G E O L O G Y   O F   T H E

E A S T   C A N Y O N   A R E A

Morgan County, Utah

by

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MASTER OF SCIENCE

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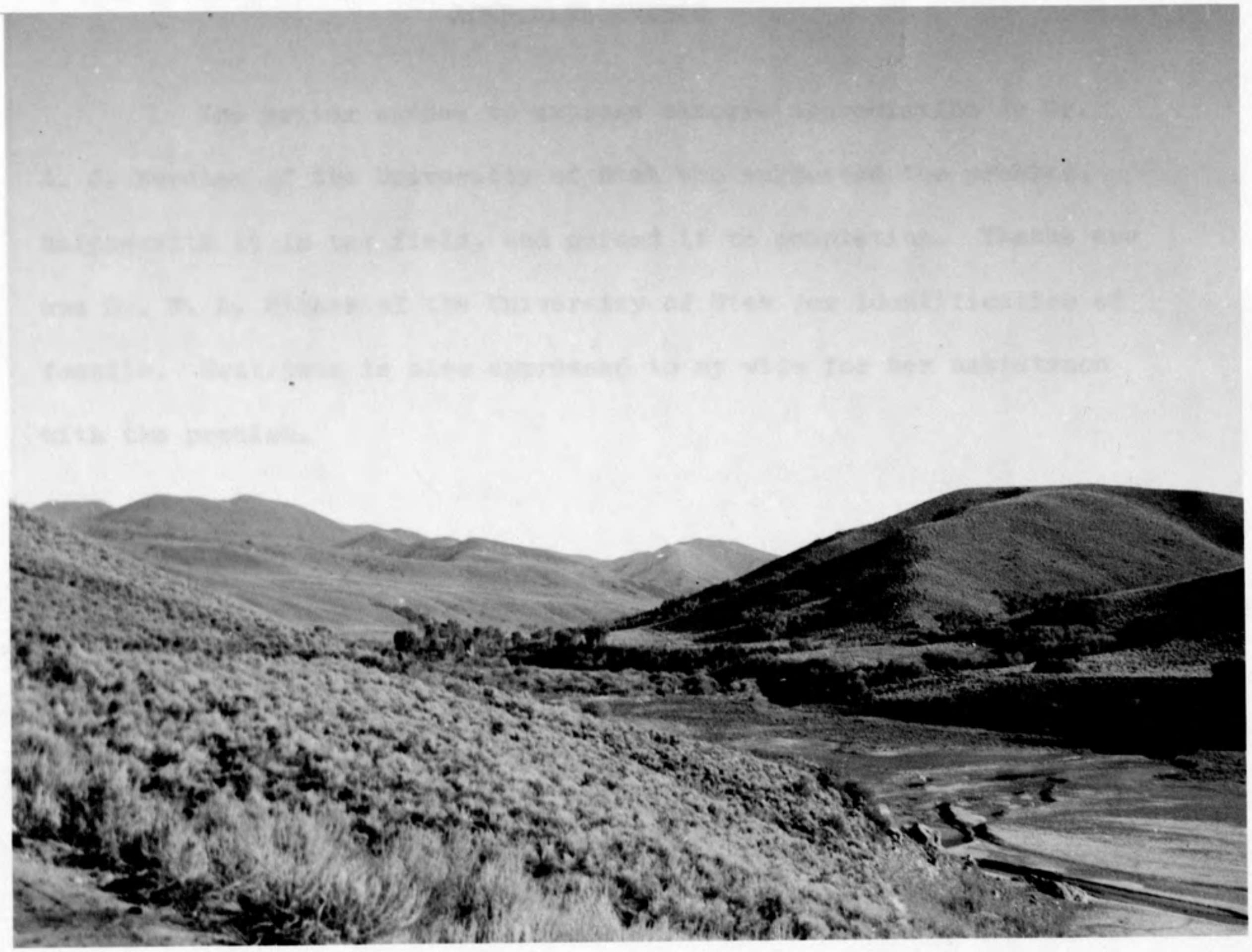

VIEW LOOKING SOUTH FROM RESERVOIR

INTO HINTERLAND OF EAST CANYON CREEK

ACKNOWLEDGEMENTS

The writer wishes to express sincere appreciation to Dr. A. J. Eardley of the University of Utah who suggested the problem, helped with it in the field, and guided it to completion. Thanks are due Dr. W. L. Stokes of the University of Utah for identification of fossils. Gratitude is also expressed to my wife for her assistance with the problem.

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INTRODUCTION

Location and accessibility

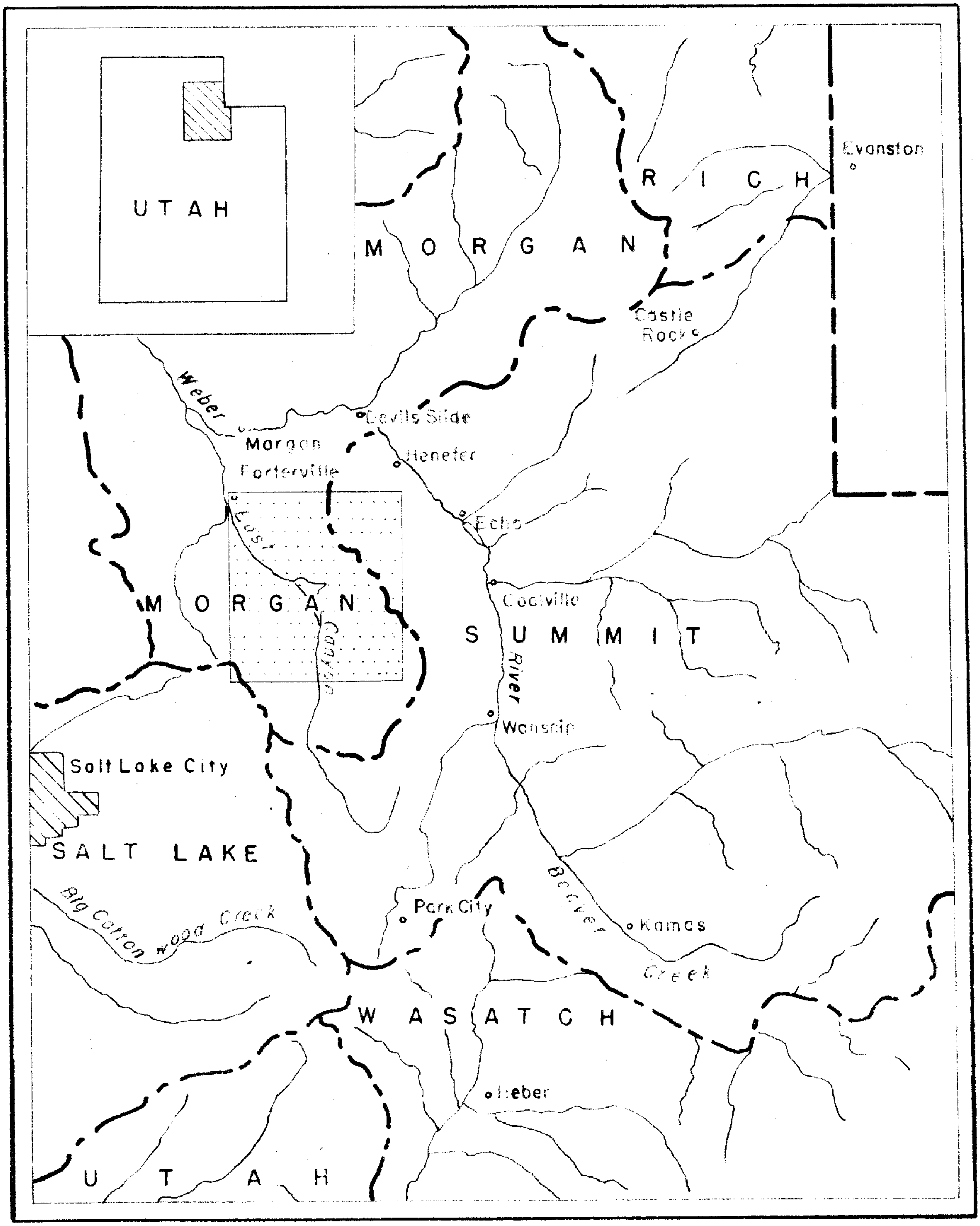
The East Canyon area comprises approximately 140 square miles and is located nearly twenty miles northeast of Salt Lake City, Utah. All or parts of Townships 1-3N, Ranges 2-4E, Salt Lake Meridian, are included in the report (see geologic map in pocket). The southern boundary of the area overlaps one studied by Crittenden, et al., (1952) of the U. S. Geological Survey. Except for the town of Porterville, Utah, which is located in the northwest corner of the area, year round habitation of the area is limited. Two ranches are situated along East Canyon Creek in the vicinity of Dutch Hollow and Monument Creek.

