THE GREENHORN LIMESTONE IN KANSAS

by

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INTRODUCTION

Purpose of Investigation

The purpose of the following investigation of the Greenhorn limestone in Kansas is fourfold: First, by a series of accurate measurements of surface sections, to describe in detail the Greenhorn limestone over its entire outcrop area in Kansas. Second, by means of these sections, to determine what precise correlation of beds within the Greenhorn limestone can be made over the state. Third, to determine the merit of the present subdivision of the Greenhorn limestone into its component members by evaluating the ease and accuracy of recognition of the members of the Greenhorn limestone by the field geologist. Fourth, to determine, so far as is possible, the environmental conditions under which the Greenhorn limestone was deposited.

Area Covered by This Investigation

This investigation is restricted to the outcrop area of the Greenhorn limestone in Kansas. This area is shown on Plate I, and includes nineteen counties. It extends from the Nebraska line in northcentral Kansas, in a southwesterly direction to the Colorado line in southwestern Kansas. The counties included therein are: Washington, Republic, Jewell,

Cloud, Mitchell, Osborne, Ottawa, Lincoln, Russell, Ellis, Ellsworth, Barton, Rush, Ness, Pawnee, Hodgeman, Ford, Kearny, and Hamilton. A break in the continuity of the outcrop area occurs between Ford County and Kearny County, the Greenhorn limestone being absent in Finney and Gray Counties. After its reappearance along the Arkansas River in Kearny County, it extends into Hamilton County and, finally, into Colorado.

Field and Office Procedures

The field work consisted of precise measurements and detailed descriptions of all lithologic zones exhibited in outcrops of the Greenhorn limestone in the nineteen counties listed above. All measurements and descriptions were made by the author. Thicknesses were determined to the nearest one-tenth of a foot. The procedure was to work up the face of an outcrop of the Greenhorn limestone and measure and describe each bed exposed in the section.

Each bed was described on the double basis of lithologic and paleontologic characteristics. The sequence of description for each bed or zone was as follows: principal lithologic character; minor lithologic character; structure; color based on a standard color chart; weathering characteristics; and any additional lithologic characteristics that would be an aid in identification of the zone. The litho-

logic description is then followed by a listing of fossils present in the zone.

The material that constitutes the bulk of the zone determines the lithologic name or principal lithologic character. The lithologic types encountered in the Greenhorn limestone are: limestone, shale, bentonite, and granular calcite. If a bed is well indurated and the greatest part of it is calcium carbonate, the lithologic name limestone is used. If a bed is composed principally of clay or silt the lithologic name shale is applied. The term bentonite connotes a chemically altered deposit of volcanic ash. Granular calcite is defined as a bed of granular, gritty, badly weathered calcite. Limestones are further described as being chalky or crystalline. If a limestone bed is soft it is described as chalky; if it is hard and crystals are visible, it is described as crystalline.

The minor constituents of a zone determine its minor lithologic character. Terms describing such constituents qualify the principal lithologic character and are used as adjectives. Terms employed in the description of the Greenhorn limestone are: silty, clayey, calcareous, and noncalcareous. These terms are used in the descriptions of beds of shale. If a shale is composed principally of silt size particles the term silty is used in describing it; if it is composed principally of clay size particles the term clayey is used. This can be determined by grinding a small portion

of the material between the teeth. If it feels gritty it is silty, and if it sticks to the teeth and feels smooth it is clayey. The term calcareous is used if the shale effervesces upon application of a weak solution of hydrochloric acid, and the term noncalcareous is used if it does not.

The following structural terms were employed in describing the Greenhorn limestone. Massive: There is a lack of bedding and the zone is relatively thick. Blocky: the bed tends to break into rectangular blocks measuring less than an inch to about a foot on a side. Platy: the bed tends to break into flat, plate-like masses. Thinbedded: the bedding planes are fairly close together. Fissle: the bedding planes are so close together that the zone breaks up into thin paper-like sheets.

Both the weathered and unweathered color was compared with a standard color chart. The color that the zone most nearly matched is the color term applied to it.

Some of these measured sections are in the Appendix, and all are on file with the United States Geological Survey office at Kansas State College.

Graphic columnar sections based upon the measured sections were constructed in the office. Correlations were then made between beds shown in the columnar sections. Cross sections were constructed as shown on Plates II and III. An index map and a map showing outcrops of the Greenhorn limestone were constructed in the office.

DEVELOPMENT OF STRATIGRAPHIC NOMENCLATURE

Greenhorn Limestone

The Greenhorn limestone is a part of what was originally the "Fort Benton Group," a name applied by Meek and Hayden in 1861[1] to the Cretaceous strata between the Dakota sandstone and the Niobrara limestone. The name, which was taken from the type locality at Fort Benton on the Missouri River about 40 miles below Great Falls, Montana, continued in use in that form for many years. Finally, however, it was shortened to Benton shale where the classification of strata cannot be subdivided, and the Benton group where the strata can be subdivided. However, the United States Geological Survey many years ago abandoned the term Benton group, because the Carlile shale, Greenhorn limestone, and Graneros shale, together with the overlying Niobrara limestone, compose the Colorado group, a broader and more useful unit.[2]

G. K. Gilbert, in 1896[3], applied the name Greenhorn to the sequence of strata underlying the Carlile shale and overlying the Graneros shale. His work was done in Colorado, and the name Greenhorn was taken from Greenhorn Station, 14

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[1] F. B. Meek and F. V. Hayden, Phila. Acad. Nat. Sci. Proc., vol. 13, pp. 419, 421. 1862.

[2] W. W. Rubey and N. W. Bass, The Geology of Russell Co., Kansas (Kansas Geol. Surv. Bull. 10), 1925.

[3] G. K. Gilbert, U. S. G. S. 17th Annual Report, 1896, pt. 2, p. 564.

miles south of Pueblo, and from Greenhorn Creek in the Pueblo and Walsenburg quadrangles.[1]

The term Benton, which included the Greenhorn limestone in Colorado, was long used for the corresponding unit in Kansas, but Logan, in 1897,[2] made comparisons with the Carlile, Greenhorn, and Graneros formations of Colorado, and in 1899 he made these correlations more positively. However, Darton, in 1904,[3] was the first to apply these Colorado names in Kansas.

Members of the Greenhorn Limestone

The Greenhorn limestone includes four members, which, in descending order are the Pfeifer shale, Jetmore chalk, Hartland shale, and Lincoln limestone.

The Pfeifer shale member was named in 1926 by N. W. Bass,[4] then a member of the Kansas Geological Survey, for exposures 2½ miles northwest of the City of Pfeifer in Ellis County, Kansas. The following description and measured section is quoted from Bass:

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[1] G. K. Gilbert, U. S. G. S. 17th Annual Report, 1896, pt. 2, p. 564.

[2] W. N. Logan, Kansas Univ. Geol. Surv., vol. 2, p. 216, 1897.

[3] W. W. Rubey and N. W. Bass. The Geology of Russell County, Kansas (Kansas Geol. Surv. Bull. 10), 1925.

[4] N. W. Bass, Geologic Investigations in Western Kansas (Kansas Geol. Surv. Bull. 11), 1926.

The Pfeifer shale member is capped by the "fencepost limestone" bed, so called because it is extensively quarried and used for fence posts throughout the region of its outcrop. The Pfeifer member is 19 to 21 feet thick and consists of alternating layers of chalky shale and chalky limestone, the latter in beds from 3 to 8 inches thick. On fresh exposure the entire mass presents a blue color, but on weathering it becomes a light tan or cream. In general the member produces gently graded slopes, the topmost bed forming a slight shoulder. Its outcrop throughout this region is commonly marked by white mounds of the overburden removed in quarrying the "fence-post limestone" bed. The following section was measured 2½ miles northwest of Pfeifer.

"Section of Pfeifer shale member in road cut in SE¼ sec. 21, T. 15 S., R. 17 W.

		Ft.	In.
24.	"Fence-post limestone," chalky limestone, light tan, even grained, including near the middle a rusty band about an inch wide and a little lower another rather indistinct band. Contains a few well-preserved fossils (Inoceramus labiatus). Top bed of Pfeifer member.		8½
23.	Soft chalky shale, cream to flesh colored . . .		11
22.	Chalky limestone, somewhat concretionary, weathers white; contains a few fossils. . . .		1
21.	Chalky shale, cream to flesh colored.		10
20.	Concretionary chalky limestone, fossiliferous; weathers white.		4
19.	Shale, cream to flesh colored	1	2
18.	Chalky limestone, with no fossils; weathers white.		1
17.	Chalky shale, cream to flesh colored		11
16.	Chalky limestone, with no fossils; weathers white.		4
15.	Shale, cream to flesh colored with a band of bentonitic clay 4 inches thick at its top. Upper part of clay band gritty and shows orange color.	1	2
14.	Concretionary fossiliferous chalky limestone		2
13.	Chalky shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.	1	6
12.	White chalky limestone, very few fossils . .		3

		Ft.	In.
11.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.	2	4
10.	Chalky limestone; weathers to rusty brown; ferruginous band near middle; contains many fossils.		2
9.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.		10
8.	Chalky limestone; very few fossils		3
7.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.	1	
6.	Concretionary chalky limestone, fossiliferous		2
5.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.		9
4.	Concretionary chalky limestone; fossils abundant.		2½
3.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.	1	4
2.	Concretionary chalky limestone; fossils abundant.		4
1.	Shale; weathers flaky; light tan; in places contains a thin discontinuous bed of somewhat fossiliferous concretionary chalky limestone.	3	1
Total thickness of Pfeifer shale member.		18	11"

The Jetmore chalk member was named, in 1925, by W. W. Rubey and N. W. Bass,[1] then members of the Kansas Geological Survey, for exposures south and east of Jetmore, along the south side of Buckner Creek, in Hodgeman County, Kansas. The following description is quoted from Rubey and Bass.

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[1] W. W. Rubey and N. W. Bass, The Geology of Russell County, Kansas (Kansas Geol. Surv. Bull. 10), 1925.

> The group of alternating thin beds of chalk and chalky shale that occupy the interval from 20-40 feet below the top of the Greenhorn formation is the Jetmore chalk member. The uppermost bed of this group--the "Inoceramus limestone" or "shell bed" of oil geologists--is a hard, thin bedded to massive, very fossiliferous, fine-grained chalky limestone, which within narrow limits of variation is about a foot thick. It is a light buff gray on fresh exposures, but weathers almost white. A bed of flat, chalky concretions occurs in the shale about 2 feet below the top of the member. Below its upper bed the Jetmore member is an alternating series of layers of chalk and chalky shale, the layers of chalk decreasing downward in thickness from 6 inches to 1 inch, and the marl beds from about 2 feet to 2 inches. The upper 10 feet or so contain the most fossils, which are found in greatest abundance in the 1-foot bed at the top of the member. The base of the Jetmore member is not sharply defined, for by a progressive thinning of the lower chalk beds it grades into the underlying chalky shale.

The Hartland shale member was named, in 1926, by Bass for exposures along the Arkansas River from a short distance west of Hartland in Kearny County, to Kendall in Hamilton County, Kansas.[1] The following description is quoted from Bass.

> Below the Jetmore chalk member is a series, about 35 feet thick, of chalky shales that contain a few thin beds of soft chalky limestone and a few thin layers of bentonitic clay. In Ellis and Russell counties these beds, which are herein named Hartland shale member, from exposures near Hartland, Kearny County, Kansas, grade into the overlying Jetmore member with no sharp change in lithology, and are defined somewhat more distinctly below by the hard, thin-bedded, finely banded, dark-colored limestone of the basal member (Lincoln limestone) of the Greenhorn limestone.

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[1] N. W. Bass, Geologic Investigations in western Kansas (Kansas Geol. Surv. Bull. 11), 1926.

