BRIGHAM YOUNG UNIVERSITY RESEARCH STUDIES

Geology Series Vol. 3 No. 7 July, 1956

GEOLOGY OF THE NORTH CANYON AREA, SOUTHERN WASATCH MOUNTAINS, UTAH

by

Cleon V. Smith

☆

Brigham Young University
Department of Geology
Provo, Utah

GEOLOGY OF THE NORTH CANYON AREA, SOUTHERN WASATCH MOUNTAINS, UTAH

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

Cleon V. Smith

August, 1956

ACKNOWLEDGEMENTS

The writer gratefully acknowledges the assistance of Dr. Harold J. Bissell for help in field work and checking the manuscript, Dr. George H. Hansen for supplying ground water information and well logs and Professor Jess R. Bushman for checking the writer's manuscript.

The writer is indebted to Dell R. Foutz, for his help in field work and to his brother, Grant B. Smith, for field assistance.

The writer expresses sincere appreciation to his wife, Meridee, for her encouragement and cooperation.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ABSTRACT

This thesis is a detailed study of the geology of the North Canyon area, a part of the Southern Wasatch Mountain Range, an area of approximately 15 square miles that was mapped in detail.

The mapped area includes rocks representative of at least parts of the Precambrian, Cambrian, Ordovician (?) and Mississippian systems. Unconsolidated sediments of Quaternary age were mapped as fans, landslides and alluvium.

Major structural movements that affected the area include east-west faults, Laramide folds, the Nebo overthrust, and Basin and Range faults.

Only one mining operation in this area has been successful. The main economic value is the exceptionally good supply of water from the canyons and from drilled water wells.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The North Canyon area is located in the north-east part of Juab County, Utah, along the Wasatch mountain front east of the towns of Santaquin and Mona.(See Fig. 1). Mount Nebo, on the southern end of the Wasatch Range lies to the immediate southeast. The Wasatch Range forms a boundary here, separating three physiographic provinces: the Basin and Range, the Southern Rocky Mountains and the Colorado Plateau. The most southerly extension of the Unita National Forest is included in the area.

The mapped area comprises about fifteen square miles lying between parallels 39° 50" and 39° 53" North Latitude and meridians 111° 46' and 111° 51' West Longitude. Included in the mapped area are sections 9, 10, 15, 16, 21, 22, parts of sections 8, 17, 20, 27, 28, 29 projected sections 11, 14, 23 and parts of projected sections 12, 13, 24, 26 to T. 11 S. and R. 1 E.

The North Canyon area is bounded on the west by U. S. Highway 91, on the south by Bear Canyon, on the east by the Wasatch ridge; Mendenhall Canyon lies to the north.

Private dirt roads that extend east from Highway 91 lead to Mendenhall Canyon, North Canyon, Pole Canyon and Bear Canyon giving easy access to the mountain front.

PHYSICAL FEATURES

The North Canyon area is moderately rugged to the east, but slopes gently into Juab Valley to the west. The greatest relief of the area is in excess of 5400 feet with an average relief of about 4400 feet. The highest elevation is 10, 431 feet and the lowest about 5, 000 feet in Juab Valley. Mount Nebo, at an altitude of 11, 877 feet, lies a short distance to the southeast, but is outside the mapped area.

The three canyons in the area are drained by North Creek, Mona Creek and Bear Canyon Creek; the first lies at the north and the latter at the south respectively. Bear Canyon Creek is ordinarily an intermittent stream but a concrete ditch has conserved the water to such an extent that it flows continuously. Mona Creek flows the year around also but the source of water is confined to an adit at the mouth of Pole Canyon.

North Canyon is very deeply eroded exposing the complete stratigraphic section treated in this thesis. Pole Canyon has been eroded

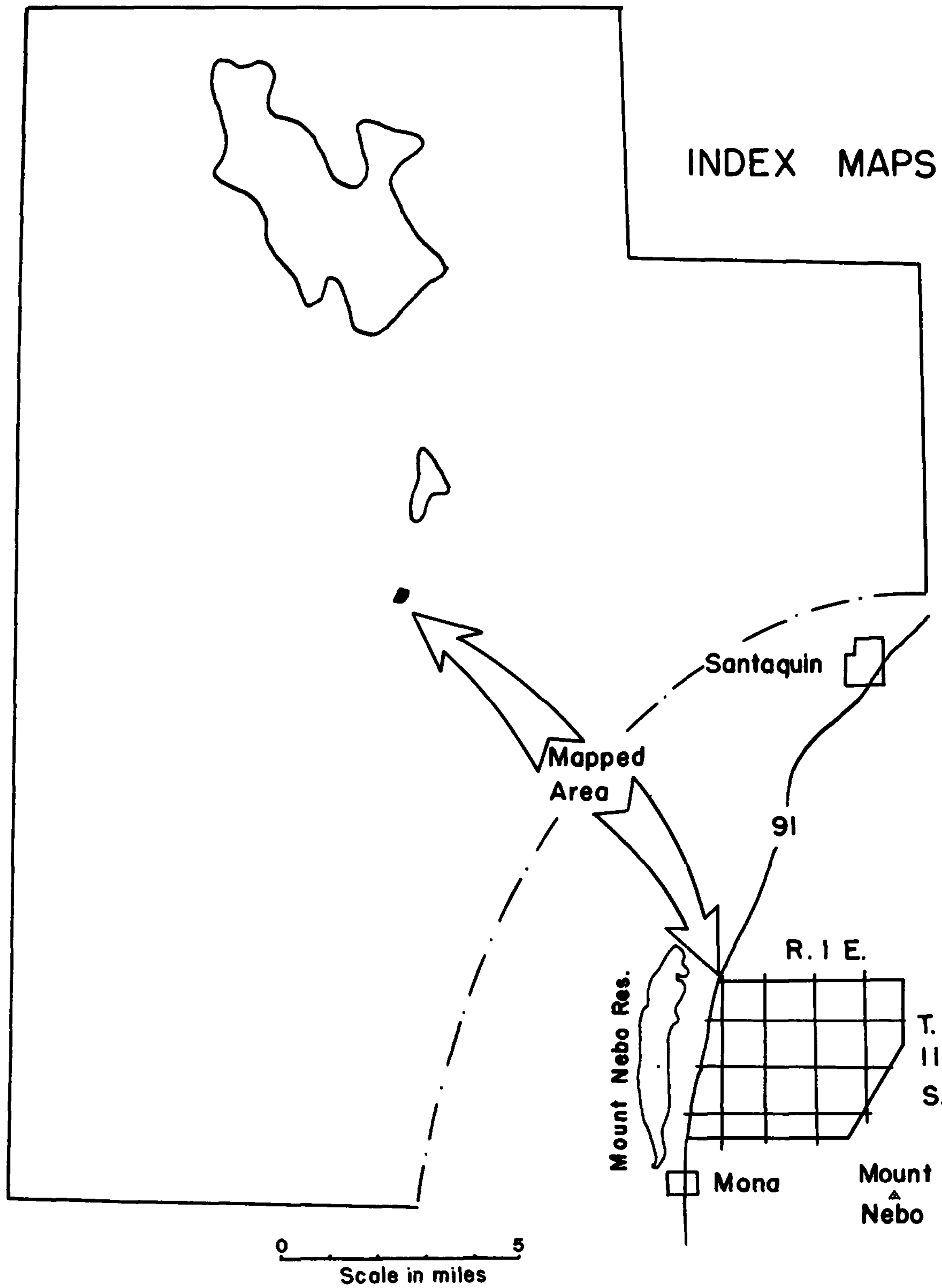


Fig. 1 Location of the North Canyon Area

more extensively than North Canyon and is much wider. Bear Canyon, on the other hand, is very narrow and rugged resulting largely from its vertical to near-vertical strata.

Vegetation of the valley consists essentially of sage brush and very little grass. On the gentle slopes Utah junipers, scrub oak, mountain maple and pinion pines predominate. Mountain mahogany, cliff-mountain rose and mountain-red junipers are common on the higher slopes. At still higher elevations the white fir, Douglas fir and aspens thrive. The canyons, particularly North Canyon, support river birch, dogwood and narrow-leafed poplars.

FIELD AND LABRATORY STUDIES

The field work was begün in July of 1955 and completed in the summer of 1956.

The entire geologic mapping was done on aerial photographs (scale approximately 1: 20, 000) taken in 1939 by the U. S. Geological Survey. The writer was able to walk over most of the formation contacts except in the deep canyons. Data from the aerial photographs was transferred to a topographic map of scale 1: 20, 000. The final map was taken from this base.

Section were measured by the use of a Brunton Compass and a steel tape.

PREVIOUS WORK

Geologists of the Fortieth Parallel Survey in 1877 apparently were the first to attempt significant geologic work in the Southern Wasatch Mountains. No mapping was done south of Provo although Mount Nebo was mentioned in the report.

The Santaquin-Mount Nebo district was treated very briefly in 1913 by Loughlin of the U. S. Geological Survey during the course of reconnaissance work in the summer of 1912.

In 1920, Loughlin published a detailed work of the area as a contribution to the Professional Paper "Ore Deposits of Utah" (Butler, et al, 1920, Plate IV). Eardley (1933, 1934) published a report and geologic map of the geology of the Southern Wasatch Mountains and presented the first adequate study of the stratigraphy, structure, and physiography of the area.

The latest detailed work was done by Abbott (1951) who mapped a diabase flow present in the Cambrian quartzite in North Canyon, and presented a detailed geologic map of part of the area.

GENERAL GEOLOGY

PRINCIPAL FEATURES

The sequence of rocks in the North Canyon area includes Precambrian metamorphics overlain by Paleozoic sedimentaries which have a few hiatuses and unconformities. Quaternary alluvial fans and colluvium are present along the piedmont area adjacent to the Southern Wasatch Mountains, while lacustrine and related unconsolidated sediment also of Quaternary age are in Juab Valley to the west.

