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THE RED EAGLE FORMATION IN KANSAS

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ABSTRACT

Discovery that members of the Red Eagle formation (Lower Permian) have been defined and correlated inconsistently between southern Nebraska and northern Oklahoma indicates need for restudy of these strata. Determination of criteria for recognition of member boundaries usable throughout the area of outcrop is required. It is shown that the Red Eagle beds include faunal and lithologic zones that can be traced entirely across Kansas and adjacent parts of Nebraska and Oklahoma, and these serve to guide identification of stratigraphic units without modifying definitions of this formation and its members.

INTRODUCTION

Recent studies in eastern Kansas, carried beyond the State's boundaries into Nebraska and Oklahoma, show rather pronounced facies changes in the Red Eagle formation, of Early Permian (Wolfcampian) age. Because of these conditions it is believed advisable to define more strictly the boundaries of the formation and its members. The position of the Red Eagle formation in the Lower Permian succession of the northern mid-continent region is shown below.

Partial classification of Lower Permian rocks in Kansas

- Wolfcampian Series
  - Chase group
  - Council Grove group
    - Speiser shale
    - Funston limestone
    - Blue Rapids shale
    - Crouse limestone
    - Easly Creek shale
    - Bader limestone
    - Stearns shale
    - Beattie limestone
    - Eskridge shale
    - Grenola limestone
    - Roca shale
    - **Red Eagle limestone**
    - Johnson shale
    - Foraker limestone
  - Admire group
- Virgilian Series (Pennsylvanian)

The Council Grove group, which has an average thickness of about 320 feet, includes principally shales and limestones; these are described by Moore and others (1951) and earlier authors (Condra, 1927; Bass, 1929; Jewett, 1941). The thickness of the Red Eagle formation along its line of outcrop ranges from about 10 to 35 feet. The included rocks are believed to be entirely of marine origin, comprising limestone and shale, most of which contain marine fossils. In Kansas the rocks included in the formation crop out from Brown, Marshall, and Nemaha Counties, along the Kansas-Nebraska boundary, to Cowley County, on the Kansas-Oklahoma boundary. Northward from Kansas River, in an area including Pottawatomie, Jackson, Brown, Marshall, and Nemaha Counties, these rocks crop out on the east and west sides of both the Nemaha anticline and the Brownville syncline (which lies east of the anticline). Along most of their line of outcrop, they dip gently north of west and hence farther west they are buried under younger strata. In the subsurface of eastern Colorado they lose identity in clastic deposits of the Fountain formation. In northeastern Nebraska, as well as in much of northern Kansas, these Paleozoic rocks are concealed except locally by Pleistocene glacial deposits; in eastern Nebraska they are overlapped by Cretaceous sediments. In Oklahoma the Red Eagle limestone is identified as far southward as the Canadian River Valley, about 120 miles from the Kansas-Oklahoma line. Farther south equivalent beds are clastic deposits included in the Pontotoc group, which overlaps older formations in the Arbuckle Mountains.

Purpose of this paper.—This report is presented to show stratigraphy of the Red Eagle formation and to define its members along its line of outcrop in Kansas. Usable criteria for placement of member boundaries where the lithology of the members differs from that in its type area are described. Confusion as to member boundaries apparent in previous reports is noted and our interpretation of members and their boundaries is shown graphically and discussed in detail.

Acknowledgments.—All geologists to whose writings reference is made in this paper have contributed to solution of problems of the Red Eagle formation; expression of indebtedness to them is appropriate. The conclusions given in this paper, however, are the responsibility of its writers. We are indebted to Dr. George J. Verville for checking the thin sections prepared for this report and identifying some of the fossil material.

PREVIOUS USAGE OF STRATIGRAPHIC NAMES

The type exposure of the Red Eagle limestone is in Osage County, Oklahoma, where 36 years ago it was recognized as a distinct stratigraphic unit, named, and classed among rocks considered to be Pennsylvanian (Heald, 1916, pp. 24-25) in age. At that time the Red Eagle was regarded as a subdivision of the Elmdale shale (Beede, 1902, p. 178), which was defined as comprising strata between the Americus limestone below and the Neva limestone above. The Americus limestone, according to present usage, is the basal member of the Foraker formation, and the Neva limestone is the upper member of the Grenola formation. Gould (1925, p. 80) gave the pre-occupied name Cushing to rocks in Oklahoma, which Miser (1926) later showed were the same as Red Eagle.

In 1927 Condra (p. 86) named the Glenrock limestone, Bennett shale*, and Howe limestone from exposures in southern Nebraska. Condra traced the three members into northern Kansas and many years ago identified them in the vicinity of Manhattan (Jewett, 1941, pp. 48-49). Bass (1929, pp. 54-55) identified the Red Eagle limestone in Cowley County, Kansas, and expressed the belief that it is continuous into central Kansas in the Cottonwood River Valley. Later, Bass (1936, pp. 41-42) stated that he recognized as members of the Red Eagle limestone beds in Cottonwood River Valley bluffs east of Elmdale that Moore and Condra had identified as equivalents of the Glenrock limestone, Bennett shale, and Howe limestone of northern Kansas and southern Nebraska. Thus, correlation of the Red Eagle limestone in northern Oklahoma and the Glenrock limestone, Bennett shale, and Howe limestone in southern Nebraska was indicated.

Two general reports on the Kansas rock section (Moore, Frye, and Jewett, 1944, pp. 167-168; Moore and others, 1951, p. 48) classed the Glenrock limestone, Bennett shale, and Howe limestone as members of the Red Eagle formation and indicated that across the State they are more or less persistent lithologic units.

In 1949, Jewett (p. 16) published a diagrammatic section measured by M. R. Mudge and Robert Burton in sec. 30, T. 11 S., R. 12 E., Wabaunsee County, Kansas. The boundary between the Howe limestone and the Bennett shale at this outcrop, according to the present interpretation, is slightly higher than shown on the diagram. Recently Moore, Jewett, and O'Connor (1951, pp. 14-15) in a report on the geology of Chase County, Kansas, used

* The town from which this shale was named is spelled Bennet (Nebraska).

