
COLTON FORMATION (EOCENE: FLUVIATILE) AND ASSOCIATED LACUSTRINE BEDS, GUNNISON PLATEAU, CENTRAL UTAH[1]

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ABSTRACT

The Colton Formation consists mostly of fluvial (floodplain and channel) deposits that are less resistant and more highly colored than the adjacent lacustrine beds of the Flagstaff and Green River Formations. The contrast between the fluviatile and lacustrine strata is indicated by several lithic and faunal characteristics that occur in a short stratigraphic interval, and that permit precise and regionally persistent recognition of the limits of the Colton Formation. The Colton is distinguished by: 1) red, yellow, or brown, fine- to medium-grained, micaceous, feldspathic subangular sandstones that are cross-bedded, thick-bedded, laterally non-persistent, and typically lens-shaped in cross-section; 2) red, green, or purple, somewhat silty or sandy mudrocks and shales that are poorly fossiliferous and poorly bedded; 3) limestone beds, locally of pastel colors, that are generally less than 1 foot thick, non-persistent, tough, platy and poorly fossiliferous; 4) far fewer fossil snails and clams than the regionally continuous carbonate units of the middle and upper Flagstaff Formation.

In contrast, lacustrine beds that bound the Colton Formation are characterized by the following features; 1) pale grey, fine-grained, subrounded sandstones, without cross-bedding, that are rather thin and widespread (Flagstaff only); 2) yellow-brown or gray, thin-bedded, tough and platy limy shales that are fossiliferous and interbedded with limestone and dolomite units; 3) limestones and dolomites of several petrographic types that are two feet thick or more, and laterally persistent.

When distinguished by the sum of these characteristics, the Colton consists in the central Gunnison Plateau of a northward-thinning wedge. From a thickness of 800 feet at South Maple Canyon, it thins to less that 550 feet at Wales Canyon, north of which it has been removed by erosion. The formation becomes much more clastic toward the north in the area studied.

INTRODUCTION

Early Tertiary formations in central Utah consist largely of rocks of lacustrine or fluviatile origin, or both. These thick and widespread units have been distinguished generally and regionally for some years (Spieker, 1946; 1949), but detailed stratigraphic distinctions are also needed. Facies changes within the several formations and gradations between formations can be better understood

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and described if precise lithic distinctions have been made. The differences between the mostly lacustrine Flagstaff and Green River Formations and the intervening mostly fluviatile Colton Formation on the Gunnison Plateau, a location nearly central to their occurrence in Utah, are the subjects of the present investigation. A subordinate objective is the determination of the northerly extent of the Colton Formation in the Gunnison Plateau.

The standard works on these formations are those by Spieker (1946; 1949). A number of his students, including Gilliland (1951), have also contributed to the knowledge of these beds in parts of central Utah, though much of this work remains unpublished.

The Flagstaff Limestone of the Wasatch Plateau is described by Spieker (1946: 136) as ". . . dominantly freshwater limestone of many kinds, with interbedded gray shale and minor amounts of sandstone, gypsum, oil shale, and volcanic ash." Gilliland (1951: 25–26) used the term Flagstaff Formation because of the significant volume of clastics that occurs in the unit in the southwestern part of the area of its occurrence. Spieker (1949: 32) gives 300 to 800 feet as the range of thickness of the Flagstaff in the area considered here.

Spieker (1946: 139) described the type Colton as ". . . gray, pepper-and-salt sandstone, greenish-buff sandstone, and siltstone that commonly weathers golden brown, and shale ranging from deep red to variegated and gray in color." He regarded it as of floodplain and channel origin. After study of the Colton farther west, Spieker (1949: 33) recognized that it there contains some units of lacustrine origin, and that some of these contain limestone. The prevailing thickness of the Colton, cited by Spieker (1949: 34), is from 300 to 1000 feet.

The principal mass of the Green River Formation lies far to the east and northeast of central Utah, and most published information about the Green River comes from that area. Spieker (1949: 35) has described it from central Utah as consisting of ". . . two members, a lower blue-gray to light blue shale . . . and an overlying unit of cream to tan limestone . . ." Its thickness in this region is from a few hundred to nearly a thousand feet (Spieker, 1949: 35).

