BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

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STRATIGRAPHY AND STRUCTURE OF THE WEST LOAFER MOUNTAIN-UPPER PAYSON CANYON AREA, UTAH COUNTY, UTAH

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A thesis submitted to

the Faculty of the Department of Geology

Brigham Young University

in partial fulfillment

of the requirements for the degree

Master of Science

by

DEVERL J. PETERSON

May 1956

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ABSTRACT

An area of approximately 12 square miles in the Southern Wasatch Mountains near Payson, Utah was mapped in detail for this thesis.

Rocks of the Cambrian, Mississippian, Pennsylvanian, Cretaceous, and Tertiary systems are found in the mapped area, as well as recent alluvium, colluvium, and related products of mass wasting.

Structurally the area contains two major thrust faults, a large wrench fault and numerous normal faults associated with the Laramide orogeny. The Wasatch fault and other normal faults of the Basin and Range system are also found in the mapped area.

Water is the most important economic resource. However, the area has a clay of potential value.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The area included in this report is located in the southern Wasatch Mountains in the southern part of Utah County, Utah. Payson Canyon lies directly south of Payson and is bounded on the east by Loafer Mountain and on the west by Dry Mountain. The mapped area is bounded between meridians 111° 39' and 111° 43' West Longitude, and parallels 39° 56' and 40° 00' North Latitude. Included in the area are sections 2, 3, 10, 11, and 15 and parts of sections 1, 12, and 13 of Township 10 South, Range 2 East, and sections 34 and 35 and parts of section 36 of Township 9 South, Range 2 East (see Fig. 1).

This region is accessible from the north and south by the Nebo Loop Road, which joins U. S. Highway 91 at Payson on the north and Utah State Highway 11 to the south approximately six miles east of Nephi. The Nebo Loop Road is paved approximately eight miles into the area from Payson.

PHYSICAL FEATURES

Payson Canyon is a relatively broad and straight north-south trending canyon with steep walls. The canyon bottom rises toward the south grading into a hummocky, plateau-like topography dissected by many small creeks in the southern extent of the region. Two east-west trending canyons join the main canyon from the east. The maximum relief is approximately 3, 600 feet from Walker Flat to the eastern extent of the mapped area on the west flank of Loafer Mountain.

Payson Canyon is drained by one perennial stream, Peteetneet Creek, which flows in a general northerly direction into Utah Valley. There are many tributaries and intermittent streams, especially at the south end of the area. The Right Fork of Payson Canyon and Wimmer Ranch Creek are the most important tributaries. The Largest intermittent streams are from Rock Canyon and Coal Pit Creek (see Plate 1).

Two lakes and two reservoirs of small size and shallow depth lie within the mapped area. Both lakes and reservoirs are located in natural basins, probably formed by slumping and related mass movements within poorly consolidated Tertiary rocks.

CLIMATE AND VEGETATION

The West Loafer Mountain-Upper Payson Canyon area is located in a region characterized by a semi-arid climate. The Weather Bureau (Annual Summary, 1954, Vol. LVI, No. 13) recorded the annual average

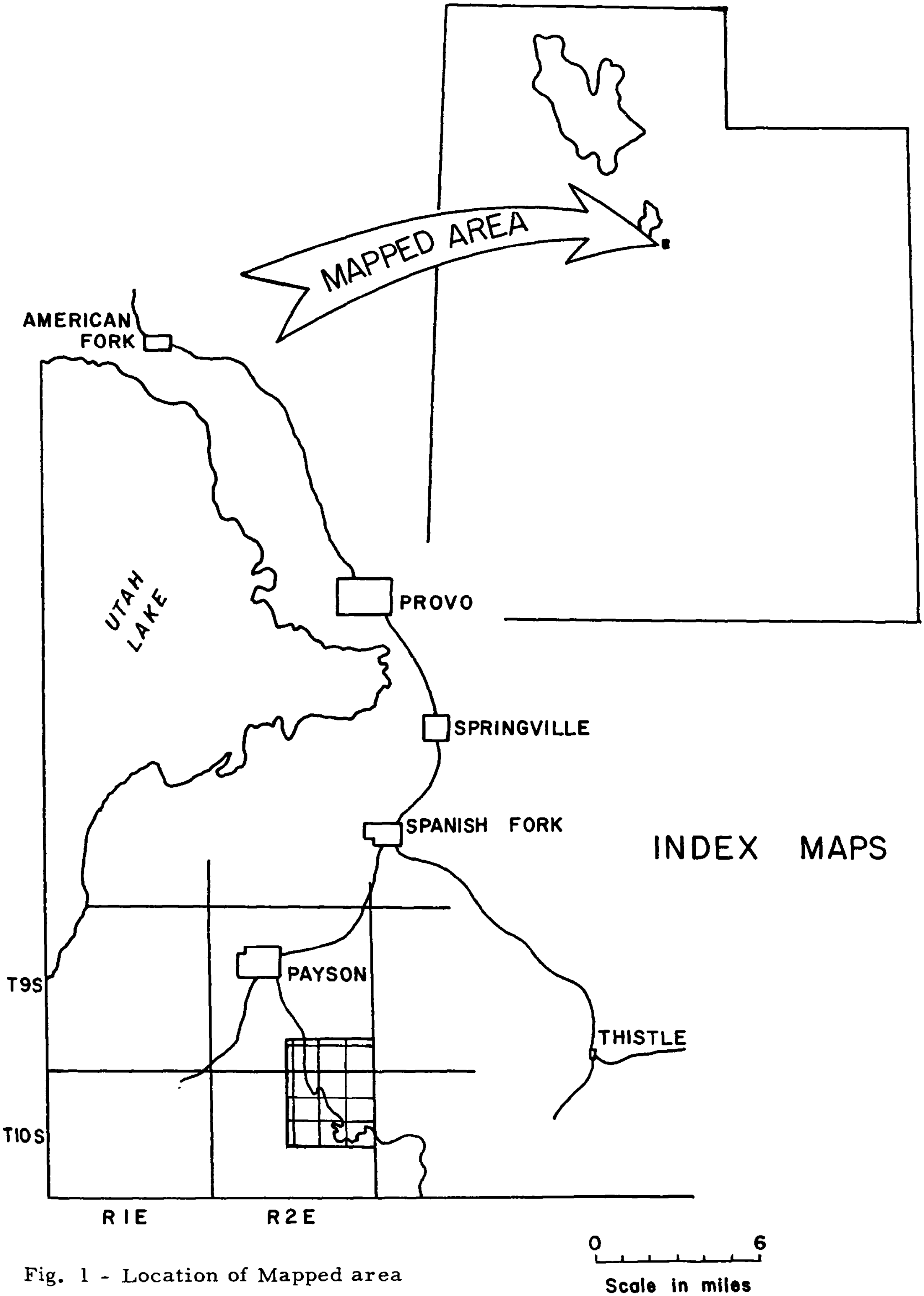


Fig. 1 - Location of Mapped area

rainfall at the Spanish Fork Power House, approximately ten miles to the east, as 17.56 inches per year for a 42 year period, and 18.40 inches per year at the Santaquin Power House approximately eight miles to the southwest. It is assumed the rainfall in Payson Canyon is within this range. The area is ordinarily covered by snow from November to late spring; the average snow depth is 55 inches for a 12 year period at an elevation of 8,050, measured in April by the Soil Conservation Service (1954, Summary of Snow Survey Data for the State of Utah) at the Payson Canyon Snow Course.

The vegetation consists of sagebrush, maple, ponderosa pine, cottonwood, scrub oak, and a few scattered fir in the wide bottoms of Payson and Bear Canyons. Scrub oak and mahogany are found on the steep slopes and in the more rugged canyons. At higher elevations white fir and varieties of spruce are found on the northern slopes, and quaking aspen and choke cherry grow in passes and saddles or wherever water is sufficient.

PREVIOUS INVESTIGATIONS

Loughlin (1913, pp. 456-477) makes no reference to the geology of Payson Canyon, neither on his map (Fig. 4) nor in writing, but reference is made to the faults throughout the southern Wasatch Mountains. The first geologic map of the state of Utah (Butler, et al., 1920, pl. IV) shows Mississippian formations on the west side of Payson Canyon, and Tertiary volcanics and conglomerates are shown on the east side of Dry Mountain in the southwest corner of the mapped area. Boutwell (1933, Guidebook 17 of the International Geological Congress) has shown Payson Canyon covered by Tertiary material and Loafer Mountain composed of Cambrian rocks.

The first investigation including Payson Canyon directly was made by Eardley (1934, Map 11) whose work included two-thirds of the area mapped by the writer. The map by Eardley (1934, Map 11) is of a reconaissance type showing the presence of Cambrian, Mississippian, Pensylvanian, and Tertiary strata.

Andrews and Hunt (1948) note the presence of Mississippian, Pennsylvanian sedimentary rocks, and Tertiary volcanics and conglomerate in this part of the state. Brown (1950) measured sections and mapped approximately four square miles adjoining the writer's area to the north, and DeMars (1955) mapped approximately six square miles directly to the west.

PRESENT INVESTIGATION

The present work consists of mapping in detail the geologic features of approximately twelve square miles in Payson Canyon and part of the west flank of Loafer Mountain. The geologic contacts and major faults were walked out with the data being plotted directly on aerial photographs having scales of 1:12,000 and 1:20,000. The geology

Plate II

A - Loafer Mountain with trace of Wasatch fault and pediment at the base. Eastern portion of mapped area at far right.

B - Mapped area with high level erosion surface in the background.

B. Y. U. Geology Dept. Photo.

A

B

was later transferred to a base map made from U. S. Geological Survey topographic sheets of 1:12, 000 and 1:62, 000 scale, from which the final map was drafted.

Laboratory work consisted of petrographic studies of thin sections of various sedimentary and igneous rocks and of identification of fossils collected during the process of mapping.

SEDIMENTARY ROCKS

The southern Wasatch Mountains include Precambrian, metamorphic and intrusive rocks, Paleozoic and Mesozoic sedimentary strata, and Tertiary sedimentary and volcanic rocks. The aggregate thickness amounts to at least 20,000 feet, and may be as much as 35,000 feet.

Sedimentary rocks in the Payson Canyon-West Loafer Mountain area consist of Cambrian quartzite, shale, limestone, and dolomite; Mississippian limestone, dolomite, and orthoquartzite, and shale; Pennsylvanian shale, limestone, and orthoquartzite; and Tertiary materials consisting mostly of volcanic breccia and conglomerates derived from the latter.

Major unconformities occur at the base of the Mississippian system, between the Tertiary and Mississippian, and between the Tertiary and Pennsylvanian systems.

CAMBRIAN SYSTEM

TINTIC QUARTZITE

The Tintic quartzite is the oldest formation which crops out in the mapped area and is exposed on the east wall of Payson Canyon just south of Rock Canyon. The outcrops are few and are covered, for the most part, by float from overlying formations. The upper and lower contacts of the formation are not exposed; however, in other areas the Tintic Quartzite is unconformable upon the Precambrian.

From the appearance of the formation in adits, outcrops, and in a quarry it is evident that faulting and folding have markedly affected the strata. These structural effects plus poor outcrops make the attitude of the formation impossible to determine with accuracy; therefore, no attempt to measure thickness was made by the writer. Eardley (1933, p. 310) measured 900 feet of the Tintic on the west flank of Dry Mountain. The writer believes an approximation near this figure would be reasonable for the thickness of the Tintic Quartzite in Payson Canyon when all local evidence and regional data are taken into account.