The Lincoln limestone member was named, in 1897, by W. N. Logan, then of the Kansas University Geological Survey, for exposures near Lincoln in Lincoln County, Kansas.[1] It was adopted as the basal member of the Greenhorn limestone by W. W. Rubey and N. W. Bass in 1925.[2] The following description is quoted from Logan.

> Lincoln Marble Horizon--Resting comformably upon the bituminous shales is the Lincoln Marble horizon. This group consists of from two to five layers of hard flinty limestone intercalated with shales. The maximum thickness of the group is 15 feet. The maximum thickness of the individual layers is 6 inches. The Lincoln Marble is of a bluish gray color, contains many impurities, is porous, hence weathers easily. It contains abundant evidence of vertebrate fossil remains. Fossils not yet fully identified, but what seem to be remains of Plesiosaurus and tracks of other saurians, have been found. Squaladont selachin shark teeth abound, as many as a dozen having been found under a single square foot of surface. The invertebrate forms are numerous. Inoceramus umbonatus, Inoceramus undabundus, and other forms, as yet undetermined, have been found.

AREAL DISTRIBUTION OF THE GREENHORN LIMESTONE

Mid-continent Area

The Greenhorn limestone outcrops as a broad belt in seven states of the mid-continent area. These are: Colorado, Wyoming, Montana, Nebraska, South Dakota, New Mexico, and

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[1] W. N. Logan, Kansas University Geological Survey, 1897, vol. 2, p. 216.

[2] W. W. Rubey and N. W. Bass, The Geology of Russell County, Kansas (Kansas Geol. Surv. Bull. 10), 1925.

Kansas. The outcrop area, in general, extends from southeastern Montana, through eastern Wyoming, into southeastern South Dakota, down into southeastern Nebraska, into north central and western Kansas, into eastern Colorado, and on into northwestern New Mexico.

Kansas

The area of outcrop of the Greenhorn limestone in Kansas is confined to nineteen counties. These have been mentioned previously and are shown in Plate I. In the northwestern part of the outcrop area the Greenhorn limestone outcrops in the river bottoms and along the valley slopes. As one moves southwest over the outcrop area the Greenhorn limestone is confined more and more to the lower parts of the walls of the stream valleys.

GENERAL DESCRIPTIONS AND THICKNESSES OF THE MEMBERS OF THE GREENHORN LIMESTONE

Pfeifer Shale Member

The Pfeifer shale member, which ranges from 15 feet thick in Jewell County to 22 feet thick in Russell County, consists of alternating layers of chalky limestone and silty shale. The beds of shale are thicker than those of limestone,

especially in the lower part of the member. Consequently, if the upper part of the member is missing, the basal part makes only a very weak outcrop. The shales are silty, calcareous, generally platy, and gray to gray orange. The limestones are chalky, tan to tan gray, and lack bedding. Shells of Inoceramus occur throughout the member. The Pfeifer shale is capped by the "fencepost limestone" which forms a minor hillside bench. A bed of granular calcite, commonly called the "sugar sand", is prominent in this member. It is about 6 feet below the "fencepost limestone."

Jetmore Chalk Member

The Jetmore chalk member consists of alternating layers of chalky limestone and silty shale. It varies from a minimum of 12 feet thick in Cloud County to a maximum of 22 feet in Hodgeman County. The beds of limestone are harder and more dense than those in the overlying Pfeifer shale member, and the Jetmore chalk, therefore, makes a stronger outcrop than does the Pfeifer shale. The limestones are hard, chalky, tan, frequently stained with limonite, and lack bedding. The shales are silty, calcareous, general platy, and gray to gray orange. There are shells of Inoceramus throughout but they are more abundant toward the top of the member. The Jetmore chalk is capped by the "shell rock limestone" which forms a prominent hillside bench.

Hartland Shale Member

The Hartland shale member consists largely of shale, but also includes a few thin beds of limestone and a number of seams of bentonite. Its thickness ranges from 20 feet in Cloud County to 35 feet in Ellis County. The shales vary from light bluish gray to tan, are silty, calcareous, and platy to thin bedded. They contain occasional shells of Inoceramus, and sharks teeth and fish scales are also common.

Frequently, in the upper part of the member are a few thin, very soft, chalky, light gray to white limestones. Lower in the member are a few very thin beds of crystalline limestone. The seams of bentonite within the Hartland shale member range from 0.1 to 0.6 foot thick, and are usually orange.

Lincoln Limestone Member

The Lincoln limestone, the basal member of the Greenhorn limestone, consists of about 20 feet of silty shales, with thin beds of light gray, chalky limestone, and hard, fine-banded, dark gray, crystalline limestone. The crystalline limestones are most abundant near the base and top of the member, contain Inoceramus, sharks teeth and fish scales, and emit a strong petroliferous odor. Several thin seams of bentonite that weather orange are contained in the shales.

The total thickness of the Greenhorn limestone ranges from 82 feet in Mitchell County to 130 feet in Hamilton County.

DETAILED STRATIGRAPHY OF THE GREENHORN LIMESTONE

Marker Beds in the Greenhorn Limestone

There are three outstanding marker beds, beds that can be easily and certainly recognized in the field, in the Greenhorn limestone in Kansas. These are, in descending order: a bed of limestone, commonly called the "fencepost limestone", which marks the top of the Greenhorn limestone and of the Pfeifer shale member; a bed of granular calcite about 5.75 feet below the "fencepost limestone" in the Pfeifer shale member, and another limestone bed, commonly called the "shell rock limestone," which marks the top of the Jetmore chalk member.

The most easily recognized of these three is the "fencepost limestone." It derives its name from the fact that it can be quarried easily and was once much used in central Kansas for fence posts. This bed is overlain by the Fairport chalky shale member of the Carlile shale. There is very little difference in the lithology of the Pfeifer shale member of the Greenhorn limestone and the basal part of the Fairport chalky shale member of the Carlile shale. The

"fencepost limestone" was picked as the top of the Greenhorn limestone because it is so easily recognized.

This bed is from 0.5 to 1.0 foot thick. It is a massive, chalky limestone, generally tan gray with a characteristic rust-colored streak in the middle part. It weathers tan and the rust-colored streak remains conspicuous, although this streak tends to become lighter in color toward the southwestern part of the outcrop area. Its color is noticeably lighter, for example, in Russell County than it is in Mitchell County. The "fencepost limestone" is an excellent structural stone, and the color difference mentioned above can be easily noted in the buildings in which it has been used, as one moves southwest over the outcrop area.

The bed contains shells of the pelecypod Inoceramus and cephalopods occasionally are found in it. It forms a minor bench, which is sufficiently well developed on many hillsides that the contact between the Greenhorn limestone and the over-lying Carlile shale can be located readily by this bench.

At an average distance of 5.75 feet below the "fencepost limestone", over a large part of the outcrop area, there occurs a bed of granular calcite. It does not occur over the full extent of the outcrop area, but is remarkably persistent and very easily recognized throughout the central part. It is from 0.2 to 0.4 foot thick and its color is orange. It is commonly called the "sugar sand" by drillers

and is frequently used by them as a marker bed.

It first appears in southern Mitchell County and extends on into Osborne, Lincoln, Barton, Ellis, and Hodgeman Counties. The interval between the "sugar sand" and the "fencepost limestone" varies only slightly. The minimum distance separating the two is in Osborne County where the "sugar sand" is 4.95 feet below the "fencepost limestone" (bed No. 11, section No. 22) and the maximum interval, 6.75 feet, is in Barton County (bed No. 12, section No. 37). Other intervals noted were: Mitchell County, 5.36 feet (bed No. 14, section No. 20); Ellis County, 5.40 feet (bed No. 10, section No. 35); Lincoln County, 5.30 feet (bed No. 13, section No. 24); Russell County, 5.45 feet, 5.55 feet, and 6.35 feet (bed No. 12, section No. 29; bed No. 12, section No. 30; bed No. 12, section No. 31); Hodgeman County, 5.90 feet (bed No. 11, section No. 42).

The fact that in sections in which the "sugar sand" appears, the bed number varies only from 10 to 14, shows that the beds intervening between it and the "fencepost limestone" can be very closely correlated.

The top of the Jetmore chalk member is marked by the third of the outstanding marker beds, a limestone commonly called the "shell rock". It is a massive, chalky limestone, usually tan. It weathers tan gray and shells of Inoceramus are exceedingly abundant in it. It is from this fact that it derives its name. It has a marked tendency to split along

zones where the shells of Inoceramus are aligned. The "shell rock" forms a more prominent hillside bench than does the "fencepost limestone."

The "shell rock bed" is also a good structural stone and has been used in the construction of many buildings, particularly in Cloud County.

The correlation of these three marker beds is shown graphically on Plates II and III. There are no outstanding marker beds in the Hartland shale or Lincoln limestone members that can be used over a wide area. Marker beds within members will be discussed in the following sections.

Marker Beds for Members

Pfeifer Shale Member. Within the Pfeifer shale are a number of thin chalky limestones, many of which pinch and swell in short distances. With the exception of the "fencepost limestone", there are no limestones that can be depended upon as markers. Plates II and III show that many limestones can be correlated over considerable distances, but are so similar that to distinguish between them is very difficult, if not impossible.

It appears, from complete sections of the Pfeifer shale that were measured, that the number of limestones in the member varies from a minimum of about 12 to a maximum of about 19. Some of these are continuous beds and others are

local only.

There are usually three limestones between the "sugar sand" and the "fencepost limestone". They are soft, chalky, and exhibit a marked tendency to pinch and swell. The upper part of the Pfeifer shale can always be easily and certainly identified by the presence of the "fencepost" and "sugar sand" beds, and the three intervening chalky limestones.

The variation in number of beds is greater between the "sugar sand" and the base of the Pfeifer shale member. The beds of limestone, however, are very similar in lithology and no one of them is a certain horizon marker.

The beds of bentonite within the Pfeifer shale member can be correlated to a certain extent. At the top of the member, just below the "fencepost limestone", is a thin bentonite about 0.1 foot thick. It was identified in sections in the following counties: Mitchell, Republic, Lincoln, Russell, Barton, and Jewell. Another thin seam of bentonite just above the "sugar sand" was recognized in sections in Russell, Barton, Lincoln, Mitchell and Osborne Counties. In all of these counties, and Hodgeman County in addition, there is another thin layer of bentonite just below the "sugar sand". One or, locally, two thin bentonites occur near the base of the member. As shown on Plates II and III, these beds can also be traced over a considerable distance.

Jetmore Chalk Member. The beds of limestone within the Jetmore chalk member are harder than those in the overlying

Pfeifer shale member, and three of them are good horizon markers. The three limestones are conspicuous near the top of the member, and erode to form small but distinguishable hillside benches. No one of the limestones in the basal part of the Jetmore chalk is this prominent, nor are any of the overlying limestones of this member with the single exception of the "shell rock" previously discussed as defining the top of the Jetmore chalk. These three beds are shown graphically on Plates II and III and the following are some examples taken from the measured sections: beds 23, 25, 27, section No. 2; beds 8, 10, 12, section No. 14; beds 55, 57, 60, section No. 24; beds 57, 59, 62, section No. 29; beds 33, 35, 38, section No. 35; beds 8, 10, 13, section No. 39.

The highest of the three beds of limestone lies from 1.8 feet to 3.0 feet below the "shell rock limestone". The average thickness of the beds is about 0.4 foot, and the interval between the beds ranges from 0.7 to 1.0 foot. The beds are chalky, tan gray, and frequently show limonite stains. A very thin bentonite occurs immediately above the third of these beds in the following counties: Lincoln, Russell, Osborne, Barton, Ellis, Mitchell, Ness, and Hodgeman.

Between the uppermost of these three limestones and the "shell rock" are from one to four thin chalky limestones that show a tendency to pinch and swell. Correlation of these beds over any great distance would be difficult.

Below the lowermost of the three limestones are, on the

average, 8 to 10 additional chalky limestones. No one of these beds is more than 0.5 foot thick, and they frequently exhibit limonitic stains. The pelecypod Inoceramus is more abundant in the upper part of the member than it is in the lower.

The base of the Jetmore chalk member is marked by the lowermost of the chalky limestones. This limestone is from 0.3 to 0.5 foot thick, chalky, tan gray, and limonite stained It contains a few specimens of Inoceramus.

Hartland Shale Member. A thin but very persistent seam of bentonite occurs at the top of the Hartland shale member. It is no more than 0.1 foot thick, but was identified in sections in the following counties: Republic, Mitchell, Russell, Lincoln, Ness, Hodgeman, Ottawa, Washington, Ellis, Cloud, and Osborne. There are many other beds of bentonite in the member, but it is not possible to correlate them over any great distance.

The Hartland shale member is predominantly shale and none of the limestones that occur in the member are persistent enough or easy enough to recognize to be used as marker beds.

Lincoln Limestone Member. The top and base of the Lincoln limestone member are marked by dark crystalline limestone beds.[1] This member outcrops only infrequently in

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[1] N. W. Bass, Geologic Investigations in Western Kansas (State Geol. Surv. of Kansas Bull. 11), p. 33, 1926.

Kansas, so the identification of the limestones is difficult for the field geologist to make. The number of sections in which the Lincoln limestone was exposed is so limited that there is not sufficient evidence at hand to attempt a correlation of beds within the member. However, on the basis of the limited information available, it is possible to ascertain that the present system of designating the top and base of the Lincoln limestone member by layers of crystalline limestone is valid. In some cases these limestones appear as much as 1.0 foot thick (Mitchell County), while in other cases they are thin limestones intercalated with shale (Washington County). There are a few thin crystalline limestones in the Hartland shale member, and also in the middle of the Lincoln limestone member. The line of contact between these members, therefore, is difficult for the field geologist to locate.

PALEOGEOGRAPHY

The Greenhorn limestone was deposited in marine water in an environment apparently confined to that of the floor of an epeiric sea extant over much of Kansas in the Cretaceous period. The sedimentary processes of the neritic environment are physical, chemical, and organic, each tending to be dominant at different places and at different times in each place.

The coarsest sediments tend to be laid down nearest the shore, but there are many exceptions and, in some cases, the opposite is true. The thickest sedimentary accumulations are usually adjacent to the mouths of streams. Zones close to the shore tend to have sediments frequently deposited and as frequently removed. This leads to the reassembling of sediments and to the development of vertical and horizontal variations in them. A section of sediments along a line normal to the shore may pass through every variety of clastic sediment deposited in those waters, and the same general kind or sequence of sediments may be repeated several times. Farther from the shore calcareous sediments may be encountered, and there may be alternations of calcareous sediments with muds, silts, and sands.

From the above information, it is apparent that there is great variety within the deposits laid down on a shallow sea floor. A slight shift in the position of the shoreline may cause a change in the kind of material deposited at any one place. A change in the temperature of the water would also cause a change in the materials deposited. Cold water will hold more calcium carbonate than will warm water, therefore, a climatic change to colder temperature would cause the deposition of more frequent limestone beds. In addition, a climatic change that affected rainfall would cause a change in materials deposited. If the rainfall was heavy, the streams emptying into the shallow sea would be carrying a

heavy load, consequently the majority of the rocks formed would be clastics. Because of these various possibilities, it is very difficult to describe exactly the environment at any given time of deposition.

It would appear, from the foregoing discussion, that the upper part of the Greenhorn limestone, the Pfeifer shale and Jetmore chalk members, were deposited at some distance from the shoreline of the epeiric sea. This would account for the many limestone beds, and also for the fact that these members are more easily distinguished because deposition took place a considerable distance below the base level of deposition. Toward the southwestern part of the outcrop area in Kansas, the water was evidently not as deep, hence the preponderance of shales in the Hartland and Lincoln members which comprise most of the outcrop in that area.

As the waters moved inland from the direction of the Gulf of Mexico and became deeper the aspect of the deposits changed. Therefore, the sequence of the Greenhorn limestone, with the basal part predominantly shale, and with limestones much more frequent near the top, is what would normally be expected with the deepening of the water as the sea advanced farther inland.

The many intercalated bentonites of the Greenhorn limestone indicate periodic explosive volcanic activity in an adjacent area during the time of deposition, since each seam

of bentonite represents a separate ash fall. Theoretically, at least, each layer of bentonite should have been deposited over much of the area covered by the Cretaceous sea and should, therefore, serve as an excellent horizon marker.

CONCLUSIONS

Division of the Greenhorn Limestone into Members

The present division of the Greenhorn limestone into members is a valid one for the most part. The "fencepost limestone" very clearly marks the top of the Pfeifer shale member. In lithology this member differs very little from the overlying Fairport chalky shale member of the Carlile shale. There is a paleontologic difference, however, chiefly marked by the abundance of Inoceramus in the Greenhorn limestone which is not true of the Carlile shale.

The "shell rock limestone" is a useful index for demarking the Pfeifer shale and Jetmore chalk members. In both lithology and paleontology the Pfeifer and Jetmore members are similar, but the limestones in the Jetmore chalk are harder than those in the Pfeifer shale. Since both the "fencepost" and "shell rock" can be easily traced over considerable distances, the two members can be mapped as separate units.

The Hartland shale and Jetmore chalk members are not as

easily distinguished, but the distinction between them is definite enough as to be useful. The base of the Jetmore chalk is a continuation of the sequence of alternating chalky limestones and shales. The lowermost of the limestones constitutes a good marker for the base of the Jetmore chalk member. Immediately below it is a considerable unbroken thickness of shale, a definite lithologic difference as compared with the lower part of the Jetmore chalk. In addition, the top of the Hartland shale member is marked by a thin but persistent seam of bentonite.

The demarcation between the Hartland shale and Lincoln limestone members is the hardest for the field geologist to establish. The top of the Lincoln limestone is defined by a hard, dark-gray, crystalline limestone. However, there are several similar limestones in the Hartland shale member, and also lower in the Lincoln limestone member. This fact makes the top of the Lincoln limestone difficult to locate, particularly when there are only limited exposures. In some cases it might be as well not to attempt to separate the lower Greenhorn limestone into two members, but to classify them together as Lincoln-Hartland members undifferentiated. This is now the practice in Ness, Hodgeman, Cloud, Republic, and Jewell Counties.

The base of the Greenhorn limestone is marked by crystalline limestones. This very clearly separates the Greenhorn limestone from the underlying Graneros shale. Further, the

Graneros shale is noncalcareous which will distinguish it from the calcareous shales of the Greenhorn limestone.

Useful Marker Beds

The most useful marker beds in the Greenhorn limestone are the "fencepost limestone" which caps the Greenhorn limestone and the Pfeifer shale member, the "sugar sand" about 6 feet below the "fencepost limestone" in the Pfeifer shale member; and the "shell rock limestone" which caps the Jetmore chalk member.

The three prominent limestones near the top of the Jetmore chalk member are also good marker beds. Seams of bentonite in the upper part of the Pfeifer shale and Hartland shale members can be used in correlation. Plates II and III indicate graphically beds that can easily be correlated.

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BIBLIOGRAPHY

(1) Bass, N. W.
Geologic investigations in Western Kansas. State Geol. Surv. of Kansas Bul. 11. 96 p. 1926.

(2) Buck, Laurence.
Geologic construction materials resources in Cloud County, Kansas. In press.

(3) Byrne, Frank E., Henry V. Beck, Vincent B. Coombs, and Wendell B. Johnson. Geologic construction materials resources in Republic County, Kansas. U. S. G. S. Prelim. Rpt. 1948.

(4) Byrne, Frank E., Vincent B. Coombs, and Charles H. Bearman. Construction materials in Ellis County, Kansas. U. S. Geol. Surv. Cir. 30. 1949.

(5) Byrne, Frank E., Max S. Houston, and Melville R. Mudge. Construction materials in Jewell County, Kansas. U. S. G. S. Prelim, Rpt. 1948.

(6) Byrne, Frank E., Wendell B. Johnson, and Denzil W. Bergman. Construction materials in Mitchell County, Kansas. In preparation.

(7) Geologic map of Kansas prepared by the State Geological Survey of Kansas.

(8) Gilbert, G. K.
U. S. G. S. 17th Annual Report, pt. 2. p. 564. 1896.

(9) Landes, Kenneth K.
The geology of Mitchell and Osborne Counties, Kansas. State Geol. Surv. of Kansas Bul. 16. 55 p. 1930.

(10) Landes, Kenneth K., and Raymond P. Keroher.
Geology and oil and gas resources of Rush County, Kansas. Resources Cir. 4. 31 p. 1938.

(11) Logan, W. N.
Kansas University geol. surv. Vol. 2, p. 216. 1897.

(12) Meek, F. B., and F. V. Hayden.
Phila. Acad. Nat. Sci. Proc. 13: 419, 421. 1862.

(13) Moss, Rycroft G.
The geology of Ness and Hodgeman Counties, Kansas. State Geol. Surv. of Kansas Bul. 19. 48 p. 1932.

(14) Rubey, W. W., and N. W. Bass.
The geology of Russell County, Kansas. State Geol. Surv. of Kansas Bul. 10. 86 p. 1925.

(15) Twenhofel, W. H.
Principles of sedimentation. New York and London: McGraw-Hill. 610 p. 1939.

(16) Waite, Herbert A.
Geology and ground-water resources of Ford County, Kansas. State Geol. Surv. Bul. 43. 250 p. 1942.

(17) Walters, Philip, and Larsen Y. Drake.
Construction materials in Osborne County, Kansas. In preparation.

(18) White, C. A.
U. S. Geol. and Geog. Surv. Tenth Annual Report. p. 21, 22, 30. 1878.

(19) Wing, Monta E.
The geology of Cloud and Republic Counties, Kansas. State Geol. Surv. of Kansas Bul. 15. 51 p. 1930.

APPENDIX

Section No. 1

A road cut on U. S. Highway 36 in the SE¼SW¼ sec. 5, T. 3 S., R. 1 E. (Washington Co., Kans.) shows the following section:

	Feet
1. Soil	0.9
Greenhorn limestone	
Jetmore chalk member (uppermost part missing)	
2. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	.3
3. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant and some Cephalopods.	.9
4. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	.4
5. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant. . .	.9
6. Bentonite; orange.	.01
7. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	.4
8. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant. . . .	.8
9. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant. .	.2
10. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant. . . .	.7
11. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant. .	.2
12. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.8
13. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant. .	.2
14. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant. . . .	1.4
15. Limestone; chalky; slabby; tan gray weathers tan; ferruginous stains. Inoceramus.	.4
16. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant. . .	2.0

	Feet
17. Limestone; chalky; light gray weathers white. Very few Inoceramus.	0.2
18. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.7
19. Limestone; chalky; light gray weathers white. Very few Inoceramus.	.2
20. Shale; silty, calcareous; thin bedded; gray orange grading into blue weathers light blue. Few Inoceramus.	.7
21. Limestone; chalky; light gray weathers white. Very few Inoceramus.	.3
Thickness of member exposed.	11.71

Hartland shale member

22. Shale; silty, calcareous; thin bedded; gray brown weathers light gray brown. Inoceramus.	.2
23. Bentonite; orange.	.1
24. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue; occasional limy zones. Very few Inoceramus.	6.4
25. Bentonite; cream and orange.	.5
26. Limestone; chalky; light gray weathers white. Few Inoceramus.	.2
27. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue; occasional limy zones. Very few Inoceramus.	2.3
28. Shale; bentonitic; calcareous; thin bedded; gray brown weathers light gray brown. Nonfossiliferous.	.1
29. Limestone; chalky; blue gray weathers light blue gray. Very few shell fragments.	.3
30. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.1
31. Shale; limonitic.	.2
32. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.4
33. Bentonite; cream and orange.	.1
34. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	3.7
35. Bentonite; cream and orange.	.1
36. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	1.1
37. Bentonite; cream and orange.	.2
38. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.7
Thickness of member.	16.70

	Feet
Lincoln limestone member	
39. Shale with numerous thin crystalline limestones; shales are silty, calcareous, and thin bedded; blue weathers light blue. Few Inoceramus. Limestones are blue gray weathers light blue gray. Inoceramus and sharks teeth.	3.0
40. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	2.5
41. Bentonite; cream and orange.	.05
42. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.4
43. Bentonite; cream and orange.	.05
44. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.6
45. Bentonite; cream and orange.	.1
46. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.2
47. Bentonite; cream and orange.	.01
48. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.6
49. Bentonite; cream and orange.	.01
50. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	3.0
51. Bentonite; cream and orange.	.3
52. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.5
53. Bentonite; gray.	.05
54. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	1.4
55. Bentonite; orange.	.05
56. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	3.6
57. Bentonite; orange.	.05
58. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.3
59. Bentonite; cream and orange.	.1
60. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	3.6
61. Limestone; chalky to crystalline at base; blue gray weathers light blue gray. Very few Inoceramus.	.1
62. Bentonite; cream and orange.	.05
63. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	3.1
64. Bentonite; cream and orange.	.1
65. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	.6
66. Bentonite; cream and orange.	.1

	Feet
67. Shale; silty, calcareous; thin bedded; blue weathers light blue. Very few Inoceramus.	1.0+
Thickness of member	25.52
Thickness of Greenhorn limestone exposed.	53.93

Base covered.

Section No. 2

A road cut on U. S. Highway 36 in the SW¼SW¼ sec. 1, T. 3 S., R. 1 W. (Republic Co., Kans.) shows the following section:

	Feet
1. Soil	1.0
Greenhorn limestone	
Pfeifer shale member (uppermost part covered)	
2. Limestone; chalky; gray-orange weathers tan gray; crystalline layers due to Inoceramus shell. Inoceramus abundant.	.15
3. Bentonite; light gray and gray orange. . . .	.1
4. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	.6
5. Limestone; chalky; gray orange weathers tan gray; crystalline layers; ferruginous concretions. Inoceramus abundant.	.15
6. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	.7
7. Limestone; chalky; gray orange weathers tan gray; crystalline layers; ferruginous concretions. Inoceramus abundant.	.1
8. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	.2
9. Limestone; chalky; tan gray weathers light gray. Inoceramus abundant.	.2
10. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	.6
11. Limestone; chalky; gray orange weathers light gray orange; Inoceramus.	.2
12. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	1.2
13. Limestone; chalky; gray orange weathers light gray. Inoceramus.	.2
14. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Inoceramus abundant.	1.1
Thickness of member exposed.	5.50

	Feet
Jetmore chalk member	
15. Limestone ("Shell rock bed"); massive; tan gray weathers tan. *Inoceramus* abundant.	1.1
16. Shale; silty, calcareous; platy; gray orange interbedded with light gray. *Inoceramus*.	1.0
17. Limestone; chalky; light gray weathers tan; reddish brown streak near base. Nonfossiliferous.	.1
18. Shale; silty, calcareous; platy; gray orange interbedded with light gray. *Inoceramus*.	.2
19. Limestone; chalky; light gray weathers tan. Nonfossiliferous.	.1
20. Shale; silty, calcareous; platy; gray orange interbedded with light gray. *Inoceramus*.	.1
21. Limestone; chalky; light gray weathers tan. Nonfossiliferous.	.1
22. Shale; silty, calcareous; platy; gray orange interbedded with light gray. *Inoceramus*.	.5
23. Limestone; chalky; tan gray weathers light tan gray. *Inoceramus* abundant.	.3
24. Shale; silty, calcareous; platy; gray orange alternating with light gray weathers light gray. *Inoceramus*.	1.0
25. Limestone; platy; gray weathers gray orange. *Inoceramus* abundant.	.3
26. Shale; silty, calcareous; platy; gray orange alternating with light gray weathers light gray. *Inoceramus*.	.8
27. Limestone; chalky; soft; tan gray weathers light tan gray; ferruginous stains on fracture surfaces. *Inoceramus* abundant.	.4
28. Shale; silty, calcareous; platy; gray orange alternating with light gray weathers light gray. *Inoceramus*.	.7
29. Limestone; chalky; tan gray weathers light gray orange; ferruginous concretions present. *Inoceramus*.	.2
30. Shale; silty, calcareous; platy; gray orange alternating with light gray weathers light gray. *Inoceramus*.	.7
31. Limestone; chalky; soft; gray orange weathers light tan gray; ferruginous stains on fracture surfaces. Few *Inoceramus* present.	.2

	Feet
32. Shale; silty, calcareous; platy; light gray with streaks of gray orange weathers tan gray. Inoceramus. . . .	.6
33. Limestone; chalky; tan gray weathers light tan gray; ferruginous concretions present and ferruginous stains on fracture surfaces. Very few Inoceramus. .	.3
34. Shale; silty, calcareous; platy; tan gray with streaks of gray orange weathers light gray orange; ferruginous streaks present. Few Inoceramus.	1.5
35. Limestone; chalky; light gray weathers light gray; ferruginous stains on fracture surfaces. Few Inoceramus. . .	.4
36. Shale; silty, calcareous; platy; gray orange interbedded with light gray weathers light gray orange. Few Inoceramus.	.8
37. Limestone; chalky; soft; light gray with orange weathers light gray orange; ferruginous stains present. Few Inoceramus.	.1
38. Shale; silty, calcareous; platy; tan gray with some streaks of gray orange weathers light gray. Few Inoceramus.	.8
39. Limestone; chalky; light gray weathers light gray; ferruginous stains present. Few Inoceramus.	.1
40. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Few Inoceramus	.7
41. Limestone; chalky; tan gray weathers light tan gray. Very few Inoceramus.	.15
42. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Few Inoceramus.	.4
43. Shale; silty, calcareous; platy; blue black weathers light gray blue. Few Inoceramus.	.3
44. Limestone; chalky; tan gray with dark gray streaks weathers light tan gray. Non-fossiliferous.	.2
45. Shale; silty, calcareous; platy; blue black weathers light gray blue. Few Inoceramus.	.5
46. Limestone; chalky; gray orange weathers light gray orange; ferruginous stains present. Very few Inoceramus.	.2
Thickness of member.	14.85

	Feet
Hartland shale member	
47. Shale; silty, calcareous; platy; blue black weathers light gray blue. Few Inoceramus.	.2
48. Bentonite; light gray and gray orange. .	.01
49. Shale; silty, calcareous; fissle; blue black weathers light gray blue; jointing evidenced. Few Inoceramus. . . .	4.1
50. Bentonite; reddish brown.	.01
51. Shale; silty, calcareous; fissle; blue black weathers light gray blue; jointing evidenced. Few Inoceramus. . . .	2.5
52. Bentonite; light gray and gray orange. .	.6
53. Shale; silty, calcareous; fissle; blue black weathers light blue gray; ferruginous stains near base. Very few Inoceramus.	2.6
54. Bentonite; light gray intermixed with gray orange.	.01
55. Limestone; chalky; dark gray weathers light gray. Few Inoceramus.	.3
56. Shale; silty, calcareous; fissle; blue black weathers light blue gray; ferruginous stains present near top. Very few Inoceramus.	.8
57. Bentonite; gray orange.	.15
58. Shale; silty, calcareous; fissle; blue black weathers light blue gray. Very few Inoceramus.	.5
59. Shale; silty, calcareous; blocky; blue black weathers light blue gray. Non-fossiliferous.	.4
60. Shale; silty, calcareous; fissle; blue black weathers light blue gray. Very few Inoceramus fragments.	2.6
61. Bentonite; cream intermixed with reddish brown.	.15
62. Shale; silty, calcareous; fissle; blue black weathers light blue gray. Very few Inoceramus fragments.	1.0
63. Bentonite; light cream intermixed with reddish brown.	.3
64. Shale; silty, calcareous; fissle; blue black weathers light blue gray. Very few Inoceramus fragments.	.2
65. Bentonite; gray brown with some reddish brown.	.05
66. Shale; silty, calcareous; fissle; blue black weathers light blue gray. Very few Inoceramus fragments.	1.4

	Feet
67. Bentonite; gray brown and reddish brown.	.01
68. Shale; silty, calcareous; fissle; dark blue black weathers light blue gray; contains crystalline layers of shells. *Inoceramus* abundant.	4.1
69. Bentonite; cream and reddish brown. . .	.01
70. Shale; silty, calcareous; fissle; dark blue black weathers light gray blue; contains crystalline layers of shells. *Inoceramus* abundant.	.4
71. Bentonite; cream and reddish brown. . . .	.01
72. Shale; silty, calcareous; fissle; dark blue black weathers light gray blue; contains crystalline layers of shells. *Inoceramus* abundant.	.6
73. Bentonite; cream and reddish brown. . .	.01
74. Shale; silty, calcareous; fissle; dark blue black weathers light gray blue; contains crystalline layers of shells. *Inoceramus* abundant.	.2
75. Bentonite; cream and reddish brown. . . .	.01
Thickness of member	23.23
Thickness of Greenhorn limestone exposed.	43.58

Base covered.

Section No. 5

A road cut in the SE¼SE¼ sec. 28, T. 3 S., R. 4 W. (Republic Co., Kans.) shows the following section:

	Feet
1. Soil	1.0
Greenhorn limestone	
Pfeifer shale member	
2. Limestone ("Fencepost bed"); massive; light gray with reddish brown streak through middle weathers tan gray with light reddish orange streak through middle. Some Inoceramus.	1.2
3. Shale; silty, calcareous; platy; tan gray with streaks of gray orange weathers light tan gray. Few Inoceramus. . . .	.3
4. Bentonite; gray.	.02
5. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Very few Inoceramus.	.5
6. Shale; silty, calcareous; platy; light gray with a few streaks of gray orange weathers light gray. Few Inoceramus. . . .	.25
7. Limestone; chalky; light gray weathers tan gray. Inoceramus abundant.	.1
8. Shale; silty, calcareous; blocky; gray orange with streaks of light gray weathers tan gray; contains thin crystalline shell layers. Inoceramus abundant. . .	.9
9. Limestone; platy; light gray weathers gray orange; laminated. Nonfossiliferous. . .	.1
10. Shale; silty, calcareous; blocky; light gray with gray orange streaks weathers light gray orange; contains thin crystalline shell layers. Inoceramus abundant. . . .	.9
11. Limestone; chalky; light gray with gray orange streaks weathers light gray orange. Nonfossiliferous.	.2
12. Shale; silty, calcareous; platy; tan gray with gray orange streaks weathers light gray orange. Few Inoceramus.	.4
13. Bentonite; light gray.	.1
14. Shale; silty, calcareous; platy; light gray with gray orange streaks weathers light gray. Few Inoceramus.	.2

	Feet
15. Limestone; chalky; gray orange with streaks of light gray weathers gray orange. Few Inoceramus.	.1
16. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Few Inoceramus.	.1
17. Bentonite; light gray and gray orange. .	.05
18. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light gray orange; contains thin crystalline shell layers. Inoceramus abundant.	.7
19. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant. . .	.1
20. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light gray orange; contains thin crystalline shell layers. Inoceramus abundant.	.3
21. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant.	.1
22. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light gray orange; contains thin crystalline shell layers. Inoceramus abundant.	.8
23. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant.	.1
24. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light gray orange; contains thin crystalline shell layers. Inoceramus abundant.	.9
25. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant. .	.1
26. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant.	.9
27. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant. . .	.1
28. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant.	.3
29. Limestone; chalky; tan gray weathers light tan gray. Inoceramus abundant. .	.1

	Feet
30. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.6
31. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.1
32. Bentonite; gray and gray orange.	.05
33. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.3
34. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.1
35. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.15
36. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.15
37. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.2
38. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.1
39. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.7
40. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.2
41. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.6
42. Limestone; chalky; gray orange weathers light gray orange. Inoceramus.	.05
43. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.1
44. Limestone; chalky; gray orange weathers light gray orange; laminated. Inoceramus abundant.	.2
45. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant.	.3
46. Limestone; chalky; gray orange weathers light gray orange; laminated. Inoceramus abundant.	.1

	Feet
47. Shale; silty, calcareous; platy; gray orange with streaks of tan gray weathers light tan gray; contains thin crystalline shell layers. Inoceramus abundant. . . .	.3
48. Limestone; chalky; gray orange weathers light gray orange; laminated. Inoceramus abundant.	.15
49. Shale; silty, calcareous; platy; olive drab with streaks of gray orange weathers tan gray. Few Inoceramus.	.25
50. Limestone; chalky; light gray weathers light gray. Inoceramus.	.15
51. Shale; silty, calcareous; platy; brown weathers light brown. Few Inoceramus. .	.5
52. Limestone; thin bedded; soft; tan gray weathers light tan gray. Nonfossiliferous.	.1
53. Shale; silty, calcareous; platy; brown weathers light brown, few gray orange streaks. Few Inoceramus.	.4
Thickness of member.	14.77

Jetmore chalk member

54. Limestone ("Shell rock bed"); massive; tan gray weathers tan. Inoceramus abundant.	1.3
55. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	.6
56. Limestone; chalky; tan gray weathers light tan gray. Nonfossiliferous.	.1
57. Shale; silty, calcareous; platy; gray brown weathers tan gray; numerous thin crystalline shell layers. Inoceramus abundant. .	.3
58. Limestone; chalky; light gray weathers light gray. Inoceramus abundant.	.1
59. Shale; silty, calcareous; platy; gray brown weathers tan gray; numerous thin crystalline shell layers. Inoceramus abundant. .	.1
60. Limestone; chalky; light gray weathers light gray. Inoceramus abundant. . . .	.1
61. Shale; silty, calcareous; platy; gray brown weathers tan gray; numerous thin crystalline shell layers. Inoceramus abundant.	.15
62. Limestone; chalky; light gray weathers light gray. Inoceramus abundant. . . .	.1
63. Shale; silty, calcareous; platy; gray brown weathers tan gray; numerous thin crystalline shell layers. Inoceramus abundant.	.4

	Feet
64. Limestone; chalky; slightly crystalline; gray orange weathers light gray orange. *Inoceramus* abundant.	.3
65. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus* abundant.	.3
66. Limestone; chalky; light gray weathers light gray. *Inoceramus* abundant. . . .	.15
67. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus* abundant.	.5
68. Limestone; chalky; slightly crystalline; gray orange weathers light gray orange. *Inoceramus* abundant.	.3
69. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus* abundant.	.8
70. Limestone; chalky; slightly crystalline; gray orange weathers light gray orange. *Inoceramus* abundant.	.3
71. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus* abundant.	.6
72. Limestone; chalky; slightly crystalline; gray orange weathers light gray orange. *Inoceramus* abundant.	.25
73. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus* abundant.	.6
74. Limestone; chalky; slightly crystalline; gray orange weathers light gray orange. *Inoceramus* abundant.	.2
75. Shale; silty, calcareous; platy; blue black weathers light blue gray. *Inoceramus*.	.5
76. Limestone; chalky; dark gray weathers light gray. Nonfossiliferous.	.2
77. Shale; silty, calcareous; platy; blue black weathers light blue gray. *Inoceramus*.	.45
78. Shale; silty, calcareous; blocky; dark gray weathers light gray. Few *Inoceramus*. . .	.5
79. Shale; silty, calcareous; platy; blue black weathers light blue gray. *Inoceramus*.	.5
80. Limestone; chalky; light gray weathers light gray; some ferruginous stains. Few *Inoceramus*.	.2
81. Shale; silty, calcareous; platy; blue black weathers light blue gray. *Inoceramus* and very few cephalopods. . .	.55

	Feet
82. Limestone; chalky; light gray weathers light gray; some ferruginous stains. Few Inoceramus.	.2
Thickness of member exposed	10.60
Thickness of Greenhorn limestone exposed.	25.37

Base covered.

Section No. 15

A cut bank along the Solomon River in the NE¼NW¼ sec. 11, T. 7 S., R. 8 W. (Mitchell Co., Kans.) shows the following section:

Greenhorn limestone

Jetmore chalk member (shown on another section)

	Feet
Hartland shale member	
1. Bentonite; orange.	.1
2. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus fragments.	4.4
3. Limestone; chalky; cream weathers white. Inoceramus.	.3
4. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	2.5
5. Bentonite; cream and orange.	.5
6. Limestone; platy; light gray weathers light gray. Inoceramus.	.4
7. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	2.8
8. Limestone; platy; gray weathers light gray. Inoceramus.	.3
9. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	.8
10. Bentonite; orange.	.2
11. Shale; silty, calcareous; platy; blue weathers light blue; contains calcite seams. Inoceramus.	.4
12. Limestone; chalky; petroliferous; blue gray weathers light blue gray. Shell fragments.	1.2
13. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	1.1
14. Limestone; chalky; petroliferous; blue gray weathers light blue gray. Shell fragments.	.1
15. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	2.0
16. Bentonite; cream and orange.	.1
17. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	1.0
18. Bentonite; cream and orange.	.1
19. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus.	3.0
Thickness of member.	21.3

	Feet
Lincoln limestone member	
20. Limestone; slightly crystalline; petroliferous; blue gray weathers light blue gray. Inoceramus fragments, sharks teeth.	1.0
21. Bentonite; cream and orange.	.05
22. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus, sharks teeth.	.4
23. Bentonite; cream and orange.	.2
24. Shale; silty, clayey at base (bentonite), calcareous; platy; blue weathers light blue. Inoceramus, sharks teeth.	.5
25. Limestone; slightly crystalline; petroliferous; blue gray weathers light blue gray. Inoceramus and sharks teeth. . .	.2
26. Shale; silty, calcareous; platy; blue weathers light blue; Inoceramus, sharks teeth.	2.7
27. Bentonite; cream and orange.	.4
28. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus, sharks teeth.	9.0+
Thickness of member exposed.	14.45
Thickness of Greenhorn limestone exposed.	35.75
Base covered.	

Section No. 16

A road cut south of the Solomon River in the NW¼NE¼ sec. 10, T. 7 S., R. 8 W. (Mitchell Co., Kans.) shows the following section:

	Feet
1. Soil	0.3
Greenhorn limestone	
Pfeifer shale member	
2. Limestone ("Fencepost bed"); massive; light gray with reddish brown streak through the middle weathers tan gray with a reddish brown streak through the middle. *Inoceramus* and a few cephalopods.	.6
3. Shale; silty, calcareous; platy; tan weathers dark gray. *Inoceramus*.	.3
4. Shale; silty, calcareous; platy; light gray and gray orange weathers gray. Occasional *Inoceramus*.	.2
5. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Few *Inoceramus*.	.2
6. Bentonite; gray and gray orange.	.1
7. Shale; silty, calcareous; platy; gray orange and light gray weathers light gray. Few *Inoceramus*.	.6
8. Limestone; chalky; light gray with streaks of gray orange weathers gray; distinct parting near middle where ferruginous stains are noted; thins and swells. *Inoceramus*.	.2
9. Shale; silty, calcareous; platy; gray orange and light gray weathers light gray orange. Few *Inoceramus*.	1.4
10. Limestone; chalky; tan gray weathers tan. Few *Inoceramus*.	.2
11. Shale; silty, calcareous; platy; gray orange with streaks of light gray weathers light gray orange. Few *Inoceramus*. .	.9
12. Bentonite; gray and gray orange.	.01
13. Shale; silty, calcareous; slightly blocky; light gray with streaks of gray orange weathers light gray orange; thin green clayey layer at base. Few *Inoceramus*. . .	.6
14. Bentonite; cream and yellow.	.25
15. Shale; silty, calcareous; platy; light gray with a light gray orange area near the top weathers light gray orange. *Inoceramus* fragments and fish scales.	.2

	Feet
16. Limestone; chalky; reddish brown with a light gray zone at the top and base weathers light reddish brown. *Inoceramus* and a few very small pelecypods.	.3
17. Shale; silty, calcareous; platy; gray orange weathers gray. Few *Inoceramus*. .	.1
18. Bentonite; white and reddish brown. . . .	.1
19. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Few *Inoceramus* and fish scales.	.6
20. Limestone; chalky; gray orange weathers light gray; thins and swells. Few *Inoceramus*.	.3
21. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus*.	1.4
22. Limestone; chalky; light gray weathers tan gray; thin calcite seams throughout. *Inoceramus* abundant.	.3
23. Shale; silty, calcareous; platy; gray orange weathers light gray orange. *Inoceramus*.	.5
24. Limestone; chalky; light gray weathers tan gray; thins and swells; thin calcite seams throughout. *Inoceramus*.	.3
25. Shale; silty, calcareous; platy; gray orange weathers light gray orange; thin calcite seams throughout. *Inoceramus*.	.5
26. Limestone; chalky; light gray weathers light gray; thin calcite seams throughout. *Inoceramus*.	.2
27. Shale; silty, calcareous; platy; gray orange weathers light gray orange; calcite seams throughout. *Inoceramus* abundant.	.5
28. Limestone; chalky; gray weathers light gray; calcite seams throughout. Abundant *Inoceramus*.	.2
29. Shale; silty, calcareous; platy; gray orange weathers light gray orange; calcite seams throughout. Abundant *Inoceramus*.	.6
30. Limestone; chalky; light gray weathers light gray. *Inoceramus*.	.2
31. Bentonite; gray orange.	.2
32. Shale; silty, calcareous; platy; dark gray weathers gray. Few *Inoceramus*. . . .	.2
33. Limestone; chalky; light gray weathers light gray; thins and swells. *Inoceramus* abundant.	.2

	Feet
34. Shale; silty, calcareous; platy; dark gray with streaks of gray orange weathers gray; calcite seams throughout. *Inoceramus* abundant.	.4
35. Limestone; chalky; gray weathers light gray; calcite seams throughout; thins and swells. *Inoceramus* abundant. . .	.2
36. Shale; silty, calcareous; platy; dark gray and gray orange weathers gray. *Inoceramus*.	.3
37. Limestone; chalky; light gray weathers light gray; thins and swells. *Inoceramus* abundant.	.1
38. Shale; silty, calcareous; thin bedded; dark gray and gray orange, grades into blue black at the base weathers dark gray. Few *Inoceramus*.	.3
39. Limestone; chalky; tan weathers light gray; thins and swells. Few *Inoceramus*. . . .	.1
40. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few *Inoceramus*.	.2
41. Limestone; chalky; tan weathers light gray; thins and swells. Few *Inoceramus*. . . .	.1
42. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few *Inoceramus*.	.7
43. Limestone; chalky; tan gray weathers light gray; occasional calcite seams. *Inoceramus* abundant.	.2
44. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Few *Inoceramus*.	.6
45. Limestone; chalky; gray orange with an irregular reddish brown streak near the middle weathers light gray orange; thins and swells. Few *Inoceramus*.	.1
46. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Few *Inoceramus*.	.5
47. Limestone; chalky; tan weathers tan gray; occasional calcite seams; thins and swells. *Inoceramus* abundant.	.1
48. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Few *Inoceramus*.	.7
49. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few *Inoceramus*.	.4

	Feet
50. Shale; silty, calcareous; platy; tan gray and gray orange weathers light gray orange; occasional calcite seams. Inoceramus and fish vertebra.	.9
Thickness of member.	18.36

Jetmore chalk member

51. Limestone ("Shell rock bed"); massive; tan weathers tan gray; shows a tendency to break along shell zones. Inoceramus abundant.	1.1
52. Shale; silty, calcareous; platy; light gray and gray orange weathers light gray orange. Inoceramus.	1.2
53. Limestone; chalky; light gray weathers tan; thins and swells. Few Inoceramus. . . .	.1
54. Shale; silty, calcareous; platy; light gray and gray orange weathers light gray orange. Few Inoceramus.	.3
55. Limestone; chalky; tan gray weathers light tan gray; numerous calcite seams; thins and swells. Inoceramus.	.2
56. Shale; silty, calcareous; platy; light gray and gray orange weathers light gray orange; numerous thin calcite seams. Inoceramus abundant.	.9
57. Limestone; chalky; gray weathers tan gray; occasional irregular calcite seams. Inoceramus abundant.	.3
58. Shale; silty, calcareous; platy; gray orange with blue black layer near top weathers light gray orange; numerous irregular calcite seams. Inoceramus.	.9
59. Limestone; chalky; light gray weathers tan gray. Inoceramus abundant.	.3
60. Shale; silty, calcareous; platy; gray orange with a blue black zone through the middle weathers light gray orange; occasional thin calcite seams. Inoceramus.	.9
61. Limestone; massive; chalky; gray weathers light gray; ferruginous concretions near middle. Inoceramus.	.9
62. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.8
63. Limestone; chalky; gray weathers light gray; ferruginous concretions near the middle. Inoceramus.	.2
64. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.8

	Feet
65. Limestone; slightly crystalline; dark gray weathers gray. Nonfossiliferous.	.2
66. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.8
67. Limestone; chalky; dark gray weathers gray; occasional thin calcite seams; ferruginous stains on weathered surfaces. Inoceramus.	.3
68. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	1.9
69. Limestone; chalky; gray weathers light gray; ferruginous concretions near middle; shows a tendency to shatter and split. Few Inoceramus.	.4
70. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.7
71. Limestone; chalky; gray weathers tan gray. Few Inoceramus.	.3
72. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.7
73. Limestone; chalky; blue gray weathers light blue gray; thins and swells. Few Inoceramus.	.2
74. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	1.0
75. Limestone; chalky; gray weathers light gray; ferruginous concretions near middle. Few Inoceramus.	.3
76. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	1.0
77. Limestone; chalky; gray to gray orange weathers tan gray. Few Inoceramus. . . .	.2
78. Shale; silty, calcareous; thin bedded; blue black weathers light blue black. Few Inoceramus.	.9
79. Limestone; chalky; gray to gray orange weathers light gray; ferruginous concretions and stains persistent near the middle; shows tendency to part near middle. Inoceramus.	.4
Thickness of member	18.20
Thickness of Greenhorn limestone exposed.	36.56

Section No. 24

A road cut in the SE¼SE¼ sec. 12, T. 11 S., R. 7 W. (Lincoln Co., Kans.) shows the following section:

Fairport chalky shale member of the Carlile shale

Greenhorn limestone

	Feet
Pfeifer shale member	
1. Limestone ("Fencepost bed"); massive; chalky; tan gray weathers tan with an orange streak at the middle. Inoceramus.	0.6
2. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.5
3. Bentonite; gray and orange.	.05
4. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.7
5. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus.	.2
6. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	1.1
7. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus.	.2
8. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	1.0
9. Limestone; chalky; laminated; light gray to gray orange weathers light gray orange. Nonfossiliferous.	.1
10. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.1
11. Bentonite; gray.	.05
12. Shale; silty, calcareous; platy; gray orange weathers light gray orange; Inoceramus abundant.	.7
13. Granular calcite ("sugar sand"); orange.	.2
14. Bentonite; light gray.	.1
15. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.3
16. Limestone; chalky; gray to gray orange weathers light gray orange; ferruginous stains. Few Inoceramus.	.3

	Feet
17. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.2
18. Bentonite; gray and orange.	.1
19. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.4
20. Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus abundant.	.2
21. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.2
22. Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus abundant.	.2
23. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	.5
24. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus.	.2
25. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.8
26. Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus abundant.	.2
27. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.5
28. Limestone; chalky; tan gray weathers tan; thins and swells. Inoceramus abundant. .	.2
29. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.8
30. Limestone; chalky; tan gray weathers tan; thins and swells. Inoceramus abundant.	.2
31. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.5
32. Limestone; slightly crystalline; gray weathers tan; ferruginous stains. Few Inoceramus.	.2
33. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.5
34. Limestone; chalky; gray weathers tan; ferruginous stains. Inoceramus abundant.	.2
35. Bentonite; orange.	.1
36. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.4

	Feet
37. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus. .	0.1
38. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.3
39. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus. . .	.2
40. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.3
41. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus.	.1
42. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.4
43. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus.	.1
44. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.8
45. Limestone; chalky; tan gray weathers tan. Inoceramus abundant.	.2
46. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	1.3
47. Limestone; chalky; gray to gray orange weathers light gray orange; ferruginous stains. Inoceramus abundant.	.2
48. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	2.1
Thickness of member.	18.90

Jetmore chalk member

49. Limestone ("Shell rock bed"); massive; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	1.0
50. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus abundant.	1.1
51. Limestone; chalky; light gray weathers tan. Very few Inoceramus.	.2
52. Shale; silty, calcareous; platy; gray orange weathers light gray orange; Inoceramus abundant.	.4
53. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus abundant. . .	.2
54. Shale; silty, calcareous; platy; gray orange weathers light gray orange; blue zone near the top. Few Inoceramus. . . .	.8
55. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	.4

		Feet
56.	Shale; silty, calcareous; thin bedded; blue with a brown zone at the middle weathers light blue. Few Inoceramus. . .	1.0
57.	Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant..	.4
58.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	1.0
59.	Bentonite; orange.	.01
60.	Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus abundant.	.4
61.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. . .	.9
62.	Limestone; chalky; gray blue weathers light gray blue. Few Inoceramus.	.2
63.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. . .	.8
64.	Limestone; chalky; gray blue weathers light gray blue. Few Inoceramus.	.2
65.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. . .	.9
66.	Limestone; chalky; gray blue weathers light gray blue. Few Inoceramus.	.3
67.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. . .	1.9
68.	Limestone; chalky; blue gray weathers light blue gray; ferruginous stains and concretions. Few Inoceramus.	.4
69.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. .	1.0
70.	Limestone; chalky; light gray weathers white. Very few Inoceramus.	.2
71.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.8
72.	Limestone; chalky; light gray weathers white. Very few Inoceramus.	.2
73.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	1.0
74.	Limestone; chalky; gray weathers light gray; ferruginous stains. Few Inoceramus.	.3
75.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus. . .	1.0
76.	Limestone; chalky; light gray weathers white. Very few Inoceramus.	.2
77.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.5
78.	Limestone; chalky; light gray weathers white. Very few Inoceramus.	.1
79.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.5

	Feet
80. Limestone; chalky; gray blue weathers light gray blue; ferruginous stains. Few Inoceramus.	0.3
Thickness of member.	18.61
Hartland shale member	
81. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	.2
82. Bentonite; orange.	.1
83. Shale; silty, calcareous; thin bedded; blue weathers light blue. Few Inoceramus.	2.0+
Thickness of member exposed.	2.30
Thickness of Greenhorn limestone exposed.	39.81

Base covered.

Section No. 30

A road cut on U. S. Highway 281 in the NE¼SE¼ sec. 27, T. 12 S., T. 14 W. (Russell Co., Kans.) shows the following section:

Fairport chalky shale member of the Carlile shale

Greenhorn limestone

	Feet
Pfeifer shale member	
1. Limestone ("Fencepost bed"); massive; chalky; tan gray weathers tan. Inoceramus.	0.6
2. Shale; silty, calcareous; platy; light gray and gray orange weathers light gray orange. Inoceramus.	.5
3. Bentonite; gray and orange.	.05
4. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	.6
5. Limestone; chalky; gray weathers light gray; concretionary. Inoceramus.	.2
6. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	1.4
7. Limestone; chalky; gray weathers light gray; concretionary. Inoceramus.	.2
8. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	1.0
9. Limestone; chalky; laminated; gray weathers light gray. Inoceramus abundant. . .	.1
10. Bentonite; orange.	.1
11. Shale; silty, calcareous; platy; gray and gray orange weathers light gray. Inoceramus.	.7
12. Granular calcite ("sugar sand"); orange. . .	.4
13. Shale; silty, calcareous; platy; gray brown weathers light gray brown. Inoceramus.	.2
14. Limestone; chalky; light gray and gray orange weathers light gray; thins and swells. Inoceramus.	.2
15. Shale; silty, calcareous; platy; light gray weathers light gray. Inoceramus. . .	.2
16. Bentonite; cream and orange.	.1
17. Shale; silty, calcareous; platy; light gray weathers light gray. Inoceramus. . .	.2
18. Limestone; chalky; gray weathers light gray; concretionary. Inoceramus.	.2

		Feet
19.	Shale; silty, calcareous; platy; light gray and gray orange weathers light gray orange. Inoceramus and sharks teeth.	0.6
20.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . .	.1
21.	Shale; silty, calcareous; platy; light gray weathers light gray. Inoceramus. .	.3
22.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . .	.1
23.	Shale; silty, calcareous; platy; gray brown weathers light brown. Inoceramus.	.8
24.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . .	.2
25.	Shale; silty, calcareous; platy; gray brown weathers light gray brown. Inoceramus.	.5
26.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . . .	.1
27.	Shale; silty, calcareous; platy; gray brown weathers light gray brown. Inoceramus.	.6
28.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . . .	.1
29.	Shale; silty, calcareous; platy; gray brown weathers light gray brown. Inoceramus.	.2
30.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . .	.1
31.	Shale; silty, calcareous; platy; gray brown weathers light gray brown. Inoceramus.	.4
32.	Limestone; chalky; gray weathers light gray; thins and swells. Inoceramus. . .	.1
33.	Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	.7
34.	Limestone; chalky; gray weathers light gray. Inoceramus.	.2
35.	Bentonite; orange.	.1
36.	Shale; silty, calcareous; thin bedded to platy; brown grading into blue weathers light blue. Inoceramus fragments. . . .	1.0
37.	Limestone; chalky; blue gray weathers light blue gray; thins and swells. Inoceramus.	.1
38.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. . . .	.6
39.	Limestone; chalky; light blue weathers light blue; thins and swells. Inoceramus.	.2
40.	Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	.9
41.	Limestone; chalky; light blue weathers light blue; thins and swells. Inoceramus.	.2

	Feet
42. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.2
43. Limestone; chalky; light blue weathers light blue; concretionary. Inoceramus.	.2
44. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus.	2.1
Thickness of member.	19.15

Jetmore chalk member

45. Limestone ("Shell rock bed"); massive; chalky; gray blue weathers light gray blue. Inoceramus abundant.	.6
46. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.5
47. Limestone; chalky; gray weathers light blue gray. Nonfossiliferous.	.1
48. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	.5
49. Limestone; chalky; gray weathers light blue gray; thins and swells. Inoceramus.	.1
50. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.0
51. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	.3
52. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. . . .	1.0
53. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	.4
54. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. . .	1.0
55. Bentonite; orange.	.05
56. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	.4
57. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	.9
58. Limestone; chalky; gray weathers light blue gray. Inoceramus.	.2
59. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. . .	.9
60. Limestone; chalky; gray weathers light blue gray. Inoceramus.	.2
61. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.0
62. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	.3
63. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	2.2

	Feet
64. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	0.4
65. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.2
66. Limestone; chalky; gray weathers light blue gray; ferruginous stains on surface. Inoceramus.	.2
67. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	2.3
68. Limestone; chalky; gray blue weathers light gray blue; ferruginous stains on surface. Inoceramus.	.4
69. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. . .	1.1
70. Limestone; chalky; gray blue weathers light gray blue; ferruginous stains on surface. Inoceramus.	.2
71. Shale; silty, calcareous; thin bedded; blue weathers light blue. Inoceramus. .	1.5
72. Limestone; chalky; gray blue weathers light gray blue; ferruginous stains on surface. Inoceramus.	.4
Thickness of member.	20.35
Hartland shale member	
73. Shale; silty, calcareous; thin bedded; dark blue weathers blue. Few Inoceramus.	.2
74. Bentonite; orange.	.05
75. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. Few Inoceramus fragments.	9.2
76. Bentonite; orange.	.05
77. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. Few Inoceramus fragments.	4.2
78. Bentonite; orange.	.4
79. Limestone; chalky; light gray weathers very light gray. Very few Inoceramus. . . .	.3
80. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. Few Inoceramus fragments.	2.5
81. Limestone; chalky; light gray weathers very light gray; ferruginous stain on surface. Very few Inoceramus.	.2
Thickness of member exposed.	17.10
Thickness of Greenhorn limestone exposed.	56.60
Base covered.	

Section No. 31

A road cut in the NW¼NE¼ sec. 11, T. 15 S., R. 14 W. (Russell Co., Kans.) shows the following section:

Fairport chalky shale member of the Carlile shale

Greenhorn limestone

Pfeifer shale member

	Feet
1. Limestone ("Fencepost bed"); massive; chalky; tan gray weathers tan. Inoceramus.	0.6
2. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus fragments.	.5
3. Bentonite; gray.	.05
4. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus fragments.	.7
5. Limestone; slightly crystalline; light gray and gray orange weathers light gray; ferruginous stains. Few Inoceramus.	.1
6. Shale; silty, calcareous; blocky to platy; gray orange weathers light gray orange. Inoceramus.	2.0
7. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus.	.2
8. Shale; silty, calcareous; blocky to platy; gray orange weathers light gray orange. Inoceramus.	1.1
9. Limestone; slightly crystalline; light gray and gray orange weathers light gray orange; ferruginous stains. Few Inoceramus.	.2
10. Shale; silty, calcareous; blocky to platy; gray orange weathers light gray orange. Inoceramus.	.7
11. Limestone; chalky; light gray and gray orange weathers light gray orange; thins and swells. Few Inoceramus.	.2
12. Granular calcite ("sugar sand"); orange.	.4
13. Shale; silty, calcareous; blocky to platy; gray orange weathers light gray orange. Inoceramus.	.6
14. Bentonite; cream and orange.	.1
15. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	1.0

	Feet
16. Limestone; chalky; gray weathers light gray; numerous calcite seams; thins and swells. Inoceramus abundant.	0.3
17. Shale; silty, calcareous; platy; gray orange weathers light gray orange; numerous calcite seams. Inoceramus abundant.	.1
18. Limestone; chalky; gray weathers light gray; concretionary. Inoceramus.	.2
19. Shale; silty, calcareous; platy; gray orange grading into blue weathers light blue; numerous calcite seams. Inoceramus abundant.	.9
20. Limestone; chalky; gray weathers light gray; concretionary. Few Inoceramus. . .	.1
21. Shale; silty, calcareous; platy; blue weathers light blue. Few Inoceramus. . .	.6
22. Limestone; chalky; laminated; gray weathers light gray; ferruginous stains; thins and swells. Inoceramus.	.3
23. Shale; silty, calcareous; platy; blue weathers light blue. Few Inoceramus. .	.7
24. Limestone; chalky; laminated; gray weathers light gray; ferruginous stains; thins and swells. Inoceramus.	.3
25. Shale; silty, calcareous; platy; blue weathers light blue. Few Inoceramus. . .	.7
26. Limestone; chalky; laminated; gray weathers light gray; ferruginous stains; thins and swells. Inoceramus.	.2
27. Shale; silty, calcareous; platy; blue weathers light blue. Few Inoceramus.	.6
28. Limestone; chalky; laminated; gray weathers light gray; ferruginous stains, thins and swells. Inoceramus.	.1
29. Shale; silty, calcareous; platy; blue weathers light blue. Few Inoceramus. . . .	.7
30. Limestone; chalky; light gray and gray orange weathers light gray orange; ferruginous stains. Few Inoceramus.	.3
31. Bentonite; sugary; gray and orange.	.1
32. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. Inoceramus.	1.0
33. Limestone; chalky; blue gray weathers light blue gray; concretionary. Few Inoceramus.	.1
34. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. Inoceramus.	.2
35. Limestone; slightly crystalline; blue gray weathers light blue gray; thins and swells. Few Inoceramus.	.1

	Feet
36. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. *Inoceramus*.	0.7
37. Limestone; slightly crystalline; blue gray weathers light blue gray; thins and swells. Few *Inoceramus*.	.2
38. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. *Inoceramus*.	.8
39. Limestone; slightly crystalline; blue gray weathers light blue gray; thins and swells. Few *Inoceramus*.	.3
40. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. *Inoceramus*.	.6
41. Limestone; chalky; blue gray weathers light blue gray; concretionary. *Inoceramus*.	.1
42. Shale; silty, calcareous; thin bedded to fissle; blue weathers light blue. *Inoceramus*.	.6
43. Limestone; chalky; blue gray weathers light blue gray; thins and swells. *Inoceramus*.	.1
44. Shale; silty, calcareous; thin bedded becoming platy at the base; blue weathers light blue. *Inoceramus*.	2.1
Thickness of member.	13.65

Jetmore chalk member

45. Limestone ("Shell rock bed"); massive; chalky; blue gray weathers light blue gray. *Inoceramus* abundant.	1.0
46. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. *Inoceramus*.	1.3
47. Limestone; chalky; blue gray weathers light blue gray; thins and swells. *Inoceramus*.	.1
48. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. *Inoceramus*.	.4
49. Limestone; chalky; blue gray weathers light blue gray; thins and swells. *Inoceramus*.	.2
50. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. *Inoceramus*.	.8
51. Limestone; chalky; blue gray weathers light blue gray; thins and swells. *Inoceramus*.	.4
52. Shale; silty, calcareous; thin bedded to platy; blue weathers light blue. *Inoceramus*.	1.1

	Feet
53. Limestone; chalky; gray weathers light gray. *Inoceramus*	0.3
54. Shale; silty, calcareous; platy; brown and blue weathers light blue. *Inoceramus*	1.0
55. Bentonite; orange	.05
56. Limestone; chalky; light gray weathers tan; ferruginous stains and concretions. *Inoceramus*	.4
57. Shale; silty, calcareous; platy; tan gray weathers light gray. *Inoceramus*	1.0
58. Limestone; chalky; light gray weathers tan; ferruginous stains and concretions. *Inoceramus*	.4
59. Shale; silty, calcareous; platy; blue weathers light blue. *Inoceramus*	1.0
60. Limestone; chalky; gray blue weathers light gray blue. *Inoceramus* fragments	.2
61. Shale; silty, calcareous; platy; blue weathers light blue. *Inoceramus*	1.0
62. Limestone; chalky; light gray weathers light gray; ferruginous stains. *Inoceramus*	.4
63. Shale; silty, calcareous; platy; light gray to light blue weathers light blue gray. Few *Inoceramus*	2.2
64. Limestone; chalky; light gray weathers light gray; ferruginous stains and concretions. *Inoceramus*	.4
65. Shale; silty, calcareous; blocky to platy; blue weathers light blue. *Inoceramus* fragments	3.9
66. Limestone; chalky; light gray weathers light gray; ferruginous stains and concretions. *Inoceramus*	.4
Thickness of member	17.95
Thickness of Greenhorn limestone exposed	31.60

Base covered.

Section No. 35

A composite section - Road cut and stream cut in the $SE\frac{1}{4}SE\frac{1}{4}$ sec. 21, T. 15 S., R. 17 W. and a stream cut in the $NW\frac{1}{4}NW\frac{1}{4}$ sec. 27, T. 15 S., R. 17 W. (Ellis Co., Kans.). Top few feet of the Pfeifer shale member taken from N. W. Bass, Kansas Geological Survey Bulletin 11 Part I. (This is the type section for the Pfeifer shale member).

Greenhorn limestone

Pfeifer shale member	Feet
1. Limestone ("Fencepost bed"); massive; chalky; tan gray weathers tan with an orange streak at the middle. Inoceramus.	0.8
2. Shale; silty, calcareous; platy; cream weathers light tan. Few Inoceramus. . .	.9
3. Limestone; chalky; light gray weathers white; concretionary. Inoceramus. . .	.1
4. Shale; silty, calcareous; platy; cream weathers light tan. Few Inoceramus. . .	.9
5. Limestone; chalky; light gray weathers white; concretionary. Inoceramus. . . .	.3
6. Shale; silty, calcareous; platy; cream weathers light tan. Few Inoceramus. . .	1.1
7. Limestone; chalky; light gray weathers white. Nonfossiliferous.	.1
8. Shale; silty, calcareous; platy; cream weathers light tan. Few Inoceramus. . .	.9
9. Limestone; chalky; light gray weathers white. Inoceramus.	.3
10. Granular calcite ("sugar sand"); orange .	.4
11. Shale; silty, calcareous; platy; cream weathers light tan. Few Inoceramus. . .	.8
12. Limestone; chalky; light gray weathers white; concretionary. Inoceramus. . .	.2
13. Shale; silty, calcareous; platy; light tan weathers tan. Inoceramus.	1.6
14. Limestone; chalky; light gray weathers white; concretionary. Inoceramus. . .	.3
15. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	.6
16. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus abundant. . .	.2
17. Shale; silty, calcareous; platy; gray orange weathers light gray orange. Inoceramus.	1.2
18. Limestone; chalky; tan gray weathers tan; ferruginous concretions. Inoceramus. .	.3

	Feet
19. Bentonite; orange.	0.05
20. Shale; silty, calcareous; platy; tan gray at the top becoming blue at the base weathers light blue; occasional thin limy zones. Inoceramus.	1.0
21. Limestone; chalky; light gray to gray orange weathers light gray orange; thins and swells. Inoceramus abundant.	.2
22. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	.7
23. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus.	.1
24. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	.9
25. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus.	.2
26. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	1.8
Thickness of member.	15.95

Jetmore chalk member

27. Limestone ("Shell rock bed"); massive; chalky; tan gray weathers tan. Inoceramus abundant.	1.0
28. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	1.5
29. Limestone; chalky; tan gray weathers tan; concretionary. Inoceramus.	.2
30. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	.4
31. Limestone; chalky; light gray weathers gray; concretionary. Inoceramus. . . .	.2
32. Shale; silty, calcareous; platy; blue weathers light blue; occasional thin white limy zones. Inoceramus.	.8
33. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus.	.4
34. Shale; silty, calcareous; platy; gray to gray orange weathers light gray orange. Inoceramus.	1.0
35. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus.	.4
36. Shale; silty, calcareous; platy; gray to gray orange weathers light gray orange. Inoceramus.	1.0
37. Bentonite; orange.	.1

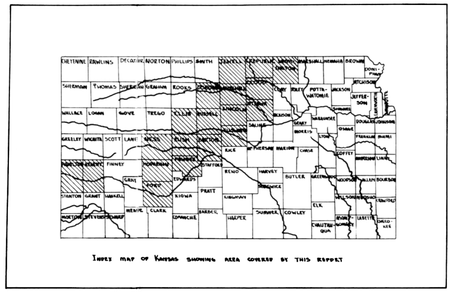
	Feet
38. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus.	0.4
39. Shale; silty, calcareous; platy; gray to gray orange weathers light gray orange. Inoceramus.	.9
40. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus. . . .	.2
41. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus. . . .	.9
42. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus.	.3
43. Shale; silty, calcareous; platy; blue weathers light blue. Inoceramus. . . .	.9
44. Limestone; chalky; tan gray weathers tan; ferruginous stains. Inoceramus. . . .	.4
45. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.9
46. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.5
47. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.0
48. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.4
49. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.0
50. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.4
51. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.1
52. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.4
53. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.0
54. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.4
55. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	1.0
56. Limestone; chalky; blue gray weathers light blue gray; ferruginous stains. Inoceramus.	.4
Thickness of member.	20.41

	Feet
Hartland shale member	
57. Shale; silty, calcareous; platy to thin bedded; light gray to blue weathers light blue. Inoceramus.	0.2
58. Bentonite; orange.	.1
59. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	4.6
60. Bentonite; orange.	.1
61. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	4.3
62. Limestone; chalky; light gray weathers white. Nonfossiliferous.	.4
63. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	.6
64. Limestone; chalky; light gray weathers white. Nonfossiliferous.	.2
65. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	.8
66. Bentonite; orange.	.01
67. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	.7
68. Limestone; chalky; light gray weathers white. Nonfossiliferous.	.3
69. Shale; silty, calcareous; platy to thin bedded; blue weathers light blue. Few Inoceramus.	.7
70. Limestone; chalky; light gray weathers white. Nonfossiliferous.	.3
71. Shale; silty, calcareous; platy to thin bedded; blue gray weathers light blue gray; occasional thin limy zones. Inoceramus.	2.4
72. Bentonite; cream and orange.	.5
73. Limestone; chalky; gray blue weathers light gray blue. Nonfossiliferous. . . .	.3
74. Shale; silty, calcareous; platy to thin bedded; blue gray weathers light blue gray; occasional thin limy zones. Inoceramus.	2.0
75. Limestone; chalky; gray blue weathers light gray blue. Nonfossiliferous. . . .	.3
76. Shale; silty, calcareous; platy to thin bedded; blue gray weathers light blue gray; occasional thin limy zones. Inoceramus.	1.0+
Thickness of member	19.81
Thickness of Greenhorn limestone exposed.	56.17
Base covered.	

PLATE I

Map Showing Greenhorn

Limestone In Kansas



INDEX MAP OF KANSAS SHOWING AREA COVERED BY THIS REPORT

JEWELL
REPUBLIC
WASHINGTON
CLOUD
OSBORNE
MITCHELL
OTTAWA
LINCOLN
ELLIS
RUSSELL
ELLSWORTH
NESS
RUSH
BARTON
STAFFORD
PAWNEE
HODGEMAN
HAMILTON
KEARNY
FINNEY
GRAY
FORD

EXPLANATION

Greenhorn limestone (Outcrop pattern taken from maps compiled by U.S.G.S. in cooperation with State Highway Commission of Kansas.)

Greenhorn limestone (Outcrop pattern taken from Geological Map of Kansas prepared by the State Geological Survey of Kansas.)

A——A' Cross Sections

Location of Measured Sections

5 Range East or West

1 Township South

PLATE 1

Map Showing Greenhorn Limestone in Kansas 1950

SCALE: 0 5 10 MILES

PLATE II

Cross Section From A To A'

As Shown On PLATE I

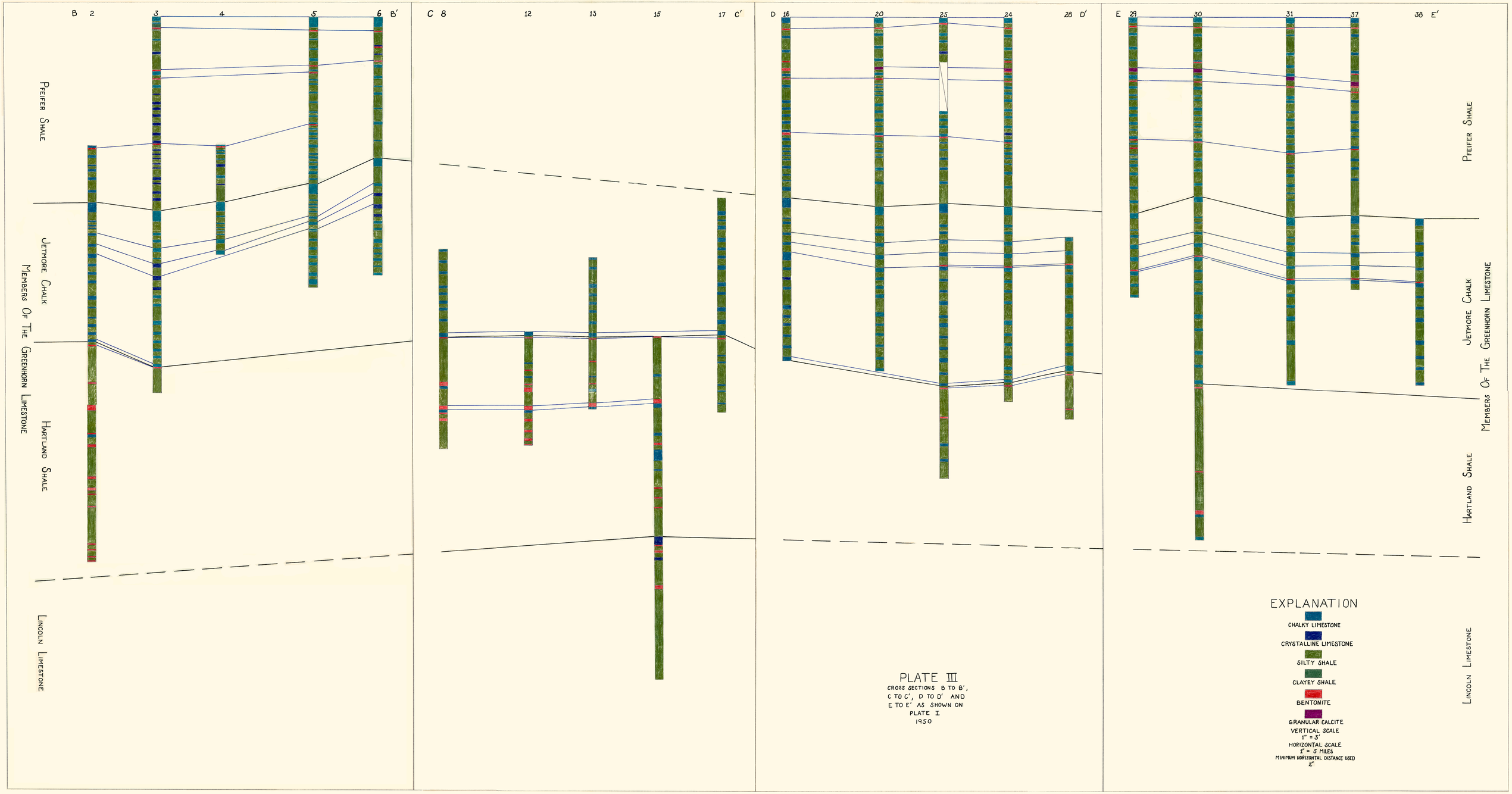


PLATE III

CROSS SECTIONS B TO B′, C TO C′, D TO D′ AND E TO E′ AS SHOWN ON PLATE I

1950

PLATE III

Cross Sections B To B', C To C',

D To D', And E To E'

As Shown On PLATE I

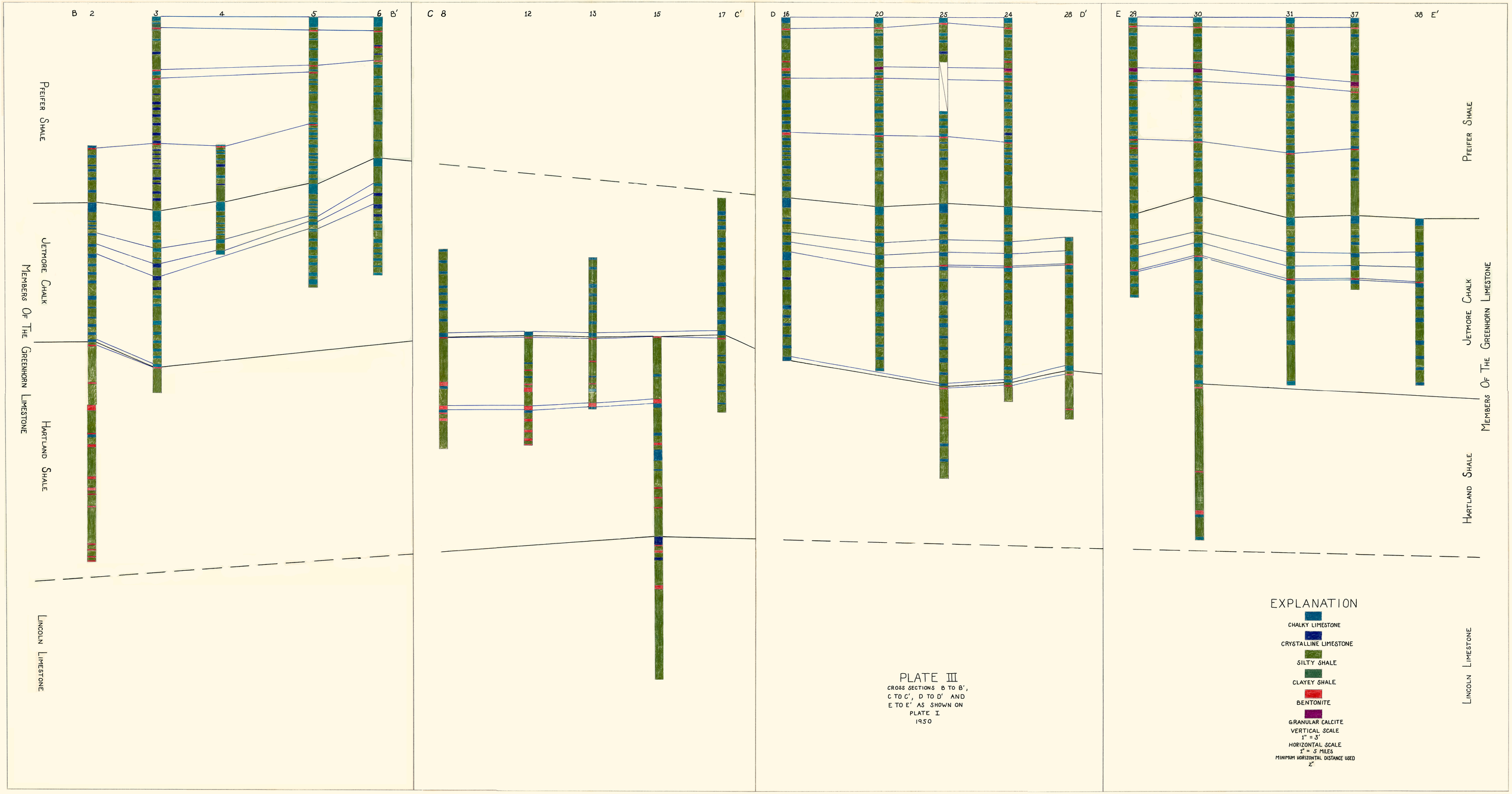


PLATE III

CROSS SECTIONS B TO B′, C TO C′, D TO D′ AND E TO E′ AS SHOWN ON PLATE I

1950