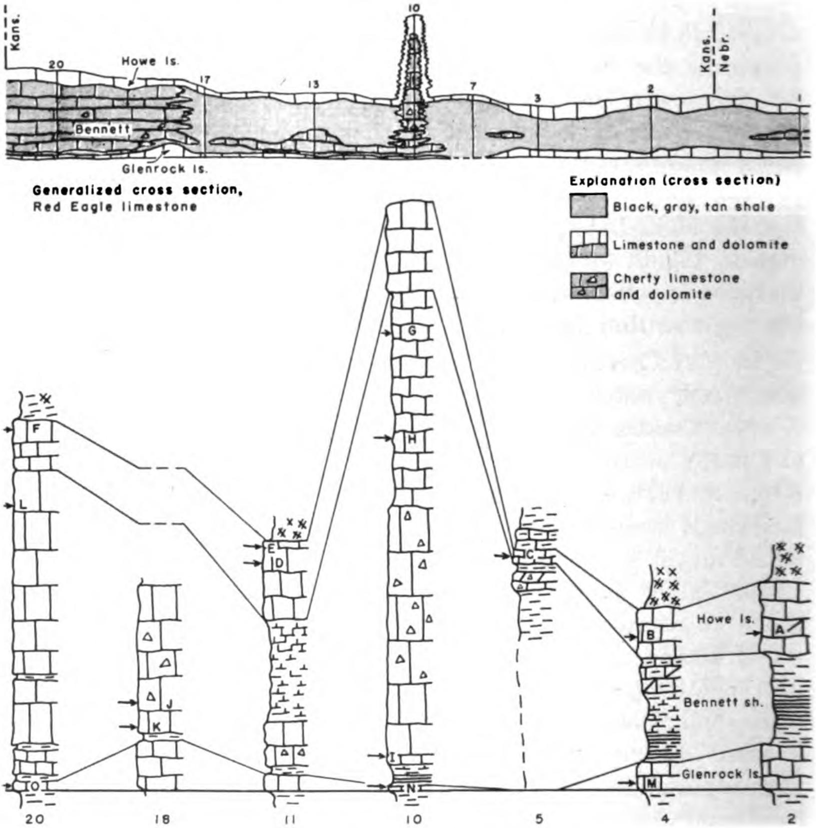
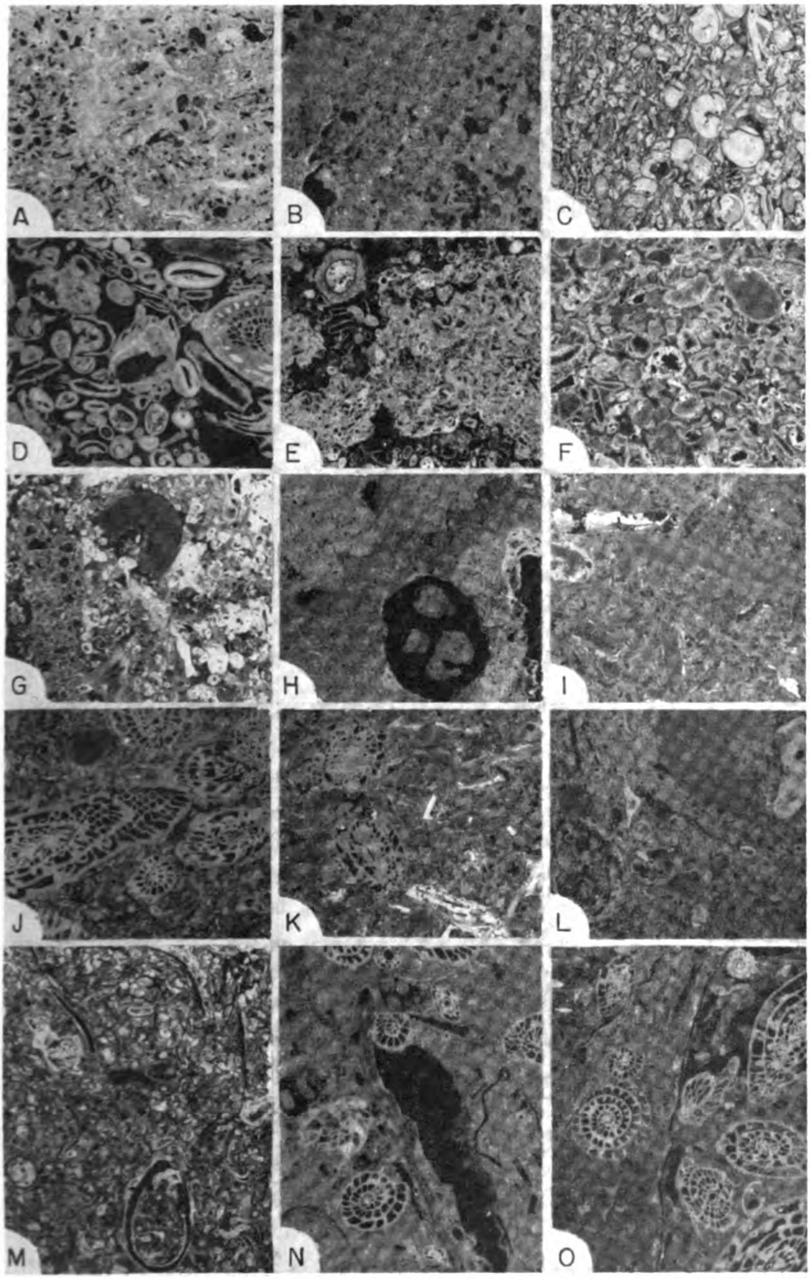


Plate 1. Photomicrographs of thin sections of Red Eagle limestone samples (magnification $\times 7\frac{1}{2}$) (collection point of thin section samples is indicated on graphic sections) and diagrammatic cross section of the Red Eagle formation in Kansas and southern Nebraska. **A** and **B**, Porous, shaly, and dolomitic Howe limestone (Nebraska and northern Kansas facies); **C, D**, and **F**, fossiliferous Howe spergenite (central and southern Kansas, northern Oklahoma facies); **E**, algal Howe limestone with entrapped ostracodes, gastropods, and foraminifers; **G**, coarsely crystalline limestone in the Bennett shale, chiefly crinoidal but containing bryozoans, algae, foraminifers, and other fossil detritus; **H**, limestone in the Bennett which contains abundant algal material but includes also bryozoans, brachiopods, and ostracodes; **I**, abundant fragments of *Orbiculoidea* in basal part of limestone in the Bennett shale; **J**, fusulinid-bearing limestone in the lower Bennett shale above *Orbiculoidea* zone; **K**, basal 0.6 foot of the limestone in the Bennett member with abundant *Orbiculoidea* fragments and fusulinids; **L**, limestone in the upper part of the Bennett member, contains echinoderm fragments, fusulinids, gastropods, encrusting algae, ostracodes, and foraminifers; **M**, nonfusulinid Glenrock limestone with abundant foraminifers, ostracodes, gastropods, algae, and shell detritus; **N** and **O**, fusulinid-bearing Glenrock limestone with foraminifers, brachiopods, gastropods, bryozoans, and ostracodes. Numbers on the sections correspond to numbers on the detailed sections.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the names Glenrock, Bennett, and Howe for strata that crop out in Cottonwood and Neosho River Valleys; this accorded with usage introduced by Bass (1936). The rock called Glenrock in the Chase County report includes part of the Bennett shale of this paper. A report by Mudge and Burton (1950, pp. 51-53, 170-175) assigns to the Howe limestone parts of the Red Eagle formation which are classed as part of the Bennett shale in this paper. In 1951 Jewett and O'Connor (p. 19) published a graphic section of an exposure in northern Lyon County (sec. 35, T. 15 S., R. 11 E.) showing classification of beds as in the Chase County report. However, a graphic section of an exposure in sec. 23, T. 15 S., R. 11 E. (Jewett and O'Connor, 1951, p. 20) shows identification of the Glenrock limestone that is believed to be correct, although rock labeled "Howe limestone" is now judged to belong partly to the Bennett shale member.

The original definitions of the Red Eagle limestone and the members of the formation are in no way modified in this paper. Deviations from former placement of member boundaries along the line of outcrop in Kansas are based on the continuation of fossil zones and other persistent lithologic characteristics of the rocks.

STRATIGRAPHY OF THE RED EAGLE FORMATION

Red Eagle Limestone

Definition.—Heald (1916, p. 24-25) named the Red Eagle limestone and designated the excellent exposures near Red Eagle school, southwest of Foraker, Oklahoma, as the type locality. He described the limestone as consisting of "a number of distinct beds of limestone, between which are beds of shale in some localities. One of the most distinctive features of the top bed of the limestone in much of the [Foraker] quadrangle is the character of the fresh surface, which shows an abundance of tiny grains of crystalline calcite, giving the surface the appearance of having been covered with frost or light snow." The thickness in some exposures "is at least 17 feet, but in others it is probably much less."

