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Early Tertiary Continental Sediments of Central and South-Central Utah*

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ABSTRACT.—The Cedar Breaks Formation (new name), spectacularly displayed in Cedar Breaks and Bryce Canyon National Parks in southern Utah, is correlated with similar strata exposed on the east side of the Pavant Mountains near Richfield, Utah. This correlation, made across an interval of 80 miles of concealment by later Tertiary volcanics, is based primarily on the recognition of two persistent mica zones enclosing white cliff and slope units near the top of the formation; and secondarily on zones of tubular fillings, fossil seeds, ball structures, similarities in the gross lithologic sequences, and both conformable and unconformable contacts with both the over and underlying formations.

The Cedar Breaks Formation in both areas was deposited in a fluctuating lacustrine environment in which limy siltstone, limy mudstone, muddy limestone, and micrite limestone alternate. The western thickening and the eastern thinning of this interval along with the coarser sediments being more common in the western sections indicate that the source for the clastics lay to the west.

Within the Pavant Mountains the orange and red colors of the dominantly clastic Cedar Breaks Formation north of Richfield grade rapidly north and east into the somber gray and light-brown colors of the less clastic Flagstaff Formation in the Valley Mountains. The Cedar Breaks Formation is thus the southern and western equivalent of the Flagstaff Formation but is deemed sufficiently different in color, topographic expression and lithologic content to merit a separate designation.

In south-central Utah the Cedar Breaks strata have been heretofore variously designated as either the lower part of the Wasatch Formation, when Brian Head Formation was not separately designated, or as the entire Wasatch Formation, excluding the Brian Head Formation. The Cedar Breaks Formation is older than the type Wasatch Formation of Wyoming and is so separated from the type Wasatch and so different in lithology that continued designation of the southern Utah sequence as Wasatch is inappropriate.

The Brian Head Formation, which overlies the Cedar Breaks Formation, has not been differentiated on most of the published maps in south-central Utah which show "Wasatch Formation" only. The lower part of this undifferentiated "Wasatch" is the Cedar Breaks Formation and the upper part should be designated separately in future mapping.

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TEXT

*A dissertation submitted to the faculty of the Department of Geology, Brigham Young University in partial fulfillment of the requirements for the degree Doctor of Philosophy, November 8, 1966.

INTRODUCTION

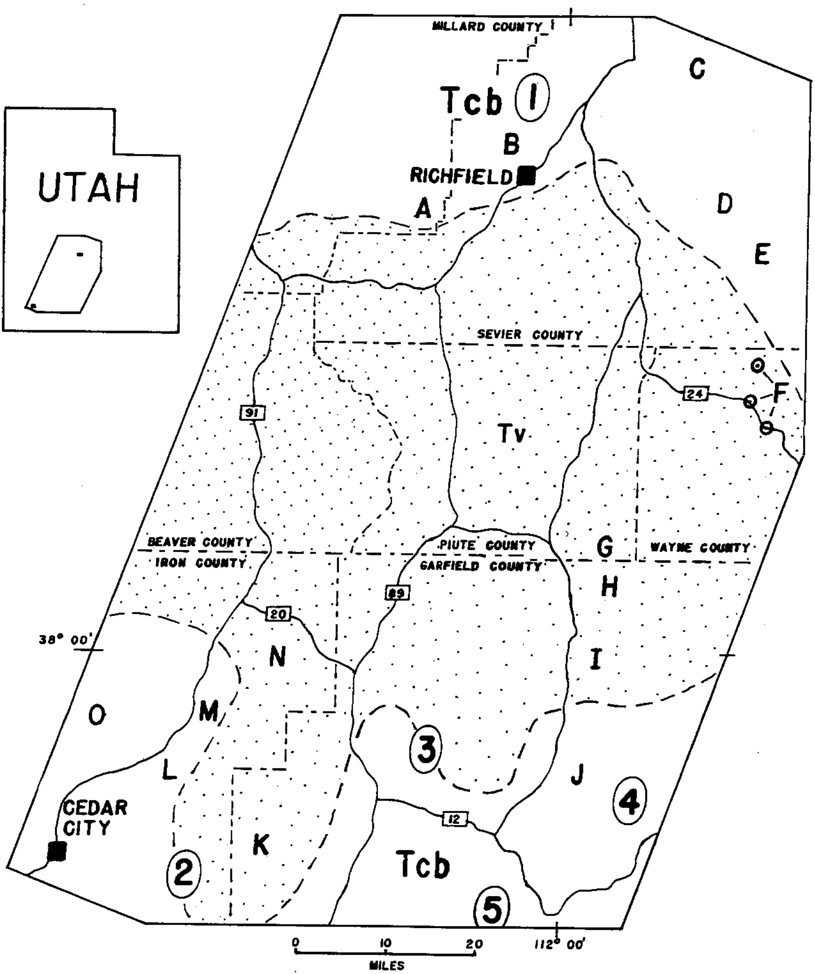
Significance, Purpose, and Location

For nearly sixty years the Early Tertiary rocks, which form the spectacularly scenic Pink Cliffs at Cedar Breaks and Bryce Canyon National Parks in southern Utah, have been assigned to the Wasatch Formation. However, the type locality for the Wasatch Formation is in southwestern Wyoming, and the formation cannot be directly traced into southern Utah. In fact, the largest volcanic area in Utah, centering around Marysvale, blankets the area north of Cedar Breaks and Bryce Canyon so completely that the closest complete exposure of rocks similar to the strata of Cedar Breaks is found over 80 miles to the north in the Pavant Mountains north of Richfield, Utah. For the past 15 years certain early Tertiary rocks of the Pavant Mountains have been classified as Flagstaff Formation (Lautenschlager, 1952). Some geologists (Hunt, 1956, p. 18; La Rocque, 1960, p. 11, and others) have suggested that the southern sedimentary rocks (heretofore called the Wasatch Formation but herein given the new name Cedar Breaks Formation) are stratigraphically equivalent units to the Flagstaff Formation. Others have expressed opposing opinions as illustrated by Gregory (1951, p. 52) who states:

> The existing evidence suggests radically unlike contemporaneous conditions of sedimentary orogeny, and erosion in two large areas less than 50 miles apart.

The purpose of this paper is to report the results of a comparative study of the early Tertiary continental sediments of the High Plateaus of southern Utah with similar sediments in the Pavant Mountains of central Utah. This investigation concludes that these are essentially continuous and contemporaneous lithologic units, and helps to delineate the extent of an early Tertiary basin that existed in Utah approximately 60-70 million years ago.

Text-figure 1 locates the strata studied along the western and southern borders of the High Plateaus of Utah. Exposures of strata occur intermittently, and for the most part contain partial stratigraphic sections although five major stratigraphic sections were obtained in the area defined by this study.



TEXT-FIGURE 1.—Index map locating the five major stratigraphic section areas (numbers one through five) and fifteen minor stratigraphic section areas (lettered A through O) of investigation referred to in this report that border the central blanket of younger Tertiary volcanic rocks (Tv) of the High Plateaus of south-central Utah. The Paleocene rocks of the Cedar Breaks Formation (Tcb) border the volcanic rocks on the north in the Pavant Mountains (Section 1) and on the south in the southern High Plateaus (Sections 2-5). Detailed locations of these five numbered major areas plus fifteen lettered minor border areas are given below.

Numbered Sections: Major stratigraphic sections studied in detail both in the field and laboratory.

1. Strawberry and South Cedar Ridge canyons (9 miles north of Richfield, Utah, in Pavant Mountains). Section 1 and its various sub-sections are described and located in detail in the appendix.

2. Cedar Breaks National Monument. Section 2 and its various sub-sections are described and located in detail in the appendix.
3. Limekiln Creek (8 miles east northeast of Panguitch, Utah). SW¼, NW¼, Sec. 24, T. 34 S., R. 4 W.
4. Headwaters of Water Canyon 14 miles west and north of Escalante, Utah, in Sec. 2, T. 35 S., R. 1 W.
5. Bryce Canyon National Park, in the Bryce Amphitheater in NE¼, NW¼, Sec. 7, T. 37 S, R. 3 W.

Lettered Sections: Minor partial and complementary stratigraphic sections studied primarily in the field with a range from general reconnaissance to detailed studies.

A. Headwaters of Corn Creek (12 miles west, southwest of Richfield, Utah in Pavant Mountains) in the area of interesction of T. 23 S., T. 24 S., R. 4 W., R. 4½ W.
B. Headwaters of Cottonwood Creek (6 miles northwest of Richfield, Utah) in Sec. 11, 13, 14, T. 23 S., R. 3 W.
C. Salina Creek (5 miles to 10 miles east of Salina, Utah) in Sec. 2, 3, T. 22 S., R. 1 E., and Sec. 36, T. 21 S., R. 1 E.
D. Niotche Creek (Sec. 35, T. 23 S, R. 2 E.)
E. Um Creek (Sec. 6, T. 25 S., R. 3 E.).
F. Fremont, Lyman, and Bicknell, Utah (areas in the vicinity of Sec. 16, T. 27 S., R. 3 E.; Sec. 3, 4, T. 28 S., R. 1 E.; Sec. 25, T. 28 S., R. 1 E.).
G. Dry Wash Canyon (6 miles northeast of Antimony, Utah) in Sec. 6, T. 31 S., R. 1 W.
H. Antimony Creek, Antimony, Utah (NW¼, NW¼, Sec. 21, T. 31 S., R. 1 W.).
I. Vicinity of North Creek, 10½ miles south of Antimony, Utah (NW¼, SE¼, Sec. 1, T. 33 S., R. 2 W.).
J. Dry Creek and Pine Canyon (area of T. 35 S., and western half of R. 1 W.).
K. Panguitch Lake area (Secs. 8, 18, 30, T. 36 S., R. 7 W.).
L. Bowery Creek (Secs. 8, 17, T. 35 S., R. 8 W.).
M. Paragonah, Utah (Little Creek and Red Creek Canyons, T. 33 S., R. 8 W.).
N. Area between Buckskin and Bear Valleys (Secs. 16, 17, T. 32 S., R. 6 W.).
O. Claron Formation in Parowan Gap approximately 8 miles west northwest of Parowan, Utah (Secs. 27, 28, T. 33 S., R. 10 W.; Sec. 18, T. 33 S., R. 9 W)

Previous Work

More than 30 recent Master's theses and Doctoral dissertations, principally from Ohio State University, have clarified the knowledge of the early Tertiary Flagstaff Formation and related strata in central Utah north of the Marysvale Volcanic Field ("Tv" of Text-fig. 1), but there has been no previous regional stratigraphic work of the nature of this investigation on the earliest Tertiary rocks of south-central and southern Utah. Previous geologic mapping in the vicinity of my major measured sections includes:

Section 1: Lautenschlager (1952), Schneider (1964)
Section 2: Gregory (1950)
Section 3: Dutton (1880), Gregory and Moore (1931)
Section 4: McFall (1956)
Section 5: Gregory (1951), Brox (1961)

Methods and Scope of Investigation

The summer of 1963 and the summer and fall of 1964 were spent in stratigraphic field work. While measuring and studying the stratigraphic sections representative hand samples were collected at fifteen-foot intervals with closer sampling taken in smaller or more critical units. These samples were studied with high intensity light and a binocular microscope under magnifications of 10x to 120x. Forty thin sections, principally of the mica-bearing rocks of Sections 1 through 5, were studied with a petrographic microscope to supplement the binocular microscope lithologic descriptions.

Twenty areas (numbers 1-5 and letters A through O, Text-fig. 1) around the perimeter of the Marysvale Volcanic Field were investigated. Eight of these (numbers 1-5 and letters I, L, N) proved complete enough for hand specimen collection and stratigraphic measurement. Five of these eight (numbers 1 to 5) were complete enough for detailed studies and comparison purposes. Sections 2 through 5 are located around the southern perimeter of the Marysvale Volcanic Field, while Section 1 is located to the north. The southern investigations were stressed because such studies of this area were lacking, while in central Utah, Spieker (1931, 1946, 1949) and his students, in particular Kathermann (1948), Fagadau (1949), Gill (1959), and McGookey (1960), have amassed considerable data on the Flagstaff Formation.

Because of limited publication space only the detailed data of the most significant sections (1—Richfield and 2—Cedar Breaks) are included in this report. Sections 3, 4, and 5 are summarized in Text-figure 5 and are on open file in the Geology Department, Brigham Young University. Copies may be obtained from the author.

Acknowledgments

This writer wishes to thank the Rotary Club of Provo, Utah, and DePauw University, for financial awards which helped to defray the costs of this research; the Shell and California Oil Companies for use of aerial photos; Mr. Byron Hazeltine and the staff at Cedar Breaks National Park and to the staff at Bryce Canyon National Park for access to and temporary use of some of their facilities. Appreciation is expressed to Dr. William K. Hamblin for suggestions, and in particular to Dr. Lehi F. Hintze for advice in the origin and development of this investigation. In addition this researcher would like to express thanks to his wife, Martha, for aid in computations, proofreading, and typing and to the good people of central and southern Utah, without whose help and interest this work would have been more difficult, time consuming and costly. Lastly, appreciation is expressed to Dr. Howard W. Schneider and to the late Dr. Charles L. Bieber whose encouragement and support have aided this research considerably.

HISTORY OF EARLY TERTIARY NAMES USED IN CENTRAL AND SOUTH-CENTRAL UTAH

Wasatch Formation

The term Wasatch was first introduced by Hayden (1869, p. 91) who stated:

> Immediately W. of Fort Bridger (Wyo.) commences one of the most remarkable and extensive groups of Tert. beds seen in West. They are wonderfully variegated, some shade of red predominating. This group, to which I have given name *Wasatch group,* is composed of variegated sands and clays; very little calc. matter is found in it. In Echo and Weber Canyons (Utah) are wonderful displays of cgls., 1,500 to 2,000 ft. thick. Although this group occupies vast areas and attains thickness of 3,000 to 5,000 ft., yet I have never known

any remains of animals to be found in it. I regard it, however, as of middle Tert. age.

Wasatch strata have been traced from southwestern Wyoming through northeastern Utah, northwestern Colorado, and along the Book Cliffs of east-central Utah to central Utah by Richardson (1909a), Schultz (1910), Gale (1910), Wegeman (1915), Sears (1924), Sears and Bradley (1925), Clark (1928), Erdmann (1934), and Fisher (1936). In a study primarily of Cretaceous coal beds, the Wasatch Formation was extended from central to southern Utah by Richardson (1909b, p. 382) on the basis of his general impressions which are as follows:

> The Eocene rocks consist of a variable succession of shale, limestone, sandstone, and conglomerate that are characteristically varicolored. Shades of red and white predominate and are beautifully developed in the Pink Cliffs. Fossils are extremely rare in these rocks, and only a few fragments of *Vivipara* and *Unio* have been obtained in this area; but the characteristic pecularities of stratigraphy and coloring of the rocks leave little room for doubt that, except possibly a few feet of basal beds containing conglomerate of doubtful significance, they belong to the Wasatch formation of the Eocene series, which is so largely developed in the High Plateaus of Utah and from which characteristic fossils have been obtained in a number of places.

In the earliest significant study of the Wasatch strata of the High Plateaus of southern Utah, Gregory and Moore (1931) state (p. 114): "All the Tertiary beds that are recognized in this region are now assigned to the Wasatch formation" and (p. 115) "Sections of Tertiary beds, here classed as Wasatch formation, were measured at a number of places." The basis for extension of "Wasatch Formation" from central to southern Utah is not stated. Consequently, it seems that the term "Wasatch" was extended to southern Utah on the basis of general impressions rather than on more detailed correlation studies.

Use of the term "Wasatch" in central Utah was considered in some detail by Spieker (1946, p. 137-139) when he introduced the Flagstaff Limestone in his revision of the Wasatch Formation in the central and southern portions of the Wasatch Plateau. Spieker (1946, p. 139) concludes his views by saying:

> Nevertheless, to turn to the question immediately in hand for central Utah, with the general status of the name in such uncertain condition it seems hardly wise to attempt to identify Wasatch strata in the Wasatch Plateau and surrounding areas.

From the High Plateaus of southern Utah (Markagunt, Paunsaugunt, Table Cliff and southern Aquarius, and Sevier Plateaus) direct correlation is made with the "Flagstaff" Formation of the Pavant Mountains of west-central Utah via Sections 1 and 2 of Text-figure 5 in this research.

Flagstaff Formation

The term "Flagstaff member" was first introduced orally by Spieker of Spieker and Reeside (1925, p. 151) at the Geological Society of America meeting in December, 1924. Spieker and Reeside (1925, p. 448) refer to the "Flagstaff limestone member" which "consists primarily of fresh water limestone" and is named after Flagstaff Peak located in the southern part of the Wasatch Plateau. They state (p. 448):

> The Wasatch formation, as recognized in the Wasatch Plateau consists of three members—a lower member of sandstone, varicolored shale, conglomerate, and

small amounts of fresh-water limestone; a middle member of fresh-water limestone, here called the Flagstaff limestone member; and an upper member of varicolored shale and sandstone.

Spieker (1946, p. 135) later changed this terminology from "Flagstaff limestone member of the Wasatch formation" and elevated it to formational rank as the "Flagstaff limestone" on the basis of it being older than Wasatch age (lower Eocene) as determined by fossil and stratigraphic evidence. Concurrently the lower Wasatch unit was redefined as the North Horn Formation and the upper unit was designated the Colton Formation.

As one goes west and southwest from the Wasatch Plateau the "Flagstaff limestone" becomes more sandy and shaly. Consequently Gilliland (1951, p. 25) dropped the term "limestone" and named the unit the "Flagstaff formation" which better suits Flagstaff lithologies in the Valley Mountains. On his geologic map Lautenschlager (1952) traced the Flagstaff Formation from the Valley Mountains into the Pavant Mountains. Section 1 of this report, studied in the Pavant Range, is located approximately 45 miles southwest of the type section of the Flagstaff Formation and contains considerably more clastics than the predominant limestone of the original "Flagstaff limestone" of the type locality.