Precambrian rocks are represented by the Big Cottonwood series, only the upper 133 feet of which is exposed, and consisting of quartzite conglomerate with quartzite matrix. Cambrian rocks include a host of weak metasediments to primarily sedimentary strata including quartzite, phyllite and shale, limestone, and dolomite; these total 2,631 feet in thickness. A sequence of dolomite and limestone measureing 336 feet is referred with query to the Ordovician. No Silurian and Devonian are recognized, but a section aggregating 2,073 feet of limestone and dolomite is referred with confidence to the Mississippian.

The area has been subjected to orogeny and epeirogeny which through Precambrian, Paleozoic, Mesozoic, and Cenozoic times has varied from strong to very mild diastrophism. The Nebo overthrust in particular, of late Mesozoic age, exercised a marked effect upon the area in overturning and thrusting Paleozoic strata eastward a considerable distance over Mesozoic rocks. Of later geologic date but of major significance is the Wasatch fault which bounds the area on the west in a magnificent escarpment, leaving the front of the range with relief of more than 5,000 feet.

EXPLANATION OF PLATE 1

(1) Dry Canyon

(2) North Canyon

(3) Pole Canyon

(4) Bear Canyon

(5) Movement of Wasatch
fault shown in alluvium

(6) Cirques on Mount Nebo

B. Y. U. Geology Dept. Photo

PLATE 1

SEDIMENTARY ROCKS

PRECAMBRIAN SYSTEM

Big Cottonwood series

The Big Cottonwood series was named for a sequence of metasediments 16,000 feet thick, in the Central Wasatch Mountains (Granger, et al, 1952, pp 3-4) and is essentially a quartz-pebble conglomerate and locally metaquartzite in the Southern Wasatch Mountains. Quartz and quartzite pebbles varying in color from white to pink and purple comprise the greatest part of the exposed conglomerate. Rocks whose grain size approach grit are found within the quartzite, and occasionally discrete fragments of cobble-size occur. The quartzite matrix exhibits several colors, mostly purple, reddish purple and light olive-green. Exposures reveal thick to massive bedded strata.

The best outcrop of the Big Cottonwood series occurs in the mouth of North Canyon. To the south the conglomerate disappears beneath the alluvium and to the north it is faulted out. In Dry Canyon, south of Mendenhall Canyon, a fault with a throw of more than 1500 feet loses the conglomerate series completely to the north and brings up a thick section to the south. This section was not measured due to very few exposures, an incomplete section and various faults cutting the series.

Rocks of Late Precambrian age were once thought to be missing in the Santaquin region but a more detailed study by Eardley (1933) indicated the liklihood of their presence. Loughlin (1919) grouped the Late Precambrian with the Cambrian quartzites but evidence now points to an unconformity between them. The position of the metaconglomerates at the base of the Cambrian quartzite bears this out. The base of the conglomerate bed is not exposed in North Canyon. About 133 feet of conglomerate was measured immediately north of North Canyon. This does not represent the thickest section in the area but the only one that has measurable continuity. About one-half mile to the north is a thicker section but is essentially covered by float. The following areas in Utah contain sections showing similar lithology and position: Big Cottonwood Canyon (the type area), American Fork Canyon, Slate Canyon, northern Long Ridge, and the Sheeprock Mountains. Geologists who have recently studied these localities have discontinued using the appelation Algonkian and are using the term Late Precambrian for these metasedimentary rocks. The present writer is also adhering to this latter practice.

CAMBRIAN SYSTEM

Tintic quartzite

The Tintic quartzite is an excellent ledge-former and can easily be recognized from a considerable distance. It stands out as a light to dark reddish-brown rock weathering darker than its fresh surface. The rock breaks cleanly and exhibits an almost conchoidal-like fracture, breaking through individual grains. Close examination reveals interstitial filling with silica around quartz grains that shows metamorphism. For this type of rock the name metaquartzite may be aptly applied.

Rounded quartz grains of larger size with no foreign material present but showing cross bedding in the enclosing strata suggest the environment of deposition to be beach and neritic sands.

A diabase flow, studied by Abbott (1951) and Eardley (1933) is present in the Tintic quartzite. Abbott considered it to be a flow and the latter a sill; the writer, however, concurs with Abbott. (See Diabase flow p. 21)

The Tintic quartzite was named by Loughlin (1919) who described the rock in the Tintic mining district. An uncomformable contact between the Big Cottonwood series and the Tintic quartzite is evident in North Canyon. It is faulted out north of Mendenhall Canyon and found only a few hundred yards south of North Canyon where it is omitted by the Wasatch fault. A full section of the quartzite is exposed between the fault and North Canyon. The diabase flow is recognized as a continuous dark band the entire length of Tintic quartzite exposure.

The fossil Olenellus was found in the Tintic quartzite by D. Peterson (1952) at Long Ridge east of Goshen, Utah. This represents the only fossil found within the quartzite (To the writer's knowledge), This, along with dated fossils in the overlying Ophir formation, indicates the age of the Tintic quartzite to be Lower Cambrian.

A complete section of Tintic quartzite was measured totalling 929 feet. The diabase flow accounts for 45 feet of this and occurs 90 feet above the base of the Tintic.

Ophir formation

This formation is dominantly shale and is typically olive-green in color. Near its base various two-to four-inch quartzite layers occur; at its top a dark blue-gray limestone unit is included. Some of the shale along parting planes shows a micaceous sheen appearing somewhat like phyllite. It has a platy weathering habit and is fissile.

A 55-foot limestone bed similar in outward lithology to the Teutonic limestone occurs 110 feet from the top of the Ophir formation. This thin-bedded limestone unit weathers medium-blue gray and is finely crystalline. Approximately 17 feet from the top, the unit becomes more sandy and argillaceous, weathering light tan in color. Oolites are common, particularly near the top.

The Ophir formation lies conformably on the Tintic quartzite throughout the area. The contact between the quartzite and the overlying shale is a gradational one as seen in North Canyon. The formation weathers readily and forms a narrow vegetated slope above the massive resistant Tintic quartzite. The outcrops of shale more or less parallel the same belt as the underlying quartzite. It is faulted out in Mendenhall Canyon and passes under the alluvium about one-quarter mile south of North Canyon.

Although Eardly (1933) measured about 300 feet of the Ophir formation at North Canyon, the writer measured only 231 feet. This however, may be due in part to the fact that a different contact was selected.

The fauna of the shale found in other parts of Utah indicate uppermost Lower Cambrian of lowermost Middle Cambrain. This age designation has resulted only after considerable arguments by Walcott, Burling and Ulrich. Eardley (1933) agrees with Guilluly (1932) that at least the lower part of the formation might possibly be Lower Cambrian in age. Only two fossils were identified by the writer:

<u>Micromitra</u> sp

<u>Lingulella</u> sp

Teutonic limestone

Probably the most characteristic feature of the Teutonic limestone is the gray-buff ribbons of argillaceous material that repetitiously occur along the thin-bedding planes. Most of the formation is a calcareous dolomite spotted with a few twiggy bodies. Some mottling is noticeable near the top along with oolite beds. For the most part the limestone is a ledge-former of blue-gray limestone and dolomite that weathers light blue-gray. Upon breaking, one discovers that it is fine to medium, sub-crystalline in texture.

The Teutonic limestone lies conformably on the Ophir formation. It outcrops in most of the area and is missing only near Bear Canyon to the south where it disappears beneath the alluvium. Some Teutonic-like limestone has been faulted down beneath the Tintic near the base of the mountain front but is so broken and distorted as to render positive identification hazardous.

An Early Middle Cambrian age has been given to the Teutonic limestone. No fossils were found in the area. The Teutonic limestone appears to thin somewhat from Tintic eastward where Loughlin (1919) measured about 565 feet; in North Canyon the limestone thins to 347 feet. In Payson Canyon, Brown (1950) measured 476 feet whereas

Muessing (1951, p. 195) measured 330 feet at Long Ridge which corresponds more closely to the measured section in North Canyon.

Dagmar limestone

The Dagmar limestone in the Tintic district lithically is a limestone but in North Canyon it is a dolomite. It is brown-gray in color but weathers almost white to form a good marker bed in the gray limestones and can be spotted easily at a distance. It is medium-to thick-bedded and finely-crystalline in texture. Laminations on the surface paralleling the beds are typical lithological features.

The best exposure of the Dagmar limestone is seen on the south side of North Canyon where it appears as a narrow white band dipping to the east along the rugged cliff. It lies conformably on the Teutonic limestone and was mapped from Mendenhall Canyon to near Pole Canyon where it passes under the alluvium. Any faults cutting the Dagmar are easily detected because of its limited thickness.

The Dagmar limestone shows a definite thinning from Tintic eastward. Tintic measurements (Loughlin, 1919) show 100 feet of the limestone while North Canyon measurements total only 40 feet. In areas closer to North Canyon, Brown (1950) at Payson Canyon reports 42 feet of Dagmar limestone and Peterson (1953) reports 49 feet in Little Valley, Long Ridge. Although the lithology changes from a limestone to a dolomite, stratigraphic position and numerous lithologic similarities give positive correlation. The Dagmar limestone is Middle Cambrian in age. No fossils were found in the mapped area.

Herkimer limestone

In North Canyon the Herkimer limestone can be divided into two units on the basis of composition. The lower half is medium blue-gray dolomite that weathers sombre-gray, is medium-crystalline, medium-bedded, mottled, oolitic, and spotted with twiggy bodies. The upper half consists of medium dark-blue limestone that weathers light blue-gray, is fine-grained, thin-bedded, and striped with pinkish-brown discontinuous bands of argillaceous material. At its type locality in the East Tintic district the Herkimer limestone is a shaly limestone superficially resembling the limestone in the Teutonic and Ophir formation. This is also true of its lithology in the North Canyon area.

The Herkimer limestone extends no farther south than Pole Canyon. It is well exposed on the south side of North Canyon where it is in conformable contact with the prominent white-weathering Dagmar limestone.