Description.—The Red Eagle limestone in southern Kansas, as in northern Oklahoma, is a nearly solid limestone section ranging from about 15 to 22 feet in thickness.

Northward from a point in southwestern Greenwood County to southern Nebraska, the formation becomes shaly and contains roughly equal percentages of shale and limestone, except in a bioherm or reef along the Lyon-Wabaunsee County boundary. Except in this bioherm, where the formation is at least 32 feet thick, it ranges from about 10 to 19 feet (cross section, Pl. 1). The bioherm in the Red Eagle limestone is elongate in a north-northeast to south-southwest direction, has a length of approximately 5 or 6 miles, and is approximately one-eighth to 1 mile wide. The lower part is hard, massive, cherty dolomite and contains a large percentage of voids. The core exhibits a variety of textures and lithologies and parts of it contain abundant fossil remains.

HOWE LIMESTONE MEMBER

Definition.—Condra (1927, p. 86) defined the Howe limestone as

> . . . named from exposures south of Howe, Nebraska; stone in its unweathered condition, dark gray, massive, and dense, with considerable free calcite; weathers buff to yellowish, granular, vesicular or cavernous, and very irregular; thickness about 4 feet. This carries geodes at places. It has few fossils.

Description.—The Howe limestone in southern Nebraska and northern Kansas is essentially as described by Condra. It ranges from about 1 to 4.5 feet in thickness and is characterized by its yellow to buff weathered color and its spongy, vesicular, cavernous, or granular appearance. Secondary calcite, celestite, and quartz occur as scattered crystals or in geodes in the limestone at many exposures. At Bennet, Nebraska, and southward as far as Kansas River the Howe is dolomitic; in this rock fossils are poorly preserved and not readily recognizable (Pl. 1 A and B; Fig. 1, secs. 1-7). Gastropods, ostracodes, and calcareous algae are the chief fossils observed but nowhere are they plentiful.

Between Kansas River Valley and Alma, Kansas (Fig. 1), the Howe limestone changes from a dolomitic, cavernous or vesicular limestone with few recognizable fossils to granular, abundantly fossiliferous spergenite. From Alma, Kansas, southward into Oklahoma the bed comprises buff, gray-brown, or light-gray limestone, generally massive and hard, but locally weathering into thin beds 1 to 3 inches thick. Its weathered surface has a granular texture which Heald (1916, pp. 24-25) noted as being

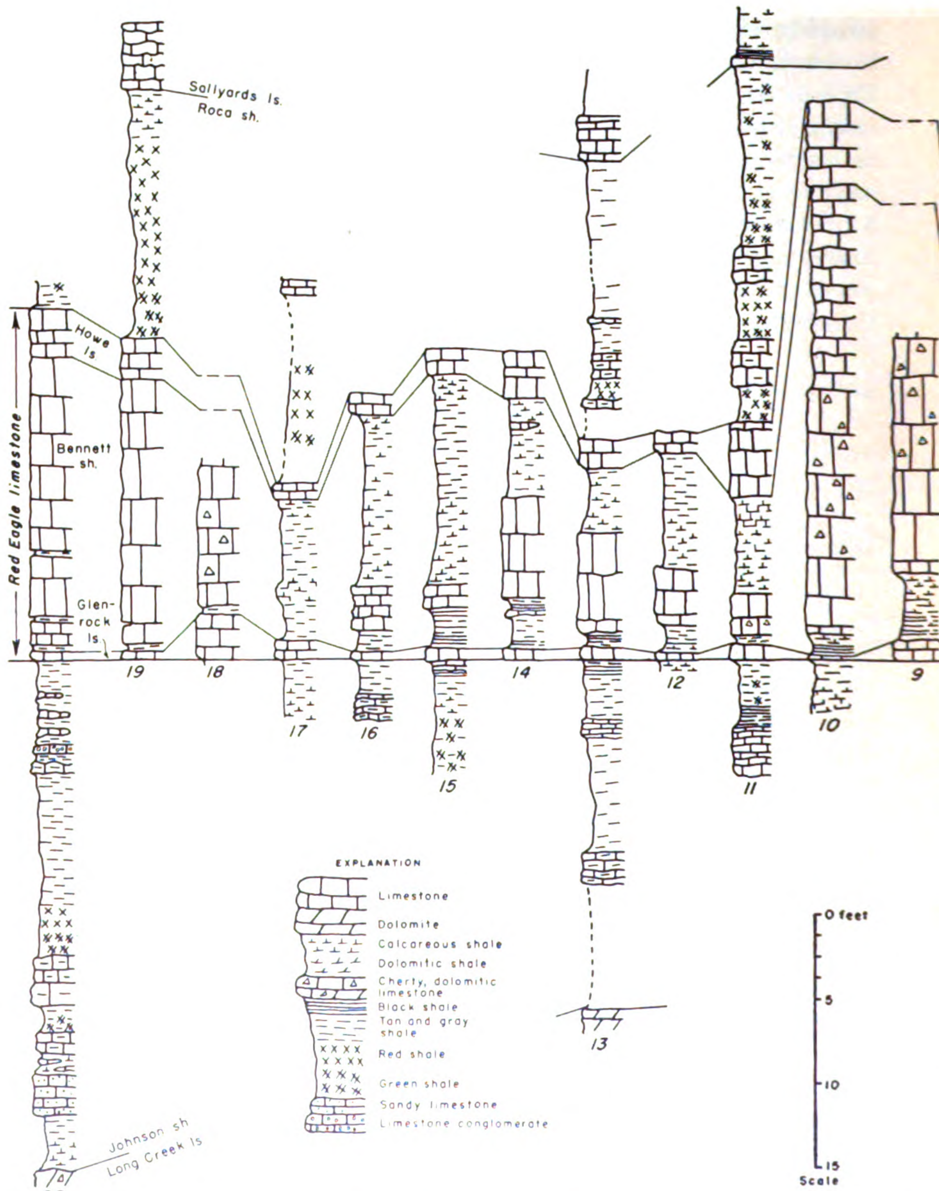
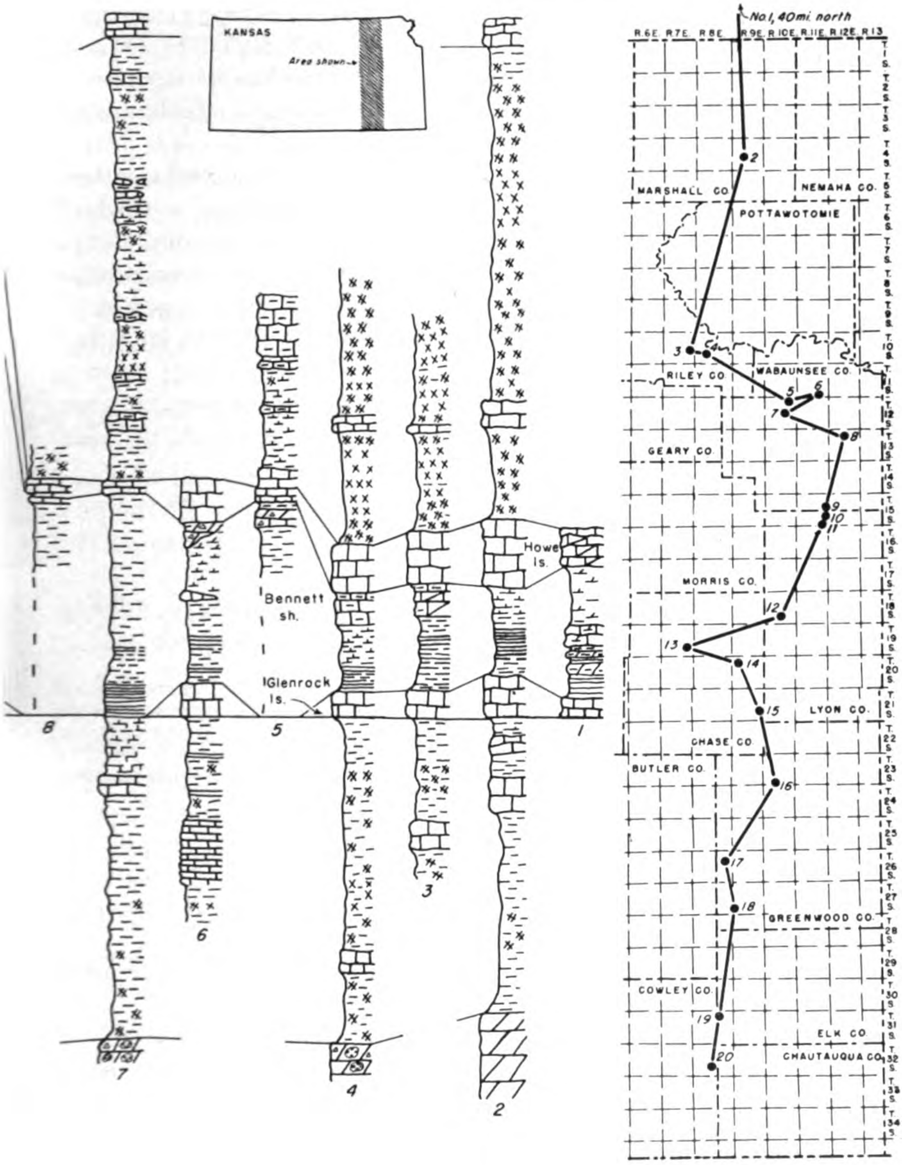