Brian Head Formation

The basal portion of the Brian Head Formation is of significance to this investigation because it establishes the top of the Cedar Breaks Formation (previously called "Wasatch") in the High Plateaus of southern Utah. The Brian Head Formation was first mentioned in the literature by Gregory (1944) who introduced the formation (p. 577) as ". . . the white tuffs and gray igneous conglomerates of the newly recognized Brian Head Formation (Miocene?) . . ." Gregory (1944, p. 591-92) originally described the Brian Head Formation-Wasatch Formation relationship as follows:

> Generally along the upper branches of the Sevier River wherever all the Tertiary formations are exposed, the conspicuous pink limestones of the Wasatch are overlain by an equally conspicuous series of white, calcareous, and siliceous shale-like beds and in turn by gray, igneous agglomerates which in places form the surface of the plateaus and in other places extend upward to capping sheets of black lava. On the Paunsaugunt and the southern Aquarius plateaus the white strata immediately below the conglomerates are essentially limestones; some of them wholly calcareous, others more or less siliceous. On the Sevier, the northern Aquarius, and the central Markagunt plateaus equivalent strata consist chiefly of volcanic ash, tuff, and highly siliceous limestones and contain much chalcedony. . . . In more recent reports on the southern High Plateaus the white strata that generally overlie the pink limestones and include pure calcareous silts, siliceous limestones, calcareous sandstones, and volcanic ash have been treated as a phase of Wasatch deposition. In the present paper these stratified beds are classed as the lower part, and the coarse igneous conglomerates above them as the upper part, of the Brian Head formation, tentatively considered Miocene in age. The name is derived from Brian Head, a prominent projection of the Markagunt Plateau near the Cedar Breaks National Monument.[12]

The small number "12" at the end of the above quoted sentence refers to "Gregory, H. E.: Geology of Eastern Iron Country, Utah; U. S. Geol. Survey Prof. Paper (in preparation)," which, however, came out under the auspices of the State of Utah (Gregory, 1950). Gregory in this 1950 publication described (p. 64) the Brian Head Formation at Cedar Breaks National

Monument as ". . . a sequence of volcanic debris, breccia, siliceous limestone, and coarse sandstones—a group of distinctive rocks for which the name Brian Head formation has been adopted." This writer concurs with the Brian Head Formation-"Wasatch" (Cedar Breaks of this report) Formation relationships and general lithologies described above by Gregory which apply to the areas of Section 3 and Section 2 (Sevier and Markagunt Plateaus respectively) of this report. However, in the areas of Sections 4 and 5 (Table Cliff and southern Aquarius, and eastern Paunsaugunt Plateaus respectively) the distinct relationships of the Brian Head-"Wasatch" formational boundary is not as clear as illustrated at Sections 2 and 3. This difficulty in distinguishing the Brian Head-"Wasatch" (Cedar Breaks) formational boundary is evidenced by Gregory's (1951, p. 50) first referring to the Bryce Canyon area (the Paunsaugunt Plateau, Section 5 of this report) as Wasatch:

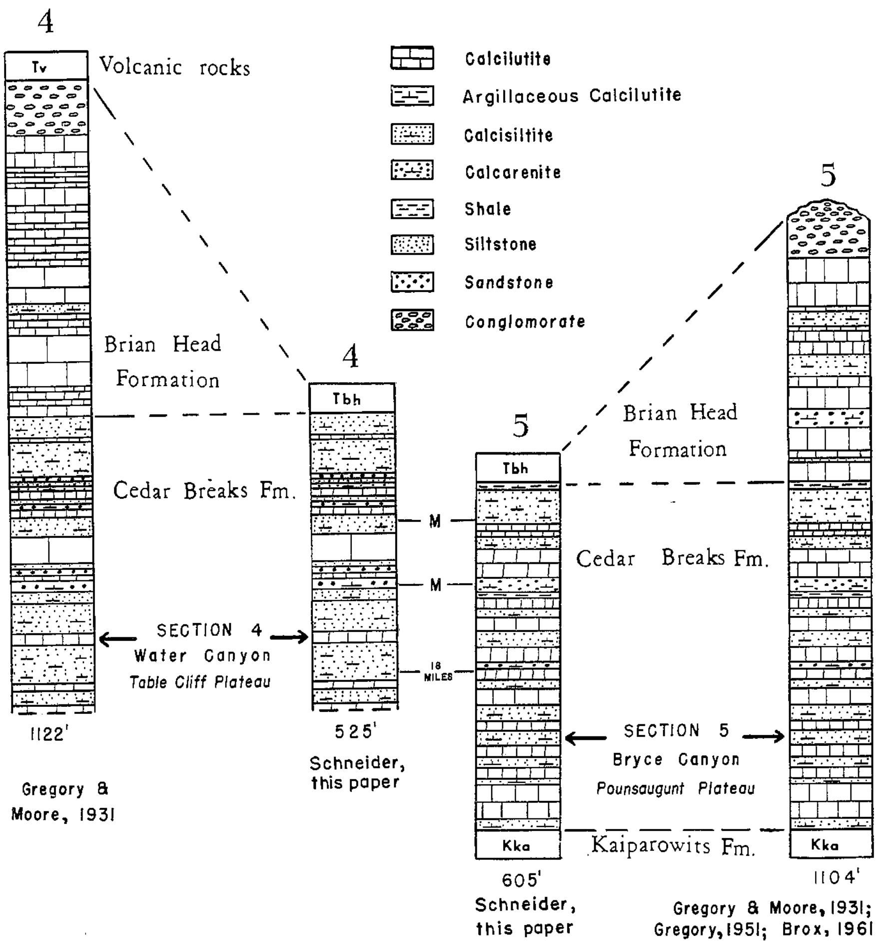
> The "white beds" that in southern Utah lie at the top of the Wasatch formation are displayed at Boat Mountain, at Whiteman Bench, along the crest of the Sunset Cliffs (fig. 1), and in a few other places but have been generally stripped from the surface of the Paunsaugunt Plateau.

and later changing his mind (Gregory, 1951, p. VI) in a frontispiece to the same above quoted publication where he states:

> Recent studies have resulted in a revised interpretation of the Tertiary of southern Utah including the Wasatch formation of the Paunsaugunt Plateau. It has been learned that strata described in this paper as "upper Wasatch" or "white beds" in the Wasatch differ from the massive limestone below in origin, make-up and probably age, as well as in color; that the light-colored rocks of Boat Mountain, Whitemans Mesa and prominences along the western rim of the Paunsaugunt are but peripheral remnants of extensive sheets of calcareous-arenaceous-pyroclastic material preserved from erosion by down-faulting and lava caps. For these distinctive beds the name Brian Head formation (Miocene?) has been adopted. (See Gregory, H. E., 1949, Geologic and geographic reconnaissance of eastern Markagunt Plateau, Utah. Geol. Soc. America Bull., Vol. 60, p. 969-997).

This last quote by Gregory would place into the basal part of the Brian Head Formation both the white to grayish cliff-forming sequence below the conglomerate underlying the Bryce Point outlook (above the upper mica zone of Section 5) and the upper white to gray micritic limestone sequence above the upper mica zone of Section 4. These are shown on current maps as "Wasatch."

The reference at the end of the last quotation above refers to a 1949 publication in which the "white beds" were distinguished as part of the Brian Head Formation (p. 983). Prior to this in 1945 (Gregory, 1945, p. 108) and again in 1944 (the first quote of this section, i.e., Gregory, 1944, p. 591) Gregory also referred to the "white beds" as part of the basal Brian Head Formation. However, a study of his 1949 and 1951 works will show the same picture of rock forms used in two different publications to illustrate two different rock formations, the Brian Head Formation in 1949 and the Wasatch Formation in 1951 (Gregory, 1949, pl. 5, fig. 2 and Gregory, 1951, fig. 22, respectively). It is difficult to understand why the text (not the frontispiece) of the most recent date (1951) is contradictory to all the previous works (1944, 1945, 1949) unless possibly the investigations of the older publications (1944-49) were the most recent works which were published immediately thereafter and the most recently dated (1951) publication was older previous work delayed in the process of publishing.



TEXT-FIGURE 2.—Location of the Cedar Breaks-Brian Head Formational contact at Sections 4 and 5. The Cedar Breaks-Brian Head Formational thickness and contacts as indicated by this report (Schneider 1967) are compared to the increased Cedar Breaks Formation thickness when the Brian Head Formation is considered as part of the Cedar Breaks ("Wasatch") strata as mapped and published by Gregory and Moore (1931), Gregory (1951), and mapped by Brox (1961). Shown are the stratigraphic thicknesses, lithologies, mica zones (M), Tertiary volcanics (Tv), Brian Head Formation (Tbh), and Kaiparowitz Formation (Kka). Broader Cedar Breaks-Brian Head Formational contact relations will be obtained by comparing this figure with Text-figure 5 where Section 2 is at the type locality for the Brian Head Formation, and as such, the Cedar Breaks-Brian Head Formational contact is the most reliable.

Since it is within the scope of this report to establish the base of the Brian Head Formation in the problem of the Flagstaff-Cedar Breaks formational relationships, it was necessary to reexamine a set of mica zones which were definitely within the top of the Cedar Breaks Formation (illustrated in Text-figs. 2 and 5). From the field relations certain facts were revealed which are described in the following two paragraphs.

At Sections 2 and 3 the lithologies on top of the Cedar Breaks Formation (above the upper mica zones) represent the lower part of the Brian Head Formation. These lithologies are comparable and contain an abundance of volcanic ash and tuff; they are thinly bedded with some of the beds at Section 3 being highly colored; and their stratigraphic positions are the same. At Sections 2 and 3 Brian Head base is distinct within a 50-foot plus or minus interval with Section 2 having minor lenses of pebble conglomerate, while Section 3 contains considerable conglomerate gravels plus associated channeling.

At Sections 4 and 5 (Text-fig. 2) the lithologies within the basal part of the Brian Head Formation (which, as used in this paper, form the "white limestones" above the upper mica zone) are different from the basal Brian Head Formation of Sections 2, and particularly 3, as described above. The "white limestones" of Sections 4 and 5 are rather massive cliff-forming "limestones," which do not contain abundant or colorful volcanic ash and tuff, and do not contain gravels or channeling.

The lithologic differences described in the above two paragraphs may be considered as facies changes between Sections 2-3 and 4-5. The "white beds" of the "upper Wasatch" of the central and southern Aquarius, Table Cliff, and eastern Paunsaugunt Plateaus (Section 4 and 5 respectively) can be best relegated to the basal Brian Head Formation. This is based on their position above their upper mica zone, their disproportionate thicknesses to the accurate Cedar Breaks-Brian Head formational contacts illustrated at Sections 2 and 3, and their relationships to the mica zones of Sections 2 and 3 (note Text-figs. 2 and 5). In addition to the mica zones, which may not be obvious at first hand for general mapping purposes, one could readily designate this formational contact at these localities as the area between the essentially upper white and lower pink lithologies.

If the lower Brian Head Formation is to contain the "white beds" as indicated by Gregory (1944, 1945, 1949, and 1951 frontispieces p. VI) then areas mapped as "Wasatch" Formation by Gregory and Moore (1931), Gregory (1951), and Brox (1961), also include the Brian Head Formation. Consequently, a large portion of what has been mapped as "Wasatch" Formation is actually Brian Head Formation, because it is the rather massive "white beds" that make up the top white cliffs which form the southern Aquarius Plateau, Table Cliff Plateau, and top a large part of the Paunsaugunt and eastern Markagunt Plateaus.

Nomenclature Problems

On the basis of the data from this study (summarized in Text-fig. 5) the "Flagstaff Formation" in the Pavant Mountains and the "Wasatch Formation" of the southern High Plateaus have been found to display a homotaxial relationship and consequently are considered the same stratigraphic unit (which also was formed at the same time). In consideration of this homotaxial relationship herein, the term "Wasatch" Formation in the southern High Plateaus is abandoned. This abandonment is necessary because the original basis for extending the term was on the general lithologic and fossil appearance. The first significant study states no basis whatever for use of the term and the Wasatch of the type locality differs distinctly from the Wasatch in the High Plateaus. They are physically discontinuous at the surface, and these areas are not homotaxial. The High Plateaus Wasatch as currently mapped contains large areas of Brian Head strata, and when the early Tertiary of the southern High Plateaus is studied referral is made to the strata and lithologies of Cedar Breaks and Bryce Canyon National Parks and not southwestern Wyoming.

In the southern High Plateaus the stratigraphic section at Cedar Breaks National Park is the thickest, is most representative, is readily accessible from both top and bottom of the section, contains a distinct lower contact with the Kaiparowits Formation, and contains the upper contact with the Brian Head Formation at the type locality of the Brian Head Formation. Thus to properly represent this southern High Plateau strata, previously referred to as "Wasatch," it is forthwith designated the Cedar Breaks Formation. A representative type section at the type locality in Cedar Breaks National Park is specifically located and the lithologies are described in Section 2 in the appendix and illustrated in Text-figure 5 and Plate 2. Although Section 2 is representative of the strata at the type locality these lithologic units change rapidly within short distances.

In central Utah the Flagstaff has been traced from the lacustrine limestones in the Wasatch Plateau west to the slightly clastic strata in the Valley Mountains (Gilliland, 1951) and then into the Pavant Mountain clastics of marginal basin facies by Lautenschlager (1952). Thus presently in central Utah Flagstaff strata include that of the Pavant Mountains and in southern Utah "Wasatch" strata include that at Cedar Breaks. Connecting these we have the homotaxial dual-named Pavant-Cedar Breaks rock unit of this report. The more clastic nature of these Pavant-Cedar Breaks strata distinguish them from the "Flagstaff limestone" of the Wasatch Plateau. This clasticity increase and limestone decrease with the corresponding increase in red, tan, and pink colors is not confined just to the Pavant-Cedar Breaks strata but is found as a transitional, marginal basin facies zone in a subdued amount in the Valley Mountains immediately northeast of the Pavant Range. The distinct clastic nature of the Pavant Range distinguishes these strata from the incipient clasticity of the Valley Mountains. Because the Pavant strata are more characteristic of the clastic Cedar Breaks strata than the Wasatch Plateau Flagstaff "limestone," they are considered part of the Cedar Breaks unit. Consequently the term Flagstaff is abandoned in the Pavant Mountains and this unit is included within the Cedar Breaks Formation. The Flagstaff Formation of the Valley Mountains and that to the east are considered northern and eastern equivalents of both the Pavant and southern High Plateaus Cedar Breaks Formation.

CEDAR BREAKS FORMATION (NEW NAME)

Type Section at Cedar Breaks National Park

Location

The Cedar Breaks Formation is best displayed at Cedar Breaks National Park (Plate 2). The type section is described in Section 2 in the appendix and is located in Cedar Breaks Park primarily along the topographic nose called "Adams Barrier" in the NW$\frac{1}{2}$, Sec. 27, T. 36 S., R. 9 W. Because the top of

"Adams Barrier" is forested and faulted and the major white cliff-forming units are readily traced laterally, the top portion of this type section was studied along the second nose to the east. This top portion is located along the upper part of the topographic nose between Labyrinth and Highleap Canyons in Sec. 23, T. 36 S., R. 9 W. The type section (Section 2) is shown in its geographical relation to the other sections in Text-figure 1.

Thickness and Lithology

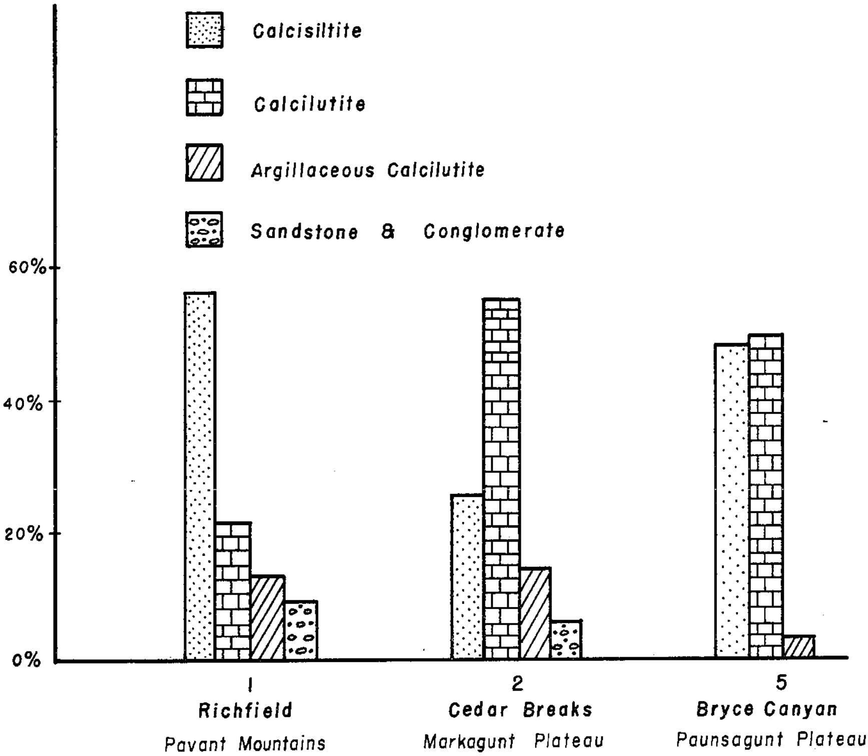
The Cedar Breaks Formation consists of 1,434 feet of variable lithology. The major lithologic categories are 25% calcisiltite, 55% calcilutite, 14% argillaceous calcilutite, and 6% sandstone and conglomerate (Section 2 of Text-figs. 3 and 4). Although most of the major stratigraphic units are laterally evident, there is evidence of rapid facies changes locally. One example is the occurrence of strata changing from quartz sandstone to conglomerate to calcilutite within 200 feet laterally along the outcrop with no indications of stream channeling. A general outcrop view of the upper portion is shown in Plate 2. The thickness of individual units along with their corresponding lithologies and facies are contained in Section 2 in the appendix.

Correlation

The type section at Cedar Breaks (Section 2) correlates to the east with Sections 3 through 5 in the southern High Plateaus and to the north with Section 1 in the Pavant Mountains. It is topped by areas of small pebble conglomerates. In the upper part of Section 2 there are two mica zones separated by white cliff-and-slope forming units. They are shown at the outcrop in Plate 2. The lower mica zone is distributed in two feet of calcarenite of unit 2.51 (Section 2, Appendix). The intervening white sequence is composed of argillaceous calcilutite and calcilutite slope-forming units 2.52-2.53 and dolomitic calcilutite and calcilutite cliff-forming unit 2.54. This intervening sequence totals 152 feet. The upper mica zone is contained in three calcisiltite units; unit 2.55 which is five feet thick, unit 2.56 which is two feet thick, and unit 2.57 which is seven feet thick. Unit 2.56 is the main loci of the mica in the upper zone. These micas of Section 2 appear in hand specimens as biotite and phlogopite and in thin sections are very dark-brown to almost black. Although the consistent occurrence and distribution of the mica zones described in Sections 1-5 are in themselves criteria for relating the individual sections, the presence of glass shards in the thin sections indicate that these mica zones are related to volcanic activity and in essence represent time planes. In the middle of Section 2 calcilutite unit 2.26 contains black fossil seeds, and calcilutite unit 2.27 has lenticular vugs and tubular fillings. The fossil seeds were tentatively identified by Aureal T. Cross (written communication, September 29, 1965) as most probably hackberry (*Celtis*) or possibly small *Prunus*. The base of Section 2 contains banded structures that are characteristic of algae and are described in calcilutite unit six. These correlation data are illustrated in Text-figure 5.