The formations have been described in terms suitable for regional mapping, but not for consistent close distinctions. It is recognized that they intertongue and are in part time-equivalent. Spieker (1946: 139) says of the Colton, for example, ". . . chronologically the entire Colton is equivalent to part of the Green River formation." A clearer understanding of the differences in lithology produced by the different environments of deposition of the Flagstaff, Colton, and Green River might permit more precise distinctions than heretofore possible.

At the type locality of the Colton, lower Colton redbeds lie on thick gray Flagstaff limestones and shales. Red color is a convenient criterion of the onset of fluvial conditions, and has been used in mapping Flagstaff-Colton contacts elsewhere. Because near-shore facies of the Flagstaff are also red in places, however, redness alone is a poor criterion. The Colton-Green River contact is only locally indistinct, where the latter is a pale-green or bluish shale that resembles similar beds in the Colton.

Of the two boundaries, that between the Flagstaff and the Colton has been the more troublesome. Those mapping on the flank of the Wasatch Plateau have usually selected a contact just below the lowest red shale, on the assumption that the hundred feet or more of creamy siltstones and limestones below the red Colton shale and above the highest cliff-forming carbonate units of the Flagstaff belong in the Flagstaff. Yet, across Sanpete Valley on the Gunnison Plateau, others have marked the contact by the top of the uppermost cliff-forming carbonate unit. The latter is overlain by about 300 feet of drab shale, siltstone, and limestone, overlain in turn by colored beds, including redbeds. The color change here is less conspicuous than in the Wasatch Plateau, so the carbonate-to-shale change appears more significant.

This study sought more satisfactory means of establishing Colton-Green River and, especially, Flagstaff-Colton boundaries, based on the total lithologic changes from unit to unit.

METHODS

Carbonate rocks were classified in the field into one of five categories, Dolomite (D or D>C), Dolomitic Limestone (D∼C), or Limestone (C>D or C), on the basis of the amount, intensity, and duration of reaction to 3N HCl. Previous experiments on samples of Flagstaff limestone showed that such a simple HCl test would distinguish major values of calcite-dolomite ratios. The degree of accuracy of the field tests, as determined by comparison with X-ray analyses for calcite and dolomite, was 75 per cent. However, only the X-ray results are shown in Table 1.

Three sections of the upper Flagstaff, Colton, and lower Green River strata were measured. Each was tied into a Flagstaff section previously measured by Weiss. The sections occur within a north-south distance of about 7 miles, and are located in the south fork of South Maple Canyon, the hills above the Dry Canyon waterfall, and the hills above the main branch of Peach (alternatively Petes) Canyon on the Gunnison Plateau (Pl. 1). Measurements were made by hand level, Jacob staff, and tape, for the dip of the rocks to the west-southwest does not exceed 3 or 4 degrees. Colors were named from the Rock Color Chart. Sampled units are indicated by asterisks in Plate 2.

Rock samples were processed in the laboratory in several ways, in order to better characterize the units described in the field (table 1). Each sample was examined under the binocular microscope for frosting of sand grains, presence of micas, occurrence of collophane, nature of fossil fragments, and textures.

Whole-rock powdered fractions of all samples were X-rayed with Ni-filtered Cu-Kα radiation in a GE XRD-6 diffractometer. Runs were made from 6 to 34 degrees (2 θ) to display calcite, dolomite, quartz, feldspars, clays, and possible aragonite, for these had been determined previously to occur in the formations. Calcite-dolomite ratios, where both occur together, and the presence of abundant quartz, clays, or feldspars were also determined. Because the carbonates masked the X-ray response of the clays and feldspars particularly, in some samples, analyses of some non-carbonate fractions were necessary. Powders of acid-resistant residues from those samples having residues in excess of 5 per cent were run from 6 to 27 degrees (2 θ) to determine qualitatively the relative amounts of quartz, clays, and feldspars. The weight per cent of the acid-resistant residue for every sample was determined by digestion in HCl.

Mollusks noted in the field or in laboratory samples were identified by reference to the work of La Rocque (1960). The genera observed and their stratigraphic occurrences are shown in Table 2. Time was not sufficient to permit a study of the ostracodes, though they are abundant in many beds; their occurrence was simply noted in the section (Pl. 1; table 1).

LITHOLOGY

The general sequence of this part of the section in the Gunnison Plateau begins with gray to buff interbedded limestones and shales in the lower slopes, grading upward into shales and channel sandstones of pastel green, red, and purple colors in the upper slopes, and finally, into the white and pale-green limestones and limy

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EXPLANATION OF PLATE 1

Correlated lithic logs of measured sections, east-central Gunnison Plateau, Utah.