No fossils were found in the Herkimer at Tintic and the writer did not find any in North Canyon. However, north of Ophir in the Oquirrh Mountains the writer discovered the cephalon of a trilobite in

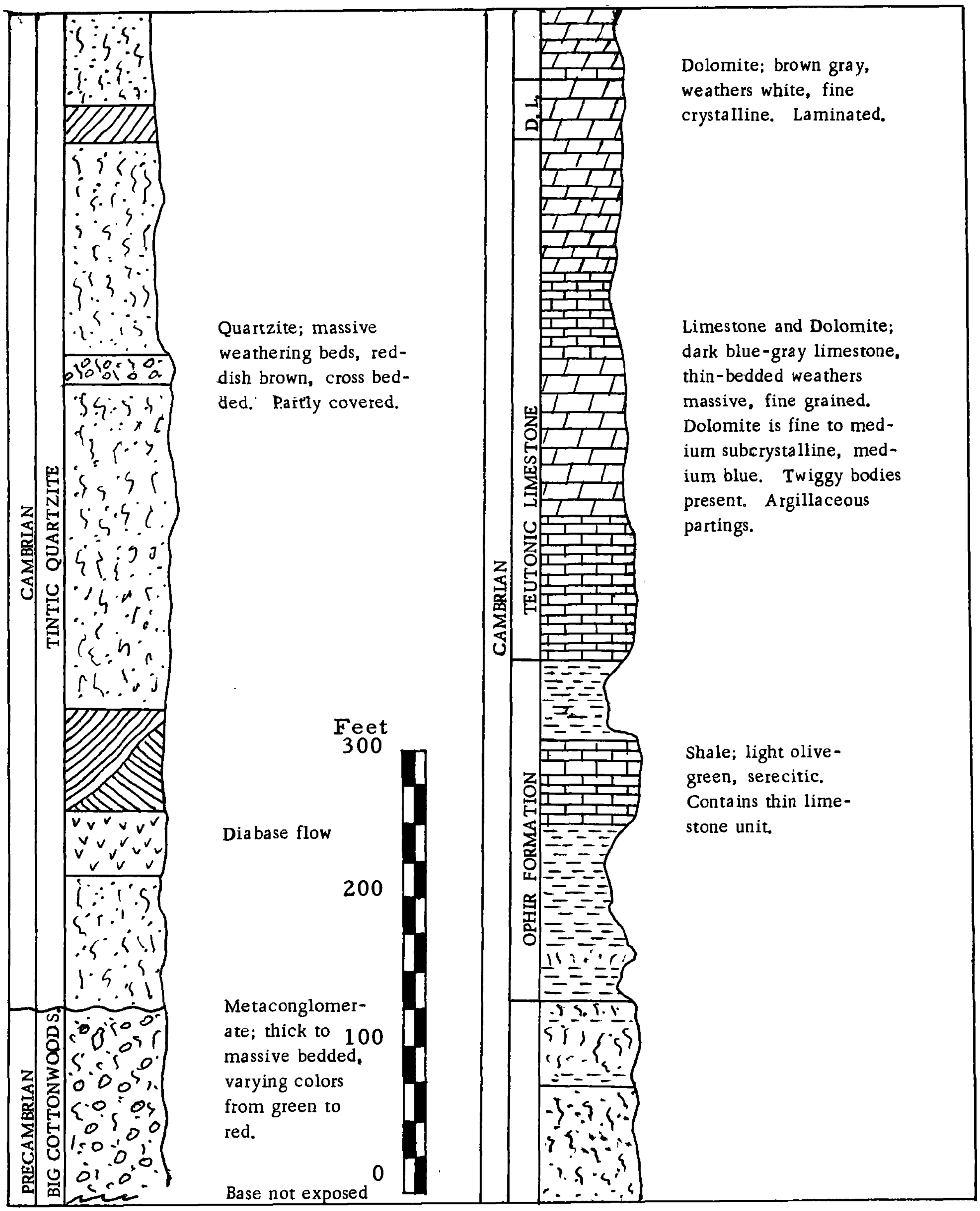


Fig. 2 Erosional chart of the stratigraphy of the North Canyon Area.

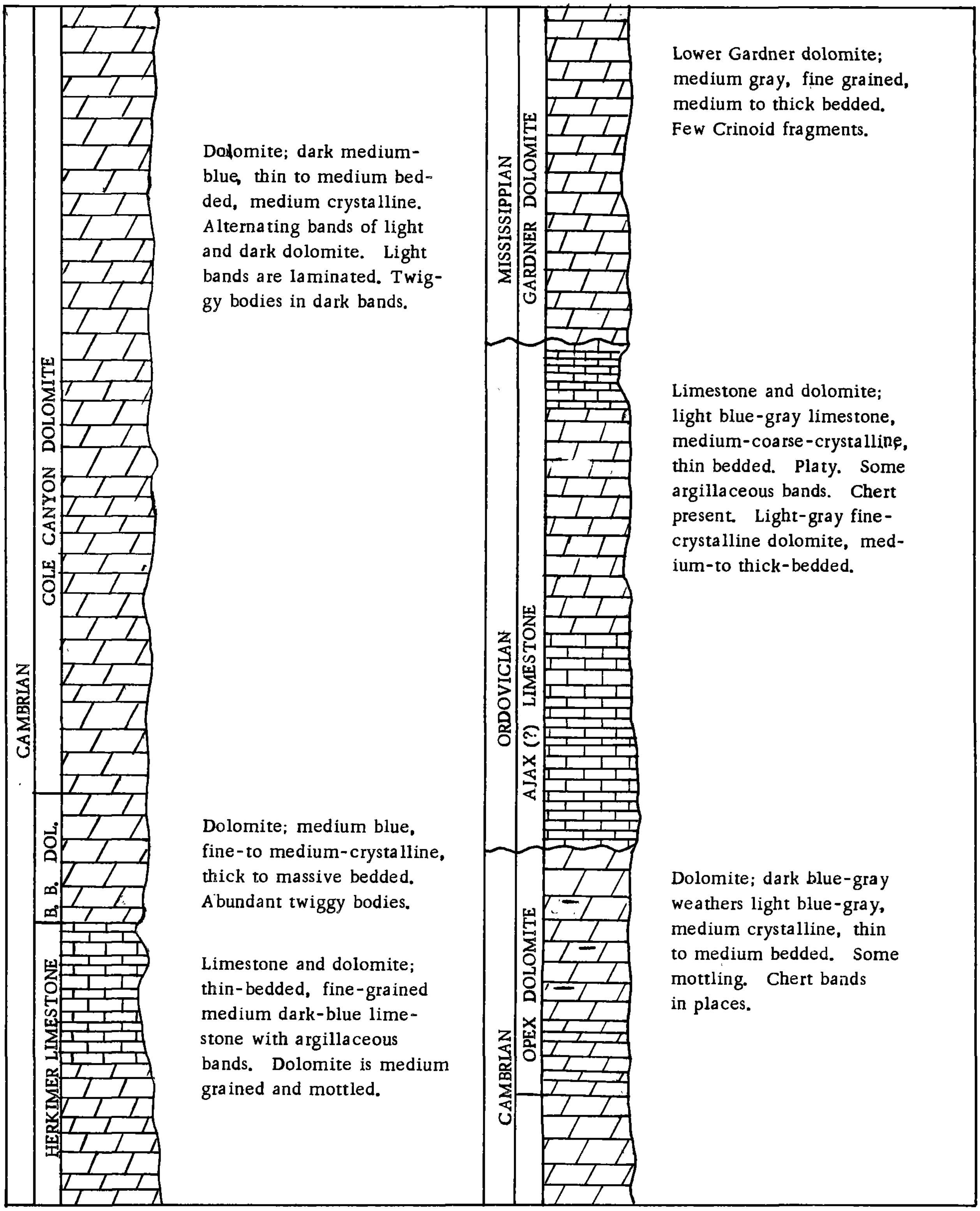


Fig. 2 (Continued)

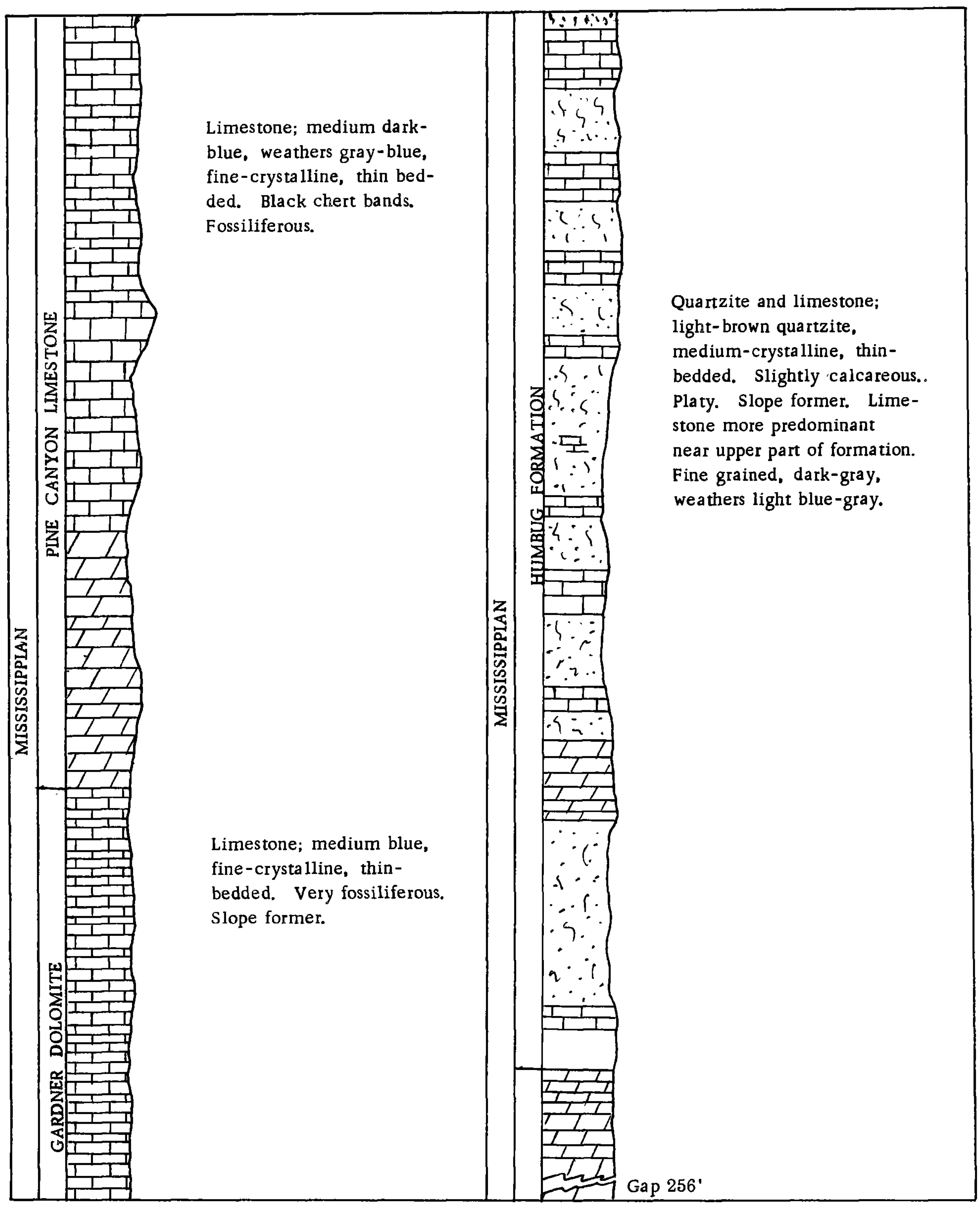


Fig. 2 (Continued)