Relation to Underlying and Overlying Beds

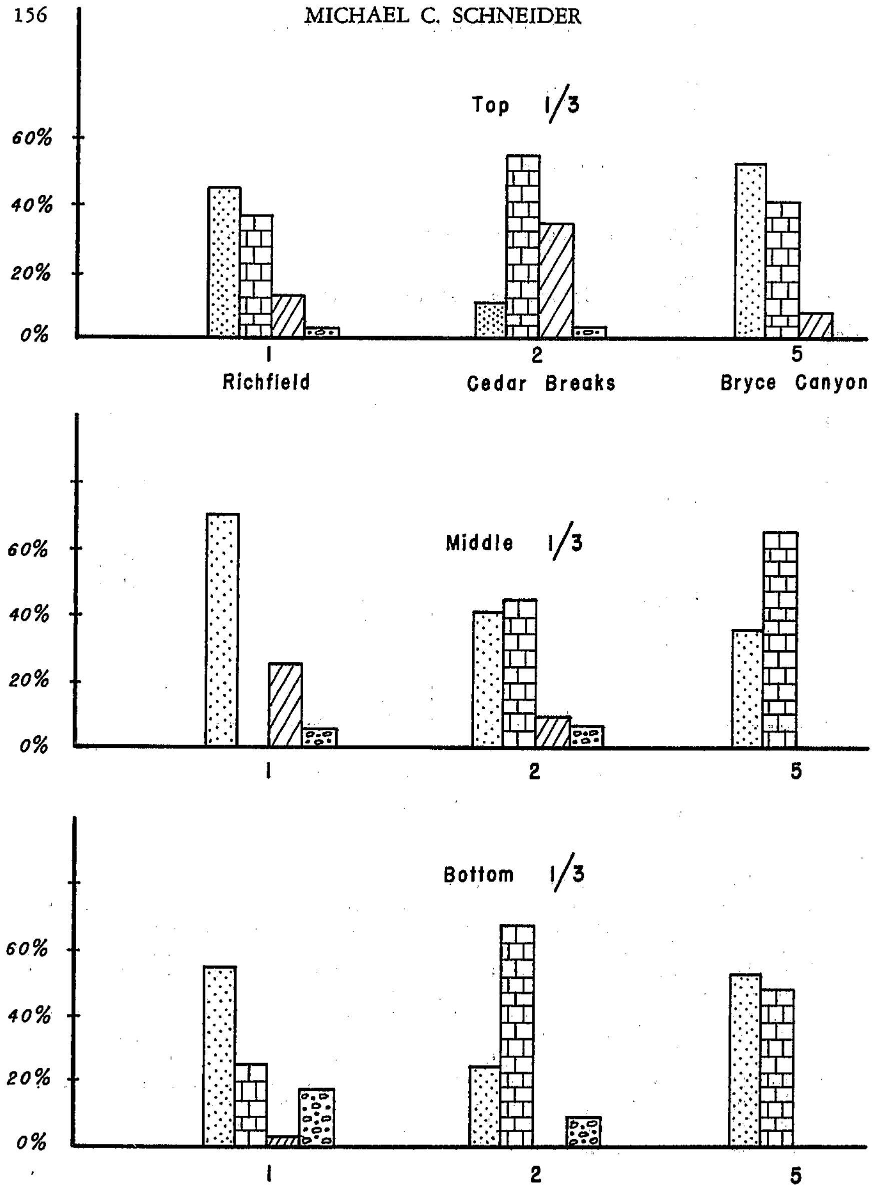
According to Gregory (1950, p. 58) the strata of Early Tertiary age in the High Plateaus of southern Utah (Cedar Breaks Formation of this report) unconformably overlie the Kaiparowits Formation of Late Cretaceous age. However, in the specific areas of this study it would be difficult to designate this contact as distinctly unconformable. This is particularly evident at Section 2 in Cedar



TEXT-FIGURE. 3—Graphic comparison by volume of combined sedimentary rock types in the Cedar Breaks Formation represented by complete continuous Sections 1 in the Pavant Mountains and 2 and 5 in the southern High Plateaus showing a calcisiltite dominance in the Pavant Range as opposed to a slight calcilutite dominance in the southern High Plateaus. This indicates more lacustrine development in the southern High Plateaus than in the Pavant Mountains. These combined rock types are defined as: primarily CALCISILTITE which includes lesser quantities of quartz sandstone, calcarenite, quartz siltstone, and argillaceous calcilutite; primarily CALCILUTITE which includes dolomitic calcilutite and lesser quantities of quartz sandstone, and siltstone, calcarenite, calcisiltite, pisolites, limeclasts, and clay-lime pellets; primarily ARGILLACEOUS CALCILUTITE which includes lesser quantities of quartz sandstone, calcisiltite, quartz siltstone, limeclasts, and shale; primarily quartz SANDSTONE & CONGLOMERATE which includes lesser quantities of calcarenite, quartz siltstone, and calcisiltite.

Breaks Park (Markagunt Plateau) where the contact is mostly a color break with lithology and bedding essentially the same on either side of the contact.

Contact relationships of the Cedar Breaks Formation to the overlying Brian Head Formation are also open to question as the field evidence is not unequivocal. At Section 2 (Text-fig. 1 and Plate 2) the Cedar Breaks Formation grades upward into the Brian Head Formation through a color transition from the varied pink colors of the Cedar Breaks, through some modified tan colors at the top, to the light grays of the Brian Head. With the exception of occasional thin pebble conglomerate lenses the lithologies at the contact are essentially the



TEXT-FIGURE 4.—Graphic breakdown of Fig. 3 showing the stratigraphic distribution of lithologies in lower, middle, and upper parts of Sections 1, 2, and 5. The relatively evenly dispersed calcilutite lithology of Sections 2 and 5 (Cedar Breaks Formation of the southern High Plateaus) and the lack of calcilutite in the middle of Section 1 (Cedar Breaks Formation of the Pavant Mountains) associated with the calcisiltite increase in the middle of Section 2 are indicative of the local basin and lake history. This figure shows that the marginal terrestrial basin and lacustrine basin phases were relatively evenly dispersed in the southern High Plateaus and not in the Pavant Mountains.

same, and the bedding is parallel. If an unconformity exists here with the parallel bedding it is less of a disconformity (i.e., in the sense of an irregular erosion surface) and more of a paraconformity. This upper contact is illustrated at the outcrop at the top right-hand corner of Plate 2.

Other Sections of Cedar Breaks Formation

Location of Significant Sections

The Cedar Breaks strata form the "Pink Cliff Series" in southern Utah. These "Pink Cliffs" were first described by Dutton in 1880. They form the uppermost of four great platforms of plateau-cliff step sequences that develop downward to the Grand Canyon to the south. The "Pink Cliffs" are most readily accessible and best displayed in Cedar Breaks and Bryce Canyon National Parks, as well as the west, south, and east margins of the Table Cliff Plateau located 10 miles northeast of Bryce Canyon.

The Cedar Breaks and Brian Head Formations make up the strata that form the High Plateaus of southern Utah. With reference to Text-figure 1, these plateaus are located as follows: Markagunt (Section 2, Cedar Breaks), southern Sevier (Section 3, Limekiln Creeks), Table Cliffs and southern Aquarius (Section 4, Water Canyon), and Paunsaugunt (Section 5, Bryce Canyon). The Cedar Breaks Formation in its northern and most clastic facies is colorfully displayed as the largely red to white east-facing cliffs of the Pavant Mountains (Fig. 1 of Plate 1 and Section 1, Text-fig. 1) as seen from the highway between Richfield and Salina, Utah.

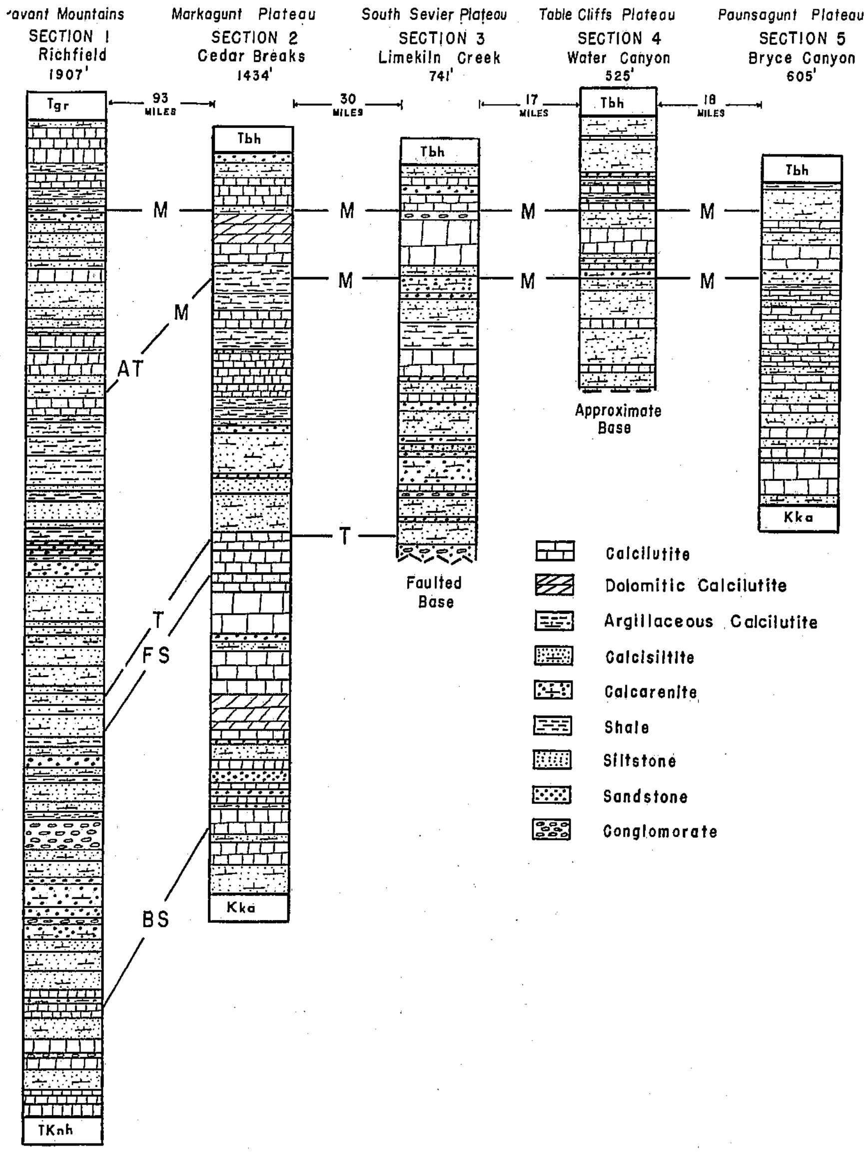
Thickness

In the Pavant Range north of Richfield, Utah, the total thickness of the Cedar Breaks Formation, traced and measured as a continuous section from the North Horn Formation below to the Green River Formation above, is 1907 feet and is described in detail in Section 1 in the appendix. This figure is approximately 900 feet less than that of Lautenschlager (1952, p. 54) who arrived at a total of "over 2800 feet thick" by combining parts of four discontinuous sections. To the south this thickness decreases to 1434 feet at Cedar Breaks, and then eastward the thickness continues decreasing to 605 feet at Bryce Canyon (Text-fig. 5). East and northeast of Bryce Canyon and northeast of Escalante, Utah, McFall (1956) reports pinch out of these strata.

Lithologies, Facies Variations, Sedimentary Features

The Cedar Breaks Formation of the southern High Plateaus has been described as containing variable lithologies (Gregory, 1950, p. 61; 1951, p. 44). Sections 2, 4, and 5 studied by the present investigator consist of over 43% calcilutite, which in some areas contains varied mixtures of argillaceous calcilutite, calcisiltite, calcarenite, quartz siltstone and sandstone, and dolomitic calcilutite. A second major lithologic category consists of approximately 40% calcisiltite which contains varied mixtures of argillaceous calcilutite, calcarenite, and quartz silt and sand. In addition there is nine percent of primarily argillaceous calcilutite which contains some shale. The remaining eight percent consists of predominantly quartz sandstone and calcarenite with lesser amounts of conglomerate and traces of shale. Definitions of these terms are contained in the appendix and representative thin-section textures are illustrated in Plate 1.

Text-figure 3 is a graphic display of the stratigraphic data which pertain specifically to Sections 1, 2, and 5 (Richfield, Cedar Breaks, and Bryce Canyon



TEXT-FIGURE 5.—Correlation by key marker zones of stratigraphic Sections 1 through 5 showing the continuity of the Cedar Breaks Formation of the Pavant Mountains of south-central Utah (Section 1) to the Cedar Breaks Formation of southern Utah (Sections 2 through 5) and their corresponding varied lithologies. The symbols are as follows: Tgr—Tertiary, Green River Formation; Tbh—Tertiary, Brian Head Formation; TKnh—Tertiary-Cretaceous (?), North Horn Formation; Kka—Cretaceous, Kaiparowits Formation; M—mica zone; AT—altered tuff fragment zone; T—tubular filling (?) zone; FS—fossil seed zone; BS—ball structure (algal?) zone.

respectively) reduced to the four dominant lithologic types present in the Cedar Breaks Formation. Text-figure 3 shows the distinct dominance of what is essentially calcilutite in the Cedar Breaks Formation of Section 2 which decreases to the east to Section 5. This calcilutite dominance is indicative of a local abundance of lacustrine in place of marginal basin development. Text-figure 4 is a breakdown of Sections 1, 2, and 5 of Text-figure 3 into their respective lower, middle, and upper sequences with each one-third tally based on its own total lithologic volume of 100%. The importance of Text-figure 4 is that it shows the stratigraphic distribution of the lithologies which indicates the significant point that the calcilutites of the Cedar Breaks Formation are relatively evenly dispersed both vertically and horizontally in the High Plateaus of southern Utah. Consequently, the marginal basin-lacustrine basin phases were relatively evenly dispersed (note southern part of Text-fig. 6). This is not true for the Cedar Breaks Formation in the Pavant Range where the calcisiltite percent increases as diagrammatically illustrated for an instant of time in mid-Paleocene of Text-figure 6. In a broad sense these divisions of sections 2 and 5 of Text-figure 4 could be associated with those described by Gregory (1950, p. 61 and 1951, p. 44-45.

The Cedar Breaks Formation in the Pavant Mountains consists of 57% calcisiltite which includes varied mixtures of argillaceous calcilutite, calcarenite, and quartz silt and sand; 21% calcilutite which includes mixtures of calcisiltite, calcarenite, pisolites, limeclasts, clay-lime pellets, and quartz sand; 13% argillaceous calcilutite which includes mixtures of calcisiltite, quartz silt and sandstone, shale, and limeclasts and nine percent of quartz sandstone and conglomerate primarily, but which includes calcisiltite, calcarenite and quartz siltstone. The upper Cedar Breaks strata are shown as they appear at Section 1 (Richfield) along with representative thin sections of the above lithologies in Plate 1.

Text-figure 3 shows graphically the lithologic volumes of Section 1 and the abundance of clastics of the Cedar Breaks Formation in the Pavant Range and how they are related to the lithologies of Sections 2 and 5. Text-figure 4 shows that of these lithologic volumes calcilutite is absent in the middle part of the Cedar Breaks Formation at Section 1 and that the remaining three lithologies are present throughout the section. The significance of Text-figure 4 is that middle Cedar Breaks rocks of the present Pavant Mountains are non-lacustrine. This non-lacustrine mid-Cedar Breaks of the Pavant Mountains corresponds to the reduced lacustrine basin indicated by the mid-Cedar Breaks of the southern High Plateaus as shown by the calcisiltite to calcilutite content of Section 2, Text-figure 4. This is diagrammatically illustrated in the middle Paleocene of Text-figure 6. The lower and upper limestone sequences of Text-figures 4 and 5 probably correspond with Gilliland's (1951, p. 26) lowest and uppermost "gray" limestones located in the Valley Mountains immediately to the north, northeast of the Pavant Mountains of Section 1. The highly altered tuff fragments (AT) of Text-figure 5 are described in unit 1-84 (Section 1, appendix) and are located at the outcrop in figure 1 of Plate 1.

The regional picture of facies variations is an extension of the same rapid change found in some of the units at the type locality. This is illustrated in Section 4 where a distinct, one-foot thick, ledge-forming, calcilutite passes into distinct, soft laminated shale in less than 10 inches. Additional examples of rapid horizontal changes are: calcilutite to calcareous quartz sandstone in less than two feet, conglomerate to calcisiltite in less than three inches, and quartz sandstone to calcisiltite within 15 feet.

In general reconnaissance and detailed studies of this area of investigation (Text-fig. 1), varied sedimentary features were encountered. These are described as representative examples of some of the sedimentary features to be expected in marginal terrestrial basin and associated lacustrine basin rock sequences.

One of the major characteristics is the variation of strata in both vertical and horizontal dimensions. Instances of rapid horizontal stratigraphic changes occurring in the same bedded unit are numerous, although the general continuity of beds within local areas with little or no distinct horizontal change is by volume most dominant. Rapid vertical stratigraphic changes are in evidence but are not as numerous as horizontal ones. Examples of rapid vertical stratigraphic changes in Section 1 (Richfield) are the presence of large clastics in the form of random pebbles, cobbles, and boulders within calcarenite and calcisiltite units and the existence of several feet of conglomerate sharply in conformable contact with several feet of underlying massive calcilutite. Rapid horizontal stratigraphic changes are more prominent in the slightly dominant lacustrine basin, High Plateau Cedar Breaks sediments, while rapid vertical stratigraphic changes are most prominent in the marginal basin Pavant Mountains Cedar Breaks sediments. These horizontal and vertical variances in clasticity are indicative of the differing and fluctuating energies expended in a marginal-lacustrine basin depositional system.

A continual effort was made to observe directional properties in an attempt to establish paleocurrent transport directions. The results were limited as the number of stratigraphic units containing directional properties were two each in Section 1 and 2 and three in Section 3. Units of Section 1 produce predominantly north (unit 1-55, Section 1, appendix) and south (unit 1-64) paleocurrents. Units of Sections 2 and 3 indicate an east (unit 2-63 and a southwest-northeast component of transport. Because this evidence of directional properties was much more limited than expected, no firm conclusions could be developed from the above data.

A series of interesting features were encountered that range from banded ball

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EXPLANATION OF PLATE 1

CEDAR BREAKS FORMATION PHOTOMICROGRAPHS AND OUTCROPS

FIG. 1.—This outcrop photo locates the mica and altered tuff fragment zones at the top of the Cedar Breaks Formation in Section 1A, the Pavant Mountains just north of Richfield, Utah (SE¼, NE¼, NW¼, Sec. 6, T. 23 S., R. 2 W.). Detailed location with accessibility route is described in Section 1 in the Appendix.

PHOTOMICROGRAPHS

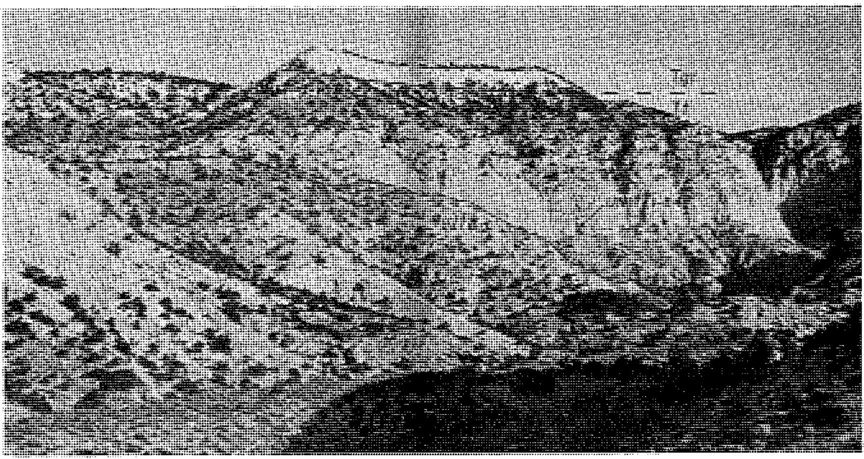
All X 6.5, Plain Light

FIG. 2.—Calcarenite, very fine with occasional fine to very fine sub-angular to subrounded quartz; Unit 1.104.

FIG. 3.—Calcisiltite, with very abundant sparry calcite; Unit 1.106.

FIG. 4.—Calcilutite, white areas are mostly recrystallized calcite; Unit 2.53.

FIG. 5.—Argillaceous calcilutite, with occasional calcisiltite and quartz silt; Unit 1.103.