Logs are compiled from sections measured in South Maple, Dry, and Peach Canyons. Mollusks collected are named in Table 2. Flagstaff-Colton and Colton-Green River boundaries are indicated.

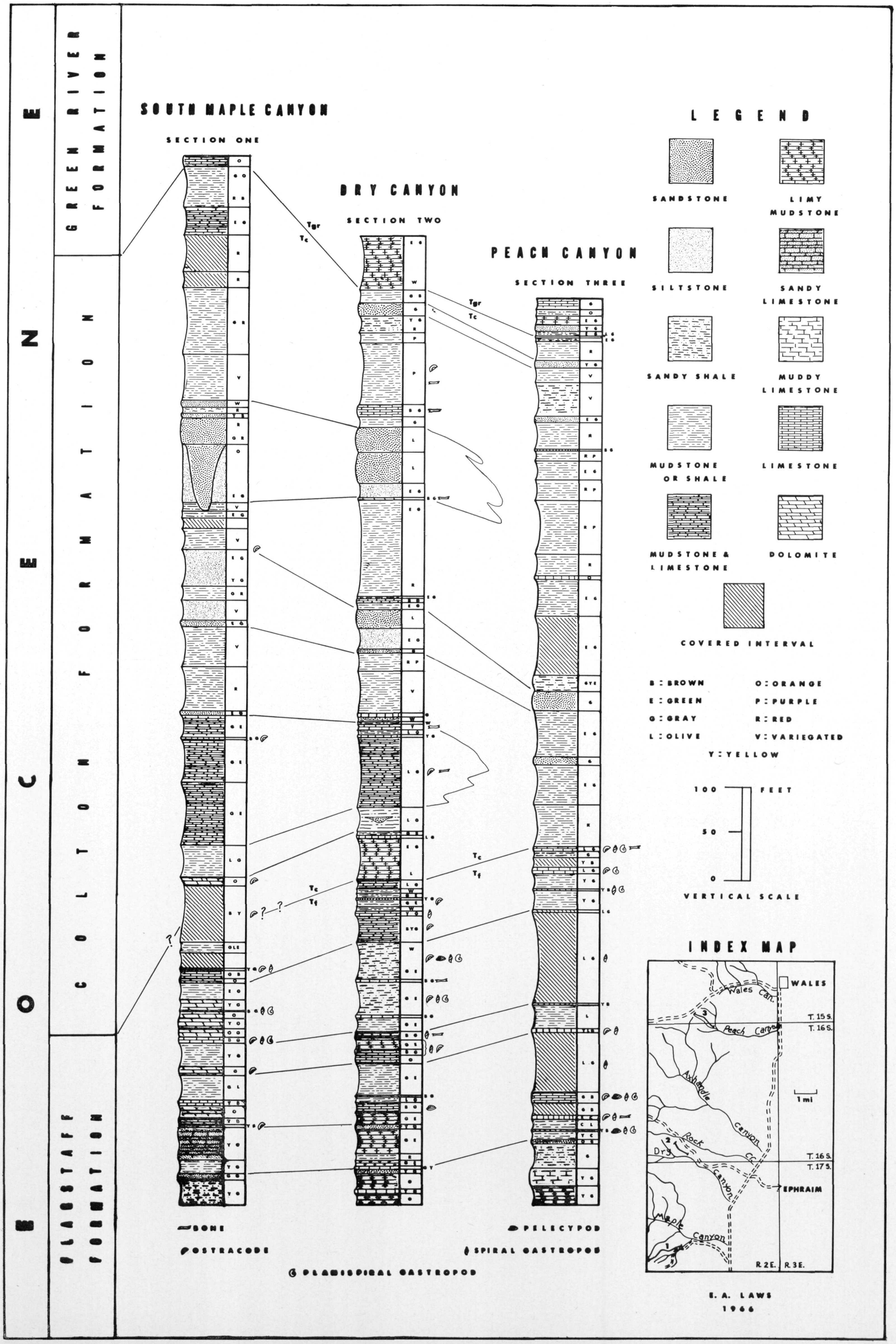
EOCENE
GREEN RIVER FORMATION
COLTON FORMATION
FLAGSTAFF FORMATION
SOUTH MAPLE CANYON
SECTION ONE
DRY CANYON
SECTION TWO
PEACH CANYON
SECTION THREE
Tgr
Tc
Tf
LEGEND
SANDSTONE
LIMY MUDSTONE
SILTSTONE
SANDY LIMESTONE
SANDY SHALE
MUDDY LIMESTONE
MUDSTONE OR SHALE
LIMESTONE
MUDSTONE & LIMESTONE
DOLOMITE
COVERED INTERVAL
B : BROWN
E : GREEN
G : GRAY
L : OLIVE
O : ORANGE
P : PURPLE
R : RED
V : VARIEGATED
Y : YELLOW
100
50
0
FEET
VERTICAL SCALE
INDEX MAP
WALES
Wales Can.
Peach Canyon
Axhandle Canyon
Rock CC
Dry Canyon
Maple Canyon
EPHRAIM
T. 15 S.
T. 16 S.
T. 17 S.
R 2 E.
R 3 E.
1 mi
BONE
OSTRACODE
PELECYPOD
SPIRAL GASTROPOD
PLANISPIRAL GASTROPOD
E. A. LAWS
1966