FIG. 1.—Correlation of the Red Eagle limestone and its members from measured sections. Detailed descriptions and locations



Bennet, Nebraska, to southern Cowley County, Kansas, and location of of these sections are given at the end of this report.

distinctive of the top bed of the Red Eagle limestone in northern Oklahoma. Thickness ranges from about 0.7 to 5 feet (Fig. 1, secs. 7-20). Its maximum thickness is observed in the vicinity of the Lyon-Wabaunsee County line where the Red Eagle limestone develops into a bioherm.

The texture of the limestone is the result of unequal weathering rates of the calcareous fossils and the calcite matrix in which they are embedded. Tiny gastropods, ostracodes, fusulinids and other foraminifers, oölites, and various forms of calcareous algae comprise most of the rock, but fragments of brachiopods, echinoids, and bryozoans occur in lesser amounts (Pl. 1 C, D, E, and F).

This bed is easily separated by faunal and lithologic characters from limestone layers in the Bennett shale, where the Bennett shale is chiefly limestone.

BENNETT SHALE MEMBER

Definition.—The Bennett shale is described (Condra, 1927, p. 86) as

> . . . named from exposures along the Little Nemaha and its branches south of Bennett, Lancaster County, Nebraska; formed of bluish gray and nearly black argillaceous shale, with one carbonaceous streak resembling coal and a thin yellowish to brownish limestone; combined thickness 5 to 11 feet.
> Fauna: Orbiculoidea missouriensis, Lingula sp., Composita subtilita, Spirifer cameratus, and a few other species.

Description.—Although much variation in lithology of the Bennett shale is observable along the strike from southern Nebraska to northern Oklahoma, certain faunal zones persist through the lithologic changes and these furnish important evidence for determining member boundaries from north-central Kansas southward.

In the type area, the Bennett shale comprises dolomite and calcareous to argillaceous shale of gray, olive, and tan colors in the upper and middle parts, locally with soft dolomitic shaly limestone near the middle (Fig. 1, sec. 1). This part of the Bennett is characterized by a fauna of calcareous brachiopods, echinoid and crinoid remains, and bryozoans. With minor variations, this faunal assemblage persists entirely across Kansas, although the lithology changes from chiefly shale to chiefly limestone. It constitutes the upper faunal zone of the Bennett shale. The fauna is very unlike that of the Howe, and in areas where the Red Eagle formation is chiefly limestone, as in southern Kansas (Fig. 1, secs. 19-20), the boundary between the Howe limestone and Bennett shale is easily determined.

The lower part of the Bennett shale in the type area comprises black to dark-gray argillaceous shale with local calcareous parts. The brachiopod *Orbiculoidea* is the most abundant and characteristic fossil but *Ambocoelia* is also numerous at many exposures. Other fossils are not abundant. The *Orbiculoidea*-bearing black shale constitutes the lower faunal and lithologic zone of the Bennett shale (Fig. 1, sec. 1). Specimens of *Orbiculoidea* were found in lower Bennett shale beds in all but 3 of the 18 lower Bennett shale exposures studied (measured sections 7, 13, and 17).

Correlation of the Bennett shale in southern Nebraska and northern Kansas (Fig. 1, secs. 1-6) with the type Bennett presents no difficulty, with one exception. Where the upper part of the Bennett shale contains calcareous or dolomitic shale or shaly limestone (Fig. 1, secs. 2-4), or secondary deposits of calcite and celestite, or chert occur (Fig. 1, secs. 5, 6, 8), the tendency is to include such beds with the Howe limestone. It is our belief, however, that they are equivalent to part of the type Bennett, inasmuch as the fauna included in the beds is typical of the upper Bennett shale, and the calcite and celestite or chert is secondary in the Bennett shale.

The bioherm in the Red Eagle formation near the Lyon-Wabaunsee County line is chiefly the result of Bennett shale expansion (Fig. 1, secs. 9-11). Where the bioherm attains maximum development, about 5 feet of Howe with spergenite lithology is underlain by about 28 feet of Bennett shale. The Bennett comprises about 10 to 12 feet of nonresistant, light-gray, partly coarsely crystalline and partly brecciated limestone containing beautifully preserved large brachiopods, crinoid remains, bryozoans (Pl. 1G), and locally much fine-grained material much of which may be of algal origin (Pl. 1H). Next lower is a resistant massive ledge-making dolomite or dolomitic limestone about 8 to 15 feet thick. It is light gray or tan to nearly white in color, cavernous and porous, and contains scattered nodules of chert. Some exposures of this bed show few or no recognizable fossils but in other outcrops horn corals, fusulinids, crinoids, calcareous algae, and brachiopods are observed. Generally the basal 1 foot or less contains abundant red-brown *Orbiculoidea* fragments. Tan, gray, and black shale beds, 0.5 to 5 feet thick, parts of which contain abundant *Orbiculoidea,* occur at the base of the Bennett shale.

From the bioherm southward as far as southwestern Greenwood County, the Bennett shale contains a rather massive, light-gray to nearly white, porous or cavernous, dolomitic limestone in the middle or lower part of the member (Fig. 1, secs. 11-17). Shale above this middle Bennett limestone contains the typical upper Bennett shale fauna, and abundant specimens of *Orbiculoidea* (Pl. 1, I and K) occur in shale below the limestone (and generally in the lower part of the limestone). The limestone contains chiefly upper Bennett shale fossils.