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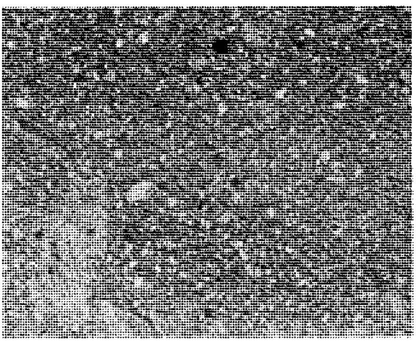

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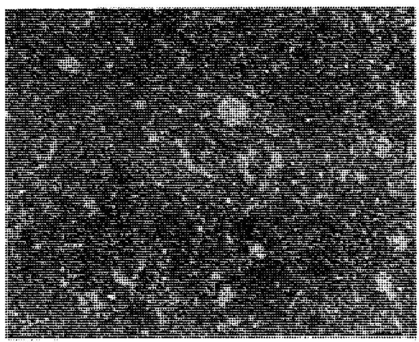

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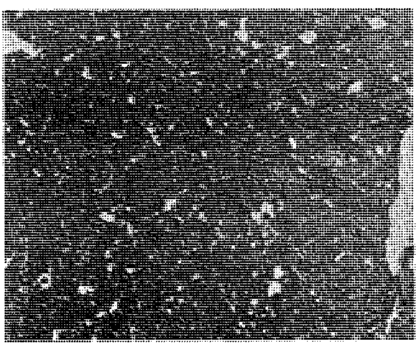

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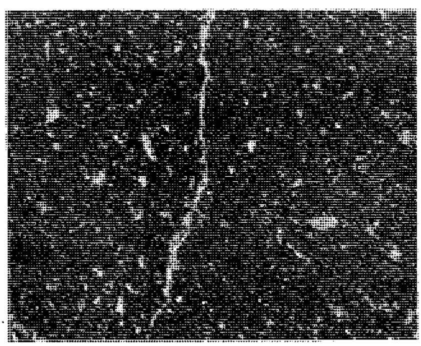

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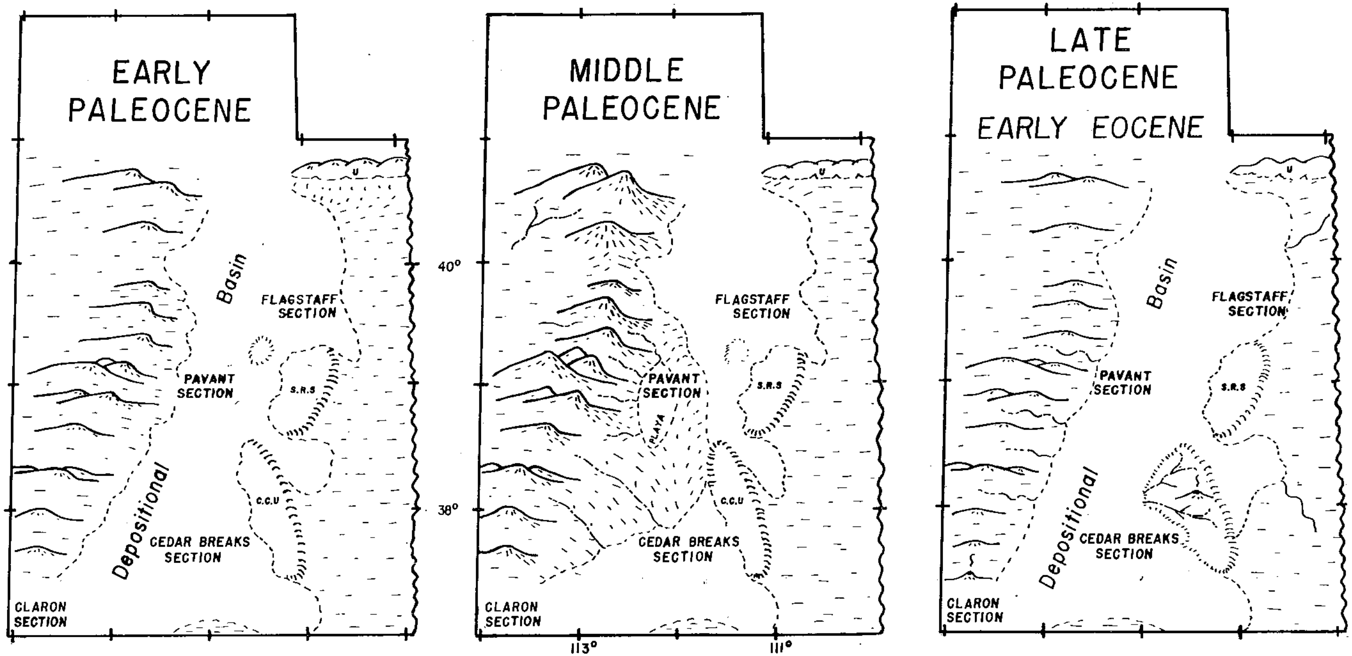
EXPLANATION OF PLATE 2

CEDAR BREAKS FORMATION TYPE SECTION

Photograph showing the characteristic lithologies and outcrop exposures at the top of the Cedar Breaks Formation at Cedar Breaks National Park, Utah (Sec. 23, T. 36 S., R. 9 W.). The upper two designated units locate the mica zones. Detailed location directions and accessibility routes are described in Section 2A in the Appendix.



TEXT-FIGURE 6.—A time and location drawing of lacustrine and marginal basin development illustrating three temporary stages within the central-southern Utah depositional basin during Early, Middle, and Late Paleocene-Early Eocene. The abbreviations are: U—Uinta Uplift, S.R.S.—San Rafel Swell, C.C.U.—Circle Cliffs Upwarp.

structures and rounded lenticular limeclasts through small lime-clay pellets to filling structures and lenticular vugs. The ball structures are predominantly spherical and rounded with some of the larger ones having banded rims and calcisiltite cores containing small calcilutite pellets. The balls range in size from 1/16 to 1½ inches in diameter, and the banded rims resemble algal structures. The lime-clay pellets and limeclasts are found in varying abundance in all the sections, and the pellets in some instances resemble oolites and pisolites. The filling structures (so named because they describe the author's interpretation of their possible origin) vary in lithology, color, and structure from their containing host rock and are basically irregular tubular forms with diameters ranging from one to eight inches with lengths up to two feet. Some of these fillings have relatively straight sides while others are irregular. Volume and percentage-wise the majority of these fillings are vertical, but some are horizontal and in few instances semispherical in shape. Examples of these fillings are described in units 1.48, 1.49 of Section 1 and units 2.16, 2.14 of Section 2 in the appendix. Lenticular vugs are closely related to the filling structures, and they probably represent a preliminary or simultaneous stage in the development of the filling structures. The first stage of this development is represented by an obvious differential color distinction in homogeneous strata outlining the lenticular vug and filling structure shapes. The last stage is made up of vug development and sediment filling. Consequently, the origin of these vugs is postulated as being due to differential weathering, solution, and filling activity. Some of these vugs and filling structures could have had their genesis related to tubular burrowing organisms or possibly plant root structures, but no evidence was ever found to indicate, or firmly suggest, an organic origin. Examples of these predominantly vertical lenticular vugs are described in units 1-14 and 2-27 (Sections 1 and 2 in the appendix).

Spherical to semi-spherical structures, similar to the above described ball structures and fillings, exist in a few units in Sections 3 and 5; however, these differ in that they contain very finely concentric banding which is most evident on weathered surfaces. The banding in its spherical shape is difficult to explain as a stationary filling phenomena, and the delicate undisturbed banding on the occasional one-foot diameter structures precludes rolling accretionary formation. The prevailing varied mottled color and the presence of calcisiltite bands abort the concept of algal derivatives, although the concentric structure is somewhat similar to algal limestone. Because of the above characteristics, the opinion of this investigator is that these structures are most easily related with Liesegang banding.

Limited evidences of stream channeling are present in all sections and usually are in the classical forms of an essentially flat top with a wedge or convex bottom with distinct borders. However, local deviations from the classical do occur where the border contacts are steep and irregular. These irregular contacts indicate phases of rapid cutting to produce stream bed overhangs and phases of slower fillings which preserved these overhangs in the strata. This suggests alluvial fan-type deposits.

The relatively pure white to gray calcilutites contain abundant mega- and almost microscopic structures in the form of clay-lime pellets (described earlier), fine irregular bedding, and limeclasts and breccias. The very fine irregular bedding contains some structures resembling oscillation-type ripple marks with a four-inch wave length and a one-half inch amplitude. Limeclast and breccia textures may intermix and occur together in the same stratum. These textures indicate a shallow lacustrine environment at the specific time that these particular calcilutites were being formed.

The shale of units 1-70 and 1-79 (Section 1, appendix) in appearance closely resemble, in some areas, the soft, crusty, dessicated "bentonitic badland" topography of the lower Brian Head Formation at the top of Section 3 and locally contain abundant gypsum (units 1-70 to 1-73). Studies of thin sections did not indicate any traces of ancient vulcanism. The gypsum, which is assumed to be primary, suggests an arid to semi-arid climate.

The mica zones and the corresponding highly altered tuff remnants which occur immediately below and above the essentially white cliff-forming units are quite meaningful for comparative purposes in that they are found only in this same stratigraphic relationship. The highly altered tuff remnants are contained and described in unit 1-84 (Section 1, appendix). The mica concentration varies from very abundant in unit 1-104 through abundant, but loosely distributed, units 2-55 through 2-57, to the presence of some mica flakes in unit 2-51 to traces of mica associated with the highly altered tuff in calcisiltite unit 1-84. As stated earlier, because of the presence of glass shards, the mica zones are indicative of volcanic activity and are considered essentially as time planes.

Correlation

In southeastern Utah the Cedar Breaks rocks have been locally removed by erosion as indicated by the Early Tertiary remanant at Canaan (Kaiparowitz) Peak. However, east of Escalante, Utah, these rocks pinch out according to McFall (1956). Cedar Breaks-type rocks probably either continuously or intermittently extended east-southeast to the western part of the San Juan Basin in southwestern Colorado and northwestern New Mexico to those rocks described by Reeside (1924, p. 44). Southwest of Section 2 (Text-fig. 1) the Claron Formation is considered equivalent to the Cedar Breaks Formation. After field investigations at Parowan Gap (N.W. of Parowan, Location O of Text-fig. 1) and Cottonwood Canyon, north of St. George, Utah, it is the opinion of this writer that the Claron-Cedar Breaks lithologies are the same. This opinion is supported by sections described by Leith and Harder (1908, p. 42) and Cook (1957, p. 37). West and northwest of Section 2 the Cedar Breaks Formation is not evident in the Great Basin, but its presence and/or equivalence in the vicinity west of the Hurricane-Wasatch fault system at depth is indicated by the Claron Formation outcrop in Parowan Gap just northwest of Parowan, Utah, and the 1434 feet of Cedar Breaks sediments that have their westward extent abruptly terminated by the Hurricane fault system just west of Cedar Breaks National Park.

North of Cedar Breaks Park the Cedar Breaks Formation becomes covered by the Marysvale volcanics and reappears again in the Pavant Mountains. Ten miles south of Section 1, in the Pavant Range, mapping by this writer (1964) has shown the Cedar Breaks to extend beneath the Central Volcanic Field of the High Plateaus of Utah. West of the Pavant Mountains the western extent of the Cedar Breaks Formation again presents a problem because of the downthrown block of the eastern edge of the Great Basin along the Wasatch Fault system. Nevertheless, it is the opinion of this investigator that the Cedar Breaks Formation is present in the subsurface some distance out into the Great Basin. This is based on the 1907 feet of the Cedar Breaks Formation present at Section 1 and the fact that the eastern equivalent of the Cedar Breaks Formation of the Pavant Range, that is the Flagstaff Formation, increases in thickness from east to west.

The top of Section 3 (Limekiln Creek) like the top of the earlier discussed type section (Section 2, Cedar Breaks) contains intermittent areas of small, pebble conglomerates. In the upper part of Section 3 there are also two mica zones separated by white cliff-slope forming units. The lower mica zone is contained in the upper part of thirty feet of calcisiltite and quartz siltstone-calcisiltite. This mica appears like phlogopite in hand specimen and is almost black in thin section. The intervening sequence consists of white cliff-forming calcilutite and slope-forming calcilutite with some interlayered conglomerate and quartz sandstone. This intervening sequence totals 129 feet. The upper mica zone is not distinct because the mica is not abundant. The base of the Cedar Breaks Formation is not exposed at Section 3 due to faulting, but in the lower part of the outcrop, which is equivalent to the middle of Section 2, there are tubular fillings and vugs in calcisiltite which structurally and stratigraphically compare with those in Section 2. This lower part of Section 3 contains banded ball structures approximately one inch in diameter which are exact duplicates of banded ball structures found along the southeast slope in the Bear-Buckskin Valley pass area (Location N, Text-figure 1).

Section 4, like Sections 2 and 3, contains two mica zones separated by slope-forming units and a white cliff. These mica zones are faint and not as obvious as those of Section 2. In Section 4 there is a question as to the upper and lower boundaries of the Cedar Breaks Formation; however, the location of the mica zone and cliff sequence is considered to be at the top of Section 4 as indicated by a comparison with Sections 2, 3, and 5 (note Text-figs. 2 and 5). This vertical boundary problem for Section 4 is discussed under the subheading Brian Head Formation. The lower mica zone is sparsely distributed in units of calcisiltite, calcilutite, calcarenite, and calcisiltite argillaceous calcilutite. Similar to Sections 2 and 3 the intervening sequence is made up of a dominant white calcilutite cliff-forming unit and essentially steep slope-forming quartz sandstone, calcarenite, calcisiltite, argillaceous calcilutite, and calcilutite units. This intervening sequence totals 89 feet. The upper mica zone consists of mica traces in calcilutite and calcisiltite units. The mica zones of Section 4 are the least distinct of all the sections.

In the upper portion of Section 5, similar to Sections 2, 3, and 4, there are two mica zones separated by cliff and steep slope-forming units (Text-fig. 5). The lower mica zone consists of mica distributed in calcarenite and calcisiltite units for a total thickness of 25 feet. The intervening sequence is made up of white to gray calcilutite and calcisiltite cliff and very steep slope-forming units which total 80 feet. The upper mica zone is abundantly distributed in the upper part of a calcisiltite unit. The mica in both the upper and lower zones appears predominantly as phlogopite in hand specimens.

The above described correlation data along with the general lithology of the Cedar Breaks Formation of Sections 2, 3, 4, and 5 in the southern High Plateaus of Utah are graphically illustrated in Text-figure 5. From west to east the ball structures, fossil seeds, and tubular fillings decrease with the thinning of the strata. The Cedar Breaks Formation at Section 2 is 1434 feet thick, and this decreases toward the east to 1004 feet thick at Section 5 if the "white beds" of Gregory (1951, p. 50) are included, or to 605 feet thick if the "white beds" are excluded as indicated in this report (Text-fig. 2 and 5).

The following locations of Text-figure 1 are sites containing some data of correlating nature from fragmented and incomplete sections of the Cedar Breaks Formation. Location I contains 534 feet of red, very fine-grained, clastic sedimentary rocks comparable to the middle of Section 3 and perhaps slightly more clastic than those in the middle of Section 4. It also contains a distinct angular unconformity at the top which could correspond with the channeling at the top of Section 3. An unmapped east-west fault is believed to exist here because the beds at the lower part of the section dip at an angle of 20° to the north, and this increases to 50° at the top of the section. Location N, on the east side of the drainage divide, contains a minimum of 575 feet of calcilutites and fine clastics comparable to Sections 1 to 3 and Location L. Banded ball structures are present which exactly match those existing in Section 3. At least two important unmapped faults are present, one north-south along the western margin and one east-west along the southern margin of these sediments which dip at 21° in a general direction of S. 45° E. It is of significant interest to note the similarity of the overall structures of Locations I and N and the fact that they appear to match up and cut across the general structural trend of the High Plateaus of southern Utah. Detailed mapping of these and intervening areas should reveal information as to whether these are merely cross faults or actual thrusts. At Location N, on the west side of the drainage divide, there is a minimum of 940 feet of conglomerates, siliceous calcilutite, and brown tuff bands which correspond to the Brian Head Formation and not the Cedar Breaks Formation or "Wasatch" as presently mapped. Location L, although mapped by Gregory (1950) as a formational contact (NW¼, Sec. 8, T. 35 S., R. 8 W.), has its base at a fault contact of over 150 feet displacement and consists of 250 feet of the upper white essentially calcilutite cliffs and the upper mica zone, all of which are comparable to Sections 2, 3, and part of Location N. Thus correlation data of Sections 2-5 and locations I, L, and N indicate that throughout this area these strata are the same stratigraphic unit, the Cedar Breaks Formation, and that Section 2 (Cedar Breaks) is the most representative and complete in the southern High Plateaus.

In the upper part of Section 1 of the Cedar Breaks Formation in the Pavant Range, similar to Sections 2-5 in the southern High Plateaus, there is an upper mica zone, an intervening white to gray cliff and steep slope-forming sequence and a lower calcisiltite zone containing highly altered tuffaceous fragments. These are located at the outcrop in Figure 1 of Plate 1. The lower tuffaceous calcisiltite zone in outcrop appears almost black to dark purple and maroon with an irregular lower surface that has up to two feet of relief in intermittent areas with a gradational upper contact. This altered tuffaceous calcisiltite is contained in unit 1.84 which varies from three to seven feet in thickness (Section 1, appendix). The intervening sequence consists of predominantly white to grayish cliff-forming calcilutites, calcisiltites, calcarenites, and quartz sandstones overlain by a few slope-forming units. This intervening sequence is composed of units 1.85 to 1.103 which total 310 feet. The upper mica zone is contained at the top of calcisiltite unit 1.104 which is fourteen feet thick. The mica is densely concentrated in an approximate eight-inch zone that produces a distinct dark band at the base of the soft, pale, reddish, argillaceous calcilutite slope above ledge unit 1.104. In the middle of Section 1 there is a fossil seed zone (unit

1.46) that is overlain by a tubular filling zone (units 1.48, 1.49). Near the base of Section 1 is a fossil seed zone (unit 1.14) and banded concentric structures resembling algal balls (unit 1.18). The Cedar Breaks Formation of Section 1 is 1907 feet thick, and this thickness decreases toward the northeast into the equivalent Flagstaff Formation to what Spieker (1946, p. 141) illustrates as an eventual pinch-out southeast of Soldier Summit, Utah.

These correlation data for Section 1 of the Cedar Breaks Formation in the Pavant Mountains are graphically depicted and associated with the correlation data of the Cedar Breaks Formation of the southern High Plateaus in Text-figure 5. These data indicate that these strata are within the same rock unit.

The remaining locations of Text-figure 1 contain strata presently mapped as Flagstaff, but which are not characteristic of either the Pavant Mountain or southern High Plateaus Cedar Breaks Formation. The Flagstaff Formation, investigated at Locations D and E, contains lithologies very generally represented by McGookey in a 308-foot section (1960, p. 597). The contrast between the Pavant Mountains Cedar Breaks and strata currently mapped as "Flagstaff" at Location D and E was also found to be true in the three areas investigated around Location F where Smith, Huff, Hinrichs, and Luedke (1963, p. 35) state:

> The Flagstaff consists of limestone, tuff, sandy tuff, and tuffaceous sandstone, sandstone, siltstone, claystone, and conglomerate. In its type area on the Wasatch Plateau, the Flagstaff is chiefly limestone (Spieker, 1946, p. 136), but in the Capitol Reef area, exposures of tuff and tuffaceous beds are as abundant as those of limestone.

Nowhere in the areas investigated in this study, either in the Flagstaff or Cedar Breaks Formations, is there any abundance of tuff and tuffaceous beds, but this is characteristic of the Brian Head Formation. Locations G and H are presently mapped as the Tertiary Flagstaff Formation resulting from the work of Smith (1957). Prior to this these rocks were considered by Gregory (1944, p. 589) as ". . . Triassic (?), Jurassic and Cretaceous in Antimony Canyon. . . ." The lithologies of Locations G and H are also quite distinct from those of the Flagstaff and Cedar Breaks lithologies except the anomalous Locations D-F discussed above in which there are color and clastic comparisons. The general color appearances, type lithologies, and stratigraphic positions immediately below the Tertiary Volcanics of these fault-bound "Flagstaff" rocks of Locations D-H, together with the absence of any definite correlating data with either the Flagstaff or Cedar Breaks Formations,. suggest strata other than the Flagstaff or Cedar Breaks Formations. This, in a considered opinion, is most probably strata of the Brian Head Formation.

Age

Richardson (1909b, p. 382) considered these strata as Eocene as did Gregory and Moore (1931, p. 114). However, in this report the age is considered to be Paleocene to earliest Eocene. This is based on the direct correlation of the southern High Plateaus with the Pavant Range in central Utah via Sections 1 and 2 of Text-figure 5. It is believed that the mica zones in the Cedar Breaks Formation were formed essentially at the same time in both central and southern Utah (interpretively illustrated in Text-fig. 6). Since the Flagstaff Formation is the eastern equivalent of the Cedar Breaks Formation in the Pavant Range, the Cedar Breaks is considered in this report Paleocene (?) after the age of the

Flagstaff Formation of Spieker (1946, p. 122) rather than Eocene after the type Wasatch.