TABLE 1

Compositional Data

Bed/sample number	Carbonate ratio*	Quartz*	Feldspars*	Clays*	Percent residue	Remarks†
			South Maple Canyon			
10	D				0.8	ostracodes
12	C>D				1.1	ostracodes
13	C>D				2.6	ostracodes
17	C>D	Q			13.3	
22	D>C				1.2	ostracodes
26	C>D				2.0	
39	C>D	Q			11.2	ostracodes, Mn-dendrites
46	C∼D		Plagioclase Orthoclase		81.1	muscovite
54	C>D	Q			80.1	
55	C>D	Q			11.3	
			Dry Canyon			
15	C	Q		Kaolinite	14.8	
16	C				5.1	ostracodes
17	C				0.7	ostracodes
18	C				1.4	bone
21	C				2.2	ostracodes
22	C				2.1	bone
23	C>D, A	Q	Plagioclase		50.6	ostracodes
24	C∼D	Q			72.2	
25	C>D				5.6	
26	D>C	Q			27.3	
27	D>C	Q			60.1	ostracodes
32	D>C	Q			62.1	
33	C>D	Q	Microcline		40.4	laminated
38		Q			80.6	coal
39	D>C	Q	Orthoclase		16.7	ostracodes, bone
40	D>C	Q			29.5	bone
41	D∼C	Q			13.5	
43	C				1.7	
51	C∼D	Q	Plagioclase		18.6	
53	C>D	Q	K-spar	Illite	18.6	
54	C>D	Q			75.7	
55	D>C	Q	K-spar		70.2	
56	C	Q	Plagioclase Microcline		82.0	muscovite, biotite, subang. qtz-feldspar silt
58		Q			97.2	muscovite, biotite subang. qtz-feldspar silt and fine sand
59	D	Q			42.2	
60	D>C	Q			16.4	
62	C	Q	Plagioclase		10.1	
63	D>C	Q	Plagioclase		42.2	muscovite, biotite
65	C>D	Q	Plagioclase Microcline		75.0	muscovite, biotite subang. qtz-feldspar silt