From a point in southwestern Greenwood County southward into Oklahoma, the Bennett shale becomes nearly a complete limestone section ranging in thickness from about 10 to 18 feet (Fig. 1, secs. 18-20). In this facies of the Bennett member, shale is restricted to one or two thin beds at and near the base of the member and some featheredge partings in the middle or upper part. The basal shale bed and generally the lower foot or less of the limestone beds contain the persistent *Orbiculoidea* fauna. In some exposures *Orbiculoidea* shells are abundant and conspicuous; in others they are sparse, so that careful observation is required to find them. Limestone beds of the Bennett are massive, light-gray to buff in color, fine-grained to coarsely crystalline, and fossiliferous. Locally, the beds may be cherty and cavernous but everywhere they are the prominent outcrop-making part of the Red Eagle formation. Fossils are typical of those of the upper faunal zone of the type Bennett, chiefly brachiopods, bryozoans, and echinoderms. In addition, these southern Kansas exposures contain abundant fusulinids, especially in the upper and lower parts. Gastropods, ostracodes, foraminifers, and encrusting calcareous algae are also observed (Pl. 1, J, K, and L).

GLENROCK LIMESTONE MEMBER

Definition.—The lower member of the Red Eagle limestone is "named from exposures high in the valleyside just northwest of Glenrock, Nemaha County, Nebraska; dark gray, dense, weathering light gray or slightly buff; thickness 1 to 2 feet. This forms rectangular blocks. The leading fossils are Fusulina, bryozoans, brachiopods, and Pinna sp." (Condra, 1927, p. 86).

Description.—The Glenrock limestone can be divided into two faunal and lithologic parts: (1) fusulinid-bearing rock above, and (2) a nonfusulinid part at the base, which may be chiefly algal, foraminiferal, or contain other fossils. The separate parts can best be observed where the Glenrock limestone is a foot or more in thickness. In a few places one or the other is not present or is poorly developed.

Exposures of Glenrock in the vicinity of the type Bennett at Bennet, Nebraska (Fig. 1, sec. 1), include an abundantly fusulinid upper part and a conspicuous algal bed at the base. The algal bed comprises lobate colonies of calcareous algae similar in size and shape to the colonies characteristic of the Houchen Creek limestone member, about 50 feet lower in the section.

At Frankfort, Kansas (Fig. 1, sec. 2), the upper division contains abundant fusulinids and the lower one is a spergenite comprising abundant foraminifers, gastropods, bryozoan and brachiopod fragments, ostracodes, and calcareous algae (Pl. 1M).

At Manhattan, Kansas, fusulinids could not be identified in one measured section (Fig. 1, sec. 4) but were abundant in another near-by exposure (Fig. 1, sec. 3). Where the fusulinids were absent, brachiopod fragments and small gastropods were the conspicuous fossils, together with rounded sand and gravel size fine-grained limestone detritus. Other fossils were not conspicuous.

From a point between Manhattan and Alma, Kansas, southward to the vicinity of Eskridge, Kansas, the Glenrock limestone is absent, either because of nondeposition or deposition and subsequent erosion in early Bennett time. Where the Glenrock limestone is absent the base of the Red Eagle formation is placed at the contact between the black or dark-gray shale beds and the gray-green or gray limy beds of the Johnson shale (Fig. 1, secs. 5, 7, 8).

The Glenrock reappears in the vicinity of Eskridge and is identified in all the sections studied in central and southern Kansas. South of Eskridge, however, the member is thinner, generally less than 1 foot thick, but ranging from a featheredge to about 3 feet (Fig. 1, secs. 10-20). Fusulinids are observed in most outcrops south of Eskridge but the rock in a few of the exposures studied (Fig. 1, secs. 13, 16) is chiefly algal. In Bennett shale sections containing abundant *Orbiculoidea* in the lower part, the Glenrock limestone may contain *Orbiculoidea* fragments in the top crust of the bed. Brachiopods, bryozoans, gastropods, echinoderm fragments, and ostracodes are present also in varying abundance.

SUMMARY AND CONCLUSIONS

Lithologic and faunal characteristics of the Howe limestone, Bennett shale, and Glenrock limestone members in their type area in southern Nebraska are essentially unchanged as far south as the area between Manhattan and Alma, Kansas. In this area the Howe limestone becomes an abundantly fossiliferous spergenite and is easily distinguished from the Bennett shale. The Glenrock limestone is absent from a point between Manhattan and Alma, Kansas, south to the vicinity of Eskridge, Kansas, where it reappears and is continuous into Oklahoma.

The distinctive spergenite-type Howe limestone can be recognized and distinguished from the fossiliferous shale and limestone beds of the Bennett shale from the vicinity of Alma, Kansas, southward into Oklahoma. The *Orbiculoidea* zone, which marks the base of the Bennett shale, persists from Nebraska through central and southern Kansas into Oklahoma, although the Bennett changes from chiefly shale to chiefly limestone.

The Glenrock limestone, except where absent in Wabaunsee County, Kansas, is continuous from Nebraska to Oklahoma and includes only the fossiliferous limestone below the Bennett *Orbiculoidea* zone. Generally it is thinner in central and southern Kansas than in Nebraska and northern Kansas.

The Howe limestone, limestone beds of the Bennett shale, and the Glenrock limestone each contain fusulinids in several of the measured sections included. Therefore, fusulinids are not useful for distinguishing member boundaries.

STRATIGRAPHIC SECTIONS

The following stratigraphic sections of Red Eagle beds are shown on Figure 1. They are numbered consecutively from north to south.

(1) *Sec. 10, T. 8 N., R. 8 E., Lancaster County, Nebraska. Along a cut bank in the Little Nemaha Valley about one-fourth mile southwest of Bennet, Nebraska.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (10.55 feet exposed)	
Howe limestone member (2.3 feet exposed)	
12. Limestone, brown, deeply weathered, slabby .... exposed	1.5
11. Limestone, brown, dolomitic, massive	0.8
Bennett shale member (7.75 feet)	
10. Shale, yellow to tan, slightly dolomitic, blocky	1.65
9. Shale, olive-gray, mottled, slightly dolomitic, harder than unit 10, blocky	1.8
8. Limestone, dove-gray, impure, vesicular, somewhat slabby	1.2
grades into	
7. Shale, gray, clayey	0.4
6. Limestone, dove-gray, dolomitic	0.3
grades into	
5. Shale, black; *Orbiculoidea, Lingula*	0.4
4. Limestone, olive-gray, dolomitic, shaly, blocky	0.4
grades into	
3. Limestone, dark-gray, dolomitic	0.3
2. Shale, black; *Orbiculoidea* sparse in lower part and more abundant in upper part	1.3
Glenrock limestone member	
1. Limestone, yellowish-gray, forming pavement in creek .... exposed	0.5

Note: About a mile eastward in the same valley the Glenrock is 0.7 to 1.3 feet thick and contains fusulinids in its upper part and lobate algal masses in the lower part.