Regional Relation to Overlying and Underlying Beds

At Section 3 (Limekiln Creek on the southern Sevier Plateau) the Cedar Breaks Formation is topped by a discontinuous sand-gravel layer with a maximum thickness of 40 feet with the top containing some sandy limestone. Here, as at Section 2 (Cedar Breaks), the bedding is also parallel. At both Sections 2 and 3 there is no obvious line or erosional plane where one could designate an exact contact, but there is an approximately 50-foot transition zone, on either side of which, are distinctly different lithologies and colors. However, approximately one-half mile north of Section 3 there is evidence of channeling.

In the vicinity of North Creek (Location I, Text-fig. 1) an unconformity exists between the Cedar Breaks and the Brian Head Formations. The unconformable relation of the Cedar Breaks with the underlying Kaiparowitz Formation was discussed earlier under the heading "Type Section." Consequently, the top and bottom contacts of the Cedar Breaks Formation in the Markagunt, southern Sevier, and Aquarius Plateaus are represented by both conformable and unconformable surfaces of varying characteristics.

At Section 1 in the Pavant Mountains the lower contact of the Cedar Breaks Formation is conformable and locally transitional with the underlying North Horn Formation. Nevertheless, in the vicinity of Sanpete Valley, Spieker (1946, p. 133, 155) describes a local angular unconformity between the Flagstaff (the eastern equivalent of the Cedar Breaks Formation) and North Horn Formations and from evidence in other areas concludes (p. 137) ". . . the disturbance between North Horn and Flagstaff time penetrated a considerable part of the border area of the Wasatch Plateau." The contact of the Cedar Breaks and overlying Green River Formations is distinctly conformable in the vicinity of Section 1, but to the south along Cottonwood Creek east of Little Valley such a conformable contact is not so certain as there is the suggestion of a soil zone (Schneider, 1964, p. 131). Thus the top and bottom contacts of the Cedar Breaks Formation and equivalent strata in the Pavant Mountain area are represented by both conformable and unconformable surfaces of varying characteristics similar to those of the Cedar Breaks Formation in the southern High Plateaus.

Environment and Mode of Deposition

The environment and manner in which these sediments were deposited are deduced and interpreted from the sedimentary features that are described under that heading and in the previous parts of this report. The paleo-environments in the areas that constitute the present Pavant Range and the southern High Plateaus were essentially the same. The paleo-topography was one predominantly continuous basin that was subjected to shallow inundations at various times. The source area was not far to the west and most likely the relief was moderate with some abrupt faulting as shown by the coarseness and rounding of the conglomerates. This environment of deposition in Early Tertiary time is depicted in Text-figure 6.

Early Paleocene time, as indicated by both the conformable and unconformable Kaiparowitz-Cedar Breaks and North Horn-Flagstaff contacts, began with a gentle relief in the topography within the major basin. The higher areas of topography were subjected to a degree of erosion which in instances rapidly filled in some of the lower areas. Either the basin underwent limited differential subsidence or the outlet became somewhat dammed (or both) so that intermittent shallow flooding occurred. Throughout Early Paleocene the Pavant area was associated more with the clastic margin of the basin while the southern High Plateaus included more of the inundated calcilutite portions of the basin.

In Mid-Paleocene time in the Pavant Range there developed broad, extensive, gently dipping, alluvial fan-type deposits. For a short period a local intermittent playa lake developed resulting in some gypsum deposits. The clastic and terrestrial influence in the Pavant area extended in a subdued fashion into the area of the southern High Plateaus. Here the earlier dominant lacustrine environment ceased to dominate because in the western portions marginal basin alluvial fans encroached on the flooded areas. In the eastern portions the lacustrine phases were maintained in a shallow intermittent fashion as the calcilutites alternated with predominantly terrestrially deposited clastics.

From Late Paleocene to earliest Eocene the basin that existed in central and southern Utah was the most extensive and contained the most widespread geographically continuous lacustrine deposits. This also was a time similar to Early Paleocene when intermittent flooding took place, and thus the basin was not timewise continually lacustrine. A minor amount of the basin deposits in the Limekiln Creek area (Section 3) could possibly have had their source as the Circle Cliffs Upwarp. Cedar Breaks deposition ceased in earliest Eocene with the advance of Green River sediments from the north and an increase in volcanic activity from the south. This volcanic activity had its incipient beginning in Late Paleocene time as indicated by its association with the mica zones in upper Cedar Breaks strata.

SUMMARY AND CONCLUSIONS

The writer has presented the summarized factual data in the first part and the resulting interpretive conclusions in the latter part of the following paragraphs.

Basis for Correlation from Central to South-Central Utah

The following are some physical stratigraphic phenomena which occur consistently at equivalent stratigraphic positions in similar strata in the Early Tertiary sediments in the areas of the Pavant Mountains and Cedar Breaks National Park: the presence of an upper mica zone; the presence of an essentially white calcilutite cliff and slope sequence; the presence of a lower, very highly altered tuff, fragment zone with mica traces in the Pavant Range and a mica zone in the southern High Plateaus; traces of glass shards in the thin sections of the mica zones; the presence of a tubular filling (?) zone, a fossil seed zone, and a ball structure zone; both conformable and unconformable upper and lower formational contacts; and strata that thicken to the west and pinch out to the east. These facts are interpreted by this writer to indicate that the Early Tertiary sediments of the Pavant Mountains and the southern High Plateaus are the same rock unit formed in an essentially physically continuous depositional basin (illustrated in Text-fig. 6), although presently these formations are physically discontinuous at the surface. While the consistent and uniform presence of the above data are in themselves sufficient for rock correlation, the mica zone relation to volcanic activity supports the rock equivalence with what is basically a time plane.

New Terminology (Cedar Breaks Formation)

On the basis of these facts: a homotaxial relationship exists between the earliest Tertiary sediments of the Pavant Mountains and those at Cedar Breaks in the High Plateaus (illustrated in Text-fig. 5); the Pavant "Flagstaff" and the Cedar Breaks "Wasatch" are the same formational rock unit. The stratigraphic section that best represents the strata found in the southern High Plateaus of Utah with respect to thickness, accessibility, good top and bottom contacts, and type locality for the overlying Brian Head Formation is located in Cedar Breaks National Park. The Pavant Mountains clastic Flagstaff Formation is not representative of the Flagstaff "limestone" Formation of the Wasatch Plateau but is more characteristic of the strata found at Cedar Breaks. Extension of the term "Wasatch" to the southern High Plateaus seems to be based on general supposition rather than on factual studies; and current maps indicate the High Plateaus to be mostly "Wasatch" strata when in fact large areas consist of Brian Head strata. The writer proposes the following change: re-name the Wasatch Formation of the southern High Plateaus and the Flagstaff Formation of the Pavant Mountains as the Cedar Breaks Formation with the type section and locality represented at Cedar Breaks National Park.

Lithology Variations Reflect Depositional Variations

The existence of varied gradual and rapid horizontal and vertical lithologic changes, occurrences of small boulders in predominantly silt-size units, a suggested (but incomplete) predominantly north-south directional component, banded ball structures, lime-clay pellets and limeclasts, filling (?) structures, evidence of stream channeling, calcilutite containing very fine irregular megascopic bedding and microscopic wavy bedding that approaches cross bedding, limeclasts and breccia, and the presence of gypsum in the upper middle of Section 1 are interpreted as follows: the above facts indicate that the Cedar Breaks Formation was deposited in a variable energy environment that would best be characterized as being a fluvial, alluvial fan, and marginal terrestrial basin which at times became shallow lacustrine. Assuming the gypsum to be primary, the climate was semi-arid, and since this evaporite is not found in localities other than Section 1, it represents a local ponding area with interior drainage (diagrammatically illustrated in Mid-Paleocene, Text-fig. 6) within the major basin.

Lithologic Units Thicken and Coarsen Toward Source

Lithologies of the Cedar Breaks Formation of the Pavant Mountains are highly clastic in nature in comparison with the Flagstaff "limestone" Formation of the Wasatch Plateau. The Cedar Breaks Formation of the Pavant Mountains is composed of 57% calcisiltite, 21% calcilutite, 13% argillaceous calcilutite, and 9% quartz conglomerate and sandstone. The Cedar Breaks Formation of the southern High Plateaus is composed of 43% calcilutite, 40% calcisiltite, 9% argillaceous calcilutite, and 8% quartz conglomerate and sandstone. Here the Cedar Breaks Formation is dominated by calcilutite in the west at Section 2 (55% calcilutite to 25% calcisiltite) which decreases to the east (49% calcilutite to 48% calcisiltite at Section 5), but Section 2 is less clastic than the above and below described Section 1 in the Pavant Mountains.

At Section 1 the Cedar Breaks Formation is 1907 feet thick measured as a continuous section, and this figure is approximately 900 feet less than earlier workers' estimates based on parts of discontinuous measurements. The Flagstaff Formation (the northeastern equivalent of the Cedar Breaks Formation) thins eastward and pinches out east of the Wasatch Plateau. At Cedar Breaks (Section 2) the Cedar Breaks Formation is 1434 feet thick while at Bryce Canyon (Section 5) it is 605 feet thick, and east of Escalante, Utah, it locally pinches out. No faulting is in evidence that is confined only to within the Cedar Breaks Formation or the immediate underlying formations to indicate a progressively faulted depositional trap which could account for the western thickening with an eastern source. This investigator's interpretation of the above facts is as follows: the wedging-out and less clastic nature of the Flagstaff Formation to the east and the wedging-out and thinning of the Cedar Breaks Formation to the east indicates that the dominant source area for these sediments was to the west of their present occurrences. The present Pavant Mountains area was closest to the source area of highest relief since it has the greatest content of clastic materials of the sections studied.

Central and Southern Utah Paleocene Basin

The existence of the essentially white calcilutite cliff-and-slope sequence between the two mica zones of all sections and in particular Sections 1 and 2; the lack of calcilutite in the middle of Section 1 and its presence in the upper and lower parts (Text-fig. 4); the presence of gypsum in upper to middle Section 1; and the decrease in the amount of calcilutite and the increase of calcisiltite in the middle of Section 2 while the calcilutite increases in the upper and lower parts (Text-fig. 4) are interpreted to mean that lacustrine calcilutite development was most uniform and widespread during late Cedar Breaks time and that this is a time of a predominantly geographically continuous lacustrine basin. This is indicated by the lithologies throughout the area of Sections 1 through 5 which are presently in the central and southern High Plateaus of Utah. The Pavant Mountain area of central Utah was a semi-arid marginal basin area and not a lacustrine basin in medial Cedar Breaks time (Text-fig. 6). A lacustrine area most probably existed to the east of the present site of the Pavant Range as the Flagstaff "limestone" Formation on the Wasatch Plateau. This non-lacustrine phase of medial Cedar Breaks time in the Pavant Mountain area of central Utah is reflected in the reduced calcilutite and increased calcisiltite content in the middle of Section 2 in the area of the southwestern High Plateaus. Early Cedar Breaks time again reflects a degree of lacustrine development but not to the extent of that of the upper. It should be noted that the terms upper, middle, and lower are orders of magnitude. A lacustrine phase exists when there is a distinct lacustrine calcilutite unit, and where there exists calcarenite, calcisiltite, quartz silt, and sandstone units the lacustrine basin has ceased to dominate and has become a marginal basin. Except for the middle Pavant Section (Section 1) there is a limited degree of this alternate flooding.

Confusion of Brian Head with Flagstaff and Cedar Breaks Strata

The abundance of tuff and tuffaceous beds described by Smith, Huff, Hinrichs, and Luedke (1963, p. 35) are not characteristic of the clastic Cedar Breaks Formation of the Pavant Mountains or its eastern equivalent, the Flagstaff "limestone" Formation of the Wasatch Plateau, but are characteristic of parts of the Brian Head Formation. Consequently, the interpretation of this writer is that the strata presently mapped as the "Flagstaff Formation" around the eastern periphery of the central volcanic field (Tv of Text-fig. 1) are open to serious question and most probably should be included in the Brian Head Formation.

There is a minimum of 940 feet of white siliceous limestones, conglomerates, and dark brown tuff (?) bands on the west side of the drainage divide at location N. In the opinion of this writer these strata are representative of the Brian Head Formation and encompass approximately one-half of the sedimentary rocks exposed amidst the volcanics and alluvium at this locality, and have been erroneously "mapped" as "Wasatch" (Cedar Breaks of this report). Whether or not these are the Brian Head Formation is dependent upon detailed mapping and stratigraphic analysis, but it is not all "Wasatch" (Cedar Breaks) as currently mapped.

On the Geologic Map of Utah (1963) the Brian Head Formation is not shown at Mt. Brian Head, the type locality, and this formation is not "mostly latitic ignimbrites" as defined. Most likely the Brian Head Formation is not shown because on the original map by Gregory (1950) the western and southern contact line with the "Wasatch" was omitted in the area centered around Sec. 14, T. 36 S., R. 9 W. and this omission was carried over to the 1963 map.

With regard to the Cedar Breaks-Brian Head formation contact the following seems significant: in Section 5 (Text-fig. 2) the white calcilutite cliff sequence above the upper mica zone, if considered part of the Cedar Breaks Formation, is anomalous to the corresponding beds of Section 2 and 3 (Text-fig. 5). The upper massive white calcilutite cliff sequence that forms the top of Section 4 above the upper mica zone is equivalent to the top of Section 5 (Text-fig. 2) and also, if considered part of the Cedar Breaks Formation, is anomalous to the corresponding areas of Sections 2 and 3 (Text-fig. 5). The interpretation of the above indicates that what is presently considered totally "Wasatch" (Cedar Breaks) on the top of Table Cliffs and Paunsaugunt Plateaus is better considered predominantly Brian Head Formation.

APPENDIX

Definition of Terms

Argillaceous calcilutite—a calcilutite containing 25% to 50% clay minerals.

Bedding—thin is 2"-4"; medium is 4"-12"; thick is 1'-4'; very thick is over 4'.

Calcarenite—a mechanically deposited carbonate rock consisting of sand-size carbonate grains (1/16 to 2 mm diameter); the particular material in this rock maye be of lithoclastic or/and bioclastic derivation and comprises 50% or more of the rock.

Calcilutite—a rock composed of 50% or more of clay-sized particles of carbonate detritus; includes biocalcilutites and lithocalcilutites.

Calcisiltite—a rock-type intermediate between calcarenite and calcilutite in that it consists mostly of silt-sized carbonate detritus that comprises 50% or more of the rock; includes biocalcisiltites and lithocalcisiltites.

Clast—an individual constituent of detrital sediment or sedimentary rock produced by the physical disintegration of a larger mass either within or outside the basin of accumulation. A lime clast, therefore, may be an intraclast of a limestone particle or a fragment disrupted from partially consolidated lime-mud on the seafloor.

Oölite—spherical or subspherical accretionary grain generally less than 2.0 mm in diameter. In section oölites display concentric structure and may also exhibit radial structure. Oölite is a coated grain and may or may not have a nucleus.

Pellet—a grain composed normally of micritic material lacking significant internal structure and generally ovoid in shape; it may also be subovoid. Most pellets in limestones are of silt-size to coarse sand-size (some are slightly larger). In some respects pellets are pseudo-oölites, for they are spherical to subspherical to oval bodies with distinct boundaries, resembling oölites; however, they do not possess comparable internal structure.

Percentages—rare is less than 5%, occasional is 5-10%, common is 10-20%, abundant is 20-30%, and very abundant is 30-45%.

Pisolite—a grain-type similar to an oölite and generally 2.0 mm or more in diameter. The term pisolite is restricted to crenulated, rounded, or semirounded commonly composite carbonate grains or bodies.

Sparry—refers to clear, transparent, or translucent, readily cleavable, crystalline particles generally having an interlocking mosaic texture. The name spar alludes to its relative clarity both in thin section and hand specimen.

STRATIGRAPHIC SECTION 1 IN THE PAVANT MOUNTAINS NORTH OF RICHFIELD, UTAH

1A. Section located approximately 600 feet up from the stream bed along the prominent topographic nose in SE¼, NE¼, NW¼, Sec. 6, T. 23 S., R. 2 W. and starts at the base of the yellowish gray massive cliff-forming unit which is located at the distinct reddish brown soft slope and ledge-forming unit. This vertical stratigraphic location is where section 1B stops and represents a continuous section measurement physically traced from section 1B. The beds were measured at a six degree dip approximately South forty-five degrees West. Accessibility to this area is via a road from the Sevier Valley Irrigation Canal to the north side of the mouth of the canyon and then by foot.

Green River Formation

Calcilutite, fresh and weathered surface are pale greenish yellow (10Y8/2)

Cedar Breaks Formation

Unit	*Description*	*Thickness*	*and Unit Total in Feet*
1.112	Calcisiltite, with abundant quartz silt; fresh and weathered surfaces are pale red (10R6/2); very soft slope-forming, bedding indeterminate	17	1907
1.111	Calcilutite, with very abundant calcisiltitic pisolites and clasts; fresh surface is yellowish gray (5Y8/1), weathered surface wash is moderate reddish orange (10R6/6); abundant euhedral sparry calcite, argillaceous calcilutite gives fresh surfaces a salted appearance, vertical jointing, medium to thick bedding, slope and ledge forming.	16	1890
1.110	Calcilutite; fresh and weathered surfaces are pale red (10R6/2); abundant sparry calcite, soft slope forming, bedding indeterminate.	16	1874
1.109	Calcilutite; fresh surface is very light gray (5YRN8) to white (5YRN9), weathered surface is yellowish gray (5Y8/1) and pinkish gray (5YR8/1); basal portion contains irregular calcilutite clasts up to one-half inch diameter, some sparry calcite, medium to very thick bedding, forms a sequence of ledges and very steep slopes.	32	1858
1.108	Calcisiltite and argillaceous calcilutite; fresh surface is a mottled, pale red (10R6/2) and very light gray (5YRN8), weathered surface is pale red (5R6/2); some quartz silt, abundant sparry calcite veinlets, very soft slope forming, bedding indeterminate.	19	1826