The Tintic Quartzite grades from an orthoquartzite to an incipient metaquartzite and varies in color from white, cream, light greenish-white, to light brownish-white on the fresh surface. Brownish-white to reddish-brown colors characterize the weathered surface. The rock is fine-to-medium-grained, and contains well-sorted, subrounded to rounded grains which are tightly cemented with silica. A diabase flow is present in the Tintic and according to Abbott (1950, p. 31) occurs approximately 160 feet above the base of the formation and varies in thickness from six inches to 40 feet. The petrography and petrology of the flow will be discussed in a later section.

The Tintic quartzite has been assigned a Lower Cambrian age by Gilluly (1932, p. 9) by means of fossils found in the overlying Ophir formation. Peterson (1952, pp. 17-18) identified *Olenellus* sp. from the Tintic Quartzite at Long Ridge east of Goshen, Utah, which further substantiates Gilluly's age assignment.

OPHIR FORMATION

Limited outcrops of the Ophir formation are exposed in the mapped area in normal stratigraphic sequence overlying the Tintic quartzite. The Ophir formation, however, is covered largely by float from overlying formations. The contact between the Tintic and the Ophir formation is not exposed in the mapped area but in other localities it is gradational.

The Ophir formation is composed characteristically of olive-drab, thinly laminated shales and olive to brownish-green sericite phyllites. The formation is more or less calcareous where it grades into the overlying Teutonic limestone.

Brown (1951, p. 12) measured 245 feet of the Ophir in the Payson-Piccayune area, and Eardley (1934, p. 316) estimated 250 feet of Ophir on the west flank of Dry Mountain.

From fossil identifications and stratigraphic position, Gilluly (1932, pp. 11-12) placed the Ophir formation in the Middle Cambrian.

TEUTONIC LIMESTONE

The lower contact of the Teutonic Limestone is covered in most places, but it is probably gradational. A partial section of the formation crops out along the east side of Payson Canyon south of the intersection with Rock Canyon (see Plate 1).

The Teutonic limestone is principally a medium-gray, fine-grained, thick-to thin-bedded limestone. In the upper part it is massive bedded and has discontinuous orange-brown argillaceous partings. Oolites are present near the base of the measured section, and argillaceous mottling is present throughout. The formation has a meringue appearance due to weathering and is brownish-gray to light-gray on the weathered surface.

The writer measured an incomplete section totaling 195 feet, but the formation is 476 feet in the Payson-Piccayune area (Brown, 1951, p. 16).

A Middle Cambrian age is assigned to the Teutonic Limestone because of its position between known Middle Cambrian formations (Lindgren and Loughlin, 1919).

DAGMAR LIMESTONE

The Dagmar limestone was named for the Dagmar mine in the Tintic district by Lindgren and Loughlin (1919, p. 27). The rock in the Tintic area is argillaceous, oolitic, finely banded, and dolomitic.

The Dagmar in the mapped area is exposed as a narrow and prominent band of limestone resting conformably upon the Teutonic limestone. The characteristic lithology and nearly white weathering habit set it apart as a key bed in the Cambrian section. Throughout the mapped area the formation is displaced by small faults (see Plate 1).

The Dagmar Limestone consists predominately of dolomitic limestone. It is medium-to thick-bedded and very fine-grained, and is light-gray but weathers almost chalky-white. The rock is typically laminated with alternating light and dark laminae, and is arenaceous in part.

The age of the Dagmar limestone is Middle Cambrian, determined by its statigraphic position between formations of known age. The thickness of the Dagmar limestone varies, but averages 30 feet in the mapped area, which compares with 80 feet in the Tintic district (Lovering, 1949, p. 9).

HERKIMER LIMESTONE

The Herkimer limestone can be traced northward along the east side of Payson Canyon and into Rock Canyon, where it is terminated by a fault. It is well exposed throughout its extent, but like the other Cambrian formations in this area is fractured and faulted. The lower contact is rather sharp but conformable with the underlying Dagmar limestone.

The Herkimer consists of dark gray, medium to very fine crystalline limestone and a 25-foot bed of dolomite approximately midway in the formation. The limestone is thin to medium-bedded and is characteristically banded with very fine arenaceous material that forms continous to discontinuous light medium-gray stringers parallel to the bedding. The dolomite is dark-gray, finely crystalline, thin to massive bedded, and has numerous "twiggy" bodies present. Fifty-six feet above the base of the formation is a nine-foot oolite bed. Near the upper contact the arenaceous material is negligible, and the formation becomes increasingly dolomitic.

The only fossil found was part of the thorax of a trilobite, but generic identification was not possible; however, the stratigraphic position of the Herkimer suggests a Middle Cambrian age.

Measurements taken by the writer indicate a total thickness of 237 feet for the Herkimer in the mapped area.

BLUEBIRD DOLOMITE

The outcrop pattern of the Bluebird dolomite is essentially confined to the same general area as the previously mentioned, stratigraphically older, formations, but it is less prominent.

The dark gray dolomite of this formation is uniquely spotted with varying amounts of white "twiggy" bodies which average ten mm. in length and one and one-half mm. in width. The dolomite is finely-crystalline and characteristically mottled in the lower part, but the bulk of the formation consists of calcareous dolomite that weathers massive, and is light-medium-gray in color.

The contact of the Bluebird dolomite is gradational and conformable with the Herkimer formation below. It is assigned a Middle Cambrian age, as determined by stratigraphic position between known formations of Middle Cambrian age (Lindgren and Loughlin, 1919, p. 8).

SYSTEM	SERIES	FORMATION	THICK	REMARKS
QUATERNARY		ALLUVIUM	?	Alluvium and colluvium
TERTIARY	MIOCENE ? OLIGOCENE	VOLCANIC CONGL.	0 - 300	Pyroclastic breccia and conglomerate
	EOCENE ? PALEOCENE	FLAGSTAFF LIMESTONE	0 - 50	White, sublithographic limestone
		NORTH HORN CONGL.	0 - 300	Red weathering conglomerate
CRETACEOUS	MONTANAN			
PENN.	DERRYAN MORROWAN	OQUIRRH FORMATION	2, 600	Interbedded limestone, quartzite and shale
	SPRINGERAN	MANNING CANYON SH.	1, 000	Black and greenish shales, mostly covered
MISS.	CHESTERAN			
	MERAMECIAN	GREAT BLUE LS.	0	Faulted out
		HUMBUG FORMATION	540	Interbedded sandstone and limestone
	OSAGEAN	PINE CANYON LIMESTONE	614	Cherty fossiliferous limestone
	KINDERHOOKIAN	GARDNER DOLOMITE	340	Thin bedded fossiliferous limestone
CAMBRIAN	CROIXAN	OPEX DOLOMITE	178	Massive weathering dolomite
	ALBERTAN	COLE CANYON DOLOMITE	230	Alternating dark and light dolomite
		BLUEBIRD DOLOMITE	101	Dolomite with numerous "twiggy" bodies
		HERKIMER LIMESTONE	237	Limestone with argillaceous banding
		DAGMAR LIMESTONE	30	White weathering laminated cal. dolomite
		TEUTONIC LIMESTONE	195	Limestone with argillaceous partings
	WAUCOBAN	OPHIR FORMATION	250	Olive drab shale mostly covered
		TINTIC QUARTZITE	900	Massive cross-bedded ortho to metaquartzite

Fig. 2 - Summary chart of the stratigraphy of the West Loafer Mountain -- Upper Payson Canyon Area.

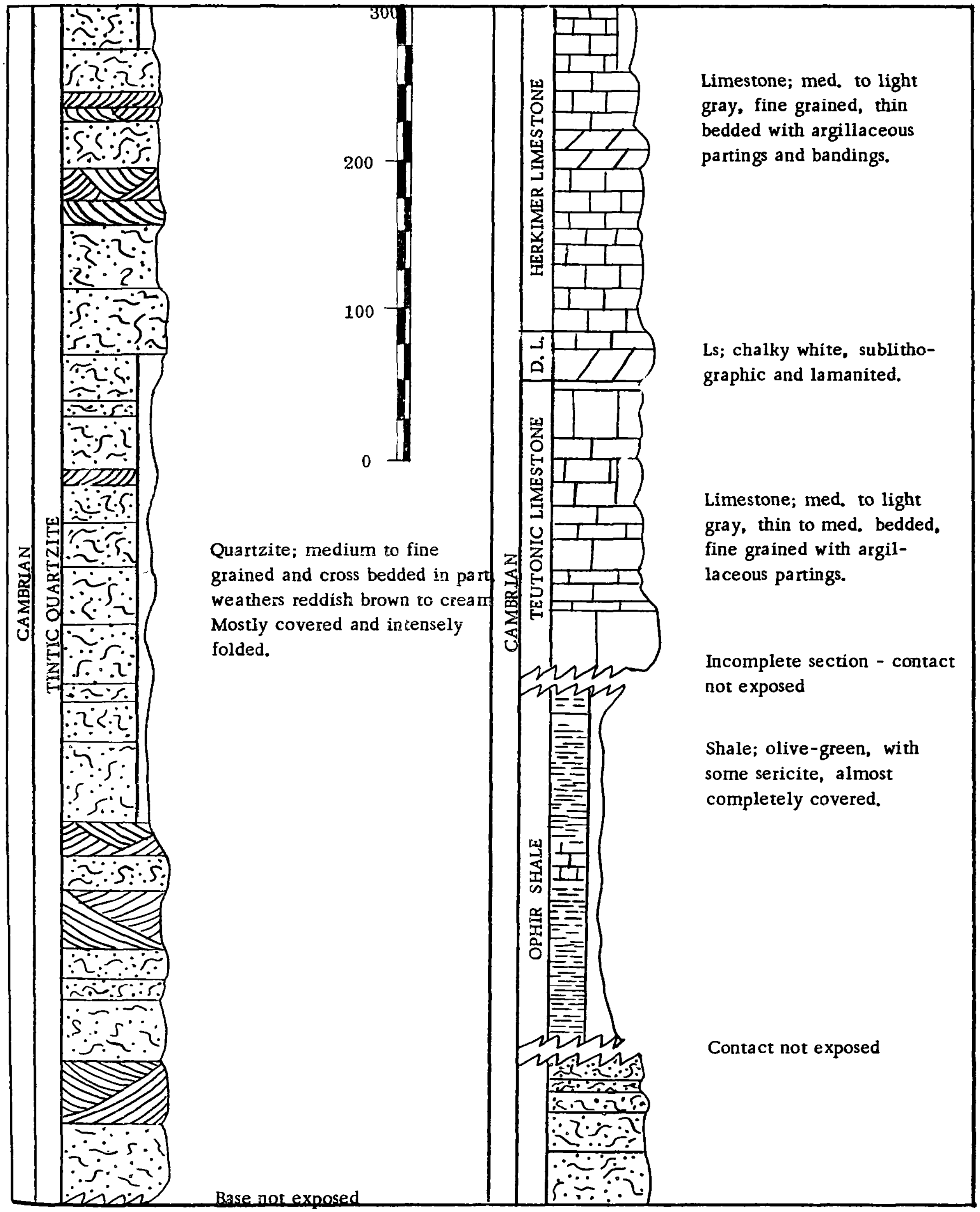


Fig. 3 - Erosion column of the stratigeraphy in the West Loafer Mountain - - Upper Payson Canyon Area.

