Manning Canyon and correlative formations in central Utah and eastern Nevada which indicates about 1,100 feet thickness for the Manning Canyon Formation in the Cedar Mountains. For a number of reasons, it seems probable the thickness in the southern Cedar Mountains is somewhat greater than 1,100 feet. The more important considerations are: 1) about 900 to 1,000 feet thickness is indicated by outcrops and attitude of beds. 2) lithology of Manning Canyon in the Stansbury Mountains (Rigby, 1958, p. 49) and Oquirrh Mountains (Moyle, 1959, p. 60-61) suggest that a lower limestone and shale sequence is not exposed in the Cedar Mountains. 3) the formation has probably undergone some thinning during post-Pennsylvanian orogeny. Young (1955, p. 33) estimated the Manning Canyon Formation in the southern Cedar Mountains to be between 1,500 and 2,000 feet thick and the writer agrees with this estimate.

Lithology

Gray to black fissile shale characterizes the Manning Canyon Formation at most exposures. Brownish-gray and brown quartzites are common and there are occasional medium to thin-bedded, brownish-gray, carbonaceous limestone layers. Some exposed brown quartzite beds are ten feet or more thick and show cross-bedding. The brown color is the result of unevenly distributed, powdery limonite cement.

At Cochran Spring, the uppermost layers of Manning Canyon Formation contain some fine-grained, greenish quartzite which was not noticed at other localities. Fissile black shale with minor, thin quartzite and limestone beds comprise the upper 600 to 800 feet of the formation. A lower unit exposed in Cochran Valley has thicker brown quartzite and limestone beds in addition to black shale. While part of the lower Manning Canyon Formation appears to underlie directly the Quaternary sand and clay in small areas southeast of White Rock, it is not exposed anywhere in the Cedar Mountains.

The contact of the Manning Canyon Formation with the underlying Great Blue Formation is not exposed in the Cedar Mountains. However, the abrupt ending of the hilly topography on the upper Great Blue Formation at its northernmost exposures indicates a rather sharp transition upward to the Manning Canyon Formation. The formation grades upward into the Oquirrh Formation. The boundary was chosen at the base of the first brownish-gray, fossiliferous limestone bed typical of Unit 1 of the Oquirrh Formation.

Age and Correlation

The Manning Canyon Formation was named by Gilluly (1932) for exposures in the southern Oquirrh Mountains and he concluded that the Mississippian-Pennsylvanian boundary in that area is in the upper Manning Canyon Formation. Moyle (1959) has restudied the Manning Canyon and correlative formations in the southern Oquirrh Mountains and several other areas in central Utah and eastern Nevada. He also concludes that the Mississippian-Pennsylvanian transition in the southern Oquirrh Mountains is in the upper part of the Manning Canyon Formation. Young (1955, p. 33) reported a collection of forms from the southern Cedar Mountains and indicated the possibility that at least 7/8 of the formation in that area is Mississippian. The writer made a collection from a location on the Cochran Spring Anticline about three or four miles south of the one made by Young. Stokes (Personal communication) identified the fossils listed below and estimated their age as Chester.

F448 *Bactrites* (?) sp.
Cravenoceras sp.
Discitoceras (?) sp.
Eumorphoceras sp.
Leiorhynchus sp.
Mooreoceras sp.

Since Sadlick (written communication) has indicated that three collections the writer made from the lower Oquirrh

Formation in the southern Cedar Mountains may be Mississippian, it appears that all the Manning Canyon Formation in the Cedar Mountains may be of Mississippian age. Tooker and Roberts (1961, p. 26) present evidence regarding the age of the lower Oquirrh Formation in the northern Oquirrh Mountains which supports the suggestion that the Manning Canyon Formation in the Cedar Mountains may be Mississippian. The evidence they cite indicates that at least the lower 550-560 feet of the Oquirrh Formation is of Mississippian age.