1.107	Calcilutite; major portion of fresh and weathered surfaces are yellowish gray (5Y8/1), basal part of unit is mottled fresh and weathered surfaces of light greenish gray (5GY8/1) and pale red (10R6/2); basal contact area is gradational with unit 106 and contains very abundant calcisiltite, some sparry calcite, vertical jointing, medium- to thick-bedding, slope and ledge forming.	26	1807
1.106	Calcisiltite; fresh surface is mottled pale red (5R6/2), pale reddish brown (10R5/4) and light greenish gray (5GY8/1), weathered surface is pale reddish brown (10R5/4); very abundant euhedral sparry calcite, mica flake trace, rare quartz silt, vertical jointing, thick bedding, forms a sequence of ledges.	21	1781
1.105	Argillaceous calcilutite with abundant calcisiltite; fresh surface is mottled pale reddish brown (10R5/4), pale red (5R6/2) and yellowish gray (5Y8/1), weathered surface is mottled moderate reddish orange (10R6/6) and pale reddish brown (10R5/4); very abundant calcite in sparry, milky, anhedral, and euhedral forms, very soft slope forming, bedding indeterminate.	16	1760
1.104	Calcarenite, very fine with occasional fine to very fine sub-angular to sub-rounded quartz; fresh surface is mottled pale red (5R6/2), grayish pink (5R8/2) and very light gray (5YRN8), weathered surface is pale reddish brown (10R5/4) with dark yellowish orange mottling (10R6/6); very abundant phlogopite-appearing mica in 8 inch zone above ledge, occasional sparry calcite, some quartz silt, vertical jointing, thick to very thick bedding, ledge and cliff forming.	14	1744
1.103	Argillaceous calcilutite with some calcisiltite and quartz silt; fresh surface is mottled pale red (5R6/2) and pinkish gray (5YR8/1) weathered surface is moderate reddish brown (10R4/6); occasional fine subrounded quartz, some sparry calcite, very soft slope forming, bedding indeterminate.	18	1730
1.102	Calcarenite, very fine with abundant quartz silt and fine sub-rounded quartz; fresh surface is a mottled light gray (5YRN7), pale red (5R6/2) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4) and pale red (10R6/2); abundant sparry calcite with some euhedral crystals, vertical jointing, thick to very thick bedded, ledge and cliff forming.	16	1712
1.101	Calcisiltite with very abundant quartz silt and abundant very fine subrounded quartz; fresh surface is a mottled very light gray (5YRN8) and pale red (10R6/2), weathered surface is a moderate reddish orange (10R6/6); abundant sparry calcite with some euhedral crystals, very soft slope forming, bedding indeterminate.	27	1696
1.100	Calcisiltite; lower portion of unit fresh surface is pale red (5R6/2) with some pale reddish brown (10R6/6), weathered surface is moderate reddish orange, upper portion of unit fresh surface is yellowish gray (5Y8/1), weathered surface is same with moderate reddish orange (10R6/6) surface wash; occasional fine to medium subangular to rounded quartz, vertical jointing, thick to very thick bedded, cliff forming, this unit		

	forms the top of the yellowish gray cliff forming sequence.	33	1669
1.99	Argillaceous calcilutite; fresh surface is pale red (5R 6/2), weathered surface is pale reddish brown (10R 5/4); weathered form is highly rounded with curved spalling surfaces, finer and coarser textures in local areas, medium bedded, soft ledge forming.	2	1636
1.98	Calcisiltite; fresh surface is pale red (5R6/2), weathered surface is pale red (10R6/2); occasional fine subangular quartz, vertical jointing, thick to very thick bedding, cliff forming.	9	1634
1.97	Calcilutite; fresh surface is very pale orange (10YR, 8/2), weathered surface is moderate reddish orange (10R6/6) and pinkish gray (5YR8/1); very abundant sparry calcite with some fine euhedral crystals, vertical jointing, thick bedding, cliff forming.	8	1625
1.96	Calcilutite, calcisiltic; fresh surface is very light gray (5YRN8), weathered surface wash is moderate reddish orange (10R6/6); abundant sparry calcite areas with occasional veinlets, some fracturing from adjacent faulting, vertical jointing, very thick bedding, cliff forming.	24	1617
1.95	Sandstone, fine to medium subangular to rounded quartz, highly calcareous; fresh surface is pale red (5R6/2), weathered surface is moderate reddish orange (10R6/6); vertical jointing, thick bedding, cliff forming.	8	1593
1.94	Calcisiltite with very abundant quartz silt; fresh surface is pale red (5R6/2) and light gray (5YRN7), weathered surface is grayish orange pink (5YR7/2) and moderate reddish orange (10R6/6); abundant fine subangular with occasional medium to coarse rounded quartz, vertical jointing, thick to very thick bedding, cliff forming.	39	1585
1.93	Sandstone and siltstone, quartz; fresh and weathered surfaces are yellowish gray (5Y8/1) with some siltstone weathering pale yellowish brown (10YR6/2); sandstone is subangular to rounded and medium to coarse, siltstone is in lower half and contains very fine horizontal bedding, vertical jointing, thin to thick bedding, cliff forming.	4	1546
1.92	Calcisiltite and calcarenite, very fine with abundant quartz silt; fresh surface is yellowish gray (5Y8/1), weathered surface is yellowish gray (5Y8/1) with some moderate reddish orange (10R6/6) mottling; irregular and intermittent areas of finer calcisiltite and coarser calcarenite with the latter containing abundant subangular to subrounded fine medium quartz, vertical jointing, very thick bedding, cliff forming.	10	1542
1.91	Sandstone in calcilutite matrix, sandstone is medium to coarse subrounded to well-rounded quartz; fresh surface is yellowish gray (5Y8/1), weathered surface is pinkish gray (5YR8/1) with salt and pepper sand texture; occasional round; small quartzite pebbles, vertical jointing, thick bedded, cliff forming.	6	1532
1.90	Calcisiltite with abundant very fine to medium subangular to subrounded quartz; fresh surface is yellowish gray (5Y8/1), weathered surface is a mottled yellowish gray (5Y8/1) and moderate reddish orange		

	(10R6/6); vertical jointing, medium to very thick bedding, cliff forming.	11	1526
1.89	Calcilutite with occasional subangular medium quartz; fresh surface is yellowish gray (5Y8/1), weathered surface is pinkish gray (5YR8/1) and yellowish gray (5Y8/1); vertical jointing, thick bedded, cliff forming.	8	1515
1.88	Calcilutite; fresh and weathered surfaces are yellowish gray (5Y8/1) with some weathered surfaces grayish orange pink (10R8/2); some chalky appearing weathered surfaces, vesicular in some areas, occasional fine to medium subangular quartz, rocks are shattered by adjacent faulting, vertical jointing, very thick bedding, cliff forming.	16	1507
1.87	Calcarenite, very fine with abundant calcisiltite and abundant very fine to fine subangular to subrounded quartz; fresh and weathered surfaces are yellowish gray (5Y8/1); vertical jointing, thick to very thick bedding, cliff forming.	9	1491
1.86	Calcilutite; fresh and weathered surfaces are pinkish gray (5YR8/1) and yellowish gray (5Y8/1); slightly chalky weathered appearance, occasional fine to medium subangular to rounded quartz, few calcisiltite areas, occasional faint horizontal bedding traces, vertical jointing with local rocks shattered by adjacent faulting, bedding is medium to very thick, cliff forming.	47	1482
1.85	Calcisiltite with abundant argillaceous calcilutite; fresh surface is mottled pale reddish brown (10R5/4) and pale yellowish orange (10YR8/6), weathered surface is pale red (10R6/2); some fine subangular quartz, vertical jointing, thick to very thick bedding, ledge and cliff forming.	15	1435
1.84	Calcisiltite, tuffaceous; the tuff is slightly lithic, very highly altered with abundant predominantly angular quartz silt; fresh surface is grayish purple (5P4/2) to pale purple (5P6/2), weathered surface is pale red purple (5RP6/2); occasional glass or pumice fragments some of which suggest collapsing structures and some containing glass shard inclusions. Some of these fragments are brown (uncrossed nicols) and black (isotropic under crossed nicols) while others are white (uncrossed nicols), abundant tiny angular lenticular quartz fragments with some boundaries rich in hematite specks, traces of altered mica; this unit occurs approximately 40 feet above the contact of the soft slope forming materials and the lowest white gray limestone. In places the color of the basal ten inches appears almost black, the bottom contact in places is distinct and irregular with up to 2 feet of relief while the upper contact is gradational; thick bedding, ledge and cliff forming.	3-7	1420
1.83	Calcisiltite with abundant very fine to medium subangular quartz; fresh surface is pale red (10R6/2), weathered surface is pinkish gray (5YR8/1); faint traces of horizontal bedding on weathered surfaces, vertical jointing, thick to very thick bedding, cliff forming.	14	1413
1.82	Conglomerate, quartzite pebbles and cobbles; fresh and weathered surfaces approximately yellowish gray (5Y		

	7/2); vertical jointing, medium bedded, cliff forming.	1	1399
1.81	Calcilutite highly variable with abundant areas of argillaceous calcilutite, calcisiltite, very fine calcarenite and sparry calcite; fresh surfaces are mottled pale red (5R6/2), grayish pink (5R8/2), yellowish gray (5Y 8/1) and very light gray (5YRN8), weathered surfaces are pale red (10R6/2) to pinkish gray (5YR 8/1); basal ten feet contains very abundant fine to medium with occasional coarse subangular quartz, vertical jointing, thick to very thick bedding, cliff forming.	40	1398

1B. Section along the prominent topographic nose of the south wall of South Cedar Ridge Canyon in NW¼, Sec. 28, T. 22 S., R. 2 W. Section 1B follows along the main ridge (Sec. 29) that separates South Cedar Ridge Canyon drainage from Sevier Valley drainage. This ridge is just to the northwest of the fault and essentially parallels it with a slight southwest divergence. The traverse for section 1B leaves the main ridge at the topographic level of the lower of two prominent flat steps in the mountain escarpment that parallels Sevier Valley. At the junction of the main ridge and this lower flat the traverse descends essentially north into South Cedar Ridge Canyon at the first accessible nose which allows access down to the top of the cliffs in the lower part of the canyon. Section 1B was physically traced from section 1C via several traverses through Strawberry and South Cedar Ridge Canyons and represents a vertically continuous stratigraphic section although spaced approximately six miles apart. The base of Section 1B begins at the base of the moderate reddish orange (10R6/6) distinct rounded ledge-forming unit immediately above the distinct pale purplish gray unit that crops out approximately 400 feet above the stream. The beds were measured at a 7 degree dip approximately South 45 degrees East. Accessibility to this area may be by road to the mouth of South Cedar Ridge Canyon and then by foot up the south canyon wall or by two wheeled trail machine up the remnants of a wood collecting road which is now a trail that begins on the northeast slope at the mouth of the canyon located in NW¼, Sec. 5, T. 23 S., R. 2 W.

1.80	Calcilutite with abundant fine to medium quartz; fresh surface is pale reddish brown (10R5/4), weathered surface is moderate reddish orange (10R6/6); medium bedding, ledge forming.	11	1358
1.79	Shale and siltstone, quartz; fresh and weathered surfaces are pale reddish brown (10R5/4); calcareous, very soft slope forming, bedding indeterminate:	30	1347
1.78	Siltstone, quartz, highly calcareous; fresh surface is yellowish gray (5Y7/2), weathered surface is moderate reddish orange (10R6/6); medium bedded, ledge and slope forming.	1	1317
1.77	Calcisiltite with very abundant quartz silt; fresh surface is grayish orange pink (5YR7/2), weathered surface is same with pale red (10R6/2) surface wash; medium bedding, ledge forming.	2	1316
1.76	Shale and siltstone, quartz, calcareous; fresh and weathered surfaces approximate grayish orange pink (5YR7/2); very soft slope forming, bedding indeterminate.	23	1314
1.75	Siltstone, quartz, highly calcareous and vesicular; fresh surface is a mottled dark yellowish orange (10YR6/6) and grayish orange pink (5YR7/2), weathered surface is yellowish gray (5Y8/1); medium bedding, slight ledge forming.	2	1291
1.74	Shale and siltstone, quartz, calcareous; fresh and weathered surfaces are approximately grayish orange		

	pink (5YR7/2); very soft slope forming, bedding indeterminate.	59	1289
1.73	Shale and siltstone, quartz, with very abundant gypsum in a lattice boxwork structure and irregular patches; fresh and weathered surfaces are grayish orange pink (5YR7/2) with whiter areas of gypsum concentrations; gypsum veins approximately 1/16" to 1/12" thick, very thick bedding, this unit forms a prominent intermittent ledge.	9	1230
1.72	Shale, very abundant quartz silt and abundant fine to coarse angular to rounded quartz sand highly calcareous; fresh surface is pale red (10R6/2), weathered surface is grayish pink (5R8/2); occasional very coarse angular quartz grains, abundant gypsum veinlets, very soft slope forming, bedding indeterminate.	28	1221
1.71	Sandstone, medium to coarse subangular to rounded quartz; fresh and weathered surfaces are yellowish gray (5Y8/1); occasional white gypsum veins up to ¼" thick, medium bedding, ledge forming; presence of unit is intermittent.	4	1193
1.70	Siltstone, quartz, with abundant shale and subangular to subrounded fine to medium quartz sand; fresh and weathered surfaces are pinkish gray (5YR8/1) with some white (5YRN9) gypsum veins; occasional coarse subangular quartz grains, very soft slope forming, bedding indeterminate.	35	1189
1.69	Sandstone, very fine, quartz; fresh and weathered surfaces are yellowish gray (5Y8/1); medium bedding, ledge forming.	1	1154
1.68	Calcilutite with abundant quartz silt; fresh surface is a mottled grayish pink (5R8/2) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4); very soft slope forming, bedding indeterminate.	21	1153
1.67	Sandstone, fine to medium rounded quartz, highly calcareous; fresh surface is a mottled pale red (5R6/2) and grayish pink (5R8/2), weathered surface is moderate reddish orange (10R6/6); medium bedding, ledge forming.	2	1132
1.66	Argillaceous calcilutite with abundant quartz silt; fresh surface is a mottled grayish pink (5R8/2) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4); very soft slope forming, bedding indeterminate.	22	1130
1.65	Calcisiltite with very abundant quartz silt to abundant fine to medium rounded quartz; fresh and weathered surfaces are pale red (10R6/2); very soft slope forming, bedding indeterminate.	11	1108
1.64	Siltstone to very fine sandstone, quartz, highly calcareous; fresh surface is predominantly yellowish gray (5Y8/1) with some pale reddish brown (10R5/4) layered areas, weathered surface is moderate reddish orange (10R6/6) surface wash and very pale orange (10YR8/2) with occasional pale reddish brown (10R 5/4) lenses along outcrop; some areas of medium quartz sand and occasional pebbles and cobbles and very fine bedded sandstone clasts with random orientations, very fine horizontal and graded bedding, occasional cross and trough bedding with unidirectional		

	properties indicating S. 30° E. and S. 10° E. currents, local areas of very thin laminated bedding to thick bedding with some bedding convex downward suggesting fillings, channel pinches out to the west and locally suggests a north to south bidirection, ledge forming, presence of unit is intermittent.	10	1097
1.63	Argillaceous calcilutite with abundant quartz silt and occasional subrounded fine to medium quartz; fresh and weathered surfaces are pale red (10R6/2) and pale reddish brown (10R5/4); very soft slope forming, bedding indeterminate.	11	1087
1.62	Calcarenite, very fine, with very abundant very fine to fine rounded quartz; fresh surface is pale red (5R 6/2), weathered surface is pale reddish brown (10R 5/4); medium bedding, ledge forming.	1	1076
1.61	Calcisiltite with very abundant argillaceous calcilutite and quartz silt; fresh and weathered surfaces are pale red (10R6/2); very soft slope forming, bedding indeterminate.	31	1075
1.60	Sandstone, very fine to fine subrounded to rounded quartz, highly calcareous; fresh and weathered surfaces are mottled yellowish gray (5Y8/1) and pale reddish brown (10R5/4); argillaceous calcilutite fillings suggesting burrows or solutioning, medium bedding, ledge forming, presence of unit is intermittent.	3	1044
1.59	Calcisiltite with very abundant argillaceous calcilutite and quartz silt; fresh surface is a mottled pale reddish brown (10R5/4) and pinkish gray (5YR8/1), weathered surface is pale reddish brown (10R5/4); very soft slope forming, bedding indeterminate.	32	1041
1.58	Calcisiltite with very abundant medium to coarse rounded quartz; fresh surface is a mottled grayish pink (5R8/2) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4); some vertical jointing, very thick bedding, ledge forming.	7	1009
1.57	Calcisiltite with very abundant quartz silt and occasionally medium to coarse subrounded to rounded quartz grains; fresh surface is pale red (5R6/2) with some mottling of pale reddish brown (10R5/4) and grayish pink (5R8/2), weathered surfaces are pale reddish brown (10R5/4); some sparry calcite, slope forming, bedding indeterminate.	44	1002
1.56	Siltstone, argillaceous calcilutite at base with occasional subrounded medium quartz grains to abundant fine to medium subangular to subrounded quartz with calcarenite in the upper portion; fresh surfaces are moderate reddish brown (10R4/6) at base to mottled pale reddish brown (10R5/4) and grayish pink (5R 8/2) at top, weathered surfaces are pale reddish brown (10R5/4); some vertical jointing, very thick bedding, cliff forming; the top of this unit forms prominent flat ledge out along the nose at the site of this traverse.	15	958
1.55	Conglomerate and calcisiltite with some argillaceous calcilutite and occasional subrounded medium to coarse quartz; fresh calcisiltite surface is mottled grayish pink (5R8/2) and pale reddish brown (10R5/4), weathered surface is moderate reddish brown (10R 6/6), fresh conglomerate and enclosed quartz sandstone lense surfaces are grayish orange pink (5YR7/2)		

	and moderate orange pink (5YR8/4), weathered surface is light brown (5YR6/4) and moderate reddish orange (10R6/6); conglomerate is pebbles and cobbles of pink, purple, white, red, and gray rounded quartzites, some dolomites, faint horizontal and cross-bedding traces indicating a general unidirectional north component, vertical jointing, very thick bedding, cliff forming, this conglomerate and enclosed sandstone lenses represent a channel which suggest a general bidirectional component of north to south.	11	943
1.54	Calcisiltite with very abundant quartz silt to occasional medium subrounded quartz; fresh surface is mottled pale red (10R6/2) and grayish pink (5R8/2), weathered surface is moderate reddish brown (10R4/6); some sparry calcite, vertical jointing, medium bedding, slope forming.	21	932
1.53	Calcisiltite with very abundant fine to coarse subrounded quartz; fresh surface is a mottled pale reddish brown (10R5/4), pale red (5R6/2) and grayish orange (10YR7/4), weathered surface is pale yellowish brown (10YR6/2) and moderate reddish orange (10R6/6); vertical joints filled with euhedral sparry calcite, weathering is in large spalling sheets, pale reddish brown sandy areas in upper half gradational with pale reddish brown calcisiltite in lower half, vertical jointing, very thick bedding, cliff forming.	30	911
1.52	Argillaceous calcilutite with some fine to coarse subrounded quartz; fresh and weathered surfaces are mottled moderate red (5R5/4) and grayish pink (5R 8/2); this unit weathers into rounded forms and small balls similar to unit 41, vertical jointing, thick bedding, cliff forming.	8	881
1.51	Calcisiltite with abundant quartz silt; fresh surface is a mottled grayish pink (5R8/2) and pale reddish brown (10R5/4) with some dark yellowish orange (10YR6/6), weathered surface is moderate reddish orange (10R6/6); occasional fine to medium subrounded quartz, slope forming, bedding indeterminate:	44	873
1.50	Calcisiltite with very abundant fine to occasional coarse subrounded quartz; fresh surface is a mottled grayish pink (5R8/2), pale red (5R6/2) and grayish orange (10YR7/4), weathered surface is moderate reddish orange (10R6/6); some predominantly vertical coarse grained solution or tube fillings, vertical jointing, very thick bedding, cliff forming.	15	829
1.49	Calcisiltite with argillaceous calcilutite tube fillings (from 1/8" diameter by 1" long to 1/2" diameter by 3" long); fresh surface is mottled grayish pink (5R 8/2) and moderate reddish brown (10R4/6), weathered surface is pale reddish brown (10R5/4); very abundant very fine subrounded quartz, tubular fillings as described in unit 48, occasional small dispersed pebbles, vertical jointing, thick bedding, slope and ledge forming.	22	814
1.48	Calcisiltite with abundant very fine to occasional subangular quartz; fresh surface is a mottled pale reddish brown (10R5/4) and grayish orange pink (10R8/2) with some grayish orange (10YR7/4), weathered surface is moderate reddish orange (10R6/6); tubular fillings 1/4" diameter by 1 1/2" long, basal part		

	contains very abundant quartz sand, contact between units 47 and 48 contains an intermittent large cobble-pebble layer, vertical jointing, very thick bedding, ledge forming.	7	792
1.47	Calcisiltite with abundant fine to occasional coarse subangular to subrounded quartz; fresh and weathered surfaces are mottled moderate reddish orange (10R 6/6) and moderate reddish brown (10R4/6); intermittent large cobble-pebble layer at top contact, vertical jointing, very thick bedding, slope forming.	10	785
1.46	Calcisiltite with very abundant very fine to medium subangular to subrounded quartz; fresh surface is a mottled moderate reddish brown (10R4/6), moderate reddish orange (10R6/6) and grayish pink (5R8/2), weathered surface is pale reddish brown (10R5/4); some fossil seeds in associated talus, vertical jointing, very thick bedding, cliff forming.	44	775
1.45	Argillaceous calcilutite with abundant calcisiltite; fresh surface is mottled moderate reddish orange (10R6/6) and moderate reddish brown (10R4/6), weathered surface is pale reddish brown (10R5/4); some fine to medium subrounded quartz and sparry calcite, slope forming, bedding indeterminate.	21	731
1.44	Calcisiltite containing abundant fine to medium subrounded quartz and irregular patches of argillaceous calcilutite; fresh and weathered surfaces are pale reddish brown (10R5/4), calcisiltite and moderate reddish orange (10R6/6), argillaceous calcilutite fillings of mottled moderate reddish orange (10R6/6), pale red (5R6/2), and medium light gray (5YRN6) calcisiltite; sparry calcite, some vertical elongate vugs, vertical jointing, very thick bedding, cliff forming.	5	710
1.43	Conglomerate, pebbles and cobbles of moderate pink (5R7/4), grayish orange (10YR7/4) and light brown (5YR5/6) quartzites; argillaceous calcilutite clasts of moderate reddish orange (10R6/6), abundant calcisiltite matrix; this unit is completely gradational with units 42 and 44, cliff forming.	1	705
1.42	Calcisiltite containing abundant fine to medium subrounded quartz and irregular patches of argillaceous calcilutite; fresh and weathered surfaces are pale reddish brown (10R5/4), calcisiltite and moderate reddish orange (10R6/6) argillaceous calcilutite, fillings of mottled moderate reddish orange (10R6/6), pale red (5R6/2) and medium light gray (5YRN6) calcisiltite; sparry calcite, some vertical elongate vugs, vertical jointing, very thick bedding, cliff forming.	17	704
1.41	Argillaceous calcilutite with abundant fine to medium subrounded quartz; fresh and weathered surfaces are a moderate reddish brown (10R4/6); weathers into rounded surfaces and ball structures, vertical jointing, thick bedding, slope forming.	3	687
1.40	Sandstone, medium to coarse subangular to subrounded quartz; fresh and weathered surfaces are pale reddish brown (10R5/4) with what appears to be fillings of light brown (5YR6/4) and pale red (10R 6/2) coarser and finer sands and silts; abundant argillaceous calcilutite matrix; vertical jointing, very thick bedding, cliff forming.	12	684