a fragment of Herkimer limestone.* Muessig (1951, p. 26) reports finding Lingulella sp. and nondescript brachiopods at Long Ridge. The formation is 233 feet thick at North Canyon, 407 feet thick in Payson Canyon (Brown, 1951, p. 19) and 287 feet thick in Long Ridge (Peterson, 1953, p. 33). The Herkimer limestone is Middle Cambrian in age according to Loughlin (1919), who dated it more on stratigraphic position related to definable beds above and below than other evidence.

Bluebird dolomite

The Bluebird dolomite is not very thick in North Canyon, however, its lithology is typical of the formation as described by Loughlin (1919) in the Tintic region. In texture the dolomite is fine-to medium-crystalline and is medium to dark blue-gray in color. Twiggy bodies similar to those present in the dolomite of the lower Herkimer limestone are also present in great abundance in the Bluebird dolomite. These white vermicular structures vary from one to three millimeters in thickness and some as much as 30 millimeters in length have been noted. Their composition is mostly white dolomite though a few contain white calcite.

The Bluebird dolomite outcrops along the west slopes of spurs between Mendenhall, North, Pole and Bear Canyons. It is well exposed in North Canyon, particularly on the first spur south of the Canyon.

At Ophir the writer and others* measured 319 feet of Bluebird dolomite. Approximately 200 feet is present in the Tintic district (Loughlin 1919). In North Canyon the Bluebird dolomite thins to only 82 feet, whereas in Payson Canyon, Brown (1950, p. 39) finds 178 feet. Measurements by Peterson (1956) in Payson Canyon indicate only 101 feet. No fossils were noted in the dolomite. The rods or twiggy bodies of white dolomite are the nearest forms to fossils but no affinities have been proven although they suggest possible bryozoans. The stratigraphic position of the Bluebird dolomite indicates that it is likely Middle Cambrian in age, because of other datable beds in the stratigraphic sequence.

Cole Canyon dolomite

The general lithology of the Cole Canyon dolomite is one of alternating light and dark beds of dolomite. It is easily detected in good exposures even from a distance. The light bands of dolomite vary from three to ten feet thick and are characteristically laminated parallel to the bedding plane. The dark beds, typically dark-gray, are medium-crystalline and are spotted with twiggy bodies. Near the middle of the formation the bedding becomes massive and the texture finely crystalline.

---

*Geology summer field camp party, 1955.

Excellent exposures of Cole Canyon dolomite are present on both sides of North Canyon and along the west face of Eva Mountain.

A total of 603 feet of Cole Canyon dolomite was measured in the area. This figure is somewhat high compared to an area ten miles to the north east where about 350 feet was measured (Peterson, 1956). Seven to eight miles northwest in Little Valley, Long Ridge, Dallas Peterson (1953) measured 442 feet. Loughlin (1919) assigns the Cole Canyon dolomite to Middle Cambrian age. The writer follows this age designation as no additional data was found.

Opex dolomite

The Opex dolomite is dark blue-gray and weathers light blue-gray.. Its texture is medium-to coarse-crystalline and its bedding thin to medium. Bands of black and white chert approximately one inch thick are found interbedded within the dolomite. Oolites were found near the center of the measured section. The surface exhibits some mottling and is weathered to a meringue-like appearance (McFarlane, 1955, p. 27).

The Opex dolomite lies comformably on the Cole Canyon dolomite. The contact between the two was taken at the top of the highest light-colored dolomite in the Cole Canyon. It can be traced with ease across the walls of North Canyon though its upper limit is not easily detected from a distance. The Opex forms good outcrops throughout the complete area, being exposed in a band trending north-south from Mendenhall Canyon to Bear Canyon.

Lithological similarity and position provide the best correlation for the Opex dolomite with contiguous areas. In the Tintic district the Opex dolomite section measures 390 feet (Loughlin 1919), at Long Ridge 199 feet (Peterson 1953, p. 48) and at Payson Canyon 217 feet (Brown, 1950, p. 24). To the north at Ophir, Utah the writer and other members of the 1955 field camp measured a total of 184 feet. This corresponds more closely to the measurment of 166 feet in North Canyon. According to fossils found by Weeks (1905) the Opex dolomite is Upper Cambrian in age; no fossils were observed by the writer in the mapped area in this formation.

ORDOVICIAN SYSTEM

Ajax limestone (?)

Only the Upper Ajax limestone (?) is present in the North Canyon area and is divided about equally into limestone and dolomite. The limestone of the lower 146 feet is light blue-gray, medium-to coarse-crystalline and thin-bedded. Within the limestone is a high percentage of sand which is particularly noticeable when it weathers out platy-like. In several places gray argillaceous banding is common. The surface of the limestone is mottled and weathered to a meringue-like appearance.

The upper part of the Ajax limestone (?) on the dolomite part is light-gray, fine-crystalline and thick-bedded. Twenty-one feet from the top of the bed is a three-foot white medium-crystalline quartzite bed. The upper 21 feet is limestone resembling the limestone at the base.

The Ajax limestone (?) is separated from the Opex dolomite at the base and the Gardner dolomite at the top by an unconformity. The upper unconformity is noted by the complete absence of Silurian and Devonian strata.

In its type locality in East Tintic the Ajax limestone (?) measures 625 feet. A total of 336 feet in North Canyon show considerable thinning of the formation to the east. In Payson Canyon D. Peterson (1956) indicates that the Ajax limestone (?) is missing as also does Demars (1956). Such being the case the Ordovician sea must have extended south and east missing the Payson Canyon area.

Crinoid fragments and "hash beds" of crinoids were found in the Ajax limestone (?) but insufficient to give an age. Stratigraphic position and lithology was used by the writer in arriving at an age date and that merely as Ordovician.

UNCONFORMITY AT BASE OF MISSISSIPPIAN

A well-known pre-Mississippian unconformity exists in the eastern and central part of Utah wherein part or all of the Ordovician, Silurian and Devonian systems are absent. In the North Canyon area this is the case, however, some questionable Ordovician rocks are present, likely the Upper Ajax limestone. The Lower Gardner dolomite rests unconformably on the Ajax limestone (?) with the Silurian and Devonian systems not represented. (See Fig. 4). Regional studies seem to indicate that the Southern Wasatch Mountains were elevated such during this time that no deposition took place. Some have suggested that erosion removed the Silurian and Devonian but this is not as widely accepted as the former idea.

Pre-Mississippian unconformities have been reported by Gilluly (1932, p. 22) to exist in the Stockton and Fairfield quadrangles, and by Nolan (1935, p. 35) in Western Utah. D. Peterson (1956) reports an unconformity between the Opex dolomite and Gardner dolomite in the Payson Canyon area to the north of the writer's area. Apparently no Ajax limestone (?) was noted.

MISSISSIPPIAN SYSTEM

Gardner dolomite

Two members of the Gardner dolomite are represented in North Canyon. The lower Gardner consists essentially of dolomite