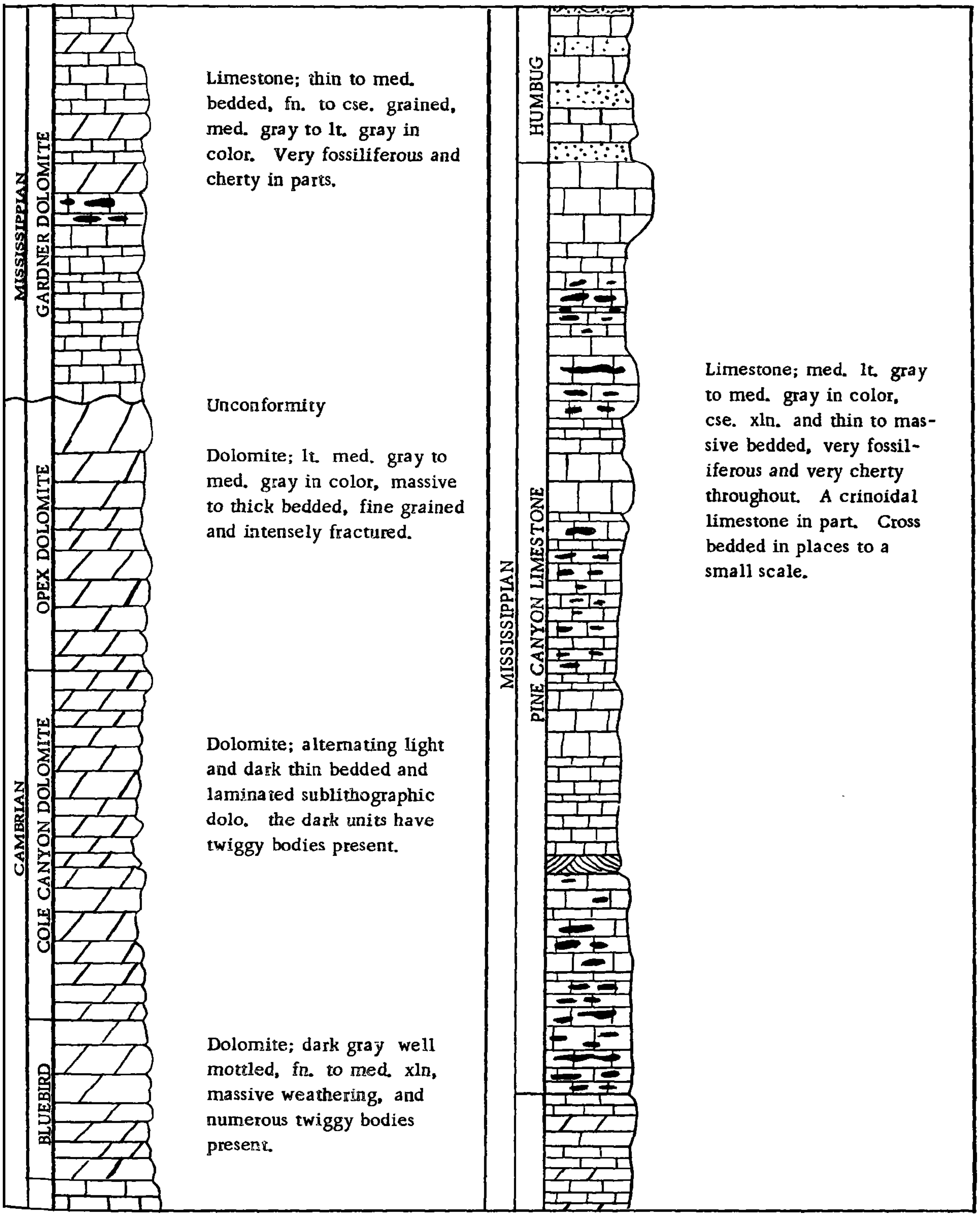


Fig. 3 - (Continued)

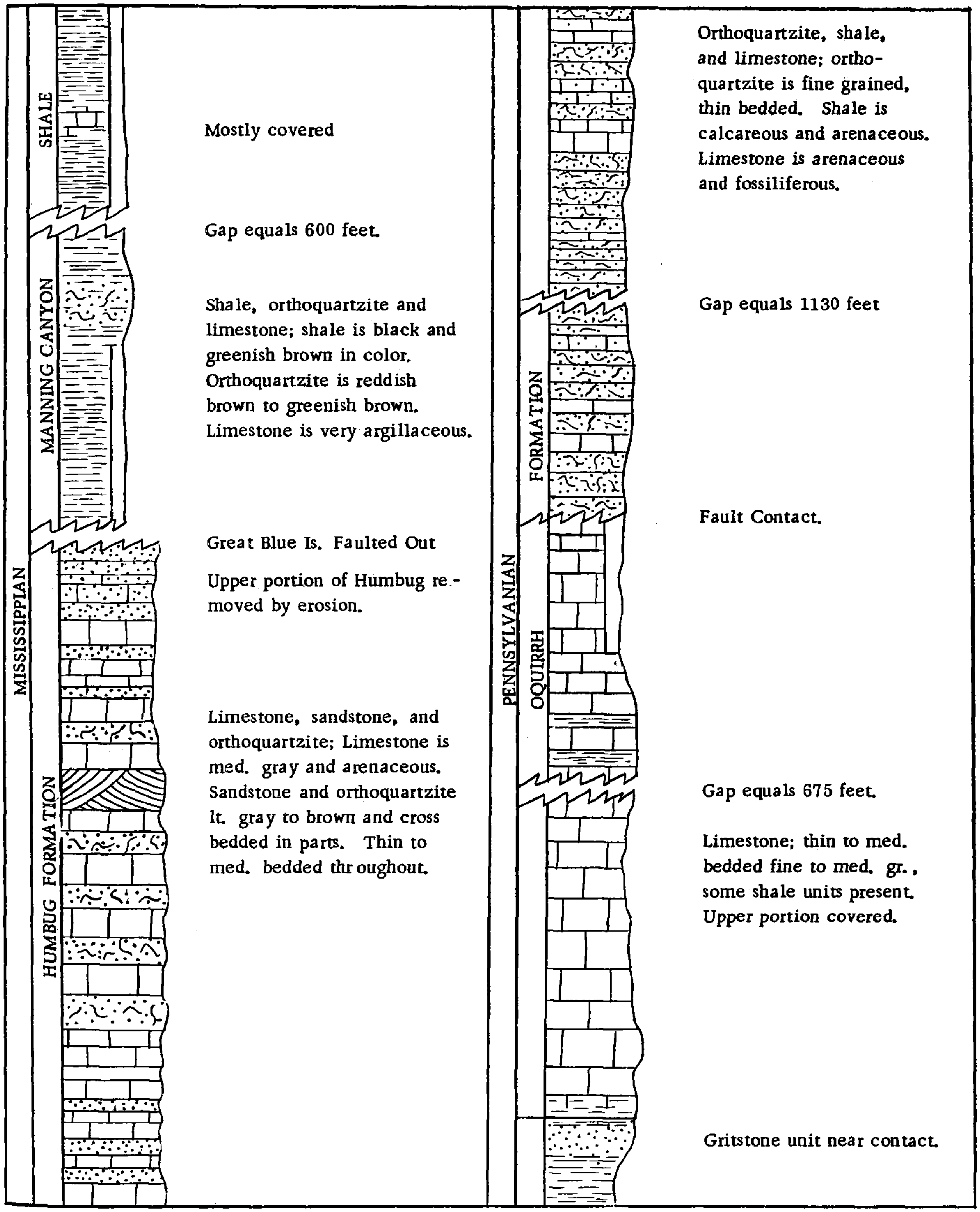


Fig. 3 - (Continued)

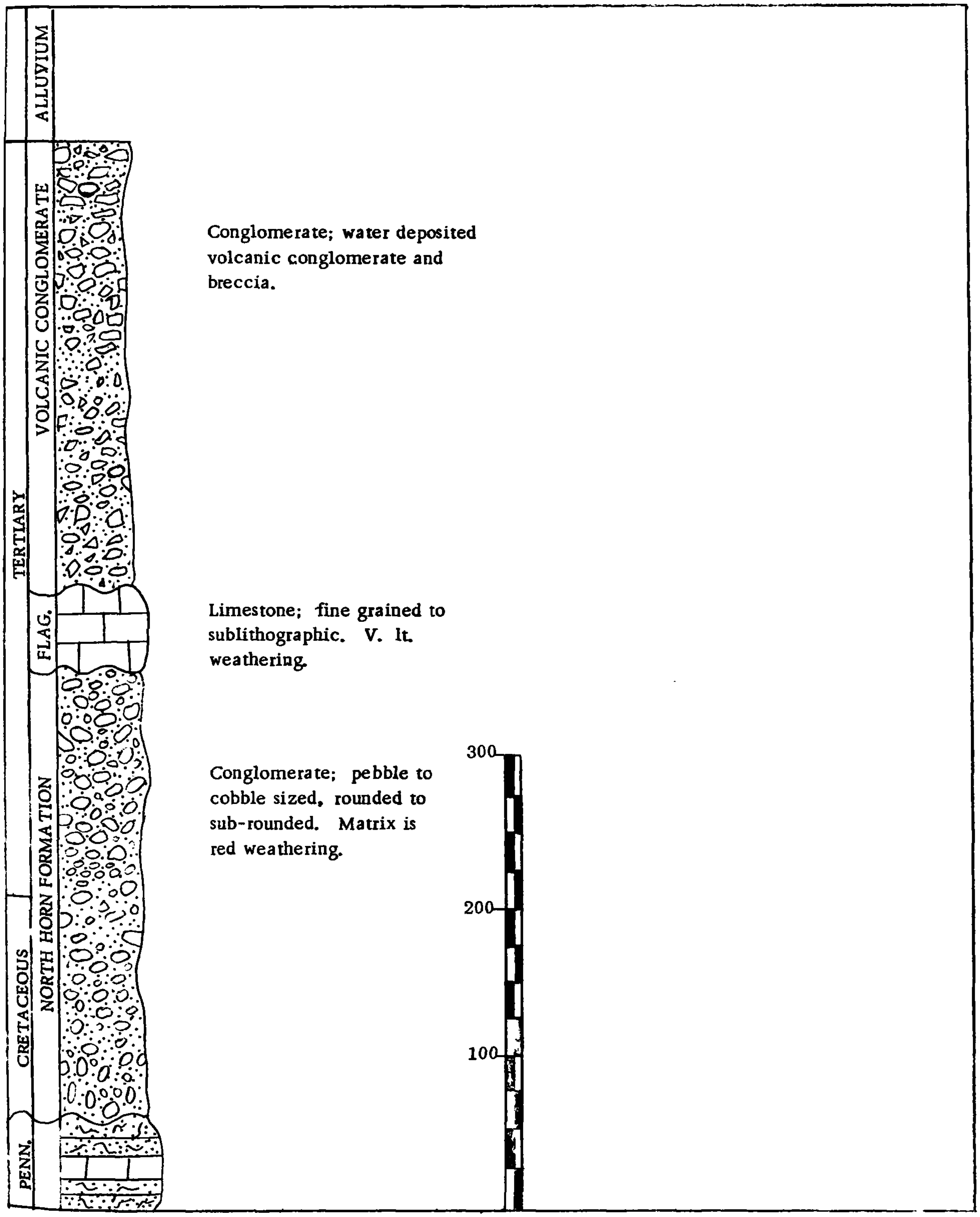


Fig. 3 - (Continued)

The writer measured 101 feet of the Bluebird dolomite in the Payson Canyon-West Loafer Mountain area

COLE CANYON DOLOMITE

The Cole Canyon dolomite overlies, in apparent conformable relation, the Bluebird dolomite and forms part of the same prominent outcrop pattern. The contact between these two formations, which appears to be both conformable and gradational, was determined by a difference of grain size, weathering characteristics, and to a certain extent composition. The Cole Canyon is finer grained, lighter colored, and slightly arenaceous.