1.39	Calcisiltite with abundant argillaceous calcilutite, very fine calcarenite and fine to medium subangular quartz; fresh and weathered surfaces are predominantly pale reddish brown (10R5/4) with a mottled pale red (5R6/2), light gray (5YR7) coarser areas believed to represent solution fillings; vertical jointing, very thick bedding, cliff forming.	22	672
1.38	Argillaceous calcilutite containing intergradational areas of calcilutite, calcisiltite and some fine to medium subrounded quartz; fresh surface is mottled pale red (10R6/2) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4); some sparry calcite, coarser and finer textures are in distinct contrast similar to unit 37, occasional vugs with euhedral calcite, vertical jointing, very thick bedding, cliff forming.	11	650
1.37	Calcisiltite with some very fine calcarenite and very abundant fine to medium subrounded quartz; fresh surface is pale red (5R6/2) and mottled moderate orange pink (10R7/4) and pale reddish brown (10R5/4), weathered surface is moderate reddish brown (10R4/6), areas of coarser texture reddish brown in irregular contact with finer textured orange pink, containing faint tiny bedding planes suggesting fillings, abundant light gray essentially vertical elongate areas of coarser material, some of which are associated with jointing, very thick bedding, cliff forming.	27	639
1.36	Calcarenite, fine, with very abundant to medium subangular quartz; fresh surface is pinkish gray (5YR 8/1), weathered surface is moderate reddish orange (10R6/6); vertical jointing, very thick bedding, cliff forming.	6	612
1.35	Calcisiltite with subangular medium quartz grains in upper half; fresh and weathered surfaces are pale reddish brown (10R5/4); some areas of mottled pale red (5R6/2) and dark yellowish orange (10YR6/6) that resemble cavity fillings with faint bedding traces of coarser calcisiltite; sparry calcite, vertical jointing, very thick bedding, cliff forming.	25	606
1.34	Argillaceous calcilutite with minor amounts of calcisiltite; fresh and weathered surfaces are pale reddish brown (10R5/4); sparry calcite cement, thick bedding, slope forming.	14	581

1C. Section along the northwest nose of the north wall at the head of Strawberry Canyon in NE¼, NE¼, Sec. 13, T. 22 S., R. 3 W. This section begins at the top of the uppermost gray algal ball calcilutite located in the saddle on the sharp divide separating Strawberry Canyon and Trough Canyon drainage and proceeds from the base of a continuous slope that terminates in a series of prominent red step cliffs with the uppermost cliff capped by a conglomerate and sandstone lense. Beds dip at an angle of 5° approximately S. 45° W. Accessibility to this area is by forest service road from Willow Creek (T. 21 S., R 1½ W. and R. 2 W.) to the head of Strawberry Canyon (Sec. 13, T. 22 S., R. 3 W.) and then by foot.

1.33 Conglomerate, pebble to boulder size; general overall fresh and weathered surfaces are approximately grayish pink (5R8/2); predominantly pebbles and cobbles, mostly white, pink, gray and tan quartzites, abundant black calcilutite, some pebbles are bedded, occasional

	fine horizontal bedded thin sandstone lenses in this dense conglomerate, this unit caps the local western peak along the north ridge of Strawberry Canyon, some vertical jointing, very thick bedding, cliff forming.	55	567
1.32	Calcisiltite to very fine calcarenite; fresh surface is mottled pale red (5R6/2), dark yellowish orange (10YR6/6) and pale reddish brown (10R5/4), weathered surface is pale reddish brown (10R5/4); very fine subangular quartz common, vertical and occasional irregularly oriented coarser filled solution cavities (?), bedding medium to thick, slope and ledge forming.	22	512
1.31	Sandstone, fine to medium, angular to subrounded quartz, highly calcareous; fresh surface is pale red (10R6/2), weathered surface is a mottled moderate orange pink (10R7/4) and light olive gray (5Y6/1); vertical jointing, thick bedding, ledge forming, presence intermittent.	6	490
1.30	Calcisiltite, occasional fine subrounded quartz; fresh and weathered surfaces are pale reddish brown (10R 5/4); sparry calcite veinlets and patches, granular texture, medium bedding, ledge forming.	4	484
1.29	Sandstone, fine angular to subrounded quartz; fresh surface is grayish orange pink (10R8/2), weathered surface is a mottled moderate orange pink (10R7/4) and light brownish gray (5YR6/1); calcareous, medium bedded, ledge forming, presence intermittent.	3	480
1.28	Calcisiltite with abundant fine to medium subrounded quartz; fresh and weathered surfaces are pale reddish brown (10R5/4); sparry calcite, occasional small calcilutite areas, some vertical jointing, medium bedded, cliff forming.	18	477
1.27	Sandstone, fine to medium, angular to subrounded quartz; very highly calcareous; fresh surface is mottled pale red (10R6/2) and yellowish gray (5Y8/1), weathered surface is grayish orange pink (5YR7/2); bedding is thin to thick, cliff forming; this unit represents a channel filling, presence is intermittent.	0-15	459
1.26	Calcarenite, very fine, with argillaceous calcilutite to fine sand sizes; fresh and weathered surface are pale reddish brown (10R5/4); occasional to abundant fine to medium subrounded quartz, some sparry calcite veinlets and patches, occasional small black calcilutite rock fragments and sand-size grains, some pale reddish brown (10R5/4) argillaceous calcilutite pellets, some vertical light gray solution vugs and associated mottled pale purple, light gray, and dark yellowish orange calcisiltite to calcarenite fillings, vertical jointing, thick to very thick bedding, cliff forming.	44	444
1.25	Conglomerate, pebble to boulder sizes; weathered surface wash is pale reddish brown (10R5/4); this layer is contained within a cubic area of approximately 20' x 20' x 1', presence is local only, no channeling.	0-1	400
1.24	Sandstone, fine to medium, angular to rounded quartz; fresh and weathered surfaces are pale reddish brown (10R5/4); black calcilutite rock fragments and sand-size grains, occasional pebbles, thick to very thick bedding, cliff forming.	13	399

1.23	Conglomerate, predominantly cobble to boulder sizes; fresh surface is grayish orange (10R7/4), weathered surface is moderate reddish brown (10R4/6) wash; white, pink, and tan quartzites; some black calcilutites, medium subangular quartz sand matrix, some vertical jointing, very thick bedding, cliff forming; this unit represents a channel filling and presence is intermittent.	0-16	386
1.22	Calcarenite, very fine, with very abundant fine to medium subangular to subrounded quartz; fresh surface is pale red (10R6/2), weathered surface is moderate reddish brown (10R4/6); basal portion contains areas of calcisiltite and argillaceous calcilutite, occasional coarse to very coarse sand-size black calcilutite grains, some vertical jointing, very thick bedding, cliff forming.	27	370
1.21	Calcisiltite with calcilutite areas; fresh surface is pale red (5R6/2), weathered surface is pale reddish brown (10R5/4); sparry calcite patches, vugs, and veinlets, limited light gray pellets, some fine to medium subangular quartz, vertical jointing, thick to very thick bedding, cliff forming.	23	343
1.20	Sandstone, fine subangular quartz, very highly calcareous; fresh and weathered surfaces are pale reddish brown (10R5/4); thick bedding, ledge forming.	3	320
1.19	Calcisiltite; fresh and weathered surfaces are moderate reddish brown (10R4/6); some fine subrounded quartz grains, pellets in places, upper part of unit has light grayish vertical solution holes and fillings of pale red (5R6/2), calcisiltite coarser than matrix and is similar to unit 32, base of this unit is the pale reddish brown base of the massive cliff units along the upper North Strawberry Canyon wall, very thick bedding, some vertical jointing, cliff forming.	35	317
1.18	Calcisiltite with calcilutite and argillaceous calcilutite pellets and clasts; fresh surface is moderate reddish orange (10R6/6) to moderate orange-pink (5YR8/4) with light gray pisolites and clasts, weathered surface is pale reddish brown (10R5/4; clasts are spherical and irregular and vary from ¼" to 1" in diameter, some evidence of banded algal structure, very thick bedding, steep slope and cliff forming.	33	282
1.17	Calcarenite, very fine, with abundant fine subrounded quartz; fresh surface is pale red (5R6/2) and light gray (5YRN7), weathered surface is light gray (5YRN7) and grayish orange (10YR7/4); spherical and elongate algal fragments and very fine bedded siltstone fragments contained at various angles, thick bedding, ledge forming.	5	249
1.16	Calcilutite with some argillaceous calcilutite; fresh and weathered surfaces are moderate reddish orange 10R6/6) with medium light gray (5YRN6); calcilutite and argillaceous calcilutite pellets, sparry calcite veinlets, vertical jointing, thick bedding, steep slope and cliff forming.	18	244
1.15	Calcarenite, very fine, and calcilutite; fresh surface is medium light gray (5YRN7), weathered surface is very light gray (5YRN8); abundant fine to very fine rounded quartz, calcilutite clasts, intermittent bedded siltstone clasts at various angles (this may represent		

	either algal material or a broken-up thin lake bed), sparry calcite, vertical jointing, thick to very thick bedding, cliff forming.	8	226
1.14	Calcilutite with some argillaceous calcilutite and calcisiltite; fresh surface is a mottled (with some banding) pale red (5R6/2), dark yellowish orange (10YR 6/6), very light gray (5YRN8) and pale reddish brown (10R5/4), weathered surface is moderate reddish orange (10R6/6); pellet and clast zones, black fossil seeds (⅛" to ¼" in diam.) and shell fragments, abundant vertical solution fillings and light gray vugs with some containing argillaceous calcilutite and calcisiltite and others containing euhedral creamy and sparry calcite crystals up to ¾" in diam., vertical jointing, bedding is thick to very thick and weathers to a rounded rubbly texture; base is slope forming with upper cliff forming.	29	218
1.13	Calcarenite, very fine with abundant fine-rounded quartz; mottled coloring of fresh and weathered surfaces is grayish orange-pink (5YR7/2), weathered surface is moderate reddish orange (10R6/6); some sparry calcite and algal balls, top of unit is thin bedded with thin layers of moderate reddish orange (10R6/6), calcilutite and calcisiltite pellets in a calcilutite matrix, vertical solution vugs on some surfaces, vertical jointing, thick to very thick bedding, cliff forming.	40	189
1.12	Calcilutite with calcilutite and argillaceous calcilutite pellets; fresh surface is light gray (5YRN7) to pale red (10R6/2)with pale reddish brown (10R5/4) and medium light gray (5YRN6) pisolites, weathered surface is grayish orange-pink (5YR7/2); sparry calcite in upper portion, slope forming, bedding indeterminate.	32	149
1.11	Conglomerate, pebble and very fine calcarenite with very abundant fine subrounded quartz, occasional cobble sizes; fresh surface is pale red (5R6/2), weathered surface is grayish orange-pink (5YR7/2); forms a sloping top of cliff-forming unit 10 below; bedding is indeterminate, within ½ mile this unit is less than 1 ft. thick.	5	117
1.10	Calcilutite with some argillaceous calcilutite and calcisiltite areas; fresh surface is pale red (5R6/2) with pale reddish brown (10R5/4) and light gray (5YRN7) micrite limestone pellets, weathered surface is a moderate reddish orange (10R6/6); sparry calcite veinlets and patches, slight granular texture on some weathered surfaces, thick to very thick bedding, cliff forming.	26	112
1.9	Argillaceous Calcilutite; fresh and weathered surfaces are pale red (5R6/2); slope forming, bedding indeterminate.	2	86
1.8	Sandstone, fine-rounded quartz, highly calcareous; fresh and weathered surfaces are pale red (5R6/2); medium to thick bedding, ledge forming, presence of unit is intermittent.	2	84
1.7	Calcisiltite with calcilutite in some areas; fresh surface is mottled pale reddish brown (10R5/4), pale red (5R6/2), dark yellowish orange (10YR6/6); weathers to a mottled grayish orange (10YR7/4) and gray-		

	ish pink (5R8/2); patches and veinlets of sparry calcite, occasional rounded fine quartz grains, slope forming; bedding is indeterminate.	36	82
1.6	Calcilutite, nodular; fresh surface is grayish pink (5R8/2), weathered surface is pinkish gray (5YR 8/1); thin to thick bedding, ledge forming.	4	46
1.5	Calcilutite; fresh and weathered surfaces are pink (10R7/4); very soft slope forming, bedding indeterminate.	3	42
1.4	Sandstone, fine, rounded quartz; fresh surface is grayish pink (5R8/2), weathered surface is moderate orange-pink (10R7/4); well indurated, highly calcareous, thin bedding, ledge forming.	2	39
1.3	Calcilutite with some argillaceous calcilutite; fresh surface is mottled light gray (5YRN7), grayish pink (5R8/2), pale reddish brown (10R5/4) and dark yellowish orange (10YR6/6), weathered surface is moderate orange-pink (10R7/4); sparry calcite veinlets, some gastropod fragments and elongate round forms suggesting tube fillings ¼" in diameter by 2" long, slope forming, bedding indeterminate.	20	37
1.2	Calcilutite with some argillaceous calcilutite; fresh and weathered surfaces are mottled grayish orange pink (5YR7/2) and pale yellowish orange (10YR 8/6) with the latter predominate; soft slope forming, bedding indeterminate.	6	17
1.1	Calcilutite, with some argillaceous calcilutite; fresh surface is mottled light gray (5YRN7), grayish pink (5R8/2), pale reddish brown (10R5/4), and dark yellowish orange (10YR6/6), weathered surface is moderate orange-pink (10R7/4); sparry calcite, gastropod fragments, elongate rounded forms suggesting tube fillings, slope forming, bedding indeterminate.	11	11

North Horn Formation

Calcilutite; fresh surface is light olive-gray (5Y6/1), weathered surface is medium light gray (5YRN6); abundant algae balls.

CEDAR BREAKS SECTION
STRATIGRAPHIC SECTION No. 2

Cedar Breaks National Park

2A. Section is measured along the nose between Labyrinth and Highleap Canyons, Sec. 23, T. 36 S., R. 9 W., Cedar Breaks National Monument. The base of section 2A begins at the top of the prominent lower white limestone at which section 2B terminated and thus represents a continuous measurement. The beds were measured at a 3° dip approximately N. 10° E. Access to the area is via foot from the northern monument boundary.

Brian Head Formation

Cedar Breaks Formation

2.65	Sandstone, from medium subangular quartz to small subrounded pebbles; fresh surface is a light greenish gray (5GY8/1), weathered surface is grayish orange (10YR7/4) to pale yellowish brown (10YR6/2); highly calcareous, sparry calcite, lower portion contains white and pink marl clasts (¼-½" diam.) interspersed with small pebbles.	10	1434

2.64	Calcisiltite; fresh surface is mottled dark yellowish orange (10YR6/6) and light gray (5YRN7); medium bedding, slope forming.	26	1424
2.63	Calcarenite, with abundant fine subangular quartz; fresh surface is very light gray (5YRN8), weathered is grayish orange (10YR7/4); faint bedding traces and tiny marl inclusions, medium bedded, ledge forming, granular texture; small (1 foot thick by 2 feet wide) channel cross-bedding showing a bidirectional orientation that runs east-west.	2	1398
2.62	Calcisiltite with some fine subrounded quartz; fresh surface is mottled dark yellowish orange (10YR6/6) and very light gray (5YRN8), weathered surface is grayish orange-pink (5YR7/2); ledge forming, medium bedded, occasional sparry calcite and small pink, marly inclusions.	1	1396
2.61	Calcilutite, argillaceous calcilutite at bottom to calcilutite at top; fresh surface is a mottled light gray (5YRN7), grayish pink (5R8/2), and moderate grayish orange-pink (10R7/4), weathered is moderate orange-pink (10R8/2) at base to pale yellowish orange (10YR8/2) at top; some sparry calcite, slope forming, bedding indeterminate.	14	1395
2.60	Calcarenite, abundant fine- to medium- subangular quartz; fresh surface is mottled moderate reddish orange (10R6/6) and light gray (5YRN7), weathered surface is moderate reddish orange (10R6/6); irregular clay-marl patches representing either inclusions or solution fillings, granular texture, medium bedded, ledge forming.	1	1381
2.59	Calcilutite with some areas of argillaceous calcilutite; fresh surface is mottled very light gray (5YRN8) and light brown (5YR6/4), weathered surface is grayish pink (5R8/2) at top to moderate reddish orange (10R6/6) at bottom; phlogopite and biotite mica common near base, slope forming, bedding indeterminate.	38	1380
2.58	Calcarenite with abundant fine to medium subangular quartz; fresh and weathered surfaces are very light gray (5YR8); medium bedded, ledge forming.	3	1342
2.57	Calcisiltite; fresh surface is pale red (5R6/2), weathered surface is grayish orange (10YR7/4); rare biotite and phlogopite mica, thick bedding, steep slope forming.	7	1339
2.56	Calcisiltite, granular texture; fresh surface is mottled grayish orange pink (5YR7/2) and very light gray (5YRN8), weathered surface is grayish orange (10YR 7/4); abundant phlogopite and biotite micas, thick bedding, ledge forming.	2	1332
2.55	Calcisiltite; fresh surface is pale red (5R6/2), weathered surface is moderate reddish orange (10R6/6); rare biotite and phlogopite mica, abundant marl clasts (1/5-1/10" diam.), thin to thick bedding, slope and ledge forming.	5	1330
2.54	Dolomitic calcilutite and calcilutite, clasts; fresh surface is a medium light gray (5YRN6) with occasional grayish orange (10YR7/4) mottling, weathered surface is white (5YRN9) to very light gray (5YRN8); dolomitic calcilutite dominates lower and calcilutite		

	dominates upper portions of unit, some chalky calcilutite areas, dense calcilutite show faint-bedded structures in a coarser matrix, bedding close-up is thin, wavy, irregular, and weathers rubbly, but overall outcrop is very thick; occasional vugs and veins of euhedral calcite, portions of the rock are vesicular and contains sparry calcite, some areas contain silt and fine sand-size particles suggesting solution fillings, some of which are rimmed by calcite, faint dolostone calcilutite clast inclusions near base (½-2" diam.) suggesting the possibility of a clast breccia; vertical jointing, cliff forming, (This unit forms the uppermost massive white cliff-forming unit at Cedar Breaks.)	60	1325
2.53	Calcilutite; fresh and weathered surfaces are white (5YRN9); some anhedral and euhedral sparry calcite; a 2-3 foot intermittent zone weathers moderate greenish yellow (10Y7/4); very soft slope forming, bedding indeterminate.	38	1265
2.52	Argillaceous Calcilutite, some fine subangular quartz grains and mica flakes; fresh surface is mottled pale reddish brown (10R5/4) and dark yellowish orange (10YR6/6), weathered surface is pale reddish brown (10R5/4); very soft slope forming, bedding indeterminate.	54	1227
2.51	Calcarenite, abundant fine subrounded quartz and sparry calcite; fresh surface is grayish orange (10YR 7/4), weathered surface wash is moderate reddish orange (10R6/6); occasional mica flakes, ledge forming, ledges intermittent.	2	1173
2.50	Argillaceous calcilutite, common fine subangular quartz grains, rare mica flakes and sparry calcite; fresh surface is mottled pale reddish brown (10R5/4) and dark yellowish orange (10YR6/6), weathered surface is moderate reddish orange (10R6/6); slope forming, bedding indeterminate.	25	1171
2.49	Calcilutite with some areas of argillaceous calcilutite; fresh surface is mottled moderate orange pink (10R 7/4) and white (5YRN9); some pellets, thin to medium bedding, slope to weak ledge forming.	7	1146
2.48	Calcilutite with pellets and calcilutite rock fragments; fresh surface is white (5YRN9) with medium dark gray (5YRN4) rock fragments, weathered surface is white (5YRN9); rock fragments range from 1/32 to 1½" in diameter, are irregular in shape; sparry calcite veinlets, thin to medium bedding, ledge forming.	22	1139
2.47	Calcilutite with argillaceous calcilutite pellets; fresh matrix color is very light gray (5YRN8) with pisolites and pellets of white (5YRN9) and medium light gray (5YRN6), weathered surface is white (5YRN9); some sparry calcite, pellet-pisolite size ranges from 1/20" diameter to 0.1" x 0.2"; slope forming, bedding indeterminate.	16	1117
2.46	Argillaceous calcilutite, occasional fine subangular quartz; fresh and weathered surfaces are grayish pink (5R8/2); slope forming, bedding indeterminate.	49	1101
2.45	Sandstone, coarse, subangular, highly calcareous; fresh surface is yellowish gray (5Y8/1), weathered surface wash is moderate orange-pink (10R7/4); medium bedding, ledge forming.	2	1052