TABLE 1. *Continued*

Bed/sample number	Carbonate ratio*	Quartz*	Feldspars*	Clays*	Percent residue	Remarks†
66	C>D	Q			20.6	bone
69		Q	Plagioclase Microcline	Kaolinite	94.7	muscovite, biotite subang. qtz-feldspar v. fine sand
70	D>C	Q			43.1	
71	C	Q			6.8	bone
72	C>D	Q			31.1	ostracodes, bone
73	C>D	Q	Microcline		30.0	muscovite, biotite
76	C	Q	Plagioclase		78.6	subang. qtz silt
77	C∼D	Q			87.5	
78	C	Q			64.4	
79	D	Q	Plagioclase Microcline	Kaolinite Illite	84.9	muscovite
			Peach Canyon			
6	C	Q			32.0	
8	C	Q			6.5	fish scales, bone ostracodes, unidentified snail
10	C				1.2	ostracodes
12	C>D	Q			7.0	oölites
14	C>D	Q			24.8	
16	D>C	Q			17.4	
17	C	Q	Orthoclase	Illite	59.8	
18	C>D	Q			9.0	unidentified snail
20	C>D	Q			8.6	bone
22	D∼C	Q			32.8	laminated
24	C>D	Q			5.2	bone
25	C	Q	Orthoclase		86.1	
27		Q	K-spar		94.7	chert, biotite
28	C∼D	Q	K-spar		79.0	muscovite, biotite
31	C∼D	Q			17.7	contorted laminae
32	C>D aragonite?	Q	Orthoclase		71.8	
33	C>D	Q	Orthoclase		72.7	muscovite, biotite laminated
34	C>D	Q	K-spar		65.8	
35	D>C	Q			70.1	
36	C>D	Q	Orthoclase		73.2	muscovite
38	C>D	Q	Orthoclase		70.8	muscovite
39	D>C	Q	K-spar	Illite	74.3	muscovite
40		Q	Orthoclase	Illite	86.5	muscovite
42	C	Q			16.5	shell flakes
44		Q			85.6	muscovite
45	D>C	Q	K-spar		69.9	
46	C>D	Q		Illite	18.2	
48		Q	K-spar	Kaolinite	90.5	
49		Q	K-spar		96.7	ang.-subang. v. fine qtz sand
50	D	Q			16.7	muscovite
51	C>D	Q			45.2	
52	C>D				3.7	calcite veins

Sample numbers correspond to bed numbers in stratigraphic section.
*Determined by X-ray.
†Identified mollusks listed in Table 2.

shales which form the prominent peaks of the area. This Flagstaff-Colton-Green River sequence shows significant differences in lithic qualities (and fossils) among the three units. The control of rock types by the environments, lacustrine or fluvial, under which they were formed is evident. It is also apparent that rocks of some clans differ according to the two environments—e.g., fluvial sandstone and lacustrine sandstone. These results show striking similarities to Picard's work on Tertiary fluviatile and lacustrine sediments in the Uinta Basin (Picard, 1957).

Sandstones occur in both the Flagstaff and the Colton, but are readily divisible into two groups. Those of one group have the following characteristics: fine grain size, subrounded particles, pale gray or tan color, absence of or inconspicuous cross-lamination or -bedding, thinness and lateral persistence of units, and regular contacts. Sandstones of the other group have in common: fine to medium grain size; colors other than gray or brown; subangular quartz grains, often frosted, with some mica and feldspar; cross-bedding; thick bedding; great differences in thickness within small distances; no lateral persistence; and irregular contacts.

Sandstones of the first group are considered to have been deposited under lacustrine conditions, for these would have produced the better size sorting, the rounding of particles, the light unoxidized material, and the persistence and regularity of units. The second group includes fluvial sands deposited under oxidizing conditions on floodplains and in stream channels. Lacustrine sands are concentrated in the lower 150 feet of each measured section, and fluvial sands between about 500 and 900 feet from the bottom (pl. 1).

The argillaceous rocks also fall into two categories. One includes the limy shales that are yellow-brown or gray, very thin-bedded, tough and platy, fossiliferous, and interbedded with conspicuous limestone and dolomite units. The second group includes shales and other mudrocks that are more sandy, highly colored (red, green, purple), poorly bedded, and have few to no fossils. These shales and mudrocks are only lime-cemented or superficially limy, and weather to soft chips. They are typically interbedded with discontinuous limestones less than a foot thick.

The limy shales, with their abundant fossils, light colors, and regular bedding, are of lacustrine origin. The soft, gritty shales that are poor in lime are fluvial. The lacustrine shales occur in the lower 150 to 300 feet of each measured section, and again in the top 50 to 60 feet. The fluvial shales and mudrocks dominate the remainder of the sections, where not replaced by channel sandstones.

The carbonate rocks are more diverse petrographically, but can still be classed into two groups on the basis of thickness and persistence of beds. The thick (2 feet or more), laterally persistent units are either 1) dark gray or brown, fossiliferous, and sometimes autoconglomeratic; 2) dark gray or brown, massive, homogeneous, and tough; or 3) light buff, pale gray or tan, massive, tough, and often dolomitic. The thin (mostly less than 1 foot), impersistent carbonate beds are light, locally pastel in color, homogeneous, tough, microcrystalline, poorly fossiliferous, rarely dolomitic, and the dolomite occurs mostly as cement. Many are argillaceous, and most are brittle and yield sharp platy shards that ring when struck.