(2) *Near SE cor. NE¼ NW¼ sec. 21, T. 4 S., R. 9 E., Marshall County, Kansas. On Kansas highway 99 one-fourth mile south of Frankfort.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (11.7 feet exposed)	
Howe limestone member (4 feet exposed)	
7. Limestone, buff to yellow, weathers spongy with network of calcite and quartz veinlets in brownish-ochre ground mass; dolomitic; fossils are not identifiable .... exposed	1.0
6. Limestone, buff, dolomitic, shaly, soft	3.0
Bennett shale member (5.2 feet)	
5. Shale, gray, calcareous	1.5
4. Shale, dark-gray; *Orbiculoidea*	1.0
3. Shale, black, fissile	2.0
2. Shale, gray	0.7
Glenrock limestone member	
1. Limestone, yellow to tan, hard; abundant fusulinids in upper part; ostracodes, gastropods, bryozoans, other shell fragments, foraminifers, and algae in lower part	2.5

(3) *NW¼ NE¼ sec. 24, T. 10 S., R. 7 E., Riley County, Kansas. In Rock Island Railroad cut about 200 feet north of U.S. highway 40.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (11.0 feet exposed)	
Howe limestone member	
8. Limestone, buff, dolomitic, massive to cellular; poorly preserved tiny snails and foraminifers .... exposed	3.0
Bennett shale member (6.4 feet)	
7. Limestone, buff, shaly, dolomitic, weathers platy	2.0
6. Shale, dark-gray, weathers gray, calcareous to clayey	1.2
5. Shale, black, thin-bedded; *Orbiculoidea*	0.4
4. Shale, gray and black mottled, weathers gray to mottled gray and tan	2.4
3. Shale, tan, weathers light-gray, calcareous, platy	0.4
Glenrock limestone member (1.6 feet)	
2. Limestone, light tannish-gray, weathers tan to buff, massive; abundant fusulinids	0.7
1. Limestone, light-tan to gray, detrital limestone, and shale fragments	0.9

Note: Beds 3-6 (Bennett shale member) contain, in addition to *Orbiculoidea*, bryozoans, crinoid and echinoid fragments, *Ambocoelia, Wellerella, Composita, Hustedia, Chonetes,* and *Juresania.*

(4) *Near Cen. N. line NW¼ sec. 20, T. 10 S., R. 8 E., Riley County, Kansas. On K Hill, Manhattan.*

	Thickness, feet
PERMIAN—Wolfcampian	
Grenola limestone	
Sallyards limestone member	
20. Limestone, poorly exposed	
Roca shale (22 feet)	
19. Shale, several shades of green, blocky; contains abundant limy nodules	9.0
18. Shale, grades from dark-purple in upper part through light- and dark-green and blue-green, to burnt-red to green in basal part; blocky; contains abundant limy nodules in middle part .... averages	4.5
17. Shale, green with red tint, massive to thin-bedded; locally contains a hard mudstone	0.8
16. Limestone, medium-gray, dense; contains clear crystalline calcite specks and irregular veins; slightly laminated in basal part; where thickest comprises two lenticular flattened discoidal beds; algal (?) .... averages	1.0
15. Shale, green, massive	0.5
14. Shale, bright burnt-red, thinly laminated, bedding contorted locally, silty .... averages	4.4
13. Shale, green, olive, and maroon, poorly exposed	1.8
Red Eagle limestone (10.2 feet)	
Howe limestone member	
12. Limestone, buff to yellow peppered with black, partly dark-gray streaked with green; lower part gray to buff; porous, brecciated-appearing; crinoid and brachiopod fragments, small high-spired and low-coiled snails, algae (?) ..	2.8
Bennett shale member (5.8 feet)	
11. Limestone, medium-gray, weathers tan, shaly .... averages	0.4

10. Limestone, medium-gray, weathers light-tan to tannish-gray, thin-bedded, somewhat oatmeal-like texture, abundantly fossiliferous; echinoid and crinoid fragments, productids, *Neospirifer* and other brachiopods 1.4
9. Shale, gray, upper part chalky, massive; *Ambocoelia, Composita,* productids and other brachiopods .... averages 1.5
8. Shale, gray, harder and more limy than unit 9; *Ambocoelia, Composita, Wellerella,* and other brachiopods .... averages 1.0
7. Shale, black, gray, and tan mottled, thin-bedded to fissile, fossils more abundant in lower part; *Orbiculoidea, Ambocoelia, Wellerella* 1.5

Glenrock limestone member

6. Limestone, light-gray, rusty splotches and streaks, tan to black at top; contains abundant *Orbiculoidea* in top crust; *Wellerella, Ambocoelia,* and small snails 1.6

Johnson shale (19.3 feet)

5. Shale, gray, tan, olive, and black, thin-bedded to blocky; contains mud cracks, poorly preserved plant fragments, and ostracodes 2.7
4. Shale, green, gray, olive, and specks of maroon, blocky, calcareous 11.0
3. Mudstone, green to gray, dense, semilithographic .. averages 1.3
2. Shale, green, olive, and gray, blocky, calcareous 4.3

Foraker limestone

Long Creek limestone member

1. Limestone

(5) *NE¼ NE¼ sec. 10, T. 12 S., R. 10 E., Wabaunsee County, Kansas. About 1 mile north of Alma.*

Thickness, feet

PERMIAN—Wolfcampian

Roca shale (16.45 feet exposed)

14. Shale, deeply weathered .... exposed 1.5
13. Limestone, gray, brecciated, algal (?) 3.6
12. Shale, gray 0.2
11. Mudstone, ashy gray, dense 0.3

grades into

10. Shale, ashy gray, brecciated, part weathers as "boxwork" 2.4

grades into

9. Mudstone or limestone, ashy gray, dense 0.25

grades into

8. Shale, gray, limy, hard 1.3

grades into

7. Shale, brownish-gray, limonite-stained, somewhat micaceous 2.2
6. Mudstone, gray, calcareous, nonlaminated 1.0
5. Shale, gray and yellow, somewhat blocky 3.7

Red Eagle limestone (5.35 feet exposed)

Howe limestone member

4. Limestone, purplish; spergenite of tiny gastropods, foraminifers, oölites, encrusting algae, and brachiopod fragments 0.85

Bennett shale member (4.5 feet exposed)

3. Shale, gray, clayey in upper part, limy and hard below 0.5
2. Limestone, brown; contains crystalline red quartz and colorless calcite; locally nearly all drusy calcite; locally color is dove-gray with flecks of red chert 1.0

1. Shale, gray, largely covered .... exposed 3.0

Note: In the area of this exposure, in the vicinity of Alma, the *Orbiculoidea*-bearing part of the Bennett shale and the Glenrock limestone are absent. The base of the Red Eagle formation is placed at the base of dark-gray or black shale that elsewhere is recognized as a part of the Bennett shale.

(6) *SW¼ SW¼ sec. 30, T. 11 S., R. 12 E., Wabaunsee County, Kansas. On Kansas highway 10 near Paxico.* Modified from section measured by M. R. Mudge and Robert Burton.

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (12.4 feet)	
Howe limestone member (2.7 feet)	
30. Limestone, tan, soft, massive, porous; contains geodes in upper part; spergenite of tiny snails, foraminifers, oölites, and ostracodes	1.4
29. Limestone, gray-orange, weathers tan, wavy bedded; contains small silicified "rosettes" in lower part; ostracodes, tiny snails, *Pleurophorous, Ambocoelia*	1.3
Bennett shale member (9.7 feet)	
28. Limestone, red-brown, weathers gray-orange, dolomitic, shaly, massive to lenticular; contains scattered siliceous or cherty nodules	1.55
27. Shale, gray-brown, weathers tan, thin-bedded; echinoid spines, bryozoans, brachiopods	2.65
26. Limestone, gray-orange, weathers tan and platy, argillaceous; *Orbiculoidea*, crinoid fragments	0.5
25. Shale, olive-drab to dark gray-brown, locally nearly black, weathers tan to blue-gray, calcareous, thin-bedded to fissile; large *Crania*, abundant *Orbiculoidea* and *Ambocoelia*	5.0
Glenrock limestone member (2.0 feet)	
24. Limestone, tan, limonite-stained, massive, abundant fusulinids, brachiopod fragments, encrusting algae, *Ambocoelia, Aviculopecten*	1.3
23. Limestone, tan, detrital; contains abundant pebbly material	0.7
Johnson shale (23.7 feet)	
22. Shale, upper 0.5 foot tan, remainder olive-drab mottled with black; weathers tan to bluish-gray; thin-bedded to fissile; part blocky; carbonaceous; contains plant fragments and small macerated ostracodes	6.0
21. Limestone or mudstone, gray, iron-stained, platy	4.0
20. Shale, gray, gray-green, and olive-drab with purple mottling near top, thin-bedded to blocky and massive, lower part silty and contains limy nodules	13.7
Foraker limestone (43.65 feet)	
Long Creek limestone member (8.4 feet)	
19. Limestone, red-brown, weathers orange-gray, soft, dolomitic, massive; contains calcite-lined cavities; 0.8-foot celestite layer at top	5.4
18. Limestone, dark-gray with brown specks, weathers bluish-gray, blocky, argillaceous	3.0
Hughes Creek shale member (32.85 feet)	
17. Shale, upper part olive-drab to black, lower 1.8 feet dark-gray; weathers bluish-gray; thin-bedded to blocky; lower part contains abundant fusulinids, crinoid fragments, and brachiopods	5.3