Access to the East Canyon area is gained by Utah Highway 65 from Emigration Canyon or Parleys Canyon, and also from Henefer, or by Utah Highway 66 through Porterville. Trails and poor Jeep roads ascend the tributary canyons.

Topography and drainage

Elevations in the area range from 8270 feet above sea level at Porcupine Peak to little more than 5200 feet near Porterville in the northwest corner of the area.

The general topography is the result of late-youthful dissection of an extensive pediment surface of probable Miocene age (Eardley, 1952, p. 59). The area is drained chiefly by East Canyon



INDEX MAP SHOWING LOCATION OF EAST CANYON AREA (Stippled)

Creek and tributaries which flow to the northwest into the Weber River. The southwest corner is drained by Mountain Dell Creek which flows southwesterly into the Mountain Dell Reservoir in Parleys Canyon. Dixie Hollow Creek carries the run-off from the northeastern portion of the area into the Weber River near Henefer to the north.

Climate and natural vegetation

The climatic variations common to mountainous regions are dominant in the East Canyon area. The lower elevations have a BsK (Koppen climatic classification) climate indicated by data from adjacent areas. Precipitation ranges from less than 20 inches per year to more than 30 inches at the higher elevations. Most of the precipitation falls during the winter months as snow which remains on the north-facing slopes until April or May.

The area is covered with many varieties of plants. Along the creeks, willows, ferns and dogwood trees abound. The lower hills have a cloak of sagebrush, rabbit grass, small cacti, scrub oak and deciduous trees. The mountain slopes have a profusion of wild flowers growing among groves of quaking aspen and pine.

Wild life present in the area includes porcupine, deer, elk, badgers, bobcats and mountain lions. Many varieties of birds also inhabit East Canyon.

Purpose and scope

The study of the East Canyon area was begun in the early autumn of 1953 at the suggestion of Dr. A. J. Eardley of the University of Utah. Previous work has been done by the University of Utah geology department in the Coalville and Hayden Peak quadrangles of the Uinta Mountain area, Utah. At present, work is being done in the Morgan Valley and Huntsville, Utah areas in the Wasatch Mountains (Schick and Lofgren, unpublished). The East Canyon area was studied in an attempt to better understand the junction area of the Uinta and Wasatch mountains.

Field work

Field work was started in September, 1953 and continued until early summer, 1954. Mapping was done on U. S. Soil Conservation Service aerial photographs BPK 3-9 to 3-18, BPK 2-7 to 2-17, and BPK 6-52 to 6-61. The geology was plotted on the Soil Conservation Service planimetric base map #58. Brunton and tape were used to measure sections in the field.

Land utilization

Most of the land of the East Canyon area is privately owned, but some small portions to the southwest are included in the Wasatch National Forest. Considerable amounts of grain and alfalfa are cultivated near the East Canyon Reservoir and throughout the length of

Dixie Hollow. The chief economic activity at the present time is the summer grazing of sheep. Of importance is the East Canyon Reservoir which is maintained by the Weber-Davis Canal Company for irrigation purposes.

Previous geologic work

The Wasatch and Uinta Mountains gained a prominent place in North American geological circles at an early date. Among the first to publish were Powell (1878), King (1876), and Gilbert (1880). The first to concentrate on the specific problems were Schneider (1930) and Hintze, F. F. (1913 and 1934). The complicated geologic history later came under scrutiny by Eardley (1930, 1944, 1951) and Williams, N. C. (1952). A number of theses have been written on local problems of the Uinta-Wasatch relationship under the direction of Dr. Williams. Bell (1951) published on the Farmington Canyon complex which lies immediately west of the area, and Crittenden, et al., (1952) have mapped the central Wasatch Mountains immediately south of the area.

GEOMORPHOLOGY

Landforms

The Wasatch Mountain relief is generally greater to the west than to the east near the East Canyon Creek headwaters. The eastern slope of the Wasatch ridge becomes sharper northward along East Canyon Creek. In Morgan Valley, where East Canyon Creek empties into the Weber River, the eastern relief is nearly as great as the western.

The East Canyon area is predominantly in the late youth stage of geomorphic development. The uplands have been totally dissected. The area is hilly and mountainous, well drained, and has no well developed flood plains or meander belts. The sediments in the southern portion of the area have eroded differentially to form hogbacks and strike valleys.

An escarpment facing east extends from near Big Mountain in the southern part of the area to Croyden on the north (see geologic map in pocket). The cliff is the result of normal faulting and has a maximum relief of nearly 2000 feet near East Canyon Reservoir. Locally, resistant conglomerates have weathered into pinnacles (figure 2).

Erosion surfaces

Herd Mountain surface: Eardley (1944) described an erosion surface that is reflected in the plateau-like nature of the higher levels in the north central Wasatch. The surface was named the Herd Mountain surface and is probably an extension of the Gilbert Peak erosion

Figure 1. Herd Mountain erosion surface expressed in constant elevations of distant peaks north of East Canyon area

Figure 2. Pinnacle of weathered Knight formation near Redrock Canyon

surface described by Bradley (1934, 1935). In the East Canyon area, the Herd Mountain surface has been almost entirely eroded away, but views of the even ridge crests to the north suggest the former existence of the surface (figure 1).

Weber Valley surface: Weber Valley is broad in places and fairly extensive pediments about 100 feet above the present streams are known as the Weber Valley surface. The surface represented by these pediments was probably formed after rejuvenation of drainage on the Herd Mountain surface. The region was elevated in Miocene time (Eardley, 1952, p. 59). The weber Valley surface then developed. Later uplift has resulted in dissection of the Weber Valley surface.

River terraces: Glaciation has interrupted the trenching of the Weber Valley surface by supplying a surplus of material for the streams to carry. The deposition associated with the glacial run-off accounts for the river terrace deposits below the Weber Valley surface. The terraces have been dissected and in many places destroyed, but some remnants have been left particularly in the vicinity of Dutch Hollow (see geologic map in pocket).

STRATIGRAPHY

General Statement

Sedimentary rocks present in the East Canyon area range from Jurassic to Pliocene (?) and represent several varied depositional environments. Jurassic beds crop out in a northeast trending strike valley that is partially a result of faulting. Lower Cretaceous (?) sediments are exposed in the vicinity of upper Mountain Dell Creek. Upper Cretaceous deposits have been exposed along the southern part of the area. These beds produce a series of hogbacks and strike valleys that extend from Big Mountain near the western edge of the area to the headwaters of Schuster Creek near the eastern boundary of the area. Paleocene and Eocene rocks crop out over most of the East Canyon area and generally rest unconformably on the older rocks. Oligocene tuffaceous rocks occur as a fill for a basin in the central portion of the East Canyon area. Pliocene (?) rocks are present in the form of scattered remnants of a flat-lying fanglomerate capping the hills of the central basin portion of the East Canyon area.

Jurassic system

<u>Preuss formation</u>: The Preuss formation outcrops in a subsequent valley near the East Canyon Reservoir damsite. Preuss rocks are also exposed in the northeast part of the East Canyon area, west of Dixie Hollow and near the southern boundary of the area in Mountain Dell Creek.