This formation is composed characteristically of beds of alternate light and dark dolomite. The dark beds are fine-grained, thin-bedded, medium-gray, and commonly have numerous "twiggy" bodies present. The light units are laminated with alternating light and dark layers which are light-medium-gray and slightly arenaceous. The upper part of the Cole Canyon dolomite consists of light colored, fine-crystalline dolomite that is thin-to medium-bedded, is slightly mottled, and has many "twiggy" bodies. There is a lithologic similarity between the light units of the Cole Canyon dolomite and the Dagmar limestone.

On the basis of the brachiopod Obolus mcconnelli, Lindren and Loughlin (1919, p. 29) date the Cole Canyon dolomite as Middle Cambrian; the writer has no evidence bearing one way or another on this assighment.

Measurements indicate a thickness of 230 feet of Cole Canyon dolomite in the Payson Canyon-West Loafer Mountain area.

OPEX DOLOMITE

Exposures of the Opex Dolomite form the north wall of Rock Canyon, near the mouth and occur in a readily defined band above the older strata (see Plate 1). These exposures weather massive and appear as one complete unit. The formation is fractured throughout its exposure, with white calcite comprising the filling.

The Opex formation is essentially a dark-gray, fine-crystalline dolomite which weathers massive, with a mottled, arenaceous surface. Numerous calcite filled fractures, one mm. to two mm. in width, characterize the formation. These fractures likely are associated with post-depositional diastrophism.

The age of the Opex in the Tintic district was determined by Weeks in 1905 (Lindgren and Loughlin, 1919, p. 30) as Upper Cambrian and confirmed by Lindgren and Loughlin, (1919, p. 30). Likely the thickness of 178 feet of Opex dolomite in Payson Canyon is also Middle Cambrian.

The contact between the Opex and Cole Canyon formation is conformable, but there is a major unconformity above the Opex as it is overlain by the Gardner dolomite of Lower Mississippian age. Although no apparent erosional contact was observed where the section was measured, it is doubtful that the thickness of 178 feet represents the full thickness of the formation that was deposited.

PRE-MISSISSIPPIAN UNCONFORMITY

The presence of an unconformity at the base of the Mississippian system is well established by the absence of rocks representing the Ordovician, Silurian, and Devonian systems. Near the mouth of Rock Canyon the eroded surface of the Opex dolomite is seen to rest disconformably below the Gardner dolomite. No evidence of an angular unconformity is shown but it is evident that some erosion has taken place, the extent of which is not known. Rocks representative of the three systems not present may have been deposited and subsequently removed by erosion, supplying sediments to a depositional basin to the west, or the area may have been a high during Ordovician, Silurian, and Devonian times. Regional studies, however, strongly suggest the latter.

Gilluly (1932, p. 22) reports an unconformity in the Stockton and Fairfield quandrangles at the base of the Mississippian, and Nolan (1935, p. 35) also reports a pre-Mississippian unconformity in western Utah. Perkins (1955, p. 14) reports an angular unconformity in American Fork Canyon between Cambrian and Mississippian rocks. From this evidence and that observed directly by the writer, the presence of the unconformity is well established and apparently is not uncommon to the eastern part of central Utah.

MISSISSIPPIAN SYSTEM

GARDNER DOLOMITE

Exposures of the Gardner dolomite occur disconformably overlying the Cambrian system to the north, to the south, and in Rock Canyon (see Plate 1). The Gardner, named by Lindgren and Loughlin (1919, p. 32) for exposures in Gardner Canyon in the Tintic District, is recognized in the field by characteristic lithology, stratigraphic position, and by the presence of *Syringopora* sp. and *Euomphalus* sp., and other distinctive fossils.

The Gardner formation, which consists of limestone with a few interbedded units of dolomite near the middle of the section, grades into a calcareous dolomite near the upper contact. The limestone is dark- to medium-gray and weathers to shades of light-gray. The rock in general is medium-to fine-grained with some units tending towards fine crystallinity. The limestone is thin-to medium bedded; a small unit containing black chert nodules and algal structures occur near the middle of the formation. Typically, corals, brachipods, and bryazoans form fossiliferous units throughout the formation. The calcareous dolomite is dark-gray and weathers medium-gray and forms angular blocks which have a meringue surface. This rock is fine-crystalline, thick- to massive bedded, and contains chert nodules near the upper part.

Apparently no break exists between the upper and lower Gardner that is so typical of this formation in other localities and at least two explanations may be postulated: first, the section in Payson Canyon should be assigned to the upper Gardner; or second, the contact may possibly be represented by the algal structure approximately 150 feet above the base of the formation. It is plausible that the algal structure may be correlative to the intraformational conglomerate described by Lindgren and Loughlin (1919, p. 38) in the Tintic district which is thought by Clark (1954, p. 29) to be correlative to the "curley bed." The "curley bed" normally separates the upper and lower Gardner in other localities.

The limestone contains fossiliferous units which are fetid when broken, and which usually contain some crinoid hash. These fossiliferous units contain the following identifiable fossils:

Euomphalus sp.
Syringopora sp.
Triplophyllities sp.
Multithecopora sp.
Caninia sp.
Cleiothyridina sp.
Composita sp.
Spirifer sp.
Crinoid fragments

From the above faunule and judging from the forms collected by others (Lindgren and Loughlin, 1919) (Clark, 1954) the Gardner has been assigned a Kinderhookian and Lower Osagian age.

Total thickness of the Gardner formation is 340 feet, measured by the writer on the ridge north of Rock Canyon.

PINE CANYON LIMESTONE

The Pine Canyon limestone conformably overlies the Gardner limestone. The contact was drawn below the first unit of limestone containing an abundance of black chert nodules and stringers. Outcrops of the Pine Canyon are exposed on the east side of Payson Canyon between Rock Canyon and Bear Canyon, where they form steep canyon walls; a characteristic ledge occurs at the upper contact. Exposures which form the south rim of Rock Canyon contain silicified fossils.

The rock characteristically consists of fossiliferous cherty limestone with units of interbedded crinoidal limestone. The fossils and chert occur in limestone that is light-medium-gray, thin- to medium bedded, fine-grained, and slightly lutaceous. The chert is black and occurs as nodules two to six inches in diameter, normally oblong, and in stringers or bands from two to four inches thick. The crinoidal limestone is composed of recrystallized fossil hash. The hash is composed mostly of crinoid stems and bryozoans. The crinoidal limestone (locally a criquina) is medium-gray, thin- to medium bedded, coarse crystalline, and cross-bedded to a small scale in a unit that is 150 feet above the base. The formation becomes dolomitic, and the chert appears more in stringers rather than nodules near the upper contact. A phosphatic oolite bed was noted south of Rock Canyon at the lower contact but is not present where the section was measured.

Lindgren and Loughlin (1919, p. 40-41), who named the Pine Canyon limestone, dated it as Lower and Upper Mississippian in age on the basis of fossils identified by Girty. More recent workers consider it to be Upper Osagian and Lower Meramecian in age. The writer believes the latter to harmonize with known data.

Gilluly (1932, p. 25) used the name Deseret limestone for lithologically similar rocks in approximately the same stratigraphic position as the Pine Canyon limestone.

The writer measured a total thickness of 614 feet of thePine Canyon limestone in Payson Canyon.

Fossils collected and identified by the writer include:

- *Polypora* sp.
- *Fennestella* sp.
- *Spirifer* sp.
- *Multithecopora* sp.
- *Triplophyllities* sp.
- *Dictyoclostus* sp.
- *Crinoid fragments*.

HUMBUG FORMATION

The Humbug formation comprises the higher part of the hill separating Rock and Bear Canyons. It is also exposed in the west wall of the upper part of Payson Canyon where it strikes slightly east of north. It is exposed throughout almost the entire length of the mapped area and comprises most of the area west of Peteetneet Creek, except where it is unconformably overlain locally by the North Horn formation(see Plate I). Outcrops of the Humbug formation form a typical ledge-and-bench topography, due to the differential erosion of the alternating limestone and orthoquartzite beds.

The contact between the Pine Canyon and Humbug was drawn at the base of the first prominent silicarenite unit of the younger formation.

A section of 540 feet of Humbug was measured between Rock and Bear Canyons, but this does not represent a complete section inasmuch as the upper part has been removed by erosion. West of Peteetneet Creek the formation dips east from a north-south strike, but is terminated near creek level by a longitudinal fault, which leaves an incomplete section here also. The wide outcrop area shown on the map (see PlateI) is due to a low east dip of the beds and is believed by the writer to be due, in part, to north-south normal faulting which evidently duplicated part of the section; however, any direct evidence for this faulting is obscured by alluvial cover.

The formation is composed essentially of alternating calcareous silicarenite beds and thin-bedded limestone units. The silicarenite is fine- to medium-grained, has a light-brown color, is rather friable, and is cross-bedded to a small extent. The limestone is arenaceous throughout and has a few units which are slightly dolomitic and display a meringue weathered surface. The lower part of the formation alternates in even-bedded, six-foot units of limestone and sandstone, whereas in the upper part of the formation the units are thin and the sandstone predominates.

Lindgren and Loughlin (1919, p. 42) dated the Humbug as Upper Mississippian in age. Thompson and Zeller identified a Meremecian form of Endothyra, which was collected from the lower Humbug by Calderwood (1951, pp. 48-49). The age of Meramecian has also been assigned to the Humbug formation by Weller, et al. (1948 p. 135) and Livingstone (1955, p. 28).

MISSISSIPPIAN AND PENNSYLVANIAN SYSTEMS

MANNING CANYON SHALE

The Manning Canyon shale forms low outcrops and very poor exposures in Bear Canyon and the Right Fork of Loafer Canyon. These two canyons have been eroded into the soft shale in comparable fashion to Manning Canyon, the type locality in the Stockton and Fairfield quadrangles (Gilluly, 1932, p. 31).

The shale is in fault contact with the Humbug formation on the south wall of Bear Canyon. The Great Blue limestone, which normally occurs in stratigraphic position between the Humbug formation and the Manning Canyon shale, is faulted out in this area.

Exposures of this formation are found sparingly in Bear Canyon and on the west side of Peteetneet Creek near the turnoff to the Goose Nest (see Plate 1).

The Manning Canyon consists largely of black and tannish-gray shale with a few thin-interbedded units of limonite stained ironstone bands two to four inches thick. Bluish-gray-orthoquartzite and fossiliferous calcisilitite are also present. Near the upper contact a light-gray quartzose gritstone occurs.

Outcrops of the shale for the most part have a variable thickness of soil cover. The shale has been distorted into folds and faults by various diastrophic episodes, therefore no accurate measurement of thickness appears evident. However, the outcrop pattern as well as regional data would suggest that at least 1,000 feet of Manning Canyon shale may have originally been present. Baker (1947) measured 1,645 feet of this formation in Pole Canyon, to the west of Cascade Ridge northeast of Provo.

Fossils identified by the writer include:

<u>Cleiothyridna</u> sp.
<u>Chonetes</u> sp.
<u>Dictyoclostus</u> sp.
Crinoid fragments

The Manning Canyon shale is Upper Chesterian and Lower Springerian in age according to available paleontological data. Girty (Gilluly, 1932, pp. 32-33) (Nolan, 1935, pp. 31-33) placed the boundary at the highest quartzite unit within the shale. However, due to the distorted nature of the formation no attempt was made by the writer to map a time-rock boundary.