2.44	Argillaceous calcilutite, some fine to very fine subrounded quartz; fresh furface is grayish pink (5R8/2), weathered surface is pale red (5R6/2) to grayish pink 5R8/2); slope forming, bedding indeterminate.	10	1050

2B. Section traverse is along "Adams Barrier," Cedar Breaks National Monument. It commences at the top of the tan Kaiparowitz Formation and at the base of a massive red cliff-forming unit in NW½, Sec. 27, T. 36 S., R. 9 W., (approximate elevation 8,700 feet) and continues up the nose for roughly one mile to the top of the lower distinct white limestone unit readily visible along the upper canyon walls. Although not previously mapped, the nose of Adams Barrier is faulted down an estimated 85 feet, and this was allowed for in the measurements. The beds were measured at a 3° dip approximately N. 10° E. Accessability to this traverse is either from the top by foot from the monument roads or from the bottom via a primitive road intersecting Highway 14 at NE¼, Sec. 12, T. 37 S., R. 10 W. and ending in Ashdown Creek, approximately in Sec. 29, T. 36 S., R. 9 W. and then by foot upstream about one mile to the base of Adams Barrier. Entrance to and from the Barrier is usually blocked by the lower massive red cliff-forming unit; however, there is passage through this cliff on the southeast and southwest flanks of the nose terminus.

2.43	Calcilutite with some argillaceous calcilutite containing pisolites, sparry calcite, and lime-clay pellets; fresh and weathered surfaces are white (5YRN9); occasional gastropods (¼" in diam.) and tubes (¼" in diam. x 1½" long) suggesting fillings, bedding medium to thick, bedding planes are wavy and irregular, unit 43 forms the upper part of the lowermost of the two massive white cliffs at the top of Cedar Breaks.	47	1040
2.42	Calcilutite, abundant clay-lime pellets; fresh and weathered surfaces are white (5YRN9); rock weathers massive, medium to thick bedding, cliff forming.	3	993
2.41	Calcilutite, with some argillaceous calcilutite; fresh and weathered surfaces are predominantly white (5YRN9) near top to moderate orange-pink (10R 7/4); sparry calcite veinlets, massive bedding, rock weathers rubbly with pink marly areas, lower 3 feet at base has fine wavy bedding planes (1/16-1/8" thick) of calcite and silica spaced approximately ¼" apart; unit bedding is very thick, cliff forming.	10	990
2.40	Calcilutite with abundant lime pellets, some sparry calcite; fresh and weathered surfaces are moderate orange-pink (10YR7/4), and occasionally moderate reddish orange (10R6/6) areas (8 in. wide by 15 in. long) extend down into unit 39 from contact with unit 40, bedding medium, cliff and slope forming.	9	980
2.39	Argillaceous Calcilutite, some argillaceous pellets and sparry calcite; fresh surface is mottled white (5YRN9) and moderate pink (5R7/4), weathered surface is pale red (5R6/2); slope forming, bedding indeterminate.	20	971
2.38	Calcarenite with subrounded, fine to medium quartz sand grains; fresh surface is very light gray (5YRN8), weathered surface is grayish orange-pink (5YR7/2); abundant euhedral sparry calcite grains, horizontal and cross-bedding with current direction S. 40° W., medium bedding, some slight graded bedding (coarse at bottom to fine at top), ledge forming, presence of unit is intermittent.	3	951

2.37	Argillaceous calcilutite, some argillaceous pellets and sparry calcite; fresh and weathered surfaces are grayish orange (10YR7/4); weathered surface evidences slight granular texture, slope forming, bedding indeterminate.	23	948
2.36	Calcisiltite, with subrounded, fine sand-size quartz grains and sparry calcite; fresh surface is pale red (10R6/2), weathered surface is moderate reddish orange (10R6/6); slope forming, bedding indeterminate.	14	925
2.35	Sandstone, fine to medium subrounded quartz to small pebble size, highly calcareous; fresh surface is yellowish gray (5Y7/2), weathered surface is grayish orange pink (5YR7/2); wavy irregular basal contact, vertical jointing, faint traces of horizontal, graded, and cross-bedding, bedding very thick, ledge forming.	7	911
2.34	Calcisiltite and sandstone, fine to medium subangular quartz grains, highly calcareous; fresh surface is mottled pale yellowish orange (10YR8/6), moderate orange-pink (10R7/4), grayish pink (5R8/2), weathered surface is moderate reddish orange (10R6/6); quartz sandstone occupies irregular areas in the calcisiltite and vice versa, thin to medium bedding, ledge forming where protected by overhang of unit 35.	4	904
2.33	Calcarenite and calcisiltite with abundant fine to coarse subangular quartz grains; fresh surface is a mottled moderate orange-pink (10R7/4), pale yellowish orange (10YR8/6), grayish pink (5R8/2), weathered surface is moderate reddish orange (10R6/6); sparry calcite, sand size more abundant in lower half and silt in upper half, slope forming, bedding indeterminate.	85	900
2.32	Sandstone, fine to medium subangular quartz; highly calcareous with abundant sparry calcite; fresh and weathered surfaces are grayish orange-pink (5YR7/2), weathered wash is moderate reddish orange (10R6/6); vertical jointing, bedding is thick to very thick, ledge forming, presence of unit is intermittent.	10	815
2.31	Calcisiltite, occasional sparry calcite; fresh surface is a mottled pale red (5R6/2), grayish pink (5R8/2), grayish orange (10YR7/4), weathered surface wash is moderate reddish orange (10R6/6); slope forming, bedding indeterminate.	24	805
2.30	Sandstone, fine, subrounded quartz, highly calcareous; fresh and weathered surface are grayish orange-pink (5YR7/2); thick bedding, ledge forming; presence of unit is intermittent.	4	781
2.29	Calcisiltite in lower half to calcarenite in upper half, abundant sparry calcite and fine subrounded quartz sand; fresh surface is a mottled dark yellowish orange (10YR6/6), grayish orange-pink (5YR7/2), moderate orange-pink (10R7/4), weathered surface is moderate reddish orange (10R6/6); predominantly slope forming, bedding indeterminate.	67	777
2.28	Sandstone, conglomerate and calcilutite, subrounded fine quartz sand to pebble-size highly calcareous, traces of cross and graded bedding, vertical jointing, occasional cobbles, irregular basal contact with 1 ft. refief, very thick bedding; Conglomerate is from pebble to cobble-size, well-rounded pink, white quartzites, black odiferous calcilutites; some argil-		

	laceous calcilutite, with sparry calcite and subangular fine quartz grains, ledge and slope forming; these lithologies occur as facies changes in less than 200 ft. along the outcrop.	4	710
2.27	Calcilutite from calcilutitic in lower half to calcarenitic in upper half; fresh surface is mottled dark yellowish orange (10YR6/6), pale red (5R6/2), grayish pink (5R8/2), moderate orange-pink (10R7/4), and moderate reddish orange (10R6/6), weathered surface is moderate reddish orange (10R6/6); weathered rock evidences a granular texture, abundant euhedral sparry calcite vein and vugs in limited areas, occasional very fine subrounded quartz sand grains, abundant irregular essentially vertical vugs (1 in. diam. by 3 ft. long), some partially clay filled, some parallel vertical joints, occasional fossil seeds in basal part; bedding is very thick at bottom to thin at top, cliff and slope forming.	38	706
2.26	Calcilutite, size and texture range from calcilutite to pebble-size calcilutite and lime-clay clasts; fresh surface is mottled gray-pink (5R8/2), moderate orange-pink (10R7/4), moderate reddish orange (10R6/6), weathered surface is moderate reddish orange (10R 6/6); black fossil seeds from 1/8" to 1/4" in diam., lime and clay-clast spherical and oblate pellets 1/16" to 1" in diam., very fine-bedded siltstone fillings or inclusions, euhedral calcite pockets and very light gray (5YRN8) vug-like areas of calcite and siltstone, rubbly weathered surfaces, vertical jointing; bedding as a unit is very thick, close up bedding planes are wavy and irregular, cliff forming.	48	668
2.25	Calcilutite, calcarenitic with clast inclusions; fresh surfaces are mottled pale red (5R6/2) and moderate reddish orange limeclasts (10R6/6), weathered surface is moderate reddish orange (10R6/6); some fine-rounded quartz sand grains, occasional sparry calcite veinlets rimming limeclast inclusions, vertical jointing, very thick bedding, cliff and slope forming.	18	620
2.24	Calcilutite, slightly calcarenitic and finely vesicular, sparry calcite veinlets; fresh surface is faintly mottled grayish orange-pink (10R8/2) and white (5YRN9), weathered surface is moderate reddish orange (10R 6/6) when surface wash is present and white (5YRN9) when exposed without the presence of covering strata wash; vertical jointing, medium to very thick bedding, cliff forming.	20	602
2.23	Calcilutite, some areas argillaceous and calcarenitic, occasional sparry calcite; fresh surface is mottled grayish pink (5R8/2) and moderate orange-pink (10R 7/4), weathered surface is moderate reddish orange (10R6/6); abundant fossil shell fragments, vertical jointing, predominantly very thick bedding with occasional thick bedding, close-up bedding is wavy and irregular, cliff forming, forms the upper part of the hoodoo sequence at Cedar Breaks.	78	582
2.22	Sandstone, quartz, very fine at the top to coarse at bottom, very calcareous; fresh surface is a very light gray (5YRN8), weathered surface is pale yellowish brown (10YR6/2) when not covered by wash from upper rocks; irregular silt-size fragments elongate and randomly oriented suggesting a thin broken bed re-		

	tained in basal sediments, basal contact relief is approximately two feet with basal area of unit 22 containing clay pellets incorporated from unit 21, traces of horizontal bedding in lower part of unit, appearance intermittent, suggests pinch out.	10	504
2.21	Argillaceous calcilutite, occasional fine rounded quartz sand grains; fresh surface is mottled grayish pink (5R8/2) and grayish orange-pink (10R8/2), weathered surface is moderate reddish orange (10R 6/6), pelletal texture, top of unit reworked by unit 22, medium to thick bedding, cliff forming.	19	494
2.20	Calcilutite, argillaceous areas; fresh surface mottled grayish pink (5R8/2), pale yellowish orange (10YR 8/6), weathered surface is a moderate reddish orange (10YR6/6); some granular weathered surfaces, some intermittent, rounded, fine quartz sand grains, vertical jointing, base has occasional limeclast and pelletal structure (1/16 to 1/2 inches in diam.), thin, wavy irregular bedding close up, unit bedding is thick to very thick, forms the base of the hoodoo section of Cedar Breaks, cliff forming.	58	475
2.19	Calcilutite, calcarenitic with sparry calcite and rounded, very fine quartz grains; fresh surface is mottled grayish pink (5R8/2) and pale yellowish orange (10R 8/6), weathered surface is moderate reddish orange (10R6/6); slope forming, bedding indeterminate.	22	417
2.18	Calcilutite, dolomitic, some calcarenite grains; fresh and weathered surfaces are mottled pale yellowish orange (10YR8/6) and very pale orange (10YR8/2) with a few faint moderate pink (5R7/4) zones in the lower and middle parts; rare fine, rounded quartz sand grains, bedding thin where exposed, weathers to a rubbly surface, bedding planes are wavy, traces of fine cross-bedding on some weathered surfaces, slope forming, forms the white slopes above the basal red cliffs of Cedar Breaks.	77	395
2.17	Calcilutite, calcarenitic with some fine subrounded, transparent quartz grains and sparry calcite; fresh surface is grayish pink (5R8/2), weathered surface is moderate reddish orange (10R6/6); bedding thin to thick, slope and ledge forming.	18	318
2.16	Sandstone, quartz, sizes range from fine sand at top to pebbles at bottom, very calcareous; fresh surface is light gray (5YR7), weathered surface is pale yellowish brown (10YR6/2) very irregular basal contact with fingers approximately 6" wide and 2' deep extending irregularly down into unit 15, fingers range from 18" to 3' apart, basal contact relief other than fingers is 1 foot, horizontal bedding becoming vertical when curving down into the fingers, cliff forming; this unit has a convex upper contact pinch out in one direction at outcrop.	9	300
2.15	Calcarenite with occasional rounded, very fine quartz sand grains; fresh surface is mottled grayish pink (5R8/2) and white (5YRN9), weathered surface is moderate reddish orange (10R6/6); rubbly weathered surface, euhedral calcite vuggy patches, some very fine laminated siltstone inclusions and limeclast pellets in basal part, vertical jointing, bedding is very thick in middle, to thick in lower part, and thin in upper and		

	becomes more quartz sandy toward the top as the reworked gradational boundary of units 16-15 is approached, cliff forming.	29	291
2.14	Calcilutite calcarenitic; fresh surface is grayish pink (5R8/2), weathered surface is moderate orange-pink (10R7/4), slope forming, bedding indeterminate.	22	262
2.13	Sandstone, quartz, rounded medium sand to rounded pebble size, highly calcareous; fresh surface is very light gray (5YR8), weathered surface is pale yellowish brown (10YR6/2); traces on weathered surfaces of horizontal and cross-bedding, some graded bedding zones; distinct lower contact which includes reworked material from the top of unit 12, vertical jointing, thick bedding, ledge forming, presence of sandstone is intermittent.	17	240
2.12	Calcilutite, some calcarenite grains and sparry calcite veinlets, rare fine quartz sand grains; fresh surface is grayish pink (5R8/2), weathered surface is pale yellowish orange (10YR8/6); slight granular texture on weathered surfaces, slope forming, bedding indeterminate.	21	223
2.11	Sandstone, ranges from silt to pebble sizes, very calcareous; fresh surface is very light gray (5YR8), weathered surface is pale yellowish brown (10YR 6/2); most pebbles are rounded limeclasts, some silt size; twisted, spherical and elongate bedded inclusions approximately 1" x 4" randomly oriented; irregular lower contact, horizontal and cross-bedding, thick bedded, ledge forming.	11	202
2.10	Calcilutite calcarenitic, with some rounded fine quartz sand and sparry calcite grains; fresh surface is pale red (5R6/2) to grayish pink (5R8/2), weathered surface is pinkish gray (5YR8/1), slope forming, bedding indeterminate.	18	191
2.9	Calcarenite with some fine rounded to subrounded quartz sand grains, abundant sparry calcite; fresh surface is mottled pale red (5R6/2) and light gray (5YRN8), weathered surface is pale yellowish brown (10YR6/2); weathers blocky, thick bedded, ledge forming.	8	173
2.8	Calcilutite, with occasional calcarenite and rounded quartz sand grains, sparry calcite; fresh surface is light gray (5YRN7) to pale red (5R6/2), weathered surface is pale yellowish orange (10YR8/6); thick bedded, ledge and slope forming.	12	165
2.7	Calcilutite, with sparry calcite veinlets; middle of unit fresh and weathered surfaces are dark yellowish orange (10YR6/6), upper and lower parts of unit fresh surfaces are pale red (5R6/2), weathered surfaces are moderate reddish orange (10R6/6); vertical jointing, very thick bedding, cliff forming.	15	153
2.6	Calcilutite, with sparry calcite; fresh and weathered surfaces at base of unit are pale red (5R6/2) to top of unit where surface is grayish orange pink (5YR 7/2) and weathered surface is grayish orange (10YR 7/4); basal portion contains nodules (1/16" to 1/4" in diam.) of calcilutite, upper part of unit contains spherical and oblate banded inclusions from 2" in diameter to 1 x 2'; very thick bedding, cliff forming.	16	138

2.5	Calcarenite, occasional fine rounded quartz sand grains, all grains translucent to transparent, abundant sparry calcite; fresh surface is mottled moderate orange-pink (10R7/4) and very light gray (5YR8), weathered surface is moderate reddish orange (10R6/6); vertical jointing, very thick bedding, cliff forming.	6	122
2.4	Calcisiltite, with occasional sparry calcite; fresh and weathered surfaces are mottled moderate reddish orange (10R6/6) and dark yellowish orange (10YR 6/6), vertical jointing, thick to very thick bedding, cliff forming.	17	116
2.3	Calcilutite, some sparry calcite; fresh surface is moderate red (5R5/4), weathered surface is moderate red (5R4/6); vertical jointing, bedding is very thick at top and bottom with a partial steep slope in between, predominantly cliff forming.	36	99
2.2	Calcilutite, with sparry calcite grains; fresh surface is dark yellowish orange (10YR6/6), weathered surface wash is moderate reddish orange (10R6/6); vertical jointing, very thick bedding, cliff forming.	7	63
2.1	Calcisiltite, occasional very fine rounded quartz sand and abundant sparry calcite in upper part of unit, lower part of unit fresh surface is pale reddish brown (10R5/4) with dark yellowish orange (10YR6/6) along bedding planes, weathered surfaces are moderate reddish orange (10R6/6); vertical jointing, faint traces of horizontal and cross-bedding, thick to very thick bedding, cliff forming; this unit forms the base of the prominent lowermost red cliff at Cedar Breaks, basal contact with Kaiparowitz Formation appears conformable.	56	56

Kaiparowits Formation

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