16. Limestone, blue-gray, weathers tan, upper part weathers platy; abundant fusulinids, bryozoans, brachiopods	1.0
15. Shale, dark-gray to black, weathers bluish-gray, fissile; *Ambocoelia*	2.3
14. Limestone, dark-grey, weathers tan, massive; fusulinids, echinoid and crinoid fragments	0.8
13. Shale, upper part olive-drab, weathers tan; lower part black, weathers blue-gray	1.45
12. Shale, dark-gray, weathers light bluish-gray, thin-bedded to platy; crinoid fragments, fusulinids, brachiopods, bryozoans	2.95
11. Limestone, dark-grey, weathers gray, massive, weathers platy	0.2
10. Shale, black, weathers bluish-gray, fissile; abundant *Ambocoelia*	1.5
9. Limestone, tan, hard, massive	0.5
8. Shale, dark-gray, fissile; *Linoproductus*, fusulinids	0.5
7. Limestone, bluish-gray, weathers tan, massive, weathers platy; crinoid and echinoid fragments	0.9
6. Shale, dark bluish-gray, weathers gray, thin-bedded to fissile	5.0
5. Shale, gray, weathers tan-gray, very calcareous, thin-bedded to platy; *Aviculopecten*, *Neospirifer*, *Dictyoclostus*, *Linoproductus*, *Ambocoelia*, *Chonetes*, *Marginifera*, and worm borings (?)	2.8
4. Shale, gray-brown and mottled, weathers tan, lower 0.6 foot gray and weathers lighter in color; thin-bedded to blocky; *Composita* and crinoid fragments in lower part	7.65
Americus limestone member (2.4 feet)	
3. Limestone, gray to tannish-gray; *Composita*, fragments of echinoderms and other fossils	1.2
2. Shale, gray, weathers tan, silty, calcareous, thin-bedded	0.2
1. Limestone, tan, weathers tan-gray, massive, blocky; microfossils	1.0

(7) *SW¼ NE¼ sec. 11, T. 12 S., R. 10 E., Wabaunsee County, Kansas. On Mill Creek about 1 mile northeast of Alma.*

	Thickness, feet
PERMIAN—Wolfcampian	
Grenola limestone (6.2 feet exposed)	
Salem Point shale member	
27. Shale, gray, weathered	exposed 5.0
Sallyards limestone member	
26. Limestone, ashy gray, weathers slightly rusty; algae-coated clams	1.2
Roca shale (26.45 feet)	
25. Shale, yellowish-gray, clayey, blocky	2.3
24. Mudstone, light-gray; ostracodes in upper part	0.65
23. Shale, olive-gray, blocky	5.4
22. Limestone nodules, bluish, dense, and nearly black and some reddish clay; more clayey in lower part; algae (?)	2.8
21. Shale, bluish-gray, flaky	1.2
grades into	
20. Clay and limestone nodules; massive limestone in lower part, mottled, has worm-eaten appearance	4.6
19. Shale, greenish-gray	1.4
18. Shale or clay, red	1.8
17. Limestone, dark-gray, slabby and nodular	0.3

16. Shale, gray		2.0
15. Shale, gray, limy; locally resistant dense limestone		1.0
14. Shale, yellowish-gray grading into greenish in lower part, flaky		3.0
Red Eagle limestone (13.9 feet)		
Howe limestone member		
13. Limestone, brownish, weathers gray, finely crystalline; spergenite		0.7
Bennett shale member (13.2 feet)		
12. Shale, yellowish-gray, weathers light-gray, mottled dark to black and gray in lower part; limonitic in lower part		11.3
grades into		
11. Shale, black and mottled black and tannish-gray		1.9
grades into		
Johnson shale (17.7 feet)		
10. Shale or mudstone, gray, hard		1.9
9. Mudstone, slate-gray, weathers lighter and rough, lower part brecciated		1.2
grades into		
8. Shale, yellowish-gray, basal part olive-green, blocky, part hard and resistant		14.6
Foraker limestone (13.35 feet exposed)		
Long Creek limestone member (9.35 feet)		
7. Limestone, yellow and gray, crystalline; contains some red chert and crystalline quartz; slabby; pitted on weathered surfaces		1.5
6. Shale, gray, clayey		3.3
5. Shale or limestone, gray, platy		2.0
grades into		
4. Limestone, brown, weathers yellow		1.5
3. Shale, gray		0.05
2. Limestone, gray, rough-weathering, pitted		1.0
Hughes Creek shale member		
1. Shale, gray	exposed	4.0

Note: In this area the Glenrock limestone is absent. The base of the Red Eagle formation is placed at the base of beds that elsewhere are recognized as a part of the Bennett shale.

(8) *NW¼ NW¼ sec. 13, T. 13 S., R. 12 E., Wabaunsee County, Kansas (2½ miles south of Keene).*

		Thickness, feet
PERMIAN—Wolfcampian		
Roca shale		
5. Shale, gray and green, deeply weathered, contains limy nodules	exposed	2.0
Red Eagle limestone (5.4 feet exposed)		
Howe limestone member		
4. Limestone, purplish-brown; spergenite of foraminifers, gastropods, oölites, and algae		0.8
Bennett shale member (4.6 feet exposed)		
3. Shale, gray		0.2
2. Limestone, brown, crystalline		0.4
1. Shale, yellowish-gray	exposed	4.0

Note: In the area of this exposure the Glenrock limestone and the *Orbiculoidea* bearing lower part of the Bennett shale are absent.