The Manning Canyon Formation has also been mapped in the Stansbury Mountains (Rigby, 1958) and the southern Lakeside Mountains (Young, 1955).

PENNSYLVANIAN AND PERMIAN SYSTEMS

Oquirrh Formation

Introduction

The very thick series of rather monotonous limestone, sandstone, and quartzite beds which today are encompassed in the Oquirrh Formation presented a problem for geologists trying to unravel the geology or to understand the mineral deposits of the eastern Great Basin even before Gilluly (1932, p. 34) named the formation. An important aspect of the problem has been the choice of a method suitable for mapping such a thick, apparently monotonous accumulation of strata. One of Gilluly's (1932, p. 35) goals in studying the Stockton and Fairfield Quadrangles in the southern Oquirrh Mountains was to discover whether certain units of the Oquirrh Formation in the Bingham Mining District could be traced into the Ophir District on the west side of the range and thus make it possible to determine the relative age and stratigraphic position of the mineralized beds. His investigation indicated that no quartzite beds in the Lewiston Peak area were continuous for more than three or four miles and he did not hold much hope that individual limestone beds would prove sufficiently continuous for correlation over significant distances. Gilluly named the Oquirrh Formation for exposures in the southern Oquirrh Mountains and determined the age of the lower and middle part of the formation to be Pennsylvanian. His studies showed the formation to be at least 15,000 and possible 18,000 feet thick.

Nolan (1935) mapped beds he referred to as Oquirrh in the Gold Hill Quadrangle. He reported that beds within the formation were lenticular and did not distinguish any subsidiary units although he noted that deciphering the structure would have been simplified had he been able to map smaller units. His (1930) use of the name Oquirrh Formation appeared in print before the publication of Gilluly's (1932) professional paper. A question has been raised as to the legitimacy of applying the term Oquirrh to strata in the Deep Creek Mountains (Welsh and James, 1961, p. 7; Bissell, 1962, p. 1087). It is not used for beds in this area on the Geologic Map of Utah, Northwest Quarter (Stokes, 1963).

Bissell (1936) studied the Oquirrh Formation in the southern Wasatch Mountains and suggested that the strata in that area be called the Oquirrh Series, containing a lower Kelley and an upper Hobble Formation. Three years later, he proposed that fusulinids could be used in subdividing Utah Pennsylvanian strata and set up a five-fold subdivision of the Oquirrh Formation based upon different fusulinid forms. Thompson, Verville, and Bissell (1950) made a further contribution to the problem of subdividing the Oquirrh Formation and provided thicknesses for the various series in the southern Wasatch Mountains. Bissell (1959) applied the method of paleontologic zonation in the Oquirrh Formation in the southern Oquirrh Mountains where he mapped a series of units about which he stated: "For the most part, these are time-rock members." Bissell relied mainly on sufulinids for zonation in this work. Rigby (1958) used the time-rock approach in his mapping of the Stansbury Mountains as did Stifel (1964) in his report on the geology of the Terrace and Hogup Mountains.

Baker (1947) investigated the stratigraphy of the southern Wasatch Mountains in the vicinity of Provo, Utah and reported that the formation attained a thickness of the order of 26,000 feet in that area. He recognized a distinct, gray limestone unit 1,245 feet thick at the base of the Oquirrh sequence but did not present a geologic map with his report. The contrast in lithofacies which he pointed out between the Pennsylvanian sediments of the northern and southern Wasatch Mountains were the basis for his recognizing the Charleston Thrust Fault.

Several investigators in recent years have distinguished lithologic units within the Oquirrh Formation and have produced geologic maps on this basis (Tooker and Roberts, 1961), (Welsh and James, 1961), (Doelling, 1964), (this paper).