The Preuss formation of this area consists of dark red sandstone, siltstone, and shale (figure 4). The sandstone beds are friable, medium to coarse grained and quartzose. Some grit occurs in the lower beds.

The lowest beds exposed terminate against the East Canyon fault. The upper beds have been covered unconformably by the later Norwood tuff, and therefore the total thickness is in excess of 1200 feet which approaches maximum figures for the formation given to the south (A. L. Baker, 1931). Probably the contact with the Morrison formation is under cover of Norwood sediments.

The Preuss formation of the East Canyon area is considered the approximate equivalent of the Entrada formation which outcrops in the San Rafael Swell (Crittenden, et al., 1952, p. 66). The Entrada lies between the Carmel and Curtis formations, (Gilluly, 1929, p. 104) for which a Jurassic age has been assigned.

Upper Jurassic (Morrison formation) sediments are not exposed in the East Canyon area. However, the Morrison formation is exposed in road cuts in nearby Emigration Canyon (Crittenden, et al., 1952).

Cretaceous system

Kelvin formation: Lower Cretaceous time is represented by the Kelvin formation. Its type locality is in nearby Emigration Canyon at Kelvin Grove (Mathews, 1931, p. 48). The formation crops out in the

Figure 3. Massive sandstone hogback of the Wanship formation in upper Schuster Creek

Figure 4. Sandstone of the Preuss formation near East Canyon Reservoir

southwestern part of the mapped area in the vicinity of upper Mountain Dell Creek. The complete Kelvin section is not exposed here, but Crittenden, et al., (1952) give the figure of 1500 feet as maximum for this unit in Parleys Canyon to the south.

The Kelvin formation contains considerable amounts of conglomerate in Kelvin Grove, but sands and mudstones predominate in the East Canyon area. Small cobble conglomerates are present and loosely cemented coarse sands are interbedded. The color is generally reddish brown with red sandy shale also present.

Eardley (1951, p. 275) has suggested a time relationship between the Kelvin and the Indianola group of central Utah. The Kelvin might also be equivalent to all or part of the Gannett group of southeastern Idaho. The coarse conglomerates in Emigration Canyon indicate sharp uplift at the time immediately to the west.

The Kelvin formation has been tilted sharply and deformed by folding and faulting.

Basal Kelvin rocks are not exposed. The Cretaceous Frontier formation overlies the Kelvin formation in a conformable fashion south of the East Canyon area (Granger, 1953, p. 4).

Frontier formation: The Frontier formation was described by Knight (1902, p. 721). The type section is in southwestern Wyoming near the town of Frontier.

The Frontier formation creates a series of hogbacks and strike valleys in the extreme south of the East Canyon area. It is exposed in the vicinity of Mountain Dell Creek, Little Hatch Canyon and Porcupine

Creek as massive sandstone ridges with interbedded shales and conglomerates. The upper sandstones are massive, weathering white, and contain numerous fossils. The author has collected and identified several species with help from Dr. W. L. Stokes. They are as follows:

Gyroides conradi

Gyroides depressa

Prionocyclus wyomingensis

Mactra utahensis

Cardium sp.

Anatina lineata

Liopistha concentrica

The Frontier formation of this area has been measured (Granger, 1953, p. 13) to be 8724 feet. Plate II (Cobban and Reeside, 1952) suggests a thickening of Frontier lithology westward and would account for the abnormal thickness in East Canyon. The transition to dominantly non-marine sediments is also expressed by Plate II. The Frontier sea probably shored near Coalville, Utah to the east (Wood, 1953) during most of Frontier time, explaining the coal present in that vicinity and the absence of lagoonal facies in the East Canyon area.

The Frontier formation was mapped by the 40th Parallel Survey in 1871 when King called it Fox Hills because the lithology was similar to Fox Hills rocks elsewhere in Wyoming. Stanton (1893, p. 40) mapped the series and dated it Coloradoan at Coalville and East Canyon, Utah.

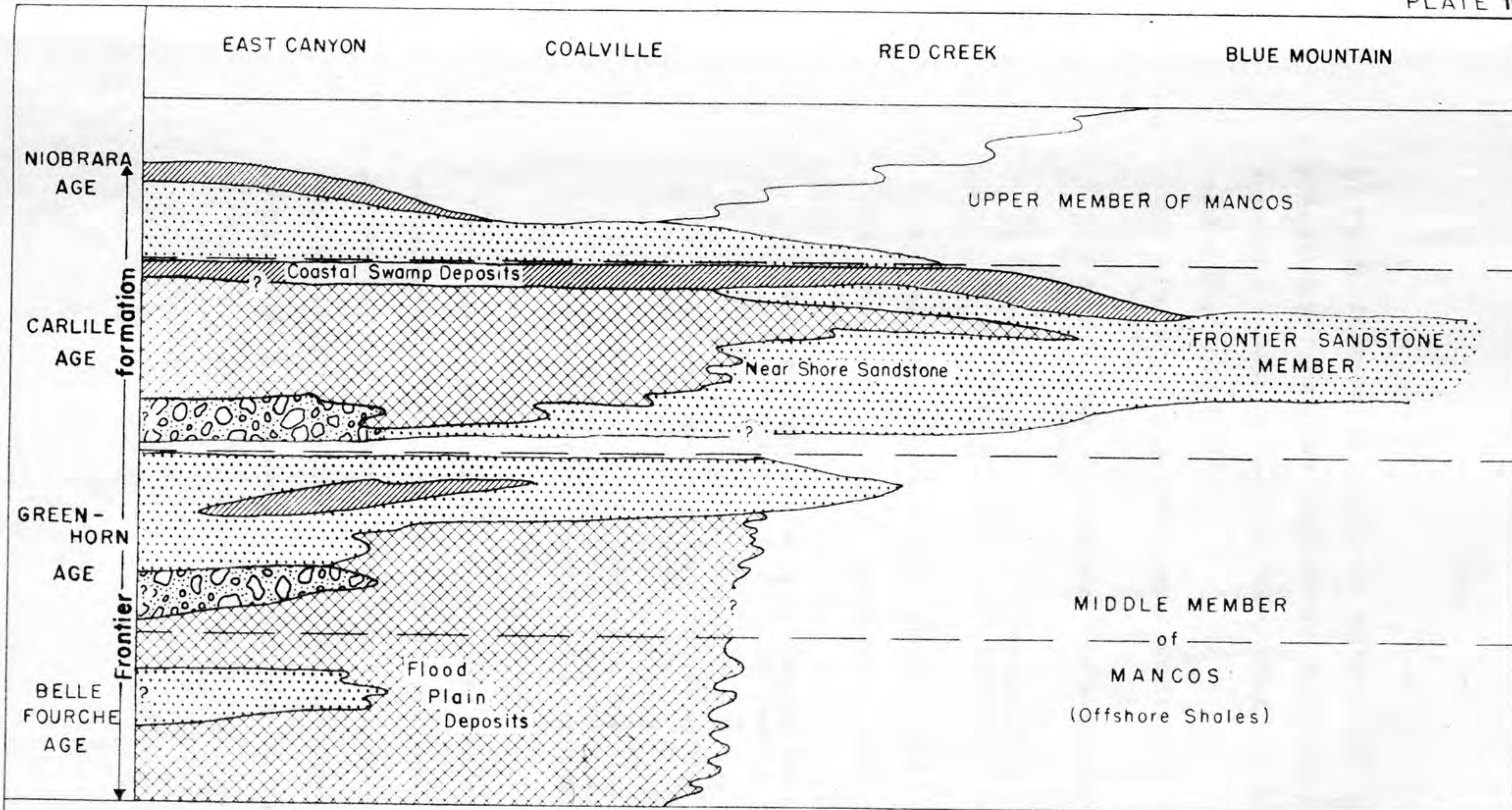
Cobban and Reeside have included beds of Hilliard age as upper Frontier and recognize the lower Frontier beds of East Canyon to be as old as Belle Fourche (Plate II).

The Frontier formation overlies the Kelvin formation conformably, as far as can be discerned. The Wanship formation overlies the Frontier with a slight discordance. The angle of discordance increases from 3° at the eastern margin of the area to about 15° at the western margin.

Wanship formation: The term Wanship formation was first applied in connection with the geologic studies of the Coalville quadrangle areas undertaken by the University of Utah. The type section is a sequence of gray and brown sandstones which crop out south of Cherry Canyon near Wanship, Utah.

The Wanship formation crops out in a broad band trending east near the southern boundary of the East Canyon area. It extends from the headwaters of Schuster Creek to the eastern slope of Mountain Dell Canyon.

The lithology of the Wanship formation of the East Canyon area is variable due to the rapid transition from east to west. Near the Schuster Creek headwaters, the formation contains massive, friable, white to tan, fossiliferous sandstones with some carbonaceous material (figure 3). The basal conglomerate at Schuster Creek is about 500 feet thick and near East Canyon Creek it is about 1400 feet thick. Several miles farther west, near Clear Creek, the Wanship formation becomes almost entirely conglomeratic. Crittenden, et al., (1952) recognized



FRONTIER FORMATION

Simplified Facies Along the South Flank of the Uinta Mountains

MODIFIED AFTER
COBBAN & REESIDE
1952

no Wanship formation in mapping the adjacent area to the west, but used the term "Cretaceous conglomerate" for the interval. The author measured a section east of East Canyon Creek near Willow Creek. The section is as follows:

8 -	Contact of Almy conglomerate overlying unconformably	
7 -	Sandstone and conglomerate, pebble to cobble size, red to brown	2390'
6 -	Conglomerate, cobble, has cobbles of sandstone (60%), quartzite (15%), Paleozoic limestone (10%)	2582'
5 -	Sandstone, coarse grained, white to gray	10'
4 -	Shale with limestone, bentonitic, red to gray	1'
3 -	Limestone, crystalline, gray weathers white, limonite concretions sparsely scattered throughout	2'
2 -	Sandstone, coarse grained, gray to mottled color, tending towards graywacke	11'
1 -	Conglomerate, basal, pebble to cobble size with interbedded sandstones, coarse grained and 2-3 feet thick, reddish color throughout	1350'
	Total	6346'

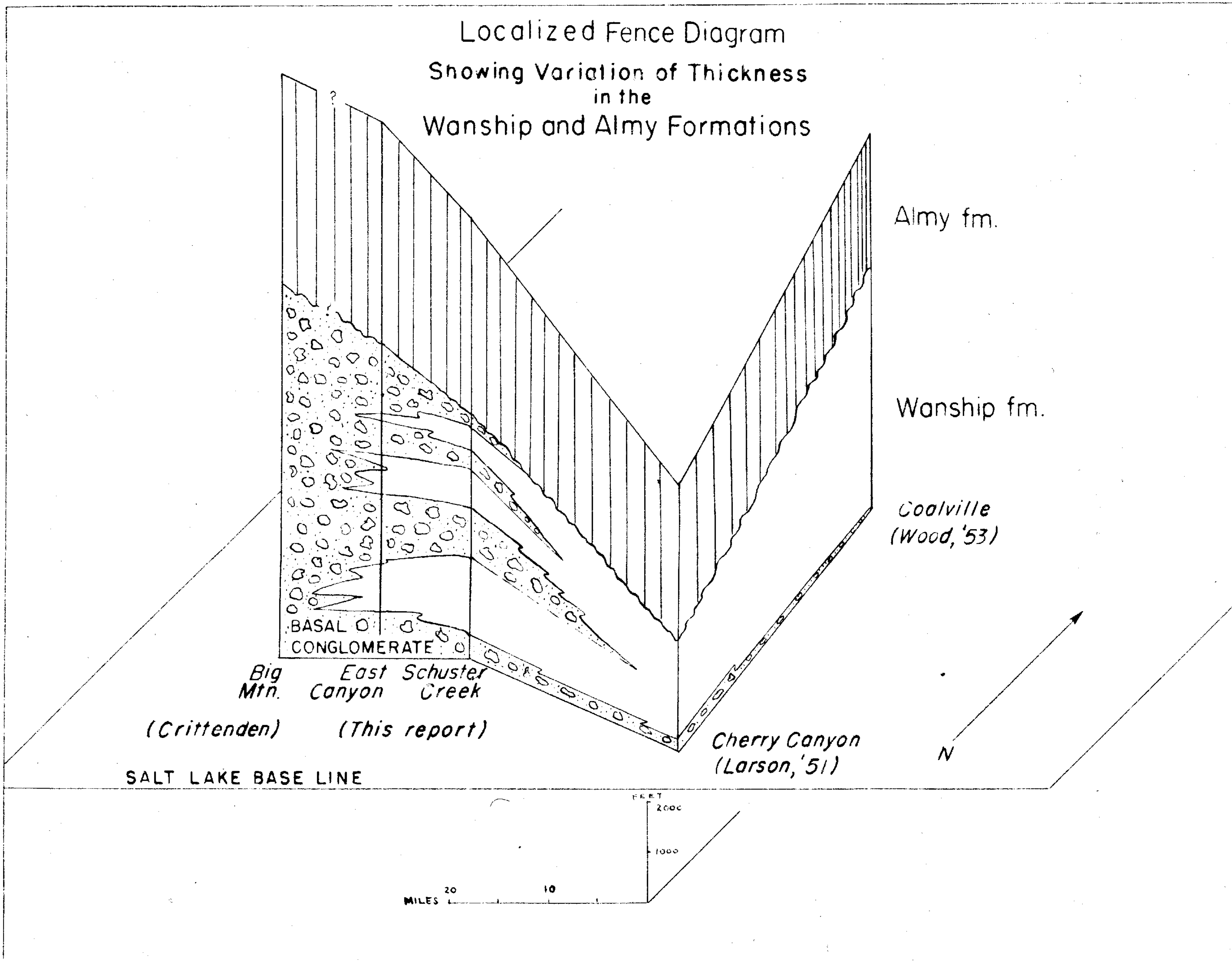
Near Clear Creek the formation has been eroded at the upper contact and the complete thickness is not available. However, an excess of 2500 feet of conglomerate was observed near Little Hatch Canyon. Plate III shows the thickening of the Wanship formation as well as the lithologic changes expressed in Wanship outcrops from east to west.

The Wanship formation contains remains of Inoceramus umbonatus (?) (identified by Dr. W. L. Stokes, University of Utah) in the vicinity of Schuster Creek. This fossil is suggestive of Montanan time. The fossil assemblage collected and identified by Lankford (1952, M.S. Thesis) was interpreted by him to mark Cretaceous-Tertiary age for the Wanship formation. A University of Utah student, W. Sadlick, found a dinosaur ungal in the formation and this plus Inoceramus led Stark (1953, M.S. Thesis) to advocate a Montanan age. More study is needed to ascertain an exact age.

The Wanship formation is, in part, a correlative of the Henefer formation as named and described by Eardley (1944, p. 840). The Henefer formation was believed by Eardley to be equivalent to all or part of the Hilliard, Adaville, and Evanston formations, but later found the upper part of the Henefer to be equivalent to lower Almy (Eardley, 1951). The Wanship would thus be pre-Almy in age.

The Montanan Price River formation of the Wasatch Plateau region (Spieker, 1946) is possibly related to the Wanship formation. Both have tentatively been placed in the Montanan epoch, and thicken greatly westward. The Price River is essentially all conglomerate near Wales, Utah and thus is similar to the Wanship section of conglomerate near Mountain Dell Canyon (Plate III).

The Wanship formation overlies the Frontier formation unconformably as previously noted. The upper Wanship contact is decidedly one of beveled beds with the overlying Almy making an angle of about 40° with the Wanship at Schuster Creek.


Localized Fence Diagram
Showing Variation of Thickness
in the
Wanship and Almy Formations
Almy fm.
Wanship fm.
BASAL
CONGLOMERATE
Big
Mtn.
East
Canyon
Schuster
Creek
(Crittenden)
(This report)
Coalville
(Wood, '53)
Cherry Canyon
(Larson, '51)
N
SALT LAKE BASE LINE
FEET
2000
1000
MILES
20
10

Tertiary system

Almy formation: The Almy formation was named for exposures of conglomerate and sandstone near Almy, Wyoming. The conglomerate, previously called Wasatch by Hayden in 1869, was designated as a member of the Wasatch group by Veatch (1907, p. 89).

The formation is exposed immediately west of the East Canyon damsite, near Big Mountain, and across the area from Clear Creek to Schuster Creek. Its resistant nature has resulted in high mountains and escarpments (figure 6).

The Almy consists of angular to subangular boulder and cobble conglomerate. Boulders of quartzite, metaquartzite, and limestone containing Paleozoic fossil fragments are abundant, while sandstone boulders are scarce. The matrix of the conglomerate is usually sandstone and mudstone, imparting a brown to red-brown color to the formation.

A section of Almy 4200 feet thick was measured in East Canyon Creek near Schuster Creek, but the entire formation is not exposed. The great thickness suggests proximity to the source area.

The conglomerate exposed in the East Canyon area is similar to the Almy conglomerate of the type area. Eardley (1944, p. 842) correlated the two. Gazin collected a primate (Plesiadapis) from the Almy along LaBarge Creek near Green River, Wyoming. Almy beds later yielded a Coryphodon skull and Eohippus jaw. These finds indicate a Clarkforkian age (Gazin, 1942).

The Almy formation is underlain by the Cretaceous Wanship formation in a discordant manner. Angular discordance of 40° is present between the two formations. The Fowkes formation of Paleocene (?) age seems conformable on the Almy near the East Canyon damsite, but it is absent near Big Mountain and Little Emigration Canyon where the Eocene Knight formation overlies the Almy unconformably.

Fowkes formation: The Fowkes formation was described by Veatch (1907) as a member of the Wasatch group. Near its type area the formation consists of rhyolitic sands, tuffaceous material interbedded with fresh water limestones and other lacustrine beds. In East Canyon it crops out near Tucson Hollow in a narrow band northwest from the East Canyon Reservoir. The exposures usually erode into a subsequent valley (figure 5).

The Fowkes formation contains sandstone and pea conglomerate. It has thin bedded carbonaceous shales and some fresh water limestone. Tuffaceous beds crop out locally.

The Fowkes is considered to be a series of local river flood plain and lake beds (Eardley, personal communication). The lenticular nature of the formation has been described by Veatch (1907). In the Tucson Hollow vicinity it is 828± feet thick. This thickness is greater than most outcrops of the Fowkes formation. A measured section is as follows:

8 - Sandstone, massive, medium grained, white to gray in color, forms small disintegrating cliff	15'
7 - Sandstone and siltstone, blue to white in color, non-resistant, vegetative cover	48'
6 - Shale and limestone, impure, carbonaceous and spotty fossiliferous nature, gray to blue-gray with few black shales	78'

5 - Sandstone, massive, fine grained, very resistant, white in color	3'
4 - Sandstone, rust to brown, extremely friable, interbedded with shales and loosely consolidated pea conglomerates	116'
3 - Shale, gray to green, with intercalated sandstone, very calcareous, usually soil covered	115'
2 - Sandstone, coarse grained, friable, white weathers rust, soil covered to a great extent	130'
1 - Shale, gray to green, with interbedded graywacke	123'
Below this there appears to be approximately 200 feet of soil-covered material that is most probably Fowkes although this contact is uncertain. This thickness is derived from projecting dips of the Almy formation beds into alluvium covered slopes	200'±
Total	828'±

Plant fossils found in zone 6 above have been identified by Dr. R. W. Brown of the U. S. National Museum as the conifer Metasequoia occidentalis (Newberry Chaney) and the broad-leafed dicotyledon Pterospermites sp. (figure 8). Both species cross the Paleocene-Eocene time boundary and are undiagnostic of specific time designation.

The Fowkes formation is overlain conformably by the Knight formation in East Canyon northwest from the reservoir.

Knight formation: The highest unit of the Wasatch group described in Veatch's report (1907) is the Knight formation. The type section is near Knight Station, Wyoming. The Knight outcrops in much of the East Canyon area as an overlying "blanket" cover of the older formations. Good exposures are present in Sheep Canyon, Priest Hollow,

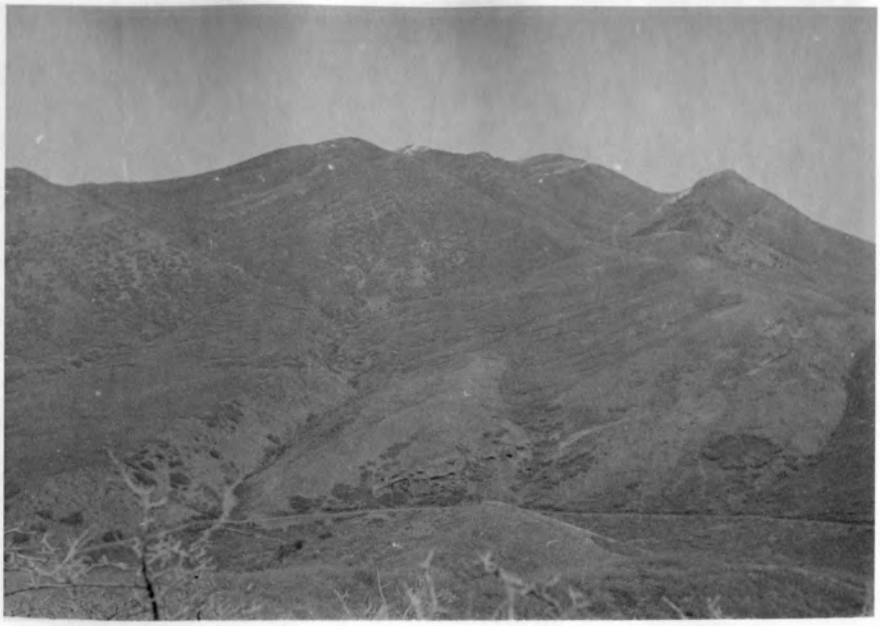


Figure 5. Subsequent valley resulting from weathering of Fowkes formation. The exposure is near East Canyon Reservoir

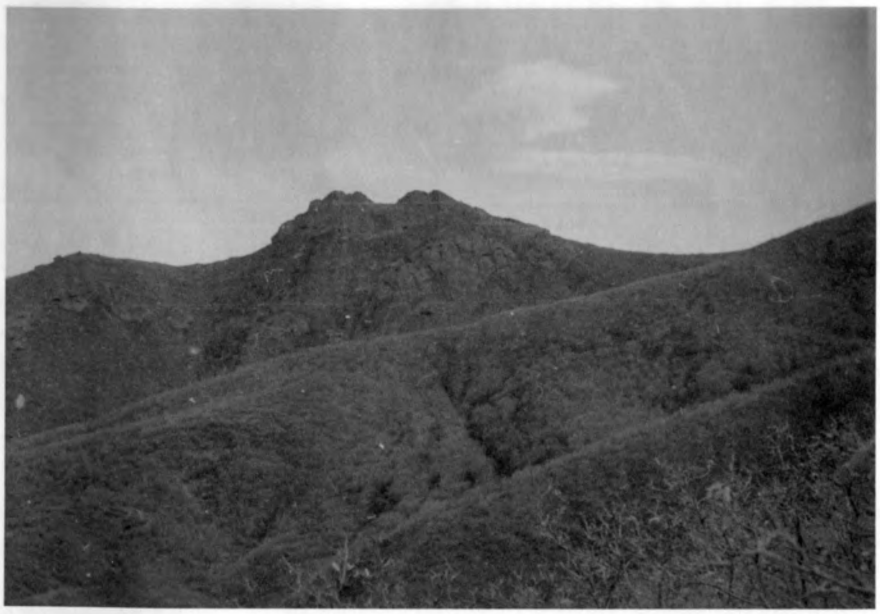


Figure 6. Vertical conglomerate beds of the Almy formation north of East Canyon Reservoir

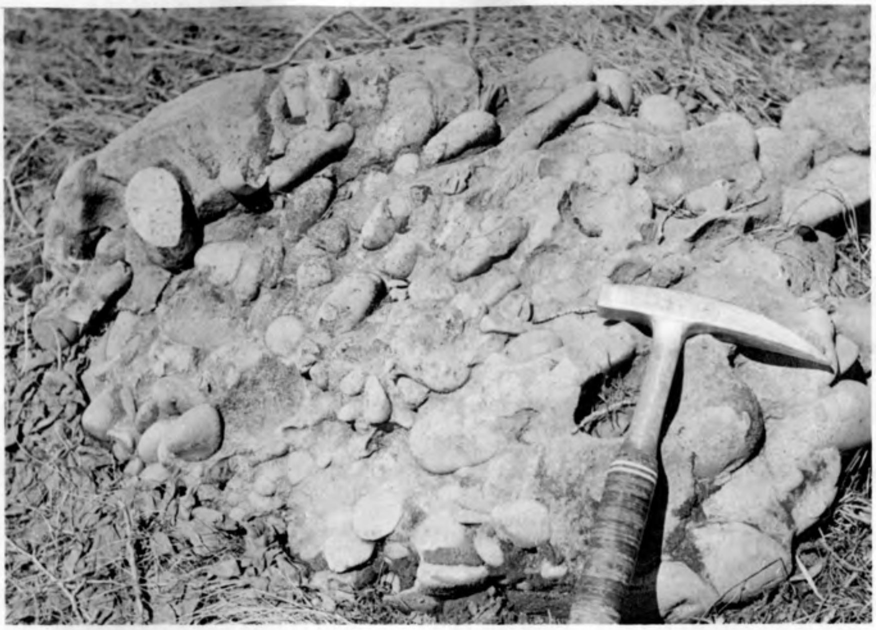


Figure 7. Heterogeneous cobbles in characteristically weathered Knight formation fragment

Figure 8. Fossil leaf (Pterospermites sp.) from limestone bed in Fowkes formation. The specimen was identified by Dr. Roland W. Brown of the U. S. National Museum

Red Rock Canyon, Taylor Hollow and Dutch Hollow. The higher mountains near Little Emigration Canyon are capped by the relatively flat-lying conglomerate.

In the East Canyon area the Knight formation has alternating beds of massive sandstone or grit and conglomerate. The phenoclasts of the conglomerate range in size from pebbles to boulders. Many are quartzites and gneisses (figure 7). Some limestone fragments are present but not as abundantly as in the Almy conglomerate. The sandstones of the formation are massive, medium to coarse grained, and poorly sorted.

The exposures of the Knight formation in lower East Canyon reveal a thickness in excess of 5000 feet. The formation was deposited on a surface of strong relief leaving variations in thickness, but a gradual overall increase is noted westward. A western highland supplied the source material for this formation.

The Knight formation of the East Canyon area has been provisionally correlated with the Knight formation of Wyoming (Eardley, 1944, p. 844). C. Lewis Gazin (1952) assigned a Wasatchian age on the basis of Coryphododon radians and Eohippus index discovered in the vicinity of Dry Piney Creek, Wyoming.

Fossils have not been found in the Knight formation in East Canyon.

The Knight formation overlies all the rocks that crop out in the East Canyon area from the Cretaceous Frontier formation to the Tertiary Fowkes formation. The angularity at the contact ranges from 13° to 80°. The Knight rests conformably on the Fowkes formation in the lower East Canyon Creek vicinity. The overlying Norwood formation rests unconformably on the Knight in the vicinity of South Norwood Canyon but rests conformably near Little Emigration Canyon. Much of the Knight is exposed to active erosion.

<u>Norwood tuff</u>: Eardley (1944) described and proposed the name "Norwood tuff" for the series of white to gray, tuffaceous, rhyolitic sands and shales that crop out in Norwood Canyon north of Porterville.

The Norwood tuff crops out in a subcircular pattern near the center of the East Canyon area. Little Dutch Hollow is filled with tuffaceous sediments which extend north to Taylor Hollow and into Dixie Hollow where extensive outcrops are evident.

The Norwood ranges in thickness from a few tens of feet near Little Dutch Hollow up to several hundred feet in the Dixie Hollow vicinity. An average thickness of 200± feet would approximate the actual thickness in most places.

The Norwood is generally tuffaceous. In the East Canyon area, shales, sandstones and conglomerates are present. The tuff ranges from fine grained, well sorted, white calcareous sandstones, to coarse grained, poorly sorted, gray to black-flecked, siliceous sandstones. The shales are gray to green, with local carbonaceous matter and limited in extent. Bentonitic clays are locally present (figure 10). Near East Canyon Reservoir outcrops of pebble conglomerates are interbedded. Most of the pebbles are rhyolitic or andesitic volcanics that have been water-rounded. Cobble sized conglomerates exist locally.

The Peoa tuff (Williams, 1950) is provisionally correlated to the Norwood. The absence of other correlate beds makes lateral tracing difficult. Titanothere remains found by Dr. Eardley have been compared with the White River Oligocene fauna of the "Plains" area. The Oligocene age designation has thus been made. Fossil finds are limited to the genus of fresh water gastropods, Planorbis, in the East Canyon area. The Norwood tuff rests on the Knight formation. The sediments were apparently deposited as an Oligocene valley fill. Much of the material was derived from volcanism that broke out during that time in the Park City volcanic field (Eardley, 1944).

Pliocene (?) fanglomerate: Ben E. Lofgren (personal communication) has recognized a fanglomerate overlying the Norwood tuff in the Huntsville, Utah area. A name has not yet been proposed for the formation which seems to be of Pliocene (?) age.

The Pliocene (?) fanglomerate is exposed as a cap rock for the higher hills in the Norwood tuff outcrop area. Large areas of exposure occur near Monument Creek.

The fanglomerate consists chiefly of loosely consolidated, sub-rounded boulders, cobbles, and pebbles (figure 9). Sandstone cobbles are numerous and some quartzite, Paleozoic limestone, and metamorphic schists and gneisses also appear. The matrix is a reddish orange, loosely compacted, poorly sorted sand.

The thickness is not fully exposed in the East Canyon area, but is probably less than 120 feet.

Correlation of the Pliocene (?) fanglomerate is difficult. No lateral continuity is existent except to the north where evidence

Figure 9. Pliocene (?) fanglomerate near Little Dutch Hollow

Figure 10. Conglomerate and bentonitic shale in the Norwood tuff near Dutch Hollow

of the formation exists in Morgan Valley and the Huntsville area.

The formation is the uppermost lithologic unit exposed in most places. The fanglomerate rests with apparent conformity on the Norwood tuff in the localities examined, but in Morgan Valley it is strikingly discordant with the underlying tuff.

Quaternary system

Quaternary (?) terrace gravels: Stream terrace gravels are exposed in the East Canyon Creek channel near Dutch Hollow and Schuster Creek. The deposits are remnants of an older stream profile. The stream gravels consist of loosely consolidated, subangular boulders and cobbles. Coarse sand and silt form a matrix in the poorly sorted deposits.

The terrace gravels range from a few to fifty feet in thickness and were deposited on an irregular erosion surface. The gravels at one time filled the valley of East Canyon Creek but subsequent uplift and active erosion has carried much of the material away.

The terrace gravels overlie the Knight, Almy and Wanship formations unconformably. The boulders and cobbles indicate an origin from the conglomerate beds of these formations.

Igneous rocks

Scattered volcanic breccia cones associated with the Norwood tuff occur in the East Canyon area. Three cones are present in the area of the Norwood outcrop and two are present in the area of Wanship outcrop. A thin section study of the breccia indicates an andesitic composition. Euhedral hornblende and a variety of mica crystals are scattered throughout the rock.

The andesitic breccias are probably associated with the Park City volcanism. When the volcanism was in progress, great amounts of debris choked the drainage of the East Canyon area (Eardley, 1952, p. 59). Additional volcanic activity at this time accounts for the East Canyon breccias.

Era	Period	Epoch	Formation	Thickness	Description
Cenozoic	Tertiary	Pliocene (?)	fanglomerate	120+	Fanglomerate, tan to rust, heterogeneous, loosely consolidated
					unconformity
Cenozoic	Tertiary	Olig	Norwood formation	200+	Sandstone, white to grey, tuffaceous, w/ andesitic breccia
					unconformity
Cenozoic	Tertiary	Eocene	Knight formation	5000+	Conglomerate, brick red, cobble to boulder, interbedded with sandstone, siltstone and shale Conglomerate, brown to red
Cenozoic	Tertiary	Eocene / Paleocene	Fowkes formation	828±	Sandstone, white to grey, tuffaceous, friable Shale and limestone, fossiliferous Sandstone and pea conglomerates,
Cenozoic	Tertiary	Paleocene	Almy formation	4350+	Conglomerate, bright red to brown, cobble to boulder, matrix of sand and silt
					unconformity
Mesozoic	Cretaceous	Montanan	Wanship formation	6346	Sandstone, white to rust colored, contains *Inoceramus* Conglomerate, brown
Mesozoic	Cretaceous	Coloradoan	Frontier formation	8000±	Sandstone, white, massive, fossiliferous Shale and sandstone – two conglomerate beds Bentonite and shale
Mesozoic	Cretaceous	Coloradoan / Lower			NOT EXPOSED
Mesozoic	Cretaceous	Lower	Kelvin formation	1500-	Siltstone and sandstone, red to purple
Mesozoic	Cretaceous	Lower			NOT EXPOSED
Mesozoic	Jurassic		Preuss formation	1000-	Sandstone, red, interbedded shales
Mesozoic	Jurassic				NOT EXPOSED

Columnar Stratigraphic Section of Sediments Exposed in the

EAST CANYON AREA

STRUCTURE

General statement

Geologists have focused attention on the Wasatch Mountains for many years and have concluded that a number of disturbances during late Mesozoic and Cenozoic time have affected the region. The structural complexity that has resulted is well exposed in the East Canyon area.

Several folds have a northeast trend in the southern portion of the area and a major fault of later age traverses the area from north to south. The younger structures generally have a more northerly alignment and are little influenced by the older trends.

Faults

Little Mountain reverse fault: Sharp and Granger (Crittenden, et al., 1952) mapped a high angle reverse fault south of the East Canyon area that extends from the Wasatch front, through Emigration Canyon, and into Mountain Dell Canyon near Big Mountain. The fault trace continues into the East Canyon area (see geologic map in pocket) and runs along the base of an escarpment to the vicinity of East Canyon Reservoir where it is well exposed. The trace follows the escarpment to a point near Croyden, Utah, north of the area.

The fault has displaced beds of the Preuss, Wanship, Almy and Fowkes formations. The total displacement is more than 5500 feet near East Canyon Reservoir. It occurred prior to Knight deposition

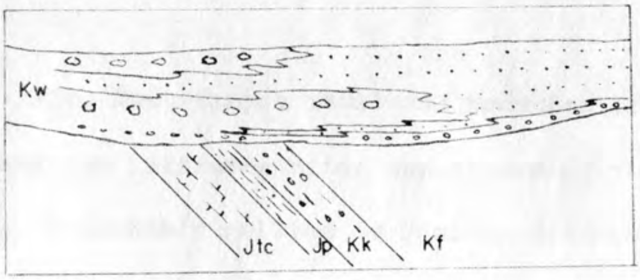
(Plate V). Movement of the fault was probably initiated by the middle Laramide orogeny. The east side of the fault was upthrown, and the Almy conglomerate on the downthrown west side was dragged upward conspicuously.

East Canyon fault: The Little Mountain reverse fault movement was a zone of weakness in the Fowkes and older formations. Later forces caused the zone to yield again along the plane of the older fault but in the opposite direction (Plate V). The new movement is here called the East Canyon fault.

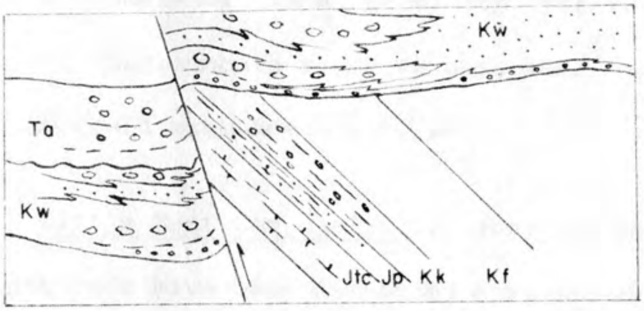
The East Canyon fault displaced the Norwood tuff beds down against Almy, Fowkes and Knight beds near Monument Creek and Little Dutch Hollow (see geologic map in pocket). In the vicinity of East Canyon Reservoir the Preuss beds that were resting against the upturned Almy beds are faulted down, thus causing much brecciation in the Preuss beds (figure 4).

The upthrown block on the west left an escarpment over 1500 feet high near Monument Creek and triangular facets on truncated spurs are well developed along the escarpment. Deposits of travertine have accumulated along the fault where it crosses Little Dutch Hollow.

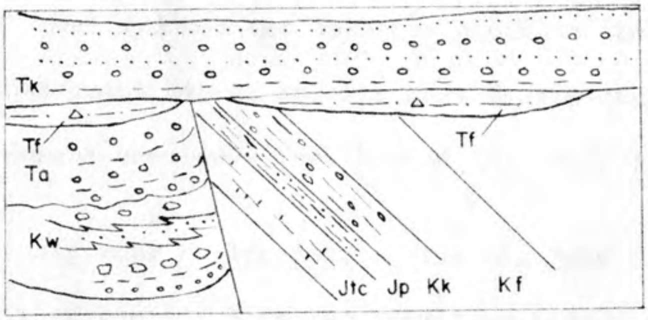
The major fault breaks into several small branches where it crosses the Morgan-Summit County line, and also near Big Mountain. The East Canyon fault dies south of Big Mountain where displacement has been only in the reverse direction along the Little Mountain reverse fault.



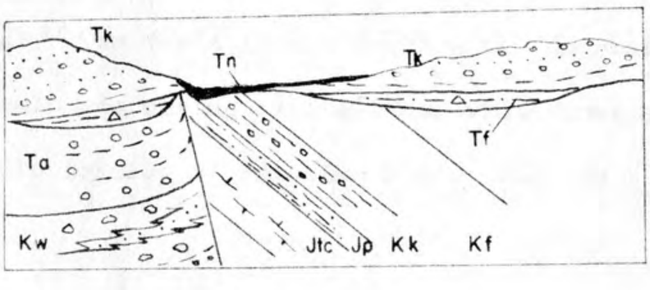
Wanship formation deposited on pre-Wanship sediments, unconformably.



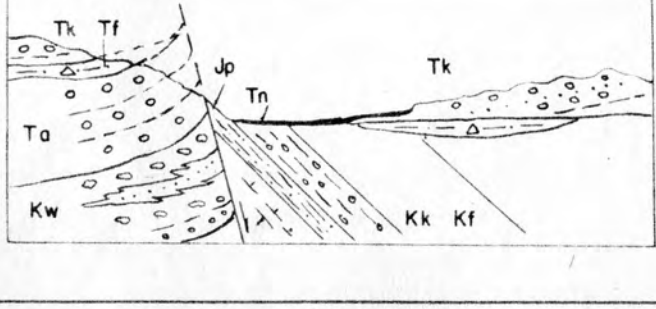
Warping, deposition of Almy, and Little Mountain thrust.