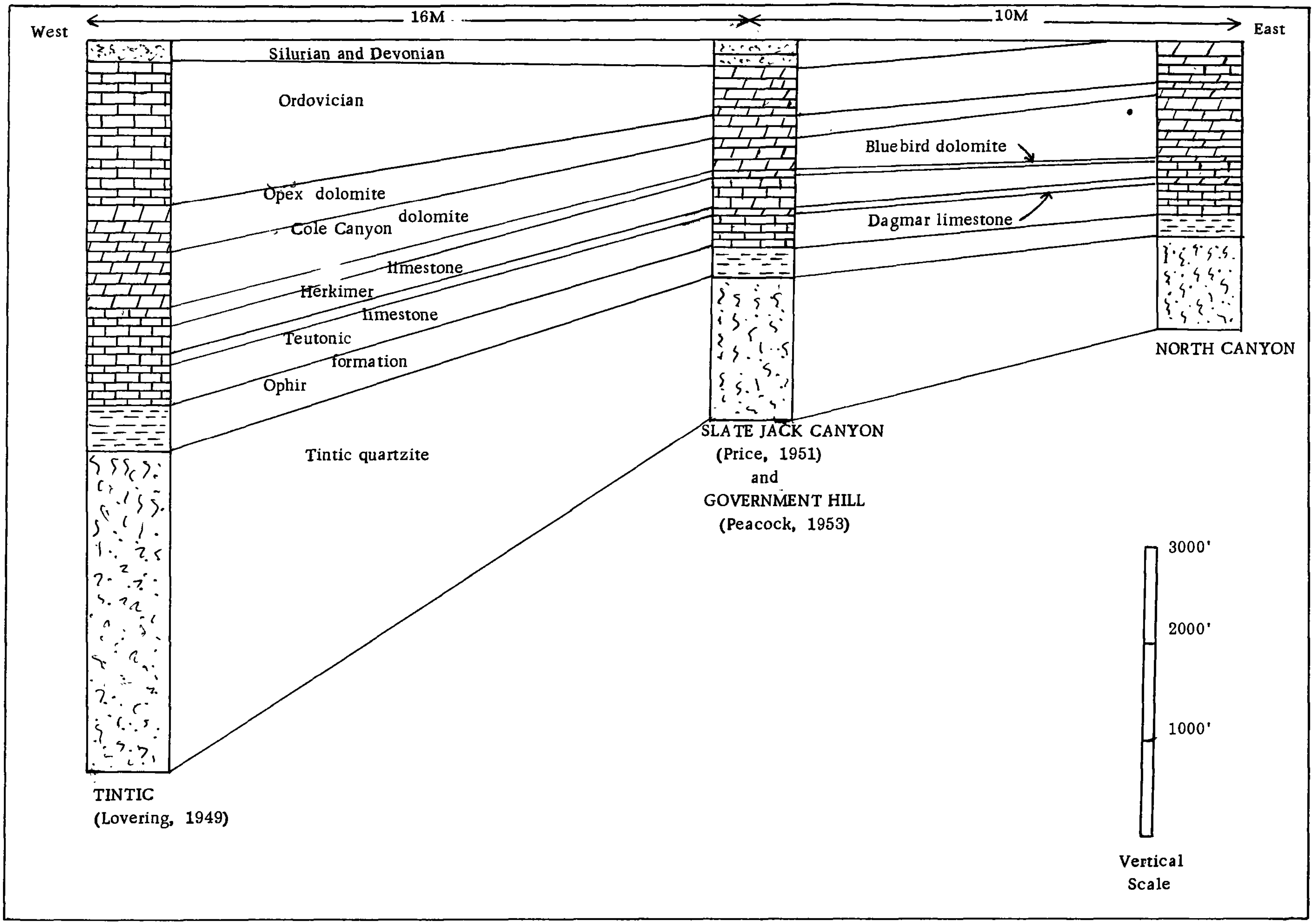


Fig. 3 Correlation diagram showing progressive thinning of Lower Paleozoic systems from Tintic eastward to North Canyon.

that weathers light to medium-gray. The texture varies from fine-grained at the base to coarse-crystalline near the top. The bedding changes somewhat also, beginning with thick beds and altering to more massive beds at the top. A few crinoid stems were found in the unit but more typical are Syringopora sp. and a few Caninid-like corals.

The upper Gardner has a 20-foot dolomite unit at the base but above consists of thin-bedded medium blue-gray limestone. Fossils are very abundant and provide data for age assignment and correlation. Both upper and lower members of the Gardner contain rocks which smell very fetid when broken.

The Gardner dolomite was mapped from near the peak of Eva mountain on the north to the near-vertical beds in Bear Canyon on the south. It is one of the first formations showing effects of the Nebo overthrust. Between Pole Canyon and Bear Canyon the outcrop appears in the form of a large "S" curve.

Measurements of Gardner dolomite total 510 feet; 231 of which is lower Gardner and 279 feet of which is upper Gardner. Peterson (1956) discovered at Payson Canyon that the lower Gardner dolomite was missing and the upper Gardner dolomite measured 340 feet. A complete section totalling 625 was measured at Long Ridge (Peterson, 1953, p. 64). The Gardner dolomite is the easiest of all the formations to correlate due to its abundant fossil assemblage. Its age, however, has not been definitely defined. Paleontologists who have studied the Gardner fossils tentatively agree that the lower dolomite is likely lower Kinderhookian, and the upper more fossiliferous limestones are most likely upper Kinderhookian and lower Osagean. Fossils collected in North Canyon and identified by the writer include the following:

Syringopora sp.

Euomphalus sp.

Caninia sp.

Multithecopora sp.

Triplophyllites sp.

Composita sp.

Cleiothyridina sp.

Chonetes sp.

Crinoid fragments

Crinoid stems

Pine Canyon limestone

The Pine Canyon limestone at its type locality in the Tintic Mining district consists largely of cherty limestone with dolomite at both the base and the top. The greater part of the formation is limestone in the mapped area. The dolomite is medium dark-gray, weathering to a sombre-gray, is medium-to thick-bedded, and is medium to coarse-crystalline. Black chert bands occur in the dolomite but are more common in the limestone. The chert bands parallel the bedding planes and vary in thickness from one to four inches. Crinoid stems are very common in the upper limestone which may be designated as crinoidal limestone, encrinite, or criquina depending upon relative abundance of these remains and their fabric in the rock.

The Pine Canyon limestone forms a massive weathered outcrop near the peak of the mountain ridge. From a distance it is seen as a bold cliff and can be easily traced along the mountain front. It lies conformably upon the upper Gardner dolomite and is overlain by the Humbug formation.

The writer discovered a narrow shale and phosphatic bed near the Pine Canyon limestone - Gardner dolomite contact in some prospect pits between Pole Canyon and Bear Canyon. No measurement could be made but an estimation of about ten feet would be liberal enough. This black phosphatic rock was also noted by the mining foreman and the writer at Bear Canyon where miners had tunnelled into the lower Pine Canyon limestone.

Some differences in measurements were made in Payson Canyon but the best corresponding measurement to fit the regional picture is one by Peterson (1956) who reports 601 feet of Pine Canyon limestone rather than Brown (1950, p. 32) who reports 1594 feet. Long Ridge measurements by Peterson (1953, p. 71) at Little Valley total 591 feet.

Other than the Tintic quartzite the Pine Canyon limestone is the thickest formation in the area. In North Canyon 851 feet was measured. The writer and others measured 755 feet of the limestone at Ophir, Utah. Tintic measurements by Loughlin (1919) total 1,000 feet, but this was largely an estimation. The writer collected and identified these fossils which suggest the age of the Pine Canyon limestone to be Osagean.

Composita sp.

Dictyoclostus sp.

Spirifer sp.

Zaphrentis sp.

Archimedes sp.

Multithecopora sp.

Fenestellid bryozoans

Crinoid fragments and ossicles

Humbug formation

The alternating bands of limestone and quartzite of the Humbug formation are probably its most distinctive feature. It is commonly light-brown quartzitic sandstone to orthoquartzite with interbedded light blue-gray limestones and dolomites. The carbonates are fine-grained to fine-crystalline and mostly medium-bedded. At the base the quartzites predominate whereas near the top the limestones are more abundant. The formation forms a characteristic slope due to its platy weathering habit.

All three peaks in the North Canyon area are capped by strata of the Humbug formation. The formation strikes north-south and dips moderately to the east, but near Bear Canyon the strata are nearly vertical because of nearness to a large over-fold and overthrust faults.

The basal and the upper contacts of the Humbug formation are arbitrarily selected to include all quartzite beds. The lower contact in this area was taken at the first well-defined and extensive light-brown quartzite bed, and the upper contact at the top of the highest quartzite bed of similar extent. In North Canyon this formation was included in the "intercalated series" that extends up in to Pennsylvanian time (Eardley 1955). In this report it will be restricted to Upper Mississippian as was done by Loughlin (1919) in Tintic.

In North Canyon 712 feet was measured by the writer. Ophir Canyon measurements by the Geology field camp (1955) totalled 872 feet of the Humbug formation. Measurements in Payson Canyon (Peterson, 1956) shows only 540 feet and incomplete sections were reported from Long Ridge.

QUATERNARY SYSTEM

Landslides

Between the mouths of Dry Canyon and Bear Canyon landslides are common and in some cases are not too easily distinguished from slump blocks. The writer mapped a landslide deposit that extends nearly the complete distance between the two canyon mouths. Undifferentiated Cambrian rocks and colluvium compose most of the landslide material.

Fans

The writer has divided the fans of the area into two divisions, the "old fans" and the "young fans." The older fans represent deposits which show erosion by more recent water action while the young fans show no erosional changes other than seasonal, ones..

Only two "old fans" could be recognized; one at the mouth of Pole Canyon and the other at the mouth of Bear Canyon. The fan at the mouth of Pole Canyon is well defined (See Plate 2). It has been

SYSTEM	SERIES	FORMATION	THICK	DESCRIPTION
QUATERNARY		ALLUVIUM	?	Alluvium and colluvium
		YOUNG FANS	?	Sorted sand, gravel and bolders
		OLD FANS	?	Sand and gravel
		LANDSLIDES	?	Undifferentiated sediments
MISS.	MERAMECIAN	HUMBUG FORMATION	712	Interbedded quartzite and limestone
	OSAGEAN	PINE CANYON LIMESTONE	851	Limestone with interbedded chert.
	KINDERHOOKIAN	GARDNER DOLOMITE	510	Dolomite and fossiliferous limestone.
ORDOVICIAN		AJAX LIMESTONE (?)	336	Limestone and dolomite cherty and argillaceous.
CAMBRIAN	CROIXAN	OPEX DOLOMITE	166	Massive dolomite.
	ALBERTAN	COLE CANYON DOLOMITE	603	Alternating bands of light and dark dolomite.
		BLUEBIRD DOLOMITE	82	Blue-gray dolomite with abundant "twiggy" bodies.
		HERKIMER LIMESTONE	233	Limestone and dolomite Argillaceous bands in ls.
		DAGMAR LIMESTONE	40	Finely laminated dolomite, waathers white.
		TEUTONIC LIMESTONE	347	Limestone and dolomite. Argillaceous partings in ls.
	WAUCOBAN	OPHIR FORMATION	231	Olive-green shale with thin quartzite partings.
		TINTIC QUARTZITE	929	Light-brown quartzite, crossbedded.
PRECAMBRIAN		BIG COTTON-WOOD SERIES	133	Quartz-pebble conglomerate. Interbedded maroon slate.

Fig. 4 Summary chart of the stratigraphy of the North Canyon area.

eroded near the canyon mouth and also visibly cut by movements of the Wasatch fault. A considerable amount of fan material, nearly 100 feet above the floor of Bear Canyon, was deposited in earlier Quaternary time and was later cut by stream erosion. This early deposit the writer has included as an "old fan" of coarse gravel deposition; likely it is of Pleistocene pre-Lake Bonneville in age inasmuch as identical fans farther north have deposits as well as wave-cut features of ancient Lake Bonneville upon them. Post-Lake Bonneville fans, possibly of Recent age only, have been deposited upon parts of the upper surfaces of the old fans and are mapped for this report as "young fans".