PENNSYLVANIAN SYSTEM

OQUIRRH FORMATION

The Oquirrh formation is by far the thickest stratigraphic unit in the mapped area. Thompson, Verville, and Bissell (1950, p. 430) report 26,000 feet of Oquirrh in central Utah, of which 16,000 feet is Pennsylvanian and 10,000 feet is Permian. Gilluly (1932, pp. 34-35) measured approximately 17,000 feet of this formation in the Oquirrh Mountains where he named the formation and designated the type locality.

In the Payson Canyon-West Loafer Mountain area rocks of the Oquirrh formation form Tithing Ridge and the small mountain centrally located between Bear Canyon, Loafer Canyon, and Utah Valley. The major portion of the west flank of Loafer Mountain is also composed of the Oquirrh formation (see Plate 1).

The rocks composing the mountain north of Bear Canyon are limestone, arenaceous limestone, argillaceous limestone, calcareous shale, and a few units of orthoquartzite and calcareous orthoquartzite. The upper one-half of this section is covered by slope wash making description and measurement difficult, but the dominance of the float is argillaceous and arenaceous limestone. The contact between the Oquirrh and Manning Canyon formation is very gradational and apparently conformable; therefore, the overlying few hundreds of feet of lower Oquirrh probably are Morrowan in age. No fossil evidence was noted to disprove this age assignment and those present suggest Lower Pennsylvanian; also, the dominant limestone lithology strongly suggests a Morraowan age. The writer measured 1,075 feet of Oquirrh rocks north of Bear Canyon. This section is incomplete as the upper beds of the exposed formation pass beneath valley fill.

The Oquirrh formation on the west flank of Loafer Mountain is in fault contact with part of the older Paleozoic rocks due to thrust faulting, which overthrust the Paleozoic rocks (the Peteetneet thrust) upon the Oquirrh formation. Rocks of the Oquirrh consist dominantly of buff- to light-tan orthoquartzites which are very fine-grained and thin-bedded. Units of argillaceous and arenaceous limestone and calcareous shale occur sparingly throughout the formation. The argillaceous limestone commonly contains fossils; the following are representative of the writer's collection:

<u>Composita</u> sp.	<u>Fenestrellina</u> sp.
<u>Cleiothyridina</u> sp.	<u>Polypora</u> sp.
<u>Marginifera</u> sp.	<u>Pinniretepora</u> sp.
<u>Spirifer</u> sp.	<u>Ameura</u> ? sp.
<u>Neospirifer</u> sp.	<u>Dictyoclostus</u> sp.
<u>Caninia</u> sp.	<u>Derbyia</u> sp.
crinoid fragments	sponge spicules

This fossil assemblage would suggest Derryan (Atokan) age, for the rocks in the east-central portion of the mapped area, as does the characteristic slope and ledge forming interbedded orthoquartzite and limestone.

Measurements from near the fault contact on the south rim of Rock Canyon indicate an incomplete thickness of 1,530 feet of Derryan (Atokan) rocks, making a minimum of 2,600 feet of Quirrh rocks in the

Payson Canyon-West Loafer Mountain area.

CRETACEOUS AND TERTIARY SYSTEMS

NORTH HORN FORMATION

The North Horn formation has a wide areal distribution in the mapped area. It is present along the west side of' Peteetneet Creek in isolated outcrops, and also occurs inthe southeast corner of the area, covering section 13 and parts of section 12 and 14 T.10S. R.2 E. (see Plate 1). A few isolated exposures crop out in the interfluve between Peteetneet Creek and the Right Fork, where erosion has removed the overlying volcanic conglomerate and exposed the North Horn.

The North Horn in this area is a red weathering conglomerate mostly of pebble and cobble size particals, though variations are found. The clasts include limestone, dolomite, orthoquartzite, and metaquartzite. Discrete fragments, recognizable as having been derived from the Cambrian, Mississippian, and Pennsylvanian rocks can be recognized as well as purple quartzite boulders and purple metaconglomerate from the Precambrian. This indicates that essentially all the Paleozoic section as well as much of the Precambrian was exposed during deposition of the conglomerate. The matrix weathers pale red and gives a reddish stain to the underlying formations.

This formation unconformably overlies the Oquirrh formation in the southeast corner of the mapped area; an angular unconformity exists between the North Horn and the Humbug formations on the west side of Payson Canyon (see structure section, Plate 1). The dip of the North Horn formation is essentially unchanged since deposition in most areas, although in a few localities the formation has been deformed (Eardley, 1934, p. 336).

The age of the North Horn is late Cretaceous and early Tertiary according to Spieker (1946, p. 134 - 135). Eardley (1934, p. 335), who described this formation as the Wasatch conglomerate, dated it as Tertiary on the basis of lower Eocene gastropods taken from an interbedded fresh water limestone in Frank Young Canyon.

This conglomerate was deposited over the folded and truncated Paleozoic strata, evidently attending rapid erosion of uplifted areas brought into relief by the Laramide orogenic pulses. The rock grades into finer sediments to the east indicating the source area was to the west. The Southern Wasatch Mountains probably lay near the western boundary of the North Horn depositional basin (Eardley, 1934, pp. 336-339).

No outcrops suitable for measurement were found in this particular area; however, Eardley (1934, p. 335) reports 1,200 feet of this formation a few miles to the south. The original thickness of the North Horn was probably much greater as it has been exposed to erosion since Tertiary times.

TERTIARY SYSTEM

FLAGSTAFF LIMESTONE

The Flagstaff limestone is exposed as an isolated outcrop, very small in areal extent, at the head of Bear Canyon. An angular unconformity is present between the underlying overturned Oquirrh formation and the relatively flat-lying Flagstaff limestone.

This area was apparently positive during North Horn deposition, but later covered by the Flagstaff lake. The original thickness and extent of the Flagstaff in this area is not known, but accelerated erosion evidently has taken place since deposition, leaving only a thin veneer of limestone here and there.

The limestone is cream-colored to white, and is very fine-grained to sublithographic in texture. The rock has red-weathering parting planes or fracture surfaces throughout, and breaks with a conchoidal fracture.

The age of the Flagstaff limestone is not precisely determined, but is regarded as being Paleocene rather than Lower Eocene by Spieker (1946, p. 136). Harris (1953, p. 88) concludes that a Late Paleocene or Early Eocene age be assigned to the Flagstaff. Muessig (Harris, 1953, p. 89) however, states that the Flagstaff limestone is Upper Paleocene or Lower Eocene or that it may be completely Eocene in age.

VOLCANIC CONGLOMERATE

Extrusive volcanic rocks evidently at one time covered a considerable area in Payson Canyon. However, most of these deposits have been reworked by water and are now present as a water-laid deposit. The interfluve between Peteetneet Creek and the Right Fork is composed of this volcanic-derived material (consists of conglomerate and breccia) which forms the hummucky topography typical of its weathering habit. Outcrops also flank the west side of Dry Mountain extending southward out of the area mapped.

The source of the conglomerate is not known at the present time, but views of some geologists (Loughlin, 1919, p. 326-327; Eardley, 1934, p. 339) indicate that the cobbles and boulders are the result of rapid weathering and attendant erosion of a soft tuff matrix of a volcanic breccia. This original breccia may still be present in places beneath the volcanic conglomerate, although no evidence was found by the writer to test this idea. Most of the cobbles and boulders are round to sub-round, but occur in a more angular matrix. This rounding may be due, in part at least, to exfoliation, although likely most of the abrasion is due to stream transit.

Outcrops one-half mile south of Maple Dell contain relatively fresh exposures (due to stream erosion of the Right Fork of Peteetneet Creek) which display stratification and deposition by water. This stratification may be due only to the filling of the then existing stream channels and small gullies in the North Horn; at least this has been suggested by Eardley (1934, pp. 339-340).

The hydropyroclastic is an andesite to hornblende andesite conglomerate with a dark yellowish-gray kaolinized matrix; the size range is variable but the material commonly takes the form of a rounded pebble-to-cobble conglomerate, as well as a granule-to-pebble breccia.

The volcanic material is younger than the North Horn as indicated by its unconformable position overlying the latter. This material probably predates the epoch of Basin and Range faulting as displacements ascribed to this system can be traced into the conglomerate.

Schoff (1951, pp. 643-645) discusses a volcanic conglomerate of Oligocene age that may possible correlate with the hydropyroclastic material in the Nebo area, which would then possibly correlate with the pyroclastics in the writer's area (?). Harris (1953, pp. 90-103) also discusses a pyroclastic rock, which he correlates with the hydropyroclastic in the Cedar Hills, there called the Moroni formation.

The writer did not use the name Moroni because there seems to be some doubt concerning its validity. Schoff named the formation in 1937 (Harris, 1953, p. 90) but in a later publication (1951, pp. 643-645) he discusses the same pyroclastic material but makes no mention of the name Moroni. Harris (1953) also uses the name with query. It is also doubtful if correlation can be made between the pyroclastics of the writer's area and that of the Birdseye area or that of the Cedar Hills.

QUATERNARY SYSTEM

ALLUVIUM

Material mapped as alluvium is of three types; fanglomerate, colluvium, and stream alluvium. Although other types, such as talus, mud flows, landslides, and slope wash are present they are of relatively small areal extent. Since the Laramide orogeny, fans have been constructed valley-ward from Loafer Canyon, Box Canyon, and the old outlet of Payson Canyon, probably in the vicinity of the Goose Nest. These fans have coalesced forming a piedmont that extends in apron-fashion to the north from these canyons. Since the disappearance of ancient Lake Bonneville the streams have dissected these fans, giving rise to the present day topography.

The residual alluvium in the flat canyon bottom west of Maple Dell has been subjected to little erosion and relatively little weathering in place. It has been mapped largely as Humbug float, inasmuch as the alluvium and soil are composed of this formation.

Stream alluvium is confined to the present-day stream channels. This alluvium forms a thin veneer of heterogeneous debris in the canyon bottoms and stream channels.

IGNEOUS ROCKS

DIABASE FLOW

A diabase flow occurs in the Tintic quartzite approximately 150 to 200 feet above the base of this formation, and outcrops in the east slope of Payson Canyon south of Rock Canyon. The exposure is small and highly weathered. The attitude of the flow cannot be determined due to the distortion of the Tintic quartzite.

The flow has been described by Eardley (1934, p. 343-344) as a still but detailed study by Abbott (1951) has shown that it is a flow. The same type of material occurs in several localities in central Utah in approximately the same stratigraphic position.

Microscopic examination reveals the rock has a porphyritic diabase texture with phenocrysts of plagioclase (labradorite) and a matrix composed of smaller plagioclase crystals and pyroxene (probably augite) and some magnetite. The original rock is intensely altered, and sericite and kaolinite occur as secondary minerals. The rock is characterized by reddish alteration bands of iron oxide in a light-green background.

Due to its position in the Tintic quartzite and its occurrence as a flow, its age is the same as the Tintic which is Lower Cambrian.

DIKE (?) ROCK

Located in the NW 1/4, NW 1/4, NE 1/4, of sec. 3 T. 10 S. R2 E. is an igneous rock (?), probably a dike, that has assimilated a large quantity of calcite. The field relations of this rock to that of the country rock could not be determined due to the thick soil cover.

Microscopically, the rock contains, in order of importance: calcite, plagioclase zoned and twinned, biotite with wavy cleavage planes, quartz, and hematite. Calcite comprises at least 50 per cent of the rock.

VOLCANIC TUFF

A small outcrop of volcanic tuff, not shown on the map, is located just south of the Boy Scout Camp along Peteetneet Creek.

STRUCTURE

The rocks of the area discussed in this report show at least these three periods of crustal unrest: Pre-Laramide, Laramide, and the Basin and Range deformation. The first episode of deformation occurred immediately proceeding the Laramide orogeny or may even have been an early phase of it. The pre-Laramide is characterized by east-west trending high angle faults. The Laramide orogeny occurred from Late Cretaceous to Late Eocene times and was characterized by folding, normal faulting and thrust faulting. The Basin and Range system, characterized by north-south normal faults, occurred from Miocene to Recent times.

FOLDS

During the early stages of the Laramide orogeny a large anticlinal fold was formed which overturns and passes into a thrust fault at the southern end of the Wasatch Mountains. Dry Mountain, at the north end of the southern Wasatch Mountains, is carved out of the east limb of this broad open fold (Eardley, 1934, p. 379). The strata forming the east flank of Dry Mountain dip approximately 30 degrees to the east and extend into the mapped area where the strata are apparently terminated by the Payson Canyon wrench fault.

The mountain north of Bear Canyon is composed of overturned Oquirrh strata, and is probably a recumbent limb of the West Mountain syncline that has been thrust and rotated into its present position during the period of thrusting (this will be discussed in a later section).

Rocks of the Oquirrh formation in the east-central portion of the mapped area have a dip of 45 to 55 degrees to the south-east, while the strata forming Loafer Mountain have an eastward dip of about 25 to 35 degrees. This additional dip may have occurred during the period of thrusting by the same compressional forces from the north and northwest, or due to tilting caused by the Wasatch fault.

FAULTS

Three principal periods of faulting can be detected in the mapped area: pre-thrust high angle faults, thrust faults, and faults occurring after thrusting.

HIGH ANGLE FAULTS

Numerous high angle normal faults occur in the mapped area which are apparently older than the thrusts. These faults trend essentially east-west and have dips as much as 80 degrees. The high angle faults are confined to the allochthonous thrust blocks and on no occasion did the writer observe the faults cutting or displacing the thrust contact. On the contrary, the Bear Canyon thrust appears to override at least one of these "older" faults indicating that the east-west fault is older than the thrusts. Possibly the age differential is not great.

Eardley (1934, p. 379) describes "pre-Laramide" east-west normal faults that occurred before Laramide folding. Croft (1956, p. 28) also gives evidence of east-west faulting in the Onaqui Mountains before thrusting took place.

This east-west system of faulting shows great stratigraphic displacement. The fault extending through Rock Canyon has a throw of about 1,400 feet, and numerous other faults have throws measured in several hundreds of feet.

THRUST FAULTS

Two large, well defined thrust faults, the Peteetneet thrust and the Bear Canyon thrust, and at least one minor thrust are present in the mapped area.

Peteetneet Thrust

The Peteetneet thrust overrides the Oquirrh formation in imbricate fashion juxtaposing Cambrian and Mississippian strata against the Oquirrh. The fault trace, about one and one-half miles long, extends from Peteetneet Creek near the west-central portion of sec. 11 T. 10S. R. 2 E., in a north-east direction to the west-central portion of sec. 1 T. 10 S. R. 2 E. where it is overridden by the Bear Canyon thrust fault. The southern end of the Peteetneet thrust is terminated by the Payson Canyon wrench fault of later date.

Bear Canyon Thrust

The largest thrust in the mapped area is the Bear Canyon thrust. The allochthonous Oquirrh material of the Bear Canyon thrust has been displaced upon Upper Paleozoic strata of the Peteetneet thrust and eastward dipping Oquirrh sediments, and the thrusting may have occurred in ramp fashion, using the incompetant Manning Canyon shale as a sole. Vertical and overturned Oquirrh strata are in juxtaposition with relatively horizontal Pine Canyon limestone, Humbug, and eastward dipping Oquirrh rocks (see structure section, Plate 1).

The fault trace, three and one-half miles long, forms a semi-circle concave toward the valley and can be followed from the Payson Canyon wrench fault eastward along the south wall of Bear Canyon, over the divide and into Loafer Canyon, where it follows the east wall of Loafer Canyon northward into the valley.

The allochthonous vertical to overturned, east-west striking Oquirrh formation is probably a southeastward extension of the Red Point thrust discussed by Brown (1950, p. 41-43). Both thrusts, the Red Point thrust and the Bear Canyon thrust, are probably small imbricate thrusts rising from

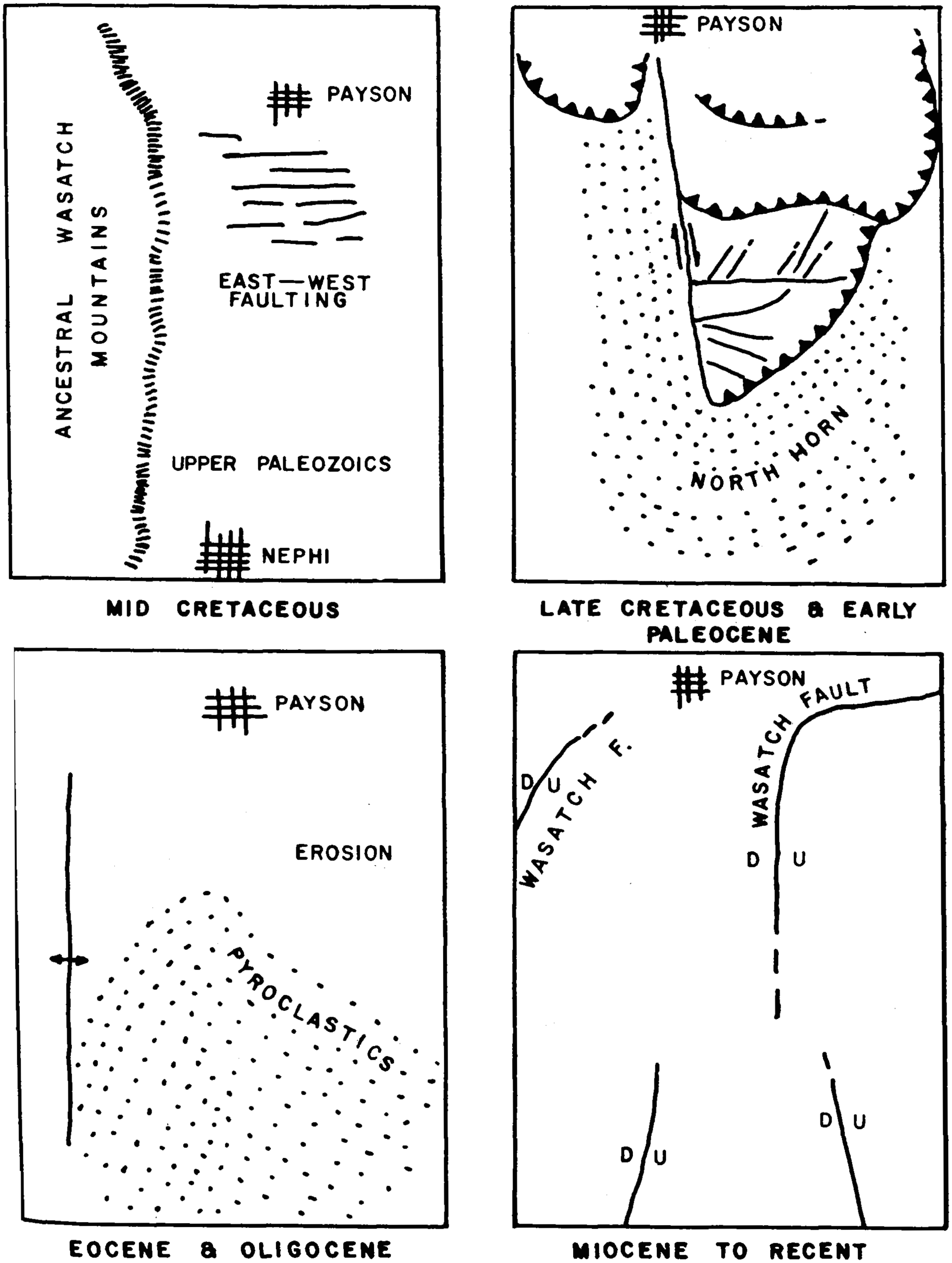


Fig. 4 STRUCTURAL EVOLUTION OF THE WEST LOAFER MOUNTAIN—UPPER PAYSON CANYON AREA

a larger thrust fault. As pointed out to the writer by Dr. H. J. Bissel, probably a close relation exists between the Oquirrh of West Mountain, about ten miles to the northwest, and the allochthonous Oquirrh material of the Red Point and Bear Canyon thrust. The writer visualizes force from the northwest acting upon a mass which formerly extended from the southern tip of Lake Mountain thrusting the Oquirrh to the southeast. The Red Point thrust eventually came to rest upon and against the northern end of the Dry Mountain anticline and the Bear Canyon thrust having been displaced farther east and south, with the drag material between the two thrusts forming Tithing Ridge.

At least one minor thrust fault was observed in the Manning Canyon shale, where overturned strata of this formation have overridden northward dipping rocks also of the Manning Canyon.

POST-THRUST FAULTS

Faults that occur in the mapped area after thrusting are, as far as can be determined, north-south trending and of two types; first, faults occurring penecontemporaneously with the thrusts, and second, faults associated with the Basin and Range system.

Payson Canyon Wrench Fault

The Payson Canyon wrench fault has been described by Brown (1950, p. 43-44) and by Eardley (1934, p. 388) as the Payson Canyon fault.

The fault trace extends up Payson Canyon from the mouth approximately five and one-half miles where it is not recognized in the volcanic conglomerate. This fault, in the writer's opinion, cannot be separated from the Bear Canyon and Peteetneet thrusts as it represents the surface along which the thrusts were displaced southward. A displacement southward along northwest-southeast lines by compressional forces from the northwest, of at least five miles is indicated by the continued occurrence of the North Horn formation along the west side of the fault and its complete absence along the east side of the fault.

The age of the Payson wrench fault, as stated above, is probably contemporaneous with the thrusts, but renewed movements have probably occurred along the original fault plane, making it possible to trace the fault into the younger volcanic conglomerate.

BASIN AND RANGE FAULTS

Two faults are inferred in this area that are probably of Basin and Range type. These faults are located in the volcanic conglomerate and were inferred due to the difficulty in obtaining direct evidence for faulting.

The trace of a fault can be followed from the junction of Wimmer Ranch Creek and the Nebo Loop Road along the canyon south and extending out of the mapped area. The displacement juxtaposes volcanic conglomerate against the North Horn formation. The fault is apparently normal and dips to the west with the hanging wall down.

The fault extending up the Right Fork of Peteetneet Creek is the same type of fault, dips west with the hanging wall down, although the displacement is not as great.

Faults of the Basin and Range type are suggested in the Humbug formation west of Peteetneet Creek by the presence of the wide outcrop pattern. The writer believes the strata have been duplicated by faults as the thickness and dip of the Humbug formation in normal sequence would not account for the wide outcrop pattern. Demars (1956, Plate 1) shows faults in the Humbug; this data to some extent supports the writer's conclusions. These faults, however, were not mapped due to inconclusive evidence and the thick soil cover.

The Wasatch Fault

The Wasatch fault extends from Collinston, Utah on the north to the southern end of the Wasatch Mountains near Nephi, Utah on the south. The length of the fault is approximately 125 miles (Gilbert, 1928, Fig. 12, p. 20).

The fault scarp and fault-line scarp can be followed southwest along the west base of Loafer Mountain to the vicinity of Payson Canyon and north to the vicinity of Red Point. Various interpretations of what happens to the fault in the Payson Canyon area are as follows.