Several studies have been completed (Bissell, 1960, 1962), (Brill, 1963), (Roberts et al, 1965), (Steele, 1960) which consider the regional aspects of the Permo-Pennsylvanian rocks of the eastern Great Basin and adjacent areas. The probable extent, shape, and tectonic characteristics of the Oquirrh and other sedimentary basins have been considered as well as a number of postulated highland areas. Roberts (Roberts and others, 1965, p. 1926) has advised that present-day structural and stratigraphic evidence must be studied together to gain a sufficient basis for drawing inferences regarding the paleogeology of the region.

The Oquirrh Formation in the Cedar Mountains has been subdivided into five mappable lithologic units. Together these represent a chronologic range from Upper Mississippian Chester (?) to Lower Permian Leonard (?). There appear to be lithologic representatives for part or all of each epoch in this time interval with the possible exception of the Missourian. The lower four units plus a partial section of Unit 5 total 6,807 feet in the southern Cedar Mountains. A thickening toward the central Cedar Mountains is indicated at least in Units 2, 3, and 4.

Unit 1

Distribution and Thickness

Exposures of Unit 1 account for about 2.5 square miles compared with the approximately 130 square miles of outcrops for the Oquirrh Formation as a whole. This results principally from the fact that Unit 1 is much thinner than any of the other units in the formation. The more extensive outcrops of Unit 1 are associated with two anticlines. Several exposures occur on either side of the axis of Cochran Spring Anticline and its southeastward extension as far as Post Hollow. A total thickness of 434 feet was measured at the outcrop just west of Cochran Spring. The second group of outcrops is near the mouth of Wildcat Canyon (sec. 23, T4S, R10W) where a northwest-trending anticlinal nose plunges toward the summit of the range. Other exposures are in sec. 19, T4S, R10W; sec. 6, T4S, R10W; sec. 1, TIS, R9W. Unit 1 is a moderately resistant unit and usually occurs as smooth hills along the margin of a flatland eroded on the Manning Canyon Formation. It is usually poorly exposed (Fig. 3).

Lithology

The basal unit of the Oquirrh Formation is mostly a composite of pure and argillaceous limestone beds which are medium to dark blue-gray, sometimes brown-gray in color, which weather gray and yellow-brown. The argillaceous beds are usually thinner-bedded with a brown color. Sand grains are very scarce throughout the unit. Fragmental crinoids, echinoid (?) spines, and other skeletal particles make up a sizeable part of several of the limestone beds, some of which contain well-preserved fossils. Fossil fragments are much more common in the float of this unit than of either under or overlying beds. Chert is very scarce in the strata of Unit 1.

In one area, west of Cochran Spring, the lower contact was fairly well exposed and was chosen where brown-gray,

Fig. 3 - Photograph taken near Cochran Spring which shows a typical exposure of Unit 1 and Unit 2 of the Oquirrh Formation. Foreground is alluvium-covered Manning Canyon Formation.

Fig. 4 - Photograph of Unit 2 of the Oquirrh Formation showing thick bedding and ledge-forming character.

fossiliferous limestone beds become predominant over a greenish-gray, fine-grained quartzite bed of the upper Manning Canyon Formation. Usually, the lower contact is not well exposed and black shales of the upper Manning Canyon Formation lie near a slope which exposes the lower beds of Unit 1.

The upper boundary was chosen in the Cochran Spring area at the base of a very sandy light brown limestone unit 14 feet thick at the base of the overlying sequence of thicker-bedded, gray, sandy limestones. A similar bed was located at the top of Unit 1 about a mile southwest of Cochran Spring but it was not present in other areas and the contact was chosen at the base of thicker-bedded, gray, sandy, steplike, chert-bearing strata of Unit 2.

Age and Correlation

It has been considered generally that the boundary between the Pennsylvanian and Mississippian Systems is somewhere in the middle or upper Manning Canyon Formation in the eastern Basin and Range Province. Some studies, however, have indicated that the boundary lies in the basal portion of the Oquirrh Formation. Dr. Walter Sadlick (written communication) examined two collections about 315 feet above the base of Unit 1 near Cochran Spring and found the following forms: