GEOLOGY OF THE SOAPSTONE BASIN AND VICINITY, WASATCH, SUMMIT, AND DUCHESNE COUNTIES, UTAH

by

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INTRODUCTION

General statement

This report presents the results of a study of the areal geology of the Soapstone Basin Area and vicinity, on the South Flank of the Uinta Mountains, Utah. The area is situated near the western end of the range, and is bounded by Pine Valley on the west, the North Fork of the Duchesne River on the east, and by the 40°30' parallel of latitude on the south. The northern boundary of the area mapped is irregular but it includes part of the Precambrian rocks which constitute the core of the Uinta Mountains.

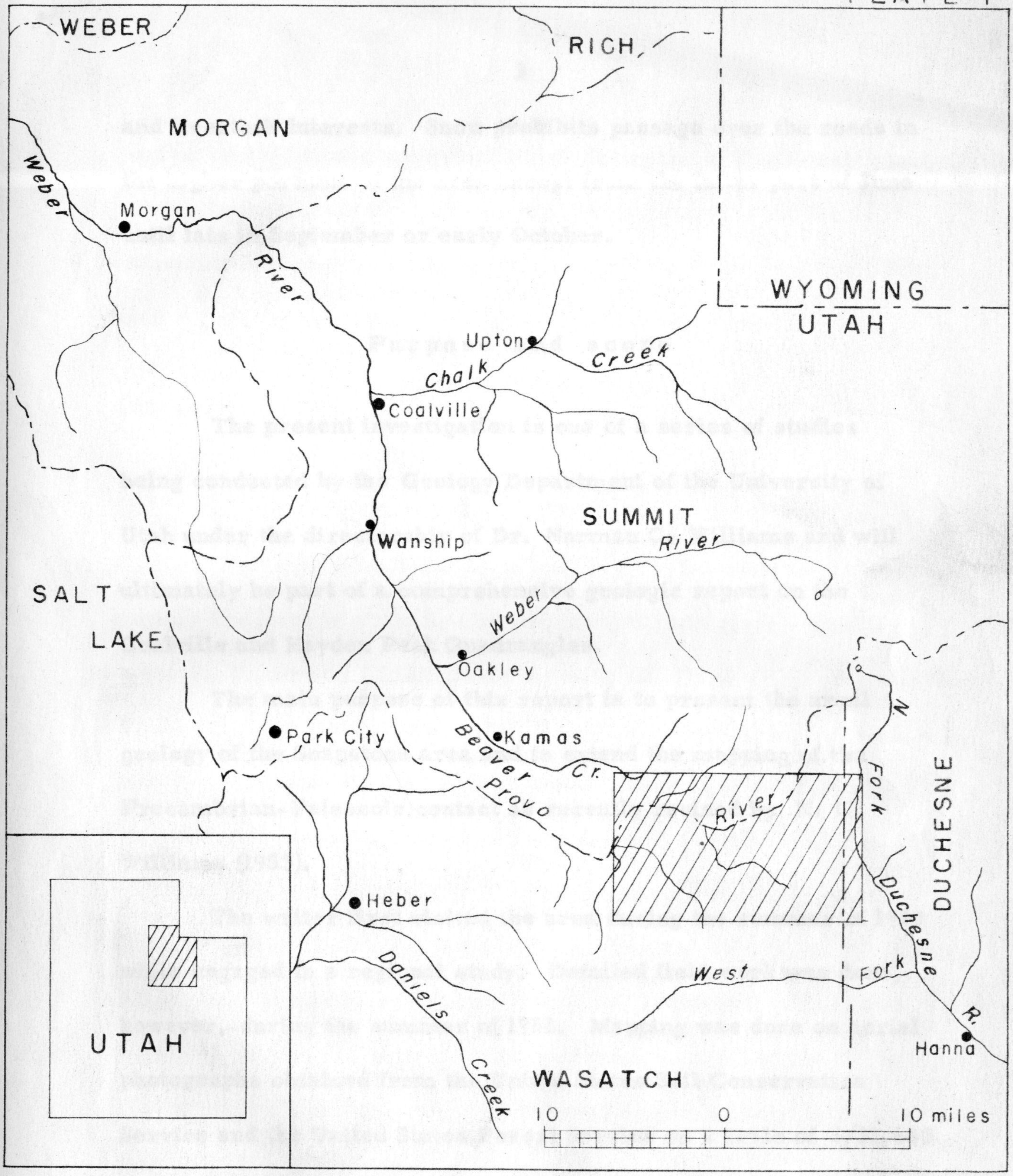
The region is of special interest from the standpoint of stratigraphy and structure. The site of sedimentation is transitional from geosynclinal facies in the Wasatch Mountains on the west to the thinner shelf sections eastward. Structurally, the Uinta Mountains stand out as the only major east trending mountain range in the Rocky Mountain System. Rocks of the area comprise Precambrian metasediments, Paleozoic, Mesozoic and Tertiary sediments and Quaternary glacial debris and alluvium. The structural relationship of the rocks representing the several geologic areas provides a basis for a rather complete interpretation of the geologic history of the area. Remnants of old erosion surfaces permit a more detailed interpretation of late Tertiary erosional episodes.

Location and accessibility

The Soapstone Area is located chiefly in Wasatch County, but extends northward into Summit County and eastward into Duchesne County (Plate I). It includes all of T. 3S., R. 8E., parts of T. 3S., R. 7E.; T. 4S., R. 7E.; T. 4S., R. 8E.; T. 3S., R. 9E.; S. L. B. and M., and parts of T. 1N., R. 10W.; T. 1N.; R. 9W.; T. 2N., R. 9W.; U. B. and M.

Several roads traverse the area. Utah Highway 150 generally bounds it on the north and Utah Highway 35 is approximately on the southern boundry. Utah Highways 150 and 35 join U. S. Highway 189 at Kamas and Francis, Utah respectively. Most of the area can be reached by roads and trails maintained by the United States Forest Service and private lumbering, mining,

PLATE I



Index Map-showing location of the

Soapstone Basin Area Q. M. Eskelsen, 1953 and livestock interests. Snow prohibits passage over the roads in the higher portions of the area except from the latter part of June until late in September or early October.

Purpose and scope

The present investigation is one of a series of studies being conducted by the Geology Department of the University of Utah under the directorship of Dr. Norman C. Williams and will ultimately be part of a comprehensive geologic report on the Coalville and Hayden Peak Quadrangles.

The main purpose of this report is to present the areal geology of the Soapstone area and to extend the mapping of the Precambrian-Paleozoic contact as recently revised by N. C. Williams (1953).

The writer first visited the area during the summer of 1950 while engaged in a regional study. Detailed field work was done, however, during the summer of 1952. Mapping was done on aerial photographs obtained from the United States Soil Conservation Service and the United States Forest Service on a scale of 1/31,680 and 1/20,000 respectively. The base map was compiled by the writer from United States Forest Service maps of the Wasatch and Uinta National Forests. The portion of the area east of the 111° Meridian had been previously mapped by Huddle and McCann (1947), and a part of their map has been used, with some modification, in this report.

Previous Geologic work

The Uinta Mountains have long been of interest to geologists. Among the first to contribute to the general geologic knowledge were J. W. Powell (1876), Clarence King (1877), C. P. Berkey (1905), S. F. Emmons (1907), Weeks (1907). W. W. Atwood (1909) made a study of glaciation in the region. Later works in the Uinta Mountains and adjacent areas have been done by J. M. Boutwell (1912), A. R. Schultz (1918), Bradley (1934-35), J. D. Forrester (1937), A. J. Eardley (1944), J. W. Huddle and F. T. McCann (1947), A. A. Baker, J. W. Huddle and D. M. Kinney (1949), H. J. Bissell (1952), and N. C. Williams (1947- ____) Unpublished material of the Geology Department of the University of Utah was also available to the writer.

Geography

The area included in this report is one of considerable relief. The lowest elevation is at the southern end of Pine Valley, approximately 7,100 feet above sea level. Iron Mine Mountain in the northeast portion of the area is the highest point and has an elevation of 10,500 feet.

The major part of the area is drained by the Provo River System which is tributary to the Great Basin. Part of the Duchesne River, tributary to the Colorado River drainage, extends a few miles into the eastern edge of the area.

Precipitation is considerably greater in the Uinta Mountains than in surrounding lower areas and snow blankets the area for most of the year. Summer thundershowers are frequent. The region is one of great importance as a watershed.

The flora in the Uinta Mountains is similar to that of surrounding regions of high elevation. Dense forests of evergreen include the Balsam fir *Abies balsamia*, White fir *Abies concolor*, Douglas fir *Pseudotsugata folia*, Colorado blue spruce *Picca pungens*, Lodge pole pine, *Pinus contorta*, and yellow pine *Pinus Ponderosa*. These are the basis for a modest lumber industry.

Other common vegetation includes Quaking aspens Populus tremuloides, Choke cherry Podus demissa, scrub oak Quercus leptaphylla and sage brush Artemisia. Several types of grasses and wild flowers are also found throughout the region.

The Uinta Mountains serve extensively as a summer range for both sheep and cattle. In the area described in this report only a small part, in the vicinity of Pine Valley is under cultivation. Hay and grain constitute the chief crops. Several saw mills are located within the area and lumbering is second only to grazing in importance of land utilization. Some prospecting has been done but no mines are operative in the area. Recreation facilities are few but of some importance. Near the mouth of Soapstone Creek the YMCA has a summer camp and the U. S. Forest Service has opened a location here for the construction of summer homes.

STRATIGRAPHY

General statement

The core of the Uinta Mountains consists of Precambrian rocks comprising purple and buff quartzites, argillites, arkosites, and micaceous shales. Paleozoic rocks crop out peripherally about the Precambrian core and are represented by quartzites of Cambrian age, limestones and sandstones of Mississippian age, shales, sandstone, quartzite and limestones of Pennsylvanian age, and sandstones and limestones of Permian age. Mesozoic rocks consist chiefly of red beds and limestone. Tertiary rocks are represented by a single formation, the Bishop conglomerate. Pleistocene and recent deposits consist of glacial debris, landslides, and alluvium.

The stratigraphic sequence in the Soapstone area is essentially the same as that mapped by Huddle and McCann (1947) in the Duchesne River Area to the east and by McDougald (1953) to the west.

Precambrian rocks

General statement.-- The age of the rocks which constitute the core of the Uinta Mountains has been a subject of considerable controversy. King (1876) first assigned them to the carboniferous on the evidence of a single fossil found in float in the vicinity of Mt. Agassiz. Weeks (1907) believed them to be Precambrian, and Berkey (1909) and Butler (1920) subsequently mapped them as Cambrian. Leith and Van Hise (1909) applied the name Uinta Series, and assigned them to the Precambrian; Hinds (1936) confirmed this age assignment, which is generally accepted at the present time. N. C. Williams (1953) demonstrated that the Uinta Series can be subdivided into several lithologic units and he defines the upper two units.

Mutual formation.-- The oldest defined unit in the Uinta Series is correlated, by N. C. Williams (1953), with the Mutual formation as defined by Crittenden (1952, p. 6) in the Wasatch Mountains. In the Soapstone area the Mutual quartzite crops out on both sides of the Provo River east of Pine Valley (Plate IIa). The formation consists mainly of a reddish-purple quartzite which is locally arkosic. Large lenses of purple shale are common throughout the formation and locally, buff beds of quartzite are present. From the mouth of Soapstone Creek westward to Pine Valley along the south side of the Provo river canyon, the upper part of the formation consists of buff quartzite which occupies the same stratigraphic position as the Box Canyon member of the Mutual quartzite described by N. C. Williams (1953).

Red Pine shale.-- The shale unit which conformably overlies the Mutual formation was named Red Pine shale by N. C. Williams (1953). Forrester (1937) had earlier correlated this unit with the Ophir shale, on the basis of lithology; thus assigning a Cambrian age to the formation. Huddle and McCann (1947) also used the term Ophir; accepting Forrester's tentative correlation. The angular unconformity between the Red Pine shale and the overlying quartzite, and the conformity of the Red Pine with older strata, as described by Williams (1953), indicate the Precambrian age of the shale unit.

No good exposure of the Red Pine shale is present in the Soapstone area. It forms part of the south canyon wall along the Provo River, but is largely covered by the talus of the overlying quartzite and otherwise obscured by heavy soil cover and vegetation. Where exposed the formation consists of a thin-bedded brown to greenish-brown micaceous shale. In the vicinity of Pine Valley, the formation is but a few hundred feet thick and thins conspicuously toward the vicinity of Soapstone Creek. Northeast of Soapstone Basin, the formation is absent in the proximity of the south flank fault.

Cambrian system

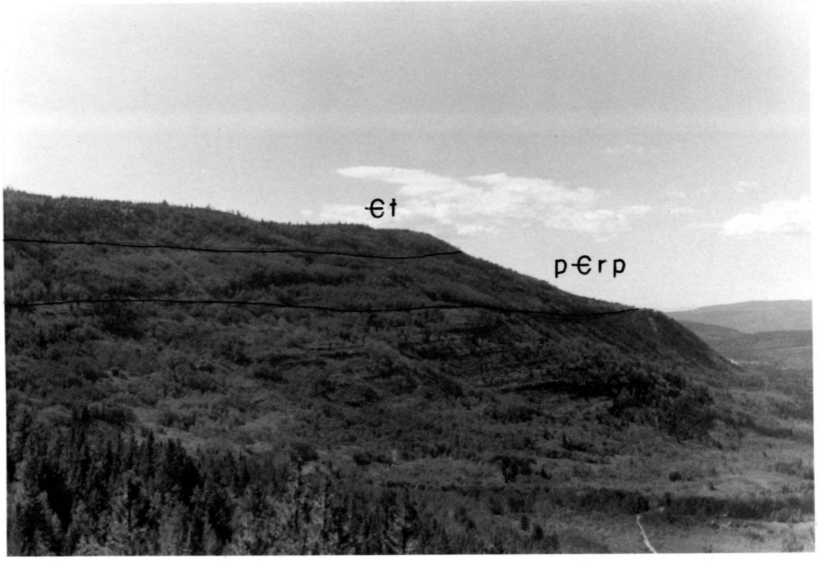
Tintic quartzite. -- Cambrian rocks are represented by a buff to brown weathering quartzitic sandstone unit. The formation is generally uniform in its physical aspects but contains lenses of pea-size conglomerate in the lower part. Limonite staining is common throughout and cross bedding occurs in some beds near the base. Near Iron Mine Creek the upper 30 to 40 feet of the formation contains beds of brown to green micaceous shales which exhibit some purple mottling. The shale zone is not everywhere present and may represent a remnant of the Ophir equivalent. The shale unit was mapped as part of the Tintic quartzite. In the vicinity of Iron Mine Mountain the Tintic is about 325 feet thick.

The name Tintic quartzite was first used in the Uinta Mountains by N. C. Williams (1953) who based his usage on correlation with the Tintic quartzite in the Wasatch Mountains on the basis of lithology and stratigraphic position. Forrester (1937) had earlier applied the name Pine Valley quartzite to what is here called Tintic believing the formation to be younger than Ophir. In adjacent regions the basal Cambrian formation is a quartzite which rests unconformably on Precambrian rocks and no known unconformity exists within the Cambrian. The angular unconformity between the Tintic and the underlying shale unit and the presence of Middle Cambrian fossils in the Tintic strongly indicate the proper placement of the Paleozoic-Precambrian contact is at the base of the Tintic. Considering the formation to be basal Cambrian it may properly be correlated with the Tintic quartzite.

Fauna collected from the Tintic, in sec. 18 T.2N., R.9W. U.M. and B., were examined by W. C. Bell (personal communication) who states:

> The collection seems to consist wholly of one species: *Westonia* cf. *W. ella* (Hall and Whitfield). It is a common sub-littoral form in the shales overlying the basal Cambrian sands in western Montana and Wyoming; I've seen it only once before in the sandstone (Flathead, Crowfoot Ridge, Yellowstone Park). You can with confidence label it Middle Cambrian in age in the Uintas, but I suspect that it is a much better index to the sand-shale contact zone than it is to any time -- stratigraphic position.

PLATE II



A. The south canyon wall, looking west, of the Provo River east of Pine Valley showing the Mutual, Red Pine, and Tintic formations.

B. A north-facing cliff composed of Tintic quartzite near Iron Mine Mountain.

Devonian system

No rocks of Devonian age were recognized in the Soapstone area. Huddle and McCann (1947) observed a dolomitic limestone in the basal 40 feet of the formation they mapped as Madison, and suggest for it a Devonian age on the basis that it is unlike the overlying positive Madison. Hooper (1951) recognized micaceous shale and a dolomitic limestone beneath the Madison. Fossils that he collected from the shale unit beneath the dolomitic limestone indicate its age as no older than Devonian. Fossils subsequently collected and identified by James E. Brooks (personal communication) demonstrate that the strata in question are Devonian.

Mississippian system

General statement. -- Mississippian rocks are represented by four marine formations. The Madison limestone of early Mississippian age consists of fossiliferous, dark gray limestone, in thin to massive beds. The Upper Mississippian is represented by the Deseret limestone and the Humbug formation. These two formations are composed mainly of arenaceous, buff to gray limestone. Though distinguishable elsewhere, the contact between the two formations is generally obscured in the greater part of the Soapstone Basin area. A "Black shale" unit is the youngest formation in the system. It is chiefly a black fissle shale with interbedded limestone and quartzite.

Madison limestone. -- The Madison overlies the Tintic quartzite throughout the Soapstone area with the exception of a small area in the vicinity of Trail Hollow, on the Duchesne River, where the Madison rests on the Red Pine shale. The basal Madison contact is very distinct, and is characterized in several localities by the development of sink holes. The formation is poorly exposed; generally forming a densely wooded, steep, north-facing slope. South-facing, gentle dip slopes are also common and an incipient karst topography is developed. Huddle and McCann (1947) reported the Madison to be about 245 feet thick in the area of the North Fork of Duchesne River. J. S. Williams (1943, p. 605) measured 1,115 feet of limestone in about the same locality and assigned it all to the Madison formation. This thickness undoubtedly includes not only the Madison as mapped by Huddle and McCann (1947) but also the two overlying Mississippian formations. No attempt was made by the writer to measure the formation because of the poorly defined limits and lack of good exposures. Since the Upper Mississippian, measured by J. S. Williams (1943), has been proved to be in part Pennsylvanian the stratigraphic division of Huddle and McCann seems more logical. It is also more in agreement with Hooper's (1951) work on the north flank of the Uinta Mountains.

The Madison formation is mainly a light weathering, dark-gray, thin-bedded limestone. Dense black to gray chert nodules are abundant near the top, and calcite stringers are common. Some freshly broken specimens yield a petroliferous odor. Fossils found, include brachiopods, gastropods, and corals. The fossils collected from the Madison limestone were examined by William Lee Stokes (personal communication) and identified as:

Syringopora sp.
Spirifer centronatus
Composita humilis
Chonetes loganensis
Producted brachiopod
Euomphalus sp.

Stokes believes that this collection is adequate to establish the unit as Madison limestone.

The type section of the Madison is in the Madison Range, Montana, and was defined by Peale (1893, p. 33). It has subsequently been recognized in Idaho and Northern Utah and extended into the Uinta Mountains by Forrester (1937, p. 639) on the basis of lithology and stratigraphic position. Forrester, however, erroneously included not only all the Mississippian limestone sequence, but also the limestone member of the Morgan formation in the Madison.

Deseret and Humbug formations. -- Conformably overlying the Madison limestone is a series of dark cherty limestone, limestone breccia and sandstone breccia correlated with the Deseret limestone and Humbug formation in the Oquirrh Mountains by Huddle and McCann (1947). They measured 600 to 650 feet of Deseret and 300 to 350 feet of Humbug in the area of the North Fork of the Duchesne River. Correlation was based on stratigraphic position and some fossil evidence. The two formations, though distinguishable locally in the Soapstone area, were mapped in part as undifferentiated because the contact between them is not everywhere evident and the formations are poorly exposed in many areas. The contact between the Deseret and Madison can be established only within broad limits and was drawn at the base of the lowest dense chert zone, containing lenses of the "zebra" chert mentioned by Hooper (1951, p. 21). Where mapped, the contact between the Deseret limestone and Humbug formation was placed on a geomorphic boundry. The Humbug formation forms a low but prominent ridge where it caps the Deseret limestone on south-facing dip slopes. The Deseret is a massive dark-gray to brown weathering limestone containing great quantities of chert. Light-brown limestone breccia and brown sandstone breccia are common in the Humbug formation.

Outcrops of the Deseret and Humbug formations generally occur on long gentle south-facing dip slopes that are pitted with numerous sink holes.

Fossils from the Deseret were identified by Walter Sadlick (personal communication) as:

Linoproductus gallatinensis (Girty)

Linoproductus sp.

Spirifer centronatus var. *minnewankensis* Shimer

Spirifer pellanensis var. *cavecreekensis* Hernon

Brachythyris sp.

Torynifera sp.

Sadlick states:

> This assemblage is characteristic of very high Madison or Deseret. Linoproductus gallatinensis and Spirifer centronatus are identified in practically every collection from the Madison, but they have also been reported in the Deseret. Brachythyris sp., and Toryhifera sp. are commonly reported high in the Madison. Spirifer pellaensis represents a Brazer species. The collection represents an Osagian fauna and may be so dated.

"Black shale". -- Overlying the Humbug formation with apparent conformity is a predominantly black shale unit. It is about 240 feet thich and is composed chiefly of a fissil black shale which is locally fossiliferous. The unit also contains lenses of limestone and sandstone. The limestone lenses in places are composed almost entirely of crinoid stems. Fossil plants are very common in the sandstone lenses. Outcrops of the "Black shale" are generally poor. The outcrops are, for the most part, in the bottoms of stream valleys and covered with alluvium and springs are common along the outcrop belt. Where the unit crops out on a slope, it has been a major geologic factor in producing landslides. Due to the nature of the outcrops it is impossible to determine the precise position of the limestone and sandstone lenses within the "Black shale."

but they are more numerous near the top of the unit. The best exposure of the "Black shale" is located in Soapstone basin in sec. 25T.3S., R.8E. (Plate IIIb).

Huddle and McCann (1947) mapped the "Black shale" on the south flank. They suggest it may be equivelent to part of the Manning Canyon shale in the Oquirrh Mountains which occupies the same stratigraphic position, and may be the same age as part of the Brazer limestone. Walter Sadlick (personal communication) is engaged in a stratigraphic and paleontological study of the "Black shale" and tentatively correlates it with the Manning Canyon shale.

Sadlick identified the fossils collected from the "Black shale" as:

Triplophyllites sp.

Derbyia sp.

Chonetes sp.

Dictyoclostus cf. *D. inflatus*

Spirifer brazerianus

Spirifer sp.

Composita sp.

PLATE III

A. An exposure of Madison limestone in a north-facing cliff in Iron Mine Creek.

B. An exposure of "Black shale" showing a limestone lense.

Girtyella turgita

crinod columns

Sadlick states:

> The Spirifer brazereanus is sufficient to date this collection as upper Chesterian in age. None of the specimens have Pennsylvanian affinities.

Pennsylvanian system

General statement.-- Pennsylvanian rocks are represented in the Soapstone area by two formations the Morgan and the Weber. The Morgan formation, which is the oldest Pennsylvanian deposit, consists of two lithologic units, a lower limestone member and an upper sandstone member. The Weber quartzite conformably overlies the Morgan formation and is the thickest Paleozoic formation mapped in the Soapstone area. It consists predominantly of a quartzitic sandstone which weathers rust-colored, but is generally white on a fresh surface.

Morgan formation.-- The Morgan as originally defined by Blackwelder (1910 p. 529), includes only the upper member as mapped in the Soapstone area. J. S. Williams (1943) included the lower member of the Morgan formation in the Brazer limestone in the Duchesne River area. Huddle and McCann (1947); however, mapped two members of the formation in the Duchesne River area believing the fauna obtained from the formation, though not diagnostic, to be of early Pennsylvanian age. In the Wasatch Mountains, Crittenden (1952, p. 11) mapped two units which correspond to those present in the Uinta Mountains.

The lower member of the Morgan formation is about 380 feet thick. It consists dominantly of a dense to coarsly crystalline limestone. Locally the unit is very fossiliferous, some of the fossils being replaced by red chert. Though not as cherty as the upper Mississippian formations, chert is abundant. White to very light-gray surfaces are produced by weathering, and give the unit a conspicuous appearance. Outcrops of the lower member are generally good in Soapstone Basin, the best being in sec. 26T. 3S., R. 8E. S. B. and M. It generally forms a north facing cliff or steep slope. The limits of the lower member are generally not well-defined. The base of the unit is commonly covered by landslides, but where observable, is gradational with the underlying "Black shale."

Fossils collected from the lower limestone member of the Morgan were identified by Walter Sadlick (personal communication) as:

Derbyia sp. cf. D. crassa

Linoproductus prattenianus

Dictyoclostus sp.

Spirifer occidentalis

Spirifer opimus

Spirifer sp.

Composita ozarkana

Composita subtilita

Composita sp.

Sadlick tentatively dates the lower limestone member of the Morgan formation as Springerian and Morrowan in age on the basis of this and other collections.

The contact between the lower and upper members was drawn at the base of the lowest red sandy bed. This horizon is not often exposed however, and a slight topographic expression manifest as a bench was mapped as the contact. The upper member consists of dark reddish brown fine grained sandstone and mudstone interbedded with limestone lenses. The unit is approximately 330 feet thick. A good exposure of the formation is located in Soapstone Basin, sec. 26T. 3S., R. 8E. S. L. and M., but generally the upper member is concealed by talus from the overlying Weber quartzite.

Weber quartzite. -- The Weber quartzite conformably overlies the Morgan formation and is gradational into it. In most localities the contact is concealed by talus from the Weber. Where exposed, the contact was drawn on the lowest white quartzitic sandstone which is persistant in the area and forms a slight topographic break.

The formation is about 1,500 to 2,000 feet thick and consists of a white to light buff, fine grained quartzitic sandstone that weathers rust brown. Locally, some limestone lenses are present. The most characteristic feature of the Weber is the talus slopes it forms. It is a prominant ridge maker but seldom forms a cliff.

No fossils were found in the Weber. The Weber has been recognized and mapped in the Uinta Mountains by Forrester (1937), Huddle and McCann (1947), and others.

Although the Weber is generally considered to be Pennsylvanian in age, it may be that some of the upper portion is Permian.

Permian system

Park City formation. -- An incomplete section of the Park City formation exposed on the southern edge of the area mapped, represents the only rocks of demonstrated Permian age in the area.

The contact between the Park City and the underlying Weber is indefinite and apparently gradational. Of the three members described by Huddle and McCann (1947), only part of the lower member is exposed in the Soapstone Basin area. It consists of a brecciated, sandy, light to dark-gray limestone containing nodules of gray to black chert.

Tertiary formations

Bishop conglomerate. -- The Bishop Conglomerate was first named by Powell (1876) in the eastern portion of the Uinta Mountains and Bradley (1934-35) defines it on the north flank of the Uintas. The conglomerate, on the divide between the South Fork of the Provo River and the West Fork of the Duchesne River near Wolf Creek Peak, was first mapped as Bishop by Schultz (1918). Forrester (1937, p. 642) believed the rocks mapped as the Bishop conglomerate in this paper were extrusives and states:

> Formations mapped as Bishop conglomerate by Shultz on Wolf Creek Peak are definitely extrusive materials.

It is true, however, that the chief components of the Bishop conglomerate at this locality are water-worked volcanic rock.

Huddle and McCann (1947) mapped the same conglomerate as volcanics and conglomerate and suggest that it may be Bishop (Plate IV). Bissell (1952, p. 619) shows the formation as undivided volcanics, however, he mentions the presence of volcanic agglomerate, tuff, tuff breccia, and volcanic conglomerate.

The Bishop crops out on the extreme southern edge of the Soapstone area. In the vicinity of Wolf Creek Peak, the formation is composed of rounded, water-transported, andesite boulders ranging in size up to four feet in diameter and cemented a sandy matrix. Paleozoic rocks are present as boulders in the conglomerate north of the West Fork of the Duchesne River divide. The Paleozoic rocks increase in proportion to andesite, south-east ward. Beyond the limits of the Soapstone area, part of the north wall of Wolf Creek canyon is formed by the Bishop which here is composed of boulder, cobbles, and pebbles of limestone and sandstone.

The Bishop conglomerate of the area rests with angular unconformity on older rocks. Since it also rests on the Gilbert Peak Surface, the term Bishop, as applied by Bradley (1934-35, p. 185), can properly be used.

PLATE IV

An exposure of Bishop conglomerate on the divide north of West Fork of the Duchesne River.

Quaternary formations

Pleistocene. -- The Pleistocene is represented by glacial debris and moraines. These are present in considerable quantity in the Provo River Valley.

Recent

Alluvium and landslides are present in the major stream valleys. Most of the landslides are caused by the slumping of the "Black shale" and oversteepening of the valley wall by glaciation.

STRUCTURE

General structure

The structure of the Uinta Mountains, in general, consists of a broad open anticline slightly overturned to the north and modified somewhat by faulting. At the western end, the axis plunges westward beneath Rhodes Valley. The general Uinta structure has been described by King (1877), Weeks (1907), Forrester (1937), and others. On the south flank of the Uinta Mountains, in the Soapstone area, the Paleozoic sedimentary formations dip gently to the south and are covered by younger rocks. Paleozoic sedimentary formations reappear in Daniels Canyon about 22 miles to the southwest, however, Bissell (1952, p. 624) believes these rocks are part of the Wasatch Mountain allochthon rather than a reappearance caused by a change in dip.

Faulting

The major fault in the Soapstone area was first mapped by Berkey (1905, p. 523) and named the Iron Creek Fault. Berkey described it as striking east along Iron Mine Creek[1] with a throw of at least 3,000 feet. Emmons (1907, p. 279) also mapped the Iron Creek fault, but did not believe it to be as important as Berkey thought, since it could be traced only 7 or 8 miles on either side of the North Fork of the Duchesne River. Emmons differed from Berkey in his interpretation of the direction of the westward extension of the fault. Emmons map shows the fault extending west along Iron Mine Creek, then striking northwest along the base of the Red Pine shale and the Tintic quartzite where the Red Pine is absent (Plate VII). Forrester (1937, p. 644) applied the name South Flank fault which is in general use today because it suggests a more lateral extent. Huddle and McCann (1947) recognized the South Flank Fault and seem to agree with both Emmons and Berkey in stating:

> A wide breccia zone that diverges from the main fault and is exposed in Iron Mine Creek suggests that the South Flank fault is not a single simple structure.

Huddle and McCann show the westward extension from the North Fork of the Duchesne River as Emmons did and the breccia zone is

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[1]Berkey and Emmons refer to this drainage as Iron Creek. Since there is another Iron Creek in the Soapstone area, the name Iron Mine Creek which is in use today will be used in this paper.

placed where Berkey mapped the fault. No evidence was found by the writer to indicate that the major fault extends westward at the base of the Red Pine shale. It is now known that the Tintic rests with angular unconformity on the Red Pine shale which accounts for the truncation of the Red Pine by the Tintic. It appears that the South Flank fault is in reality a complex zone of faulting with a large strike slip component rather than 3,000 feet vertical displacement as described by Berkey. The displacement along the fault becomes less to the west, and it cannot be recognized in the lower part of Soapstone Basin. The complex zone of faulting at the head of Iron Creek tributary to the South Fork of the Provo River, is thought to be a westward extension of the South Flank fault. The east striking faults near Hewlett's ranch are also part of the zone of faulting connected with the South Flank fault. Evidence for dating the South Flank fault is absent in the Soapstone area. Forrester (1937, p. 660) dates it as late Eocene or early Oligocene on the assumption that it accompanied the vertical uplift of the Uinta Mountains which warped and faulted Eocene sediments but which did not affect the Bishop conglomerate.

There are several small north striking faults in the

Soapstone Basin area. None is of great extent, but they may be related in time of origin to the South Flank fault.

Unconformities

Basal Cambrian unconformity.-- The angular discordance of the Tintic and Red Pine, as described by Hooper (1951, p. 41), is not conspicuous in the Soapstone Basin area. The only suggestion of the unconformity is the gradual, low-angle truncation of the Red Pine by the Tintic near the South Flank fault. Previous to the discovery of the angular discordance between the Tintic and Red Pine shale, the Paleozoic-Precambrian contact was drawn at the base of the Red Pine shale. N. C. Williams (1953) believes the placing of the Paleozoic-Precambrian contact at the basal Tintic unconformity is proper (Plate V).

Basal Madison Unconformity.-- No rocks of Ordovician, Silurian, or Devonian age were recognized in the Soapstone Basin area. Hooper (1951) and N. C. Williams (1953) report remnants of Devonian strata on the north flank. The Madison rests locally on Precambrian rocks in the Duchesne River area, but elsewhere

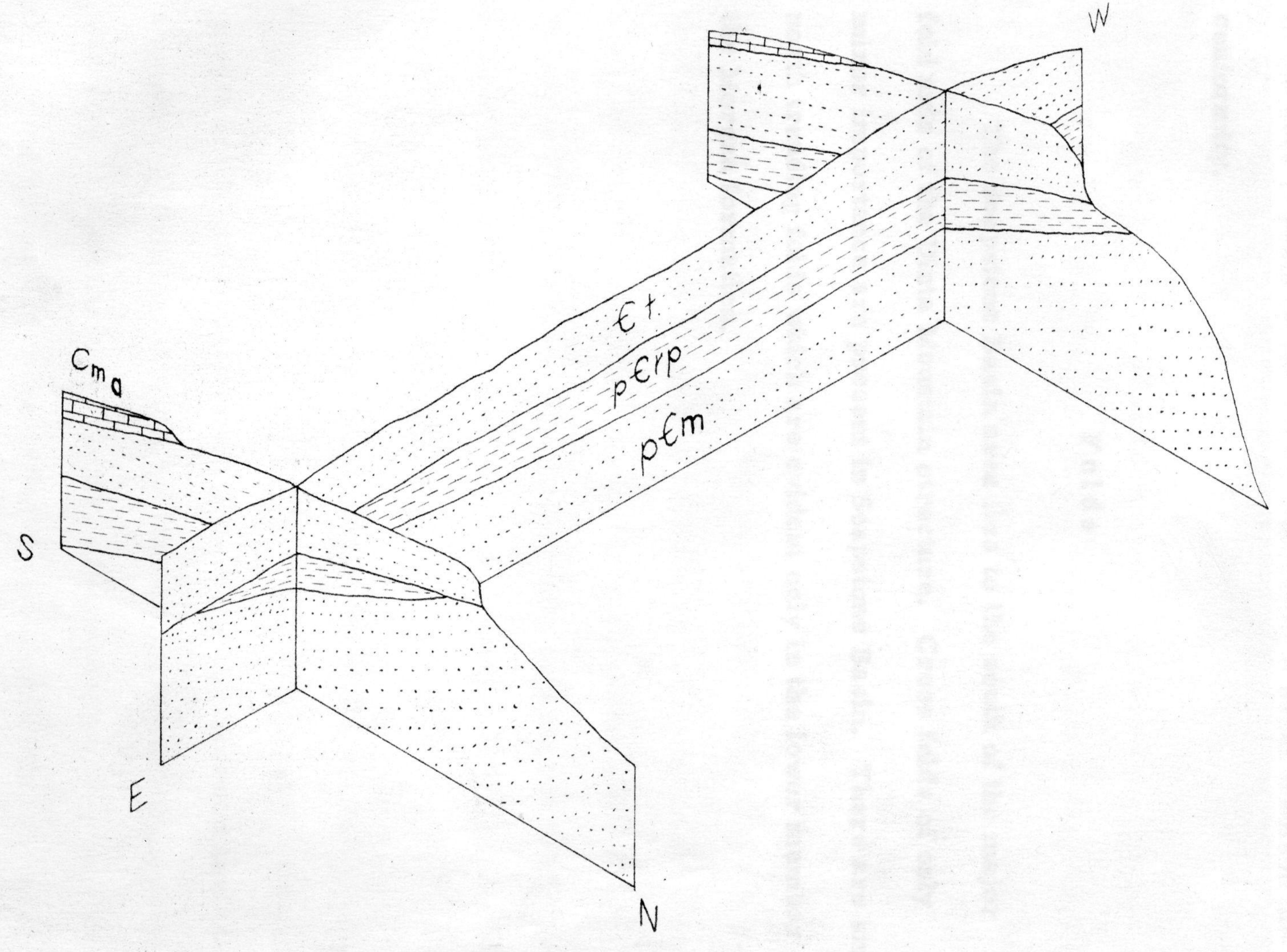

PLATE V

Composite isometric crossection of basal Cambrian unconformity be-
tween Iron Mine Mountain and North Fork Duchesne River.

in the area it rests on the Tintic, indicating a basal Madison unconformity.

Folds

The Soapstone Basin area lies to the south of the major fold axis of the Uinta Mountain structure. Cross folds of only minor importance are present in Soapstone Basin. There are small north trending folds which are evident only in the lower member of the Morgan formation.

GEOMORPHOLOGY

Evidence of two cycles of stream erosion are present in the Soapstone Basin; the first is one of peneplanation described by Bradley (1934-35, p. 170) as having formed the high level Gilbert Peak surface, and the second is the present erosion cycle which shows several sub-stages. The presence of an erosion surface, which corresponds in elevation to the Gilbert Peak surface, in the vicinity of Soapstone Mountain is demonstrated by the fact that the Gilbert Peak surface can be reliably traced from the area where it was originally defined to the vicinity of the North Fork of the Duchesne River. Westward of this vicinity only remnants are preserved, but the identity of these remnants with the Gilbert Peak surface is established by projection.

Further evidence of the identity of the high level surface in the Soapstone area consists of the Bishop conglomerate, which, was originally defined as capping portions of the Gilbert Peak surface. According to Bradley (1934-35, p. 170) this survace developed in Oligocene or Miocene time. Later, intermittent uplift gave rise to the present erosion cycle and allowed dissection of this surface leaving only remnants which are usually capped by Bishop conglomerate. Today the streams are, with few exceptions, well adjusted to the anticlinal structure.