Gilbert (1928, Fig. 12, p. 20) has drawn an outline map of the Wasatch fault showing the fault cutting through this general area. Gilbert's map however, was not intended to give detail but to furnish only an outline pattern.

Eardley (1934, map 11; p. 388) mapped a southern extension of the Wasatch fault as extending up Payson Canyon.

Andrews and Hunt (1948) show a branch of the Wasatch fault extending south of this area, and continuing west into the valley and along the west side of Long Ridge. The fault along the Nebo front is shown joining this branch near Payson. From recent work of Brown (1950) and that of the writer it is evident that the Wasatch fault does not pass through either of these two areas and it is doubtful that evidence is strong enough to extend the fault to Long Ridge.

It is the opinion of the writer that the Wasatch fault actually extends up Payson Canyon similar to that shown by Eardley (1934, map 11). The fault scarp swings south in the vicinity of the Goose Nest and is lost in the volcanic conglomerate farther up the canyon. The fault trace to some extent follows the trace of the Payson Canyon wrench fault. The Wasatch fault extending along the Nebo front can be traced north to the vicinity of Red Point where it appears to be lost in alluvium; this is also suggested by the low relief of the hills around Red Point.

The displacement is taken up by an echelon type movement between Red Point and the writer's area rather than one complete fault line.

Briefly stated, the rocks of the allochthonous plates have been thrust into the area, and later elevated into the present position by the Wasatch fault. The form and proportion of the Wasatch Range in this area are due to a long series of tectonic events with attendant erosion, which began as early as Cretaceous time and are still continuing. Seismic activity evidently has not ceased.

AGE OF GEOLOGIC STRUCTURE

The area undertaken for study in this report is not large enough to determine the age of the structural features on direct evidence, therefore, the writer has tried to correlate the structural features with those of contiguous areas. Much of the data has been marshalled by Eardley (1951) who has summarized most of the material of other writers dealing with the structural evolution of the Wasatch Mountains. He (Eardley, 1951, p. 273-276) describes the Cedar Hills orogeny, as suggested by the Indianola group, as a prelude to the Laramide orogeny. This orogeny was a belt of deformation that extended from southern Nevada to eastern Idaho during Mid-Cretaceous time.

The first phase of the early Laramide orogeny (Montana time) produced a series of east-west trending folds between the northern Utah uplift and the Cottonwood uplift. A second phase was characterized by intense thrusting from the west producing the Bannock, Willard, and Nebo overthrusts. During this phase the small imbricate thrusts of the Payson Canyon area were probably formed.

During Paleocene time the Mid-Laramide pulsation produced epeirogenic uplift followed by more coarse conglomerates. The late Laramide or Eocene phase produced the present system of broad north-south trending folds in central Utah. During Oligocene times the Absarokan orogeny was characterized by volcanics and folding.

Immediately following the Laramide orogeny adjustments began to take place in the form of faulting. These faults, the Basin and Range system, have been occurring from Miocene (?) to the present. These faults tend to block out the Mountain ranges by a system of high angle normal faults. Apparent movement of this type during Pliocene or early Pleistocene times caused the major displacement along the Wasatch front causing the Wasatch fault. However, renewed movement may be observed along the base of Loafer Mountain that may be only a few hundred or a few thousands of years old. In numerous localities evidence indicates the footwall block to have been elevated 100 to 200 feet since ancient Lake Bonneville disappeared from this area. This suggests a "normal upthrust" type of faulting.

SUMMARY OF GEOLOGIC EVENTS

The Cambrian period was characterized by long and in part continuous deposition in a sea that was transgressing slowly eastward across the Cordilleran area. The sediments were deposited near the eastern shoreline of the broad orthogeosyncline in relatively shallow water, probably in the neritic zone and likely upon a slightly unstable shelf. The finely laminated, oolitic, sublithographic texture of the Dagmar and the Cole Canyon formations indicate very shallow water of the epineritic zone and/or the tidal flat ("Wattenschilick", Hantzschel, 1939, pp. 195-206). The Cambrian section in general decreases in thick ness to the east. This decrease is especially noticeable between the Tintic district and the Southern Wasatch Mountains (see Fig. 5).

The shoreline of the Ordovician, Silurian, and Devonian seas most likely lay at some place between this area and what is now the site of the East Tintic Mountains. Representatives of these three systems in that district which thin to feather edges eastward through the Long Ridge area, but are absent in Payson Canyon. Most likely during this part of the Paleozoic this part of the state was near the eastern edge of the Cordilleran miogeosyncline, the orthogeosyncline having been more or less divided into a western trough or eugeosyncline, and an eastern basin or miogeosyncline by the Manhattan orogenic area as early as Ordovician time (Bissell, 1955, pp. 1643-1644).

Mississippian sediments also show a general eastward thinning in this part of Utah; this is true of the Gardner formation. The lower Gardner is also absent in the writer's area, but is present on Long Ridge, indicating that the lower Gardner wedges out some where between. In this respect the conditions may have been somewhat similar to the Ordovician, Silurian, and Devonian sedimentary history. The area was continually subsiding during Mississippian and Pennsylvanian times, characterized by shelf and miogeosynclinal sedimentation. During these times, notably the Pennsylvanian period, great thicknesses of sediments accumulated.

The Cedar Hills orogeny caused uplift with attendant and subsequent deposition of the Indinola formation during Mid-Cretaceous time. The first phase of the Laramide orogeny produced uplifts in northern Utah and the Cottonwood area with east-west trending folds between. A second phase of the Laramide orogeny, during Late Cretaceous and Early Paleocene times, produced north-south trending folds which were overturned and thrust eastward causing the Bannock, Willard and Nebo thrusts. Uplift during these pulsations caused the coarse clastics of the North Horn formation. The late stages of the Laramide orogeny produced broad north-south trending folds superimposed over the thrusts during the compressional stage. During Oligocene times the Absarokan

Plate III

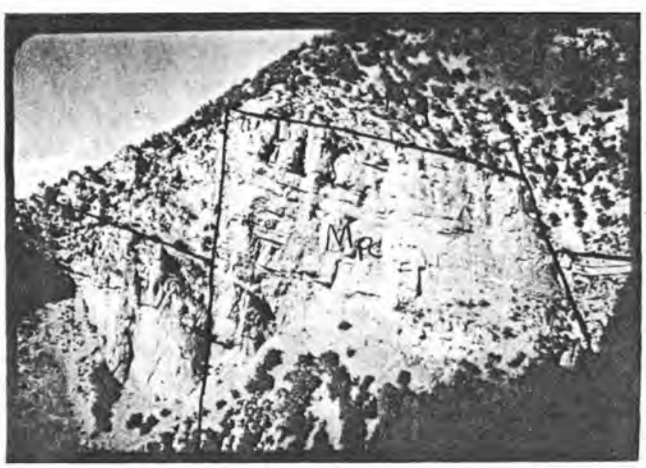
A - Mapped area from the west.

B, C, and D - Normal faults on the north side of Rock Canyon.

A

B

C



D

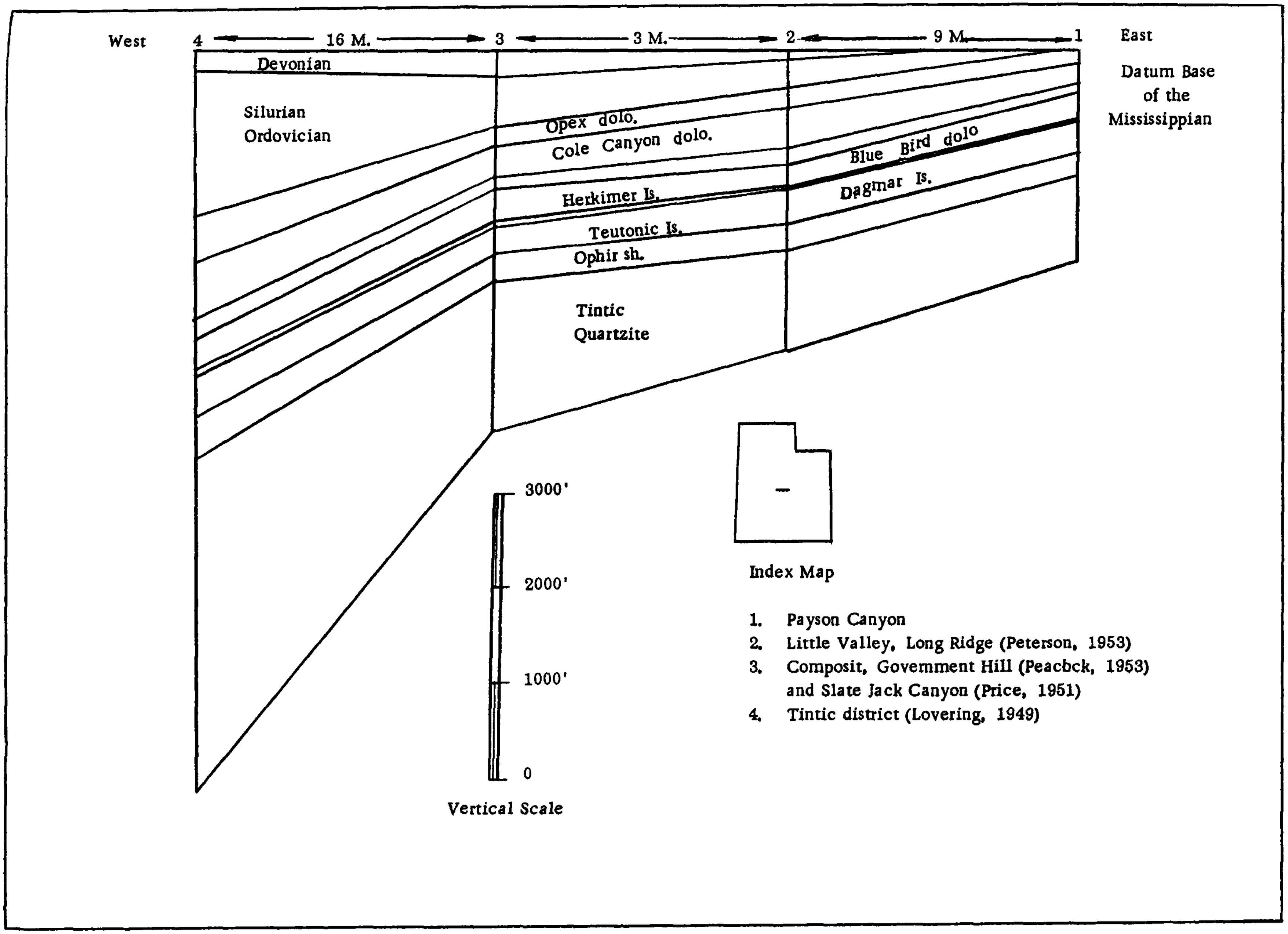


Fig. 5 - Stratigraphic diagram showing thinning of the Lower Paleozoic systems from the Tintic district eastward to Payson Canyon.

orogeny caused mild diastrophism and volcanism. The pyroclastics may have been spread across much or all of the area during this phase. Beginning in Miocene times and continuing to the present the north-south faulting of the Basin and Range system occurred. Movements along the Wasatch fault may be as recent as a few hundred years, and likely the area is seismically active.

Ancient Lake Bonneville did not reach as far south as this part of Payson Canyon. However, it left spits, bars, and other embankment deposits a few miles to the north and no northeast.

Alluvium, colluvium, and related products of weathering and mass wasting have been accumulating in parts of the area at least since Late Tertiary times.