The thicker, more persistent carbonates represent long-continued and widespread deposition, as might be expected from a major lacustrine environment. The thin, dirty carbonates represent short-lived lacustrine conditions, perhaps in minor floodplain lakes or nearshore lagoons. Again, the open-lake limestones and dolomites are found in the lower 150 to 300 feet of the sections and the other limestones in the succeeding 300 feet of section.

The changes from the lacustrine sandstones, shales, and carbonates to those of fluvial origin all occur at about the same place in the stratigraphic succession. The same is true for the change from fluviatile to lacustrine lithologies high in the section, except that sandstones are insignificant in the Green River and its limestones are mostly above the measured sections. The petrologic differences in the three classes of rocks seem to permit clear distinction of the older, lacustrine Flagstaff, younger, mostly fluviatile Colton, and youngest, lacustrine Green River formations (Pl. 1).

FOSSILS

An abundant and varied fauna is present, but occurs only in the limestones and dolomites of the basal 150–200 feet of the measured sections (Pl. 1, table 2).

TABLE 2

Fossils identified

	Elliptio	*Gyraulus*	*Viviparus*	*Goniobasis*	*Physa*
South Maple Canyon		12,13,17		13,17,22	13
Dry Canyon	15,23	17,21,23	16	15,23	15,17,18,21
Peach Canyon	6,10	6,10,18,20		6,10	

Numbers refer to beds in stratigraphic sections.

Ostracodes, pelecypods, and four genera of gastropods occur in the carbonates and, to a lesser extent, in the shales of this lower interval. At a particular level in each section, the snails and clams undergo a drastic reduction in number. A few bone fragments and a few ostracodal layers are the only conspicuous fossils above that particular level in each section. The molluscan species of this fauna were all highly adaptable (La Rocque, 1960), and could exist in lakes, streams, or floodplain lakes. Nevertheless, their abundance and lateral persistence low in the section, and their paucity above, leads us to believe that they lived in a lake, and that their reduction indicates the onset of less favorable conditions, probably a fluvial environment. This change is another criterion of the Flagstaff-Colton boundary.

STRATIGRAPHY

Flagstaff-Colton Boundary

On the basis of the changes in rock assemblages and inferred environments of deposition, summarized in Plates 1 and 2 and Tables 1 and 2, the Flagstaff-Colton boundary is placed where:

1) the clastic nature of the rocks increases significantly and persists,
2) the fossil content of the rocks shows a marked and persistent decrease,
3) the abundance of the carbonate units decreases strikingly, and
4) the prevailing color of the rocks changes from brown or gray to red, green, and pastel colors.

These are all characteristics that can be reasonably accurately detected in the field and, when combined, form workable criteria for identifying the Flagstaff-Colton contact. Although any one kind of change may not occur at the same stratigraphic level as the others, they do cluster in a small interval. The upper Flagstaff is quite argillaceous, and it interfingers with the lower Colton rock types (Pls. 1, 2).

Colton Formation

The Colton is dominated by fluviatile deposits — channel sands and floodplain muds and silts. A few freshwater carbonate beds are concentrated in the lower two-fifths of the formation. Most of the channel sandstones occur in the upper two-fifths of the unit. Because fluviatile deposits are characteristically not persistent laterally, most individual units within the Colton cannot be identified from section to section, as can the major carbonate beds below, in the Flagstaff

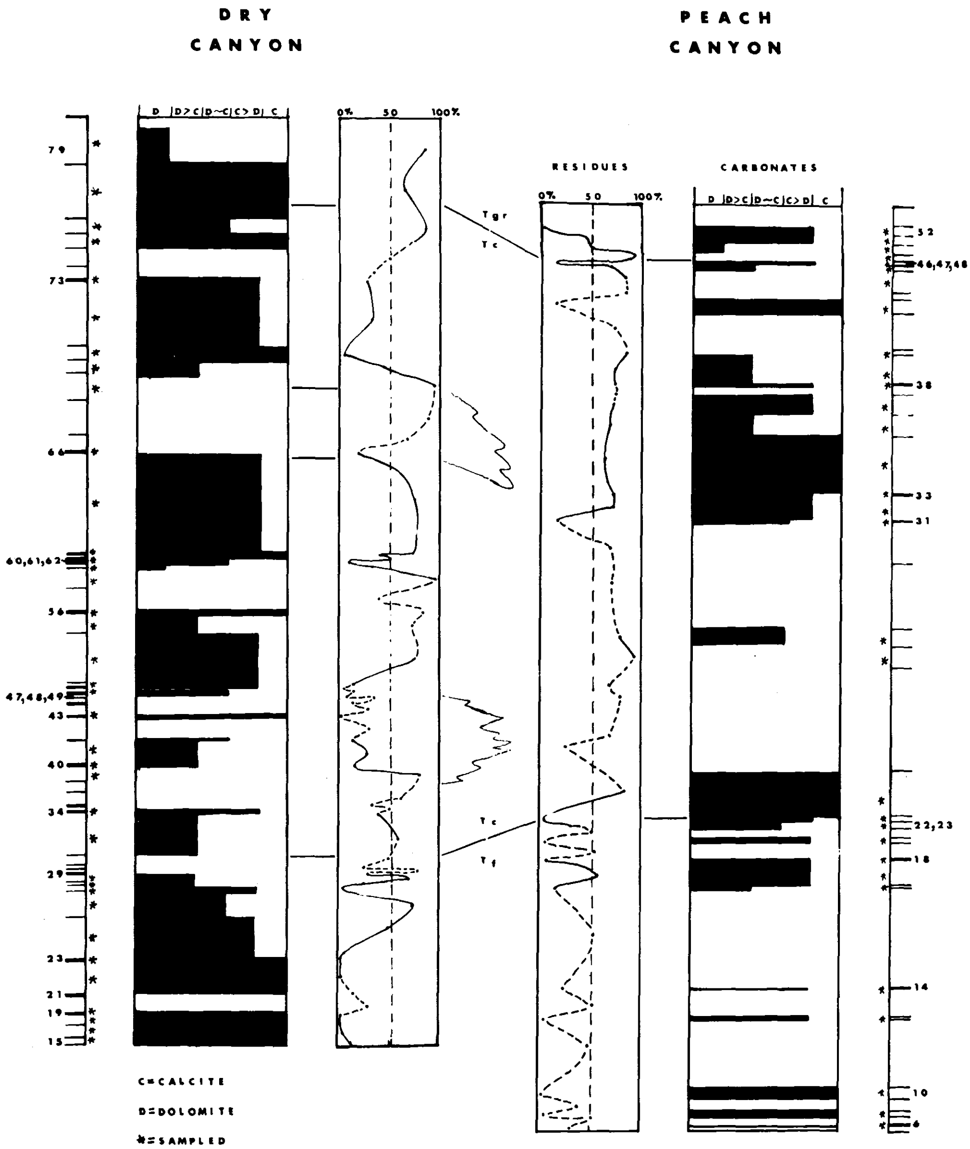

PLATE 2

Comparison of clastic and limestone-dolomite ratios between Dry and Peach Canyons.

Columns at far left and right represent units in the measured sections; the numbers correspond to unit numbers given in Table 1. Carbonate data is given on the bar graph only for units actually sampled. Thus blank spaces in the bar graph represent a lack of samples or sampled units which contained no carbonates. The limestone-dolomite ratios are based on X-ray data. Each point on the insoluble residue graph represents a unit in the measured section. Sampled units for which laboratory results are available are connected by solid lines. Units from which no samples were taken have been assigned an estimated residue percentage on the basis of their similarity to sampled units. These are indicated by dashed lines. Formation boundaries and the continuity of two tongues in the Colton are from Plate 1.

Formation. Continuity of clusters of beds in the Colton may, however, be distinguished (Pl. 1). Intervals of either predominantly sandy, or argillaceous, or argillaceous and limy composition suggest, in the small area studied, deposition during the same period of time.

The Colton Formation, distinguished by the criteria recommended here, is shown to be 800 feet thick in South Maple Canyon, 650 feet in Dry Canyon, and 550 feet in Peach Canyon. It is thinner still where it crops out at the head of Wales Canyon, and appears to have been eroded away north of there. Spieker believed that Colton beds do not occur in the north-central part of the Gunnison Plateau, because of intertonguing with the Green River Formation (Spieker, 1949: 34). Thus, although the Colton does occur farther north than previously believed, it thins markedly toward the north and becomes more clastic (Pl. 1). This suggests that a local highland somewhere north of Wales Canyon shed detritus southward, at least during Colton deposition. Whether that highland was flooded by Flagstaff or Green River lakes cannot be determined now, because of post-Eocene erosion.

Colton-Green River Boundary

The return to lacustrine conditions, in the form of Green River Lake, is recorded by 1) an increase in liminess of the shales, 2) a return to thicker, more persistent carbonate units, and 3) a change in color from the reds of the upper Colton to the pale greens of the lower Green River beds. This transition occurs more completely and in a thinner interval than that from the Flagstaff to the Colton, with the result that this boundary is more easily identified. Clearly the spread of Green River Lake was more rapid in this area than the occlusion of Flagstaff Lake. Only the lowest of the Green River beds were measured, for the lacustrine shales and limestones typical of the formation persist for hundreds of feet above the Colton. This condition is conspicuous and regionally persistent.

CONDITIONS OF DEPOSITION

The rather high carbonate and low clastic content of the later Flagstaff sediments suggest that Flagstaff Lake, the lake in which the Flagstaff carbonates accumulated, was surrounded by a land surface of low relief, from which little terrigenous material was being removed. The small amount of carbonaceous matter indicates that lake-bottom vegetation was sparse or that favorable oxidizing conditions existed, or both. Mud cracks indicate that the lake was prevailingly shallow in the later stages in the area studied. A vigorous fauna developed locally or intermittently.

All of this was ended as fluvial conditions progressively overwhelmed the lake. As Flagstaff Lake shallowed late in its development (La Rocque, 1960: 67–71; 83–84), Colton fluvial sediments encroached upon the nearshore bottom, and emerging islands further reduced its size. The lake receded gradually to the locus of the northern Wasatch Plateau, where its remnants merged with the early stages of Green River Lake. The presence of large amounts of mica (muscovite: biotite: chlorite:: 12:3:1) and feldspar in the Colton sandstones suggests detritus from basement rock in the nearby Sevier Arch, as well as volcanic contributions. The amount of clays in most of the rock units is apparently small; the X-ray method used, which will distinguish clays only in amounts larger than 5–10 per cent, showed clays in only a few samples. The relative paucity of clays and the freshness, abundance, and large particle size of the micas suggest minimal chemical weathering at the source or during transport. Accordingly, we believe that renewed tectonism along an old Laramide axis (Sevier Arch) to the west of the Gunnison Plateau may have induced both volcanism and the spread of the terrigenous material that bulks so large in the Colton Formation. Regionally, of course, the Colton had a number of sources and directions of deposition, but the

Colton in the Gunnison Plateau was probably supplied from the west and, subordinately, from the local highland in the northern part of the Gunnison Plateau.

SUMMARY

The fluviatile Colton Formation is made up of shales or mudstones, channel sandstones, and thin argillaceous limestones. In the stratigraphic intervals measured on the Gunnison Plateau, 1) Colton shales and mudstones exceed the combined Flagstaff-Green River mudstones in total thickness by an average ratio of 3 to 1; 2) Colton sandstones have 20 times the total thickness of those in the Flagstaff and Green River, except in Peach Canyon, where the massive channel variety of sandstone is absent; 3) Flagstaff-Green River carbonates, on the other hand, are three times thicker than those of the Colton. The clastic fraction of most Colton beds exceeds 50 per cent, and the clastic fractions of the limestones are generally larger than those of Flagstaff limestones. Although dolomitic material occurs in the Colton, as it does in the Flagstaff, it is mostly in the form of cement. The few dolomites and dolomitic limestones present in the Colton are neither as thick nor as persistent as those of the Flagstaff.

The Colton is distinguished from the mostly lacustrine Flagstaff Formation by a combination of features: abundance of persistent shale and mudstone units; presence of channel sandstones; sparseness of fossil mollusks; smaller volume of carbonate rocks; carbonate rocks in thinner and less persistent beds, and colorful mudstones, shales and sandstones of red, green brown, and bluish gray. The Colton is distinguished from the lacustrine Green River Formation by similar features, although the lower part of the Green River is not conspicuously fossiliferous and includes much green shale.

So conceived, the Colton thins from 800 feet in thickness in South Maple Canyon to 550 feet in Peach Canyon, and to somewhat less in Wales Canyon. This northward thinning is accompanied by an increase in clasticity.

The area studied is relatively small, but the criteria established here for the boundaries of the Colton Formation are applicable wherever the Colton occurs. Boundaries based on the abundant evidence of changes from lacustrine to fluviatile rocks, or *vice versa,* distinguish the formation according to the qualities by which it was originally differentiated and named.

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