The run-off from the Soapstone Basin area contributes to two major drainage systems. The North Fork of the Duchesne River is tributary to the Colorado River system and hence, the Pacific Ocean. The western portion of the area is drained by the Provo River system and is tributary to the Great Basin. The relative erosion activity of the two systems is conspicuous in that the Colorado River system, being more vigorous, produces cliffs or very steep slopes at its headwaters; whereas the headwaters of the Great Basin drainage rise on much gentler slopes.

The North Fork of the Duchesne River is an entrenched consequent stream flowing south across the strike of the formations. It has been subjected to glaciation and is at present, an excellent example of a glacially modified valley. The Provo River drainage, for the most part, is in adjustment with the structure. The major tributaries are subsequent streams generally seeking the softer formations. Near Nobletts gulch, the South Fork of the Provo River departs from the strike valley formed in the upper Morgan and flows northwestward across the strike of the lower Morgan and the "Black shale" before turning westward again and flowing along the strike of the Upper Mississippian limestones. This departure from the general drainage pattern may be due either to superposition or possibly to weak zones caused by complex faulting that occurred in the immediate area. Pine Valley is of interest because at its northern end the Provo River cuts abruptly across the strike of the formations. There is no evident break in the structure at this point and the possibility of cross folding or faulting to account for the behavior of the drainage is remote. The Provo River Valley is apparently much older than the Valley at the head of Beaver Creek which indicates that stream capture did not take place. The best possibility seems to be one of superposition since the Gilbert Peak surface at one time probably extended into this area and the small segments of drainage that are still out of harmony with the structure were probably established on this old surface.

In the upper part of Soapstone Basin the Mississippian limestones dip very gently to the south. The area is poorly drained by streams and a youthful karst topography is developing. Sink holes in the region develope in all of the Mississippian limestone formations without any apparent preference. Undrained depressions are also present as high stratigraphically as the Weber quartzite, and are undoubtedly due to collapse of solution cavities developed in the underlying limestone.

Glaciation has modified both the valleys of the North Fork of the Duchesne River and the main drainage of the Provo River. The glacially steepened valley walls, further undercut by subsequent stream erosion, have given rise to many landslides. Atwood (1909, p. 58) believes that Soapstone Basin underwent at least one period of glaciation. The evidence for glaciation is very meager and some doubt remains that a glacier ever occupied Soapstone Basin.

GEOLOGIC HISTORY

General statement

Interpretations of all or part of the geologic history of the Uinta Mountains have been given by Forrester (1937), Walton (1944), N. C. Williams (1953) and Mount (1952). Mesozoic and early Tertiary rocks are absent in the Soapstone area and evidence for the post-Paleozoic history is therefore lacking. Data collected by others in adjacent regions is used as a basis for a more complete interpretation of the geologic history of the region than could otherwise be made.

Pre-Laramide

During Precambrian time the Uinta Mountain region received great quantities of clastic sediments. The Precambrian episode of deposition was terminated by gentle arching which affected the region especially in the western Uinta Mountains. Erosion and partial removal of the Precambrian strata followed. The axis of the Precambrian arch is believed by Hooper (1951, p. 44) to roughly parallel the Laramide axis of Uinta arching about a mile to the south. The Tintic quartzite was then deposited with local angular discordance on older rocks. Some evidence of an Ophir equivalent near the top of the Tintic is present, but correlations are as yet tentative. If Cambrian shales and limestones were deposited in the Uinta Mountains, as they were to the west in the Wasatch, they have been removed by erosion except for small shale remnants. No Ordovician and Silurian rocks have been found to date but Devonian rocks have been recognized by N. C. Williams (1952) on the North Flank. In areas adjacent to the Uinta Mountains, remnants of Devonian rocks have also been reported. Other investigators have suggested that about 40 feet of Devonian dolomite is present locally below the Madison in the Uinta Mountains. Though no Devonian rocks were recognized in the Soapstone area they were probably deposited and removed by the post-Devonian pre-Madison erosion interval. The pre-Madison erosion cut deep into the earlier rocks and in places exposed Precambrian rocks. Subsequently the Madison was deposited on this erosion surface.

The remaining Pre-Laramide history was largely one of sedimentation.

Laramide

In the Soapstone Basin area, Mesozoic and Tertiary rocks are not preserved; therefor no interpretation of the Laramide history may be obtained. According to Mount (1952, p. 32) the sequence of events on the north flank of the Uinta Mountains is as follows:

I. First stage of early Larimide orogeny (Montana phase).
  a. Development of northeasterly trending folds and thrusting in the Wasatch Mountains and adjacent areas.
  b. Normal faulting which followed very shortly stage Ia. . . .
  c. Deposition of the "Wanship formation" upon eroded fold structures and faults of Ia. and Ib.

II. Second stage of early Laramide orogeny (Montana phase).
  a. Initial arching of the Uinta Mountains.
  b. High angle reverse faulting, shortly after, and probably in part contemporaneous with IIa. . . .
  c. . . . a period of considerable erosion of the arched beds of the Uinta Mountains. . . .

III. Middle Laramide orogeny (Paleocene phase).
  a. Deposition of the Wasatch group on highly contorted beds.

IV. Late Laramide orogeny (Eocene phase).
  a. Gentle folding affecting the Wasatch group. . . .
  b. Main uplift of the Uinta Mountains and Normal faulting along the flanks.

The Laramide history of the south flank is undoubtedly similar to that of the north flank. Walton (1944, p. 126) dates the movement of the Uinta Mountains in relation to a study of the Uinta Basin. The Currant Creek formation of Montana to Paleocene (?) age, which Walton shows as being deposited contemporaneously with the Uinta arching, is probably equal to the Wanship. Wasatch group equivilents are represented by the Green River shale and the Uinta (?) formation. Walton considers the greatest uplift to be marked by an unconformity between the Duchesne River formation and the older Uinta (?) formation. Simpson (1947, p. 632) considers the Duchesne River as latest Eocene placing the date of vertical uplift as late Eocene.

Post-Laramide

Considering the deformation of the Wasatch group to be representative of the last episode of Laramide deformation, a period of volcanisum followed this last Laramide manifestation in the Oligocene (Mount 1952). Following the volcanisum, erosion reduced the region to a post-mature surface mantled by the Bishop conglomerate.

Bradley (1934-35, p. 185) considers the Bishop conglomerate as Oligocene or Miocene and has given the name Gilbert Peak to the surface covered by the Bishop conglomerate. The Gilbert Peak Surface is younger than the volcanism as evidenced by the presence of great quantities of volcanic material as a constituent of the Bishop conglomerate.

Since the development of the Gilbert Peak Surface, the Uinta Mountains participated in a regional uplift causing the entrenchment of streams and the development of the present relief and drainage pattern.

Bradley (1934-35) recognized three erosion surfaces younger than the Gilbert Peak surface in the eastern and northern areas of the Uinta Mountains, and attributes them to probable change in temporary base levels of the streams and/or climatic changes.

During Pleistocene time, the drainage was modified by three stages of glaciation which Bradley (1934-35) suggests may be correlative with the three stages of glaciation in the Wind River Mountains.

ECONOMIC ASPECTS

Mining

No significant mineralization, with the possible exception of the iron deposit at the head of Iron Mine Creek, was found or is known to be present in the Soapstone area. Boutwell (1904, p. 226) examined the iron deposit and described it in part as follows:

> The iron was probably discovered and first used by the Indians, . . . the red ore of these iron deposits was used by them for paint. . . . In 1879, upon the completion of the Smelter at Park City, . . . (Mr. T. W. Potts) mined 200 tons of this iron ore and delivered it at the smelter for flux. The following year he delivered 300 tons, and further shipments were then stopped by the closing of the smelter. . . . .
>
> The ore is a red hematite of two varieties, the red ocherous and the gray massive semispecular. . . . .
>
> The following analysis is of a selected sample of the high-grade massive, semispecular variety:

Analysis of red iron ore (hematite)
(Analyst, E. T. Allen)

Fe_2O_3	79.34
Al_2O_3	.15

TiO_2	------------------------------------	None
CaO	------------------------------------	None
MgO	------------------------------------	Trace
SiO_2	------------------------------------	18.55
S	------------------------------------	None
P_2O_5	------------------------------------	Trace
Au	------------------------------------	None

The iron ore occurs in the breccia zone of the South flank fault. Fossil remains were found in samples of the ore indicating that the hematite was formed by replacement of the limestone.

Mr. A. B. Thomas (personal communication) investigated the iron deposit in 1952 for possible development. He reports that due to the nature of the ore and transportation costs it is not economically feasible to mine the ore.

Water development

The Duchesne tunnel was made to divert water from the North Fork of the Duchesne River to the Provo River as part of the Deer Creek project. The water, thus diverted from the Colorado River drainage, will be utilized in the Salt Lake Valley.

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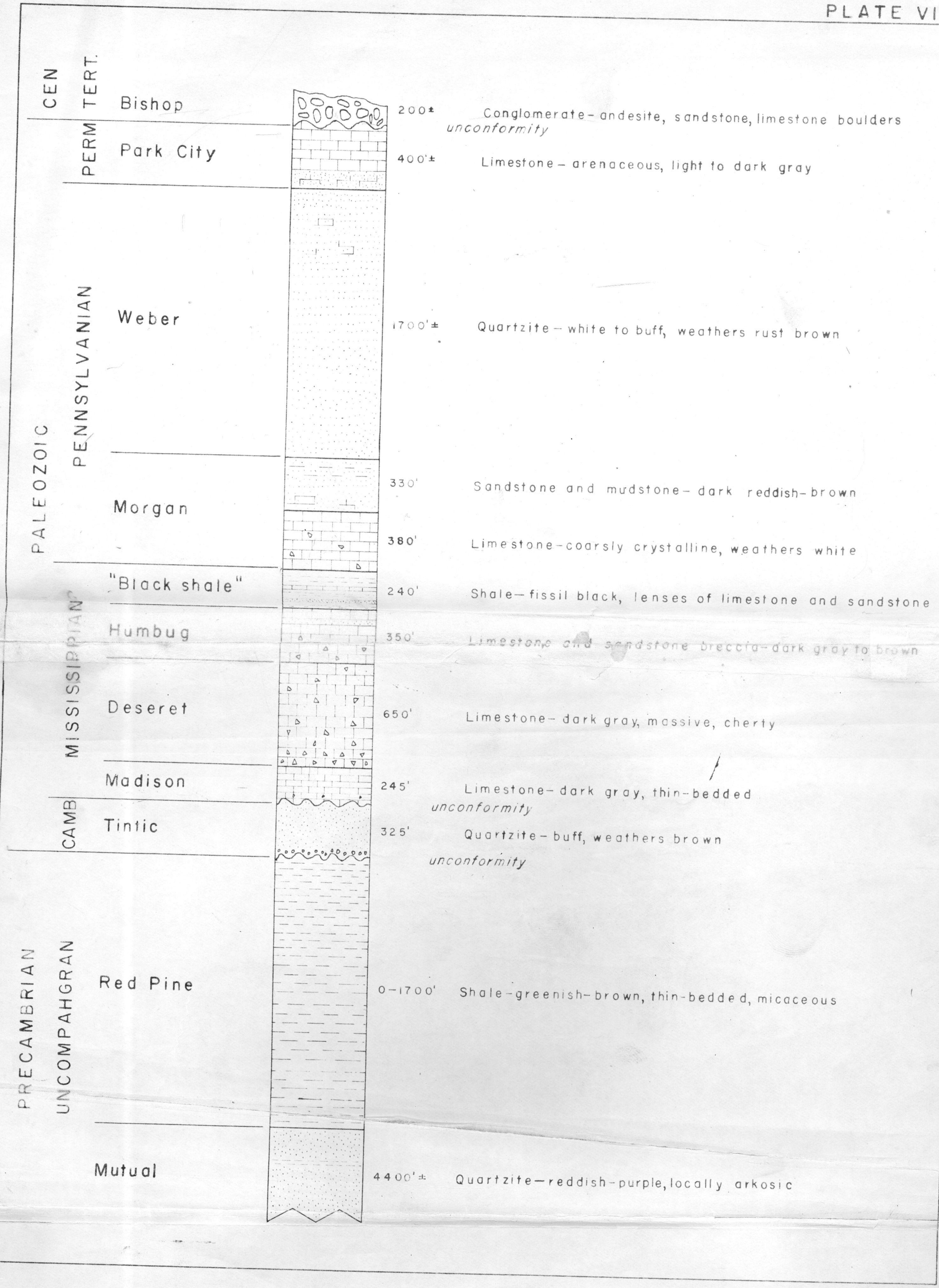
A P P E N D I X



COLUMNAR SECTION OF SOAPSTONE BASIN AREA