Planation and deposition of Fowkes and Knight formations.



Warping, deep erosion and deposition of Norwood tuff.



East Canyon fault on same plane as Little Mountain thrust and erosion of profile of today.

History of the East Canyon Fault

The East Canyon fault and branches of it belong to a period of deformation initiated after deposition of the Norwood tuff. The faulting is probably related to Basin and Range faulting of regions to the west of the East Canyon area, but is earlier than the Pliocene (?) fanglomerate. This age of faulting is proposed because the Pliocene (?) fanglomerate seems to have been eroded from the escarpment of the fault near Monument Creek.

Little East Canyon fault: Near the northern boundary of the area Knight beds have been displaced against the Fowkes formation and the fault is here designated the Little East Canyon fault. It strikes north 30° west and has the upthrown block to the south. Diagonal slip displacement has offset the East Canyon fault to the east and carried Knight beds 400± feet beyond the older fault trace.

Big Bear Hollow fault: The Big Bear Hollow fault is a minor displacement of Frontier formation beds. It is located near the southern boundary of the East Canyon area and has a displacement of 29 feet. The fault trends northwest. Movement along the Big Bear Hollow fault was during earliest Laramide times and is associated with pre-Wanship folding of Frontier beds. The fault is covered by Wanship beds.

Folds and unconformities

Basal Wanship unconformity: In the vicinity of Big Bear Hollow, an unconformity exists between Wanship and Frontier beds. The discordance ranges from 1° to 20°. In East Canyon Creek the beds are nearly conformable.

Little Hatch syncline and pre-Almy unconformity: The Little Hatch syncline is exposed in the southwestern portion of the East Canyon area. Dips have been observed (see geologic map in pocket) of 23° north on the southern limb of the syncline in Little Hatch Canyon. The northern limb is steeper and the beds dip from 25° east to 35° east on the eastern side of Mountain Dell Creek. The syncline plunges to the northeast and is covered by Almy conglomerate in the vicinity of the junction of the three counties (Salt Lake, Summit, and Morgan). The plunge is from 5° to 9° northeast. The syncline is expressed in Wanship beds and the post-Almy formations rest across the syncline unconformably.

The Little Hatch syncline is a result of late early Laramide folding and affects Wanship and older beds.

Clear Creek syncline and post-Almy unconformity: The Clear Creek syncline is located in the southern part of the East Canyon area in the vicinity of Clear Creek Canyon (see geologic map in pocket). The syncline is asymmetrical with the steeply dipping limb to the north. The axis of the syncline lies north of Clear Creek and plunges to the northeast. The beds dip from 17° to 26° south on the northern limb and from 8° to 16° north on the southern limb.

The Clear Creek syncline is expressed in Almy conglomerate beds. The Almy beds rest unconformably on Wanship conglomerate beds. Above the Almy, in this portion of the East Canyon area, the Knight covers all older formations unconformably. The central part of the Clear Creek syncline is covered by the Knight with a discordance of beds ranging from 3° to 14°.

The Clear Creek syncline is a product of middle Laramide orogeny. During late middle Laramide time, upturned Almy beds were beveled by erosion and the Knight formation was deposited unconformably.

Morgan Valley syncline and pre-Norwood unconformity: The Morgan Valley syncline (Eardley, 1944) extends from Morgan Valley south into the East Canyon area. It is a nearly symmetrical fold trending north and formed in Knight beds. The dips on either limb range from 15° to 23°. The syncline plunges about 4° north.

The Morgan Valley syncline developed prior to deposition of the Norwood tuff. The pre-Norwood unconformity exists between the Knight and Norwood beds and discordance of 15° was measured in Taylor Hollow. The syncline is latest Laramide in age and is part of the broad folding that produced the mountain-valley arrangement of the present topography (Eardley, 1951, p. 331). The Norwood tuff was deposited during the Absarokan orogeny (Eardley, 1949, p. 21) after the syncline had been folded.

<u>Post-Norwood unconformity</u>: There is little evidence of the post-Norwood unconformity in the East Canyon area which is present in Morgan Valley (Eardley, personal communication). The Norwood formation has been tilted as much as 41° in South Norwood Canyon, but the attitude of the overlying Pliocene (?) fanglomerate is undiscernable there. Because the Norwood tuff has been deformed and no exposures of Pliocene (?) fanglomerate show such deformation, it is logical to assume that an unconformable relationship does exist between the two formations to the north.

GEOLOGIC HISTORY

Late Jurassic time

The oldest rocks of the area record part of late Jurassic time. The Preuss rocks were deposited on an ancient fluvial plain and became sandstones, mudstones and grits. The Jurassic Morrison formation is not exposed, but adjacent areas show the Morrison (?) was deposited conformably upon the Preuss.

Early Cretaceous time

During early Cretaceous time a highland was formed to the west of East Canyon and a conglomeratic formation was deposited over the area. The Kelvin formation is probably a product of the orogenic movement of the Wasatch area corresponding to the Cedar Hills orogeny of Sanpete County, Utah (Eardley, 1951, p. 275).

Coloradoan time

In the East Canyon area, a period of quiescence followed the deposition of the Kelvin formation. While the Frontier was being deposited the highland to the west was still shedding sediments, but the piedmont conditions were not so pronounced as during Kelvin deposition (Jones, et al., 1953). The East Canyon area was very near the oscillating seashore because marine fossils are contained in the Frontier formation as well as terrestrial conglomerates.

Montanan time

Earliest Montanan time was quiet until the beginning of the Laramide activity. Prior to deposition of the Wanship formation, the first influence of the Laramide orogeny is expressed in the Frontier-Wanship unconformity in the East Canyon area. A highland was raised to the west and the old Uinta Mountain highland raised to the east. The Wanship sediment was eroded from the highlands and deposited upon the East Canyon area. The western conglomeratic facies of the Wanship formation suggest a proximity to the western source.

Paleocene time

The middle Laramide orogeny tilted Wanship beds forming the Little Hatch syncline. The orogenic movement caused another western source to be elevated, probably associated with the Willard thrust (Eardley, 1944). From this highland a great mass of coarse conglomerate, the Almy formation, was shed eastward. The orogenic forces caused additional deformation and the Little Mountain reverse fault (Plate V).

Eocene time

The late Laramide orogeny followed Fowkes deposition. By late Eocene time broad bands of folds had been imposed on the region. The frontal Wasatch ridge and the Henefer anticline to the northeast (Eardley, 1951, p. 330) had been uplifted. The Almy and Fowkes beds were tilted, the Clear Creek syncline was formed and the deluge of Knight conglomerate covered all previous structures to depths of several thousand feet.

Oligocene time

After Knight deposition, the Laramide activity subsided. Broad, gentle folding ensued, and the present day relief features began to form (Eardley, 1944, p. 854). The Morgan Valley syncline is a result of this deformation. Vulcanism again broke out and the Norwood tuff was deposited.

Miocene and Pliocene time

Following Norwood deposition, a long erosion cycle formed the Herd Mountain erosion surface. Later uplift, apparently to the west, caused dissection of the surface and mild deformation of the Norwood and older beds. This uplift brought about the East Canyon fault.

The Norwood beds were cut by the fault which moved on the same plane as the Paleocene Little Mountain reverse fault, but in the opposite direction (Plate V). The stress which caused the fault had become a tensile force due to uplift in the area. Later, another erosion surface was formed. This was the Weber Valley surface.

Quaternary time

The East Canyon area has had little or no glaciation but alluvium from the higher Wasatch and Uinta glaciers was carried to the East Canyon Creek headwaters and deposited as valley fill. Subsequent erosion has left conspicuous terraces.

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