Fans of younger age and designated as "young fans" extend from the base of the mountains to the Mount Nebo Reservoir about two miles to the west. However, these fans were mapped as extending only a short distance, probably one-half mile at the most, to the west as alluvium covers the fans at these points. The fans are composed of unconsolidated poorly-sorted alluvium.

Alluvium

Lacustrine fine-textured materials, used as farm land in Juab valley at present was formed mostly by ancient Lake Bonneville although no definite shore line can be seen in this area. The alluvium is composed of very fine sand, silt, and clay which is very conducive to irrigated row-crop farming. Gravel deposits from the lake are absent in the area. Recent colluvium, largely slope-wash materials from the mountains, mantles parts of the area along the foothills.

IGNEOUS ROCKS

DIABASE FLOW

Controversy once existed as to the true nature of an igneous rock found in the Tintic quartzite outcrops in central Utah. Abbott (1951) under took to solve the problem of whether the rock was a sill as proposed by Eardley (1933) or a lava flow interbedded in the Tintic quartzite. Xenoliths up to four feet long and cross-cutting of the intrusion favored its origin to be that of a sill.

Four separate areas were studied by Abbott: Slate Canyon and part of the west face of Buckley Mountain, the North Canyon Area, the east slopes of Payson Canyon and the northwest part of Long Ridge immediately east of Slate Jack Canyon. Although these four areas were not the only places where outcrops could be found, he felt that they were sufficient to complete his study.

Evidence supporting the igneous rock as an interbedded diabase flow were summarized by Abbott as follows:

1. Channeling and Erosional Surfaces: Erosional surfaces were noted at the bottom and top of the flow in all

areas of outcrop, and channeling is evident on the post flow erosional surface. This indicates the flow to be younger than the underlying rocks and older than those above.

2. Basal Conglomerate: A basal conglomerate is noted immediately above the igneous body with detrital fragments and pebbles of the igneous rock incorporated within it. These fragments show rounded to sub-rounded outlines, and lie up to three and one-half feet above the contact.

3. Contact Metamorphism: The base of the overlying sediments is not metamorphosed at the contact, but slight metamorphism can be noted on the underlying sediments at the contact.

4. Areal Distribution and Position Above Base of the Tintic Quartzite: The igneous body is confined within the Tintic quartzite at an average distance of 160 feet above the base. The flow has been traced from Y-Mountain 45 miles south to North Canyon and west nine miles to Long Ridge. Only a flow could maintain such a wide areal distribution and maintain the same horizon in a uniform quartzite formation.

5. Conforms to Laramide Folding: This igneous body exhibits a parallelism with the formations above and below and conforms to the Laramide folding. It is involved in the same structural pattern as the associated quartzite formation and has approximately the same attitudes. The strata in most cases dip very steeply and in both Slate Canyon and Long Ridge the strata and the flow are over-turned.

6. Pre-Block Faulting and Black Faulting: In the Slate Canyon-Buckley Mountain area and in the North Canyon area the igneous body has been cut and displaced by faults that are pre-block faulting in age, and it has also been cut by the faulting associated with the Basin and Range orogeny.

7. Vesicules and Amygdules: The igneous body displays amygdules at the top and the bottom. In a flow one would expect vesicules and or amygdaloidal structures, whereas in a sill they are not developed.

8. Apophyses and Dikelets: There were no apophyses or dikelets noted in the sediments above or below the igneous body. If a sill were present, the overlying sediments would be cut by stringers and dikes, however, this is not the case. One "xenolith" of quartzite was broken and cut by igneous material. (Abott 1951, pp. 62-66)

Petrographic studies by Abbott indicate the flow to be a porphyritic diabase rock with plagioclase feldspar phenocrysts. Chemical analyses reveal the following minerals to be present: basic plagioclase (labradorite) pyroxene (augite), magnetite, possible ilmenite, sericite (paragonite), kaolinite, limonite, hematite, chlorite, serpentine and calcite. The first four are primary minerals and the remainder are secondary minerals.

The igneous body was considered Tertiary in age by Eardley (1933). Conclusive evidence by Abbott that the igneous body is a flow must of necessity restrict its age to Early Cambrian time.

LAMPROPHYRE DIKE

First mention of a lamprophyre dike in North Canyon was made by Loughlin (1918, pp. 101-109) although his discovery came during reconnaissance field work in 1912. This dike crops out in the mouth of Bear Canyon at the base of the Pine Canyon limestone and although no outcrops were found in Pole Canyon to the north, float contains much of the igneous rock. About five miles north of Mona a lamprophyre dike of approximately the same chemical composition outcrops in Precambrian granite (Loughlin 1918) showing the likelihood of the intrusion to be properly designated as a dike. The outcrop on both sides of Bear Canyon follows the bedding plane of the Pine Canyon limestone and appeared to the writer as a sill. However, taking the evidence from a more detailed study of the dike by Loughlin (1918) and Eardley (1933) the writer will also refer to it as a lamprophyre dike.

Examination of the lamprophyre in hand sample shows it to be dark greenish-gray and porphyritic. The peculiar luster of the dike is due to the abundance of biotite, probably as high as 20% of the rock. Dilute hydrochloric acid reveals the presence of carbonates, probably as an alteration product of olivine.

Thin section studies by Loughlin indicate the following minerals to be present: biotite (20%), augite, apatite, magnetite in a ground mass of feldspar; alteration products are pyrite, calcite, chalcedonic quartz chlorite and hematite.

Correlation of the dike with intrusive igneous bodies in the area is not easily made. The granite in the Santaquin district is Precambrian in age while the lamprophyre dike at Bear Canyon cuts Mississippian rocks. Intrusions during Tertiary time have been located in the surrounding districts at Cottonwood, American Fork and Tintic. The dike was most likely intruded at this same time in the Tertiary. Bissell (1948) noted a very fresh, that is unaltered, lamprophyre dike overlain by Lake Bonneville sediments along the foothills east of Springville.

STRUCTURE

GENERAL FEATURES

Regional structural trends of the Wasatch Mountains and adjacent ranges to the west appear as broad north-south folds controlled by resistant land blocks and buttresses that locally altered the fold trends. These folds are evident in the Oquirrh Mountains, the Stansbury Mountains, the Tintic Mountain ranges and Long Ridge all to the west of the Wasatch Mountains. Pulses of the Laramide revolution coupled with broad uplifts of the Central Wasatch Mountains, the Sheeprock at Tintic and the Uinta to the east have been observed as main structural influences. Basin and Range faulting following the Laramide orogeny and has been noted in Recent times, as earthquakes of today suggest that local adjustments are still taking place.

Of greatest influence on the structure of the area since uplift was the Nebo overthrust, followed later by east-west faults and more recently by the north-south Wasatch fault. Local folds of small dimension can be seen in both Pole Canyon and Bear Canyon arising from the eastward movement of the Nebo overthrust. Strata unaffected by the thrust fault dip moderately to the east at 25 - 30 degrees, suggesting the possibility that it is the east limb of a now eroded anticline or broad extensive north-south fold. Eardley (1933) describes the general structure as an anticlinal fold that is "practically isoclinal and overturned from Pole Canyon south" but only isoclinal to the north.

East-west faults

Though several minor normal east-west faults were mapped by the writer (See Plate 3), only one major fault shows considerable displacement. This fault will be referred to as the Dry Canyon fault as it almost parallels Dry Canyon just south of Mendenhall Canyon. Here, the Ophir formation is brought in contact with the Opex dolomite giving a total stratigraphic throw of about 1500 feet to the fault.

The only evidence of age dating of the east-west faults found by Eardley (1933, p. 379) was on the north side of the mouth of Santaquin Canyon where an east-west fault is cut by the Santaquin overthrust. The writer found no other evidence for or against this so interprets the east-west faulting as pre-Laramide in age.

Laramide folding

The Laramide revolution affected the structure of the North Canyon area more than any other major disturbance. A post-Archean disturbance of older non-exposed rocks is evidenced in the Santaquin area a few miles to the north, however. The major structure in the southern Wasatch Mountains resulting from the Laramide orogeny is the overthrust fold shown to advantage in the North Canyon area at Bear Canyon. The fold broadens to the north at Eva Mountain and dips moderately to the east at angles of 25° to 30°. From the near vertical front of the fold at Bear Canyon it passes into the recumbent limb south at Nebo and dips just opposite (30° W) to the strata in Eva Mountain.

The axial plane of the fold as seen in both North Canyon and Pole Canyon shows the plane to be near the mouth of these canyons, particularly at Pole Canyon. In general the axis parallels the western front of the Wasatch Range in approximately a north-south direction.

The Nebo overthrust

It has been postulated by Eardley (1933 p. 379) that the overthrust fold of the Nebo overthrust involved "a series of strata in excess of 20,000 feet in thickness." Recognition of the fault as being overthrust is found at the southern base of Mount Nebo whereas the area presented in this report contains only inferential evidence of the movement. The stress involved in the movement of the thrust originated from the west during the Laramide orogeny of Late Cretaceous time. Broad folds came into being to the west of the overthrust block and more gentle folds resulted east of the Wasatch Mountains. In Pole Canyon the strata show effects of the overthrust as the dips become steeper and finally vertical in Bear Canyon. Local folds can be seen in Bear Canyon (See Plate 2) showing effects of non-resistant beds to thrusting.

The Wasatch fault

The western front of the Wasatch Mountains is not entirely the result of the Wasatch fault though many geologists feel that it is so. This is pointed out by Eardley (1933, Strong Relief Before Block Faulting, p. 243-245) in the Nebo district wherein the total relief of Mount Nebo is 7000 feet from the top to the alluvium and the total displacement of the fault here is only 6000 feet. The thickness of the alluvium is about 2000 feet which suggests that relief of 2000 to 3000 feet must have preceded block faulting. Movement of the Wasatch fault shows very plainly (See Plate 2) in the alluvium along the western front of the Southern Wasatch Mountains in the alluvium at the base. At North Canyon the writer was able to measure the dip of the fault in an old prospect pit, as 50 degrees West.