ECONOMIC GEOLOGY

Water is the most valuable mineral resource in the mapped area. The watershed is characterized by steep slopes and a broad canyon bottom in the lower part. The higher watershed to the south and near the divide is characterized by relatively flat topography dissected by many small streams. The high altitude, with heavy snowfall and flatter topography, tends to retain the water longer and make the area a valuable watershed. The flat hummocky topography has many small basins in which the Payson Lakes, Winward and Dry Lake reservoirs, Maple Lake and Red Lake are located. Many small springs which issue from the North Horn and overlying volcanic conglomerate are also found in the area.

The area supplies culinary water to Payson City, water to the Strawberry Water Users power plant at the mouth of the canyon, and irrigation water to the area in and around Payson. Peteetneet Creek drains the area and discharges 30-50 second feet of water in the spring and may become essentially dry in the fall.

In the deep gully north of the Goose Nest paleosals are exposed that contain lenticular deposits of residual clay. This clay however, has a high content of lime and is probably of little economic value in ceremics. Clays and shales of the Manning Canyon formation are best exposed near the forest boundary marker along the Nebo Loop Road. The best clays of the Manning Canyon are non-calcareous light greenish to dark gray in color (Hyatt, 1953, p. 47). The shales observed by the writer are, for the most part, the black carbonaceous variety. These deposits are easily accessible and the writer believes (with exploration) commercial deposits might be found.

A few prospects and adits are located in the area, mostly along slightly mineralized fault zones. Adits were driven into the diabase flow (sec. 2 T. 10 S. R. 2 E.) where copper showings were found at the surface but nothing of commercial value was realized from the tunnel (Eardley, 1934, p. 344). A steeply inclined shaft has been driven in the Manning Canyon shale near the Forest boundary along the Nebo Loop Road (sec. 3 T. 10 S. R. 2 E.). The shaft (now caved) follows ironstone bands in the shale as the prospectors apparently anticipated mineralization along the ironstone.

No sand and gravel are found within the mapped area, although a pit has been excavated in the badly fractured Tintic quartzite. The quartzite was apparently used as road metal along the trails and roads of the Maple Dell Boy Scout Camp and to a limited extent along the Nebo Loop Road.

The west flank of Loafer Mountain and the southern part of the area are used as range land.

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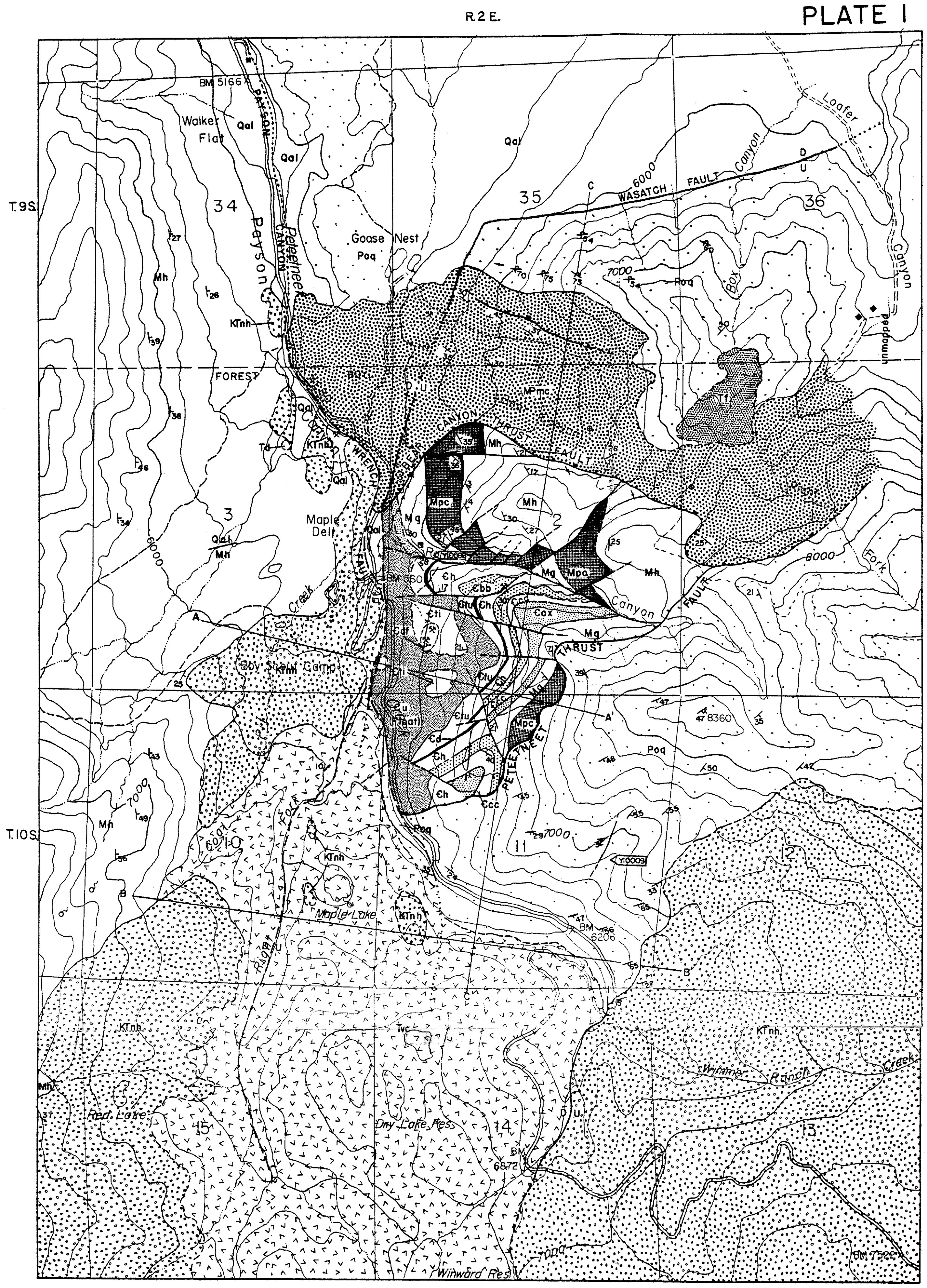
PLATE I



Base Map traced from U.S.G.S. Santaquin Peak Quadrangle

Mapped on 1:12,000 & 1:20,000 Aerial Photographs During 1955

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY
- Qal — Alluvium

TERTIARY
- Tvc — Volcanic conglomerate
- Tf — Flagstaff limestone

CRET-TERT
- KTnh — North Horn formation

PENN.
- Poq — Oquirrh formation

MISS-PENN.
- MPmc — Manning Canyon shale

MISSISSIPPIAN
- Mh — Humbug formation
- Mpc — Pine Canyon limestone
- Mg — Gardner dolomite

CAMBRIAN
- Cox — Opex dolomite
- Ccc — Cole Canyon dolomite
- Cbb — Bluebird dolomite
- Ch — Herkimer limestone
- Cd — Dagmar limestone
- Ctu — Teutonic limestone
- Cti — Tintic quartzite
- Cu — undifferentiated (covered by cambrian float)

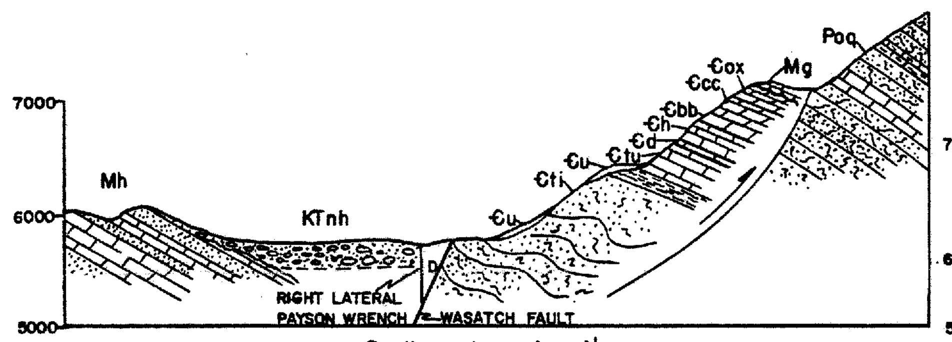
IGNEOUS ROCKS

TERT.?
- Td — Dike rock?

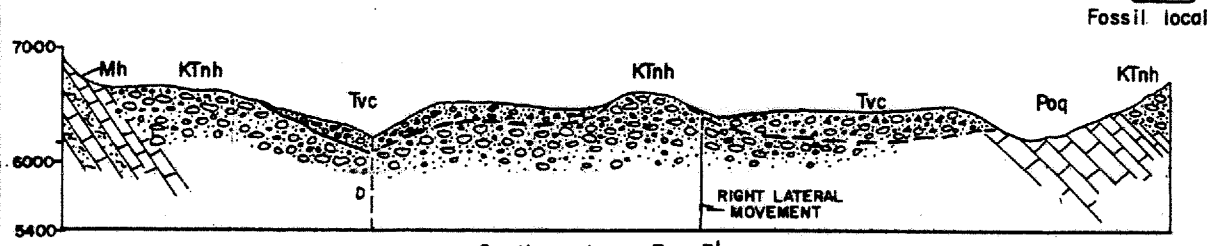
CAMBRIAN
- Cdf — Diabase flow

SYMBOLS

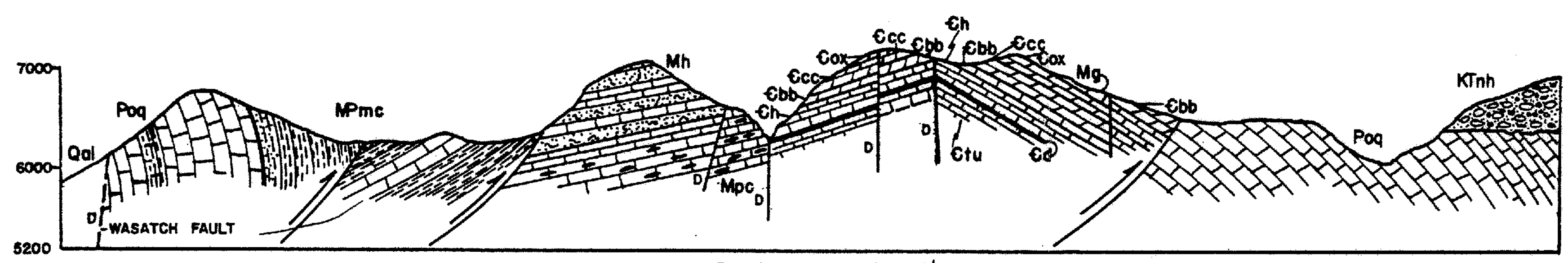
- Horizontal beds
- Dip and Strike
- Strike of vertical beds
- Strike and dip of overturned beds
- Prevailing dip of beds
- Fault— dashed where doubtful dotted where concealed, D= downthrown side, U=upthrown
- Fault showing relative movement
- Thrust Fault (teeth on upper plate)
- Prospect
- Adit
- Mine shaft
- Fossil locality



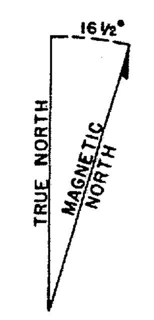
Section along A—A'



Section along B—B'



Section along C—C'



GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE WEST LOAFER MOUNTAIN—UPPER PAYSON CANYON AREA, UTAH

by

DEVERL J. PETERSON

1956

1000 0 1000 2000 3000 4000 5000 FEET

Contour Interval 200 feet