It is the concensus that the Wasatch fault is a high-angle normal fault and this dip suggests the same. However at local areas east of Provo the dip of most recent movement of the fault is to the east denoting the possibility of a reverse fault, the mountain range being the hanging wall. In this respect, certain areas may be termed "normal upthrusts".

The strike is nearly north-south and passes through the east side of sections 10, 15, 12 and 27, in R. 1 E., T. 11 S.

The Wasatch fault is considered to be part of the block-faulting that occurred in the Basin and Range during Tertiary time.

> Movement is believed to have started in latest Pliocene time and most of the displacement was attained in early Pleistocene. Fresh scarps in the alluvium and across terminal moraines also attest post-Wisconsin movements. (Eardley, 1951, p. 484)

SUMMARY OF GEOLOGIC EVENTS

During Late Precambrian time the Big Cottonwood series was deposited and later eroded leaving the present thickness. Conditions existing at the time led to deposits of continental origin rather than marine (Blackwelder 1910 p. 520).

At the beginning of Paleozoic time Cambrian seas began sedimentation of sandstone and clay which later compressed to from the Tintic quartzite and the Ophir formation. Correlation of sedimentation shows a thinning of sediments from west to east, a transgressing sea. Igneous activity during Cambrian time deposited a thin flow-rock upon Tintic sands during an emergent phase, and was later covered by more Tintic sand, being only locally reworked.

Shallow seas gave rise to oolitic, laminated and dense limestone and dolomite characteristic in the Dagmar limestone and Cole Canyon dolomite.

If the Ajax limestone is present in the North Canyon area, the Ordovician sea reached as far east as present Mount Nebo. However, this must have been very near the shoreline of the Ordovician sea because Ordovician rocks are missing at Payson Canyon a few miles to the north (D. Peterson 1956). The Ordovician, Silurian and Devonian systems are represented in the East Tintic Mountains but thin toward Long Ridge and are completely absent except for Ordovician (?) in North Canyon. A regional picture seems to indicate that this part of the state of Utah lay near the eastern edge of the Cordilleran Paleozoic miogeosyncline (Bissell, 1955, pp. 1643-1644).

The Wasatch Mountains and adjacent areas to the east apparently emerged as a high during Silurian and Devonian time but submerged during Mississippian time. Outcrops of Mississippian and Cambrian rocks show a definite thinning toward the east. Submergence reached its peak during Pennsylvanian time as evidenced by the tremendous thickness of the Oquirrh formation deposited during this period.

Minor east-west faulting first disturbed the area in pre-Laramide Cretaceous time. Major structural changes began with the Laramide orogeny in Late Cretaceous time which produced extensive north-south folding. A result of this folding led to widespread overthrusts such as the Bannock, Willard and in the North Canyon area, the Nebo overthrust. An igneous dike was injected into the area during Tertiary time, now altered and known as a lamprophyre dike. The north-south Wasatch fault, part of the Basin and Range faulting, has been active since at least Pliocene time (Eardley, 1951, p. 484), and possibly since Eocene time.

Lake Bonneville deposits are present only in the form of lake-bottom sediments and young alluvium in Juab Valley although gravel deposits are common approximately four miles to the north.

EXPLANATION OF PLATE 2

(1) Outline of an "old fan" displaced on the left by the Wasatch fault

(2) Breccia zone of Wasatch fault, and prospect pit

(3) A three-foot lamprophyre dike

(4) Local folds resulting from the Nebo overthrust

1

2

3

4

PLATE 2

Alluvial fans and alluvium of Quaternary and Recent Ages have been deposited along the base of the Wasatch Mountain front.

ECONOMIC POSSIBILITIES

To the present time very little mining has been done in the North Canyon area; no activity was noted, and the possibility of future mining doesn't appear favorable. Extensive prospecting has been done, likely around the turn of the century, and some occasional work since that time. No current claims were posted, no recent assessment work (most recent just north of Bear Canyon) has been done and no mines in the area are active. Most promising, however, is an operating lead mine not in the writer's area but immediately south of Bear Canyon at its mouth.

Sugar beets, corn and grain are raised in the valley, supplied with water from North Canyon, Pole Canyon, Bear Canyon and water wells. Cattle are raised on range land in the foot hills, Pole Canyon and Bear Canyon.

MINES

The Mount Nebo or Timmons Mining District was organized in 1870 and included the area treated here by the writer. According to E. Hauton of Mona, Utah (one time mining foreman of the Eva mine) no prospect in the area ever produced enough to cover the cost of the development work done. However, the Eva mine now known as the Privateer Mine, produced over and above expenses.* Information compiled in 1940 by Margetts on Juab county indicates that the Mount Nebo district from 1870 to 1914 produced $190, 762 of ore. This most likely came from the Eva Mine which produced lead and zinc in equal quantities and small amounts of silver.

At the mouth of Bear Canyon a lead mine (previously mentioned) produced 5 per cent lead ore (galena) which is then concentrated to about 55 per cent before shipping. The operators plan to begin open pit operation in the near future and concentrate the ore at the mine as they are now doing. The mine is owned by the Temple Mountain Uranium Company, Utah.

WATER

Water possibilities in the district are undoubtedly of greater economic value than the mining prospects. All three Canyons contain surface streams which flow throughout the summer, the greatest flow being from North Canyon and the least from Pole Canyon.

---

* Personal Communication June 7, 1956 Mona, Utah

Average flow from North Canyon during the summer months is estimated by the writer to be approximately six second-feet. This stream is divided at the Canyon mouth and flows north-west in a surveyed gravel ditch while the stream to the south west flows in a concrete ditch down the steepest gradient of the fan.

Water from Pole Canyon itself is very intermittent and has eroded through 15 to 20 feet of alluvial fill material. The water source is traced to an old adit at the mouth of Pole Canyon where it flows directly into a concrete ditch and west toward the farming area.

The quantity of water flowing through Bear Canyon is approximately the same as the flow in North Canyon. A very steep gradient and a porous bed from the Canyon made it necessary to build a concrete ditch to convey the water to the Mona area. The Temple Mountain Uranium Company at the mouth of Bear Canyon uses some of this water in connection with mining operations.

A few water wells have been drilled in the valley and good flows of water have resulted, particularly at the Roundy farm (Starr Ranch) below North Canyon and about one-quarter mile from U. S. highway 91 in Sect. 9. Here, a well drilled 304 feet produces water for irrigation purposes and is being pumped at the rate of six second-feet. This well may be classed as one of the best in the State.

Several flowing wells about one mile west of the Roundy well supply irrigation water for farms on the immediate east side of the Mount Nebo Reservoir. Most of these wells are very shallow, the deepest being about 90 feet.

In 1912 a water well was drilled in sect. 8 for the Union Pacific Railroad. This well was drilled 351 feet and maintained a flow of 223 gallons per minute from a heavily perforated pipe. By 1955, however, the flow had decreased to about 161 gallons per minute.

The future possibility of more good productive water wells in the area appears good. The alluvial fans leading from the mountain front into Juab valley are well developed and show fairly good sorting. The relief of the Wasatch Mountains to the east affords a good water shed for replenishing the fans.

SELECTED REFERENCES

Abbott, W. W. (1951), Cambrian Diabase Flow in Central Utah, Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Bissell, H. J. (1955), "Paleotectonics of the Upper Ordovician, Silurian, Devonian and Lower Mississippian Rocks of Part of the Great Basin" (abstract), Bull. Geol. Soc. of Amer., Vol. 66, pp. 1643-1644.

__________ (1948), Pleistocene Sedimentation in Southern Utah Valley, Utah. Unpublished Ph. D. dissertation, Dept of Geol., State University of Iowa, pp. 154-322.

Blackwelder, Eliot (1910), "New Light on the Geology of the Southern Wasatch Mountains," Geol. Soc. of America Bull., Vol. 21, pp. 517-542.

Brown, R. S. (1950), Geology of the Payson Canyon Area, Southern Wasatch Mountains, Utah. Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

Butler, B. S., Loughlin, G. F., and Hikes, V. C. (1920), "The Ore Deposits of Utah." U. S. Geol. Survey Prof. Paper 111.

Demars, L. C. (1956), Geology of the Northern Part of Dry Mountain, Southern Wasatch Mountains, Utah. Masters Thesis, Dept. of Geol., Brigham Young University.

Dutton, C. E. (1882), "Tertiary History of the Grand Canyon District", U. S. Geol. Survey, Mon. 2, Atlas sheet 3.

Eardley, A. J. (1934), Structure, Stratigraphy and Physiography of the Southern Wasatch Mountains, Utah. Michigan Academy of Science, Arts, and Letters, Vol. XVIII, pp. 243-414.

__________ (1939), "Structure of the Wasatch-Great Basin Region". Bull. Geol. Soc. Amer., Vol. 50, pp. 1277-1310.

__________ and Hatch, R. A. (1940), "Pre-Cambrian Crystalline Rocks of North-Central Utah." Journal of Geol., Vol. XLVII, pp. 53-72.

__________ (1951), Structural Geology of North America, Harper and Brother, New York City.

Foutz, D. R. (1956), Geology of the Wash Canyon Area; Southern Wasatch Mountains, Utah. Masters Thesis, Dept. of Geol., Brigham Young University.

Gilbert, G. K. (1890), "Lake Bonneville", Monograph of the U. S. Geol. Survey, Vol. l, Washington, pp. 340-361.

_______________ (1938), "Studies of Basin and Range Structure," U. S. Geol. Survey, Prof. Paper 153.

Gilluly, James (1932) "Geology and Ore Deposits of the Stockton and Fairfield Quadrangles Utah." U. S. Geol. Survey Prof. Paper 173.

Granger, A. E., Sharp, B. J. and Calkins, F. C. (1952) "Geology of the Wasatch Mountains East of Salt Lake City", Utah Geol. Soc.

Hague, Arnold, and Emmons, S. F. (1877) "Descriptive Geology" U. S. Geol. Expl. 40th Par. (King) pp. 191-468.

Hintze, F. F. (1934) "The Proterozoic-Paleozoic Contact in the Western Uinta and Central Wasatch Mountains, Utah." Utah Academy of Sciences Vol. ll.

Lewis, R. S. and Varley, T. (1919), "The Mineral Industry of Utah" Bull. of the University of Utah. Vol. 10, no. 11.

Lindgren, W. and Loughlin, G. F. (1919), "Geology and Ore Deposits of the Tintic Mining District, Utah." U. S. Geol. Survey, Prof. Paper 107.

Loughlin, G. F. (1913), "Reconnaissance in the Southern Wasatch Mountains, Utah" Journal of Geol., Vol. XXI. The University of Chicago Press, Chicago, Illinois.

_______________ (1918), "Two Lamprophyre Dikes Near Santaquin and Mount Nebo, Utah" U. S. Geol. Survey Prof. Paper 120 E, pp. 101-109.

_______________ (1919), "Santaquin and Mount Nebo Regions" Ore Deposits of Utah, U. S. Geol. Survey Prof. Paper 111.

Lovering, T. S. (1949), "Rock Alteration as a Guide to Ore--East Tintic District, Utah." Monograph 1 Economic Geology.

Mangetts, S. G. (1940), "Basic Data of Economic Activities and Reserves, Juab County." Compiled by the Utah State Planning Board.

McFarlane, J. J. (1955), Silurian Strata of the Eastern Great Basin, Unpublished Masters Thesis, Brigham Young University.

Muessig, S. J. (1951), Geology of a Part of Long Ridge, Utah. Unpublished Pn. D. dissertation, University of Ohio.

Peacock, C. H. (1953), Geology of the Government Hill Area a Part of Long Ridge, Utah. Unpublished Masters Thesis, Brigham Young University.

Peterson, D. J. (1956), Stratigraphy and Structure of the West Loafer Mountain-Upper Payson Canyon Area, Utah County, Utah. Masters Thesis, Dept. of Geol. Brigham Young University.

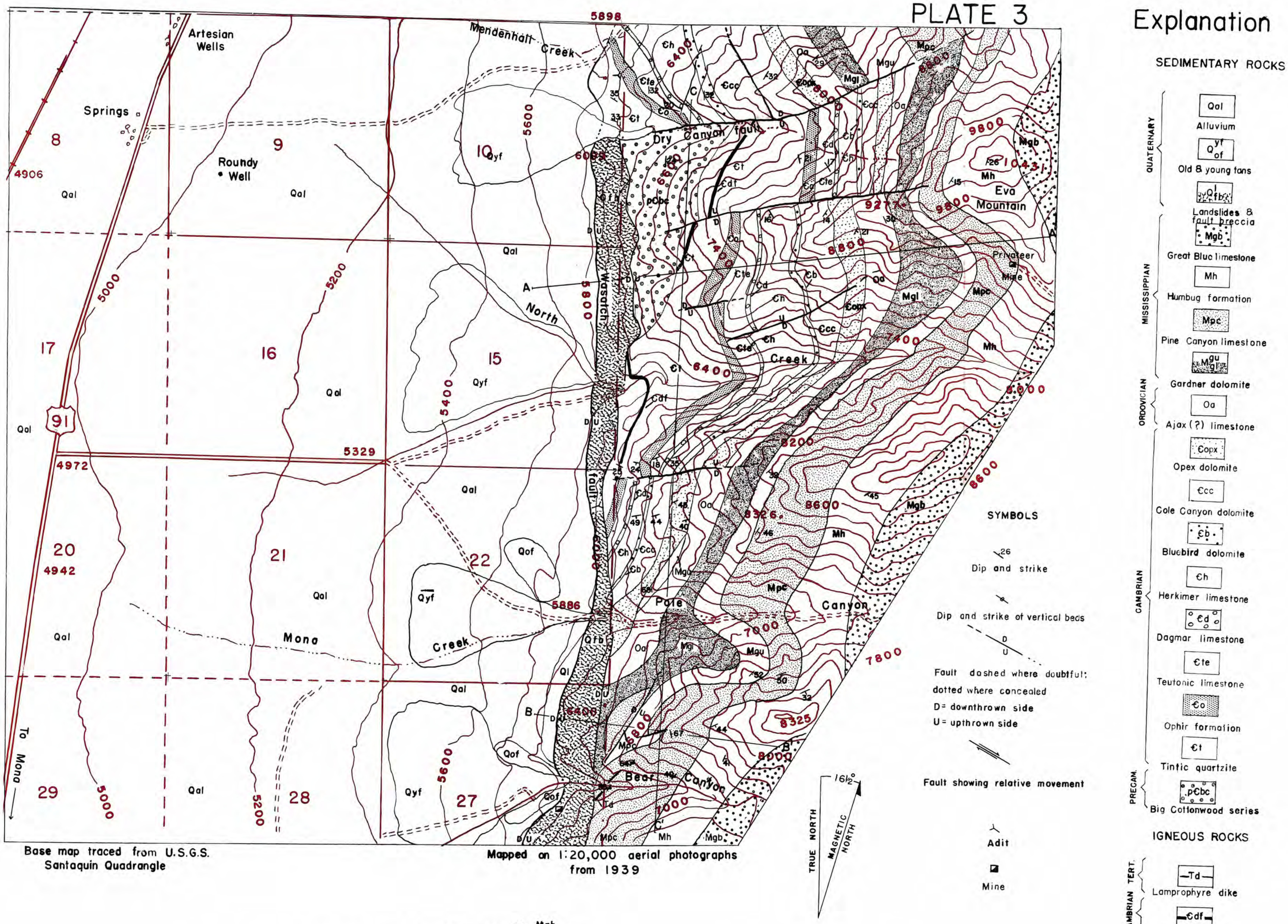
Peterson, D. O. (1953), Structure and Stratigraphy of the Little Valley Area, Long Ridge, Utah. Unpublished Masters Thesis, Dept. of Geol., Brigham Young University.

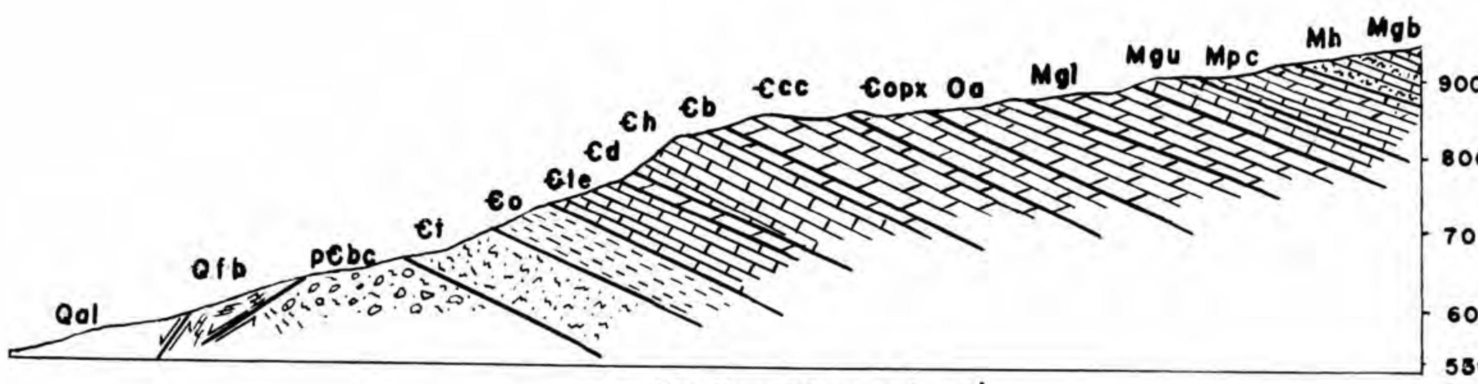
Price, J. R. (1951), Structure and Stratigraphy of the Slate Jack Canyon Area, Long Ridge, Utah. Un published Masters Thesis, Dept. of Geol., Brigham Young University.

Spieker, E. M. (1946), "Late Mesozoic and Early Cenozpic History of Central Utah" U. S. Geol. Survey, Prof. Paper 205-D.

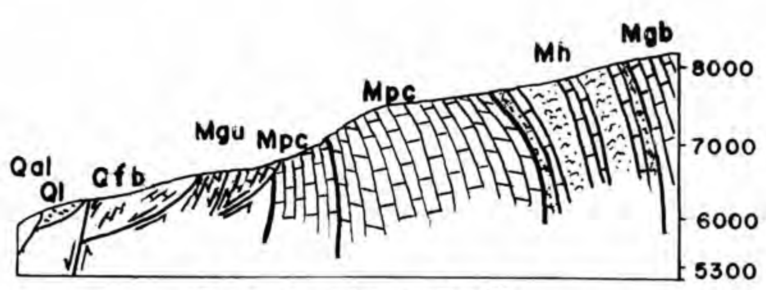
T11S R1E

PLATE 3





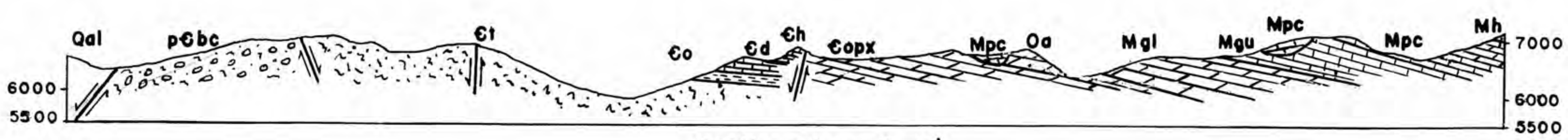
Section along A - A'



Section along B-B'

1000 0 1000 2000 3000 4000 5000 feet

Contour interval 200 feet



Section along C - C'

GEOLOGIC MAP AND STRUCTURE SECTIONS OF THE NORTH CANYON AREA, SOUTHERN WASATCH MOUNTAINS, UTAH

by

CLEON V. SMITH

1956