(9) *NE¼ NE¼ sec. 12, T. 15 S., R. 11 E., Wabaunsee County, Kansas. Along Locust Creek about 6 miles south and 1 mile west of Eskridge.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (18.8 feet exposed)	
Bennett shale member (17.8 feet exposed)	
4. Limestone, light-gray to nearly white; sparse chert nodules mostly in upper and middle parts; styolites; fractured and cut by solution channels; sparse echinoderm and brachiopod fragments in upper part; lower 3 feet contains sparse fusulinids and tabulate corals and fairly abundant algal colonies .... exposed	13.2
3. Limestone, light brownish-gray; sparse crinoid fragments, abundant brown chitinous fragments of *Orbiculoidea*, and conodonts (?)	0.7
2. Shale, light-gray, lower part dark-gray and olive mottled, upper part highly calcareous	3.9
Glenrock limestone member	
1. Limestone, light-tan to light gray-tan; abundant fusulinids .... exposed	1.0

(10) *NE¼ NE¼ SW¼ sec. 23, T. 15 S., R. 11 E., Lyon County, Kansas, on the Hoffman Ranch.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (33.15 feet)	
Howe limestone member	
7. Limestone, light-gray, weathers into pitted rounded boulders; massive outcrop around hill; spergenite of oölites, foraminifers, gastropods, algae, sparse brachiopods, and other fossils .... averages	5.0
Bennett shale member (27.95 feet)	
6. Limestone, light-gray, in part limestone breccia, part coarse crystalline crinoidal limestone, part weathers shaly to nodular; unbroken crinoid columnals up to 1 foot in length; large brachiopods	12.2
5. Limestone, light-gray to nearly white, dolomitic, massive, porous, cavernous, cherty	13.9
4. Limestone, light-gray; contains an abundance of red-brown *Orbiculoidea*	0.5
3. Shale, gray, blocky and calcareous in upper part, lower part black to dark-gray, fissile; *Orbiculoidea*	1.35
Glenrock limestone member	
2. Limestone, tan to light-gray; abundant fusulinids	0.2
Johnson shale	
1. Shale, gray, becomes blocky and calcareous downward .... exposed	3.0

(11) *Along W. line NW¼ SW¼ sec. 35, T. 15 S., R. 11 E., Lyon County, Kansas. On county road 3 miles north of Allen.*

	Thickness, feet
PERMIAN—Wolfcampian	
Grenola limestone (11.3 feet exposed)	
Burr limestone member (2.3 feet exposed)	
25. Limestone, brown, with specks of light-gray in lower part, pebbles or inclusions of light-gray limestone up to 1 foot in length in part of bed; *Pseudomonotis, Aviculopecten, Myalina,* and other clams, rhomboporid and fenestellid bryozoans .... exposed	1.1
24. Shale, silty and limy, locally weathers as limestone; contains crinoid fragments, rhomboporid and fenestillid bryozoans, *Allerisma, Pseudomonotis,* and *Neospirifer*	0.7
grades into	
23. Limestone or siltstone, gray, mottled, shaly; fossils as in unit 25	0.5
Legion shale member (8.7 feet)	
22. Shale, tan, calcareous, contains large nodules and vertical stringers of chert and fine crystalline quartz; limy nodules and plates in upper part	8.2
21. Shale, dark-gray to black, limy zone at top, subfissile	0.5
Sallyards limestone member	
20. Limestone, gray, mottled, shaly; crinoid fragments, *Aviculopecten, Pseudomonotis,* and other clams	0.3
Roca shale (21.1 feet)	
19. Shale, light and dark greenish-gray and tan, calcareous, nodular to blocky	9.5
18. Shale, dark-green, calcareous, blocky	1.2
grades into	
17. Limestone or marl, greenish tint, green clayey veinlets, lithographic	2.1
16. Shale, red, purple, and green; contains limy nodules; blocky; partly covered	3.5
15. Limestone, light-gray, green tint, part lithographic, secondary calcite specks, laminated, algal-like structures	2.6
14. Shale, green, calcareous, silty, platy bedding	2.2
Red Eagle limestone (14.1 feet)	
Howe limestone member (4.4 feet)	
13. Limestone, gray and greenish, crenulated, almost entirely *Cryptozoon*-like algae up to 1 foot in diameter and 0.1 to 0.5 foot thick .... averages	0.4
12. Limestone, light-gray; upper part dense, suboölitic; lower is spergenite of snails and clams, oölites, algae, ostracodes, fusulinids, and other foraminifers, echinoderm and bryozoan fragments; upper 0.3 to 0.8 foot separated from lower part by very thin clay parting	2.8
11. Limestone, light-gray, fragmental and crystalline, locally dense; foraminifers, snails, clams, crinoid fragments, and algae	0.9
10. Limestone, gray and greenish; echinoderm fragments, algae	0.3
Bennett shale member (8.8 feet)	
9. Shale, tan and gray, calcareous, thin-bedded, very fossiliferous in upper part; echinoderm spines, crinoid fragments, *Neospirifer* and sparse other brachiopods	5.8
grades into	
8. Limestone, light- to dark-gray, silty; somewhat sparse crinoids, bryozoans, and brachiopod fragments	1.2

7. Limestone, mottled light- and dark-gray, weathers light-gray; contains sparse chert in upper part; *Orbiculoidea*, fusulinids, *Hustedia*, shark teeth, and algae (?) 1.3
6. Shale; upper part gray, contains *Hustedia*, *Wellerella*, *Chonetes*, *Ambocoelia*, *Derbyia*, *Marginifera*, *Orbiculoidea;* lower part brown, is a coquina of *Orbiculoidea* 0.5

Glenrock limestone member

5. Limestone, gray to brownish; contains small pebblelike masses of gray and brown limestone; abundant fusulinids; *Marginifera* and *Orbiculoidea* in top crust of bed 0.9

Johnson shale (6.8 feet exposed)

4. Shale, gray to tan, argillaceous, blocky 0.7

grades into

3. Shale, gray to tan and olive, calcareous, thin- to medium-bedded, blocky 2.0
2. Shale, dark-gray to black, subfissile; contains carbonized plant fragments, small white snails 1.2
1. Siltstone and impure limestone, gray in upper part grading downward into tan, weathers slabby .... exposed 2.9

(12) *Along N. line NE¼ sec. 17, T. 18 S., R. 10 E., Lyon County, Kansas, 3 miles west and 1 mile south of Americus.*

Thickness, feet

PERMIAN—Wolfcampian

Red Eagle limestone (13.5 feet exposed)

Howe limestone member

9. Limestone, light-gray, weathers to drab grayish-brown, a spergenite, very hard, medium to coarsely crystalline .... exposed 1.1

Bennett shale member (12.0 feet)

8. Shale, olive, clayey to silty; bryozoans, pelecypods, *Chonetes*, *Composita*, *Juresania*, and abundant *Meekella* and *Derbyia* 3.4
7. Shale, yellow to buff; bryozoans, *Derbyia*, *Chonetes*, *Composita*, *Juresenia*, and *Dictyoclostus* 3.7
6. Limestone, light-gray to light-tan, no color change when weathered, porous, algal (?) 2.5
5. Limestone, mottled gray, shaly and slabby; abundant fusulinids, bryozoans, and crinoid fragments 0.7
4. Shale, brown, clayey, thin-bedded; sparse fusulinids and abundant *Crurithyris* 0.6
3. Shale, gray, calcareous; fusulinids, *Crurithyris*, and *Orbiculoidea* 1.1

Glenrock limestone member

2. Limestone, dark-gray, mottled, weathers tan; very abundant fusulinids 0.4

Johnson shale

1. Mudstone, light tannish-gray, calcareous .... exposed 0.7

(13) *Near Cen. sec. 26, T. 19 S., R. 7 E., Chase County, Kansas. On Elmdale hill.*

Thickness, feet

PERMIAN—Wolfcampian

Grenola limestone (40.8 feet exposed)

Neva limestone member (11.0 feet exposed)

75. Limestone, light-gray, cavernous, brecciated in part, massive .... exposed 4.8

74.	Limestone, light-gray, styolites in upper part, lower part wavy bedded, sparsely fossiliferous throughout; contains fusulinids in lower part	1.6
73.	Shale, gray; locally contains thin fusulinid-bearing limestone and brachiopods	0.35
72.	Limestone and shale, slabby limestone mostly in upper half, partly a mass of shell fragments	0.2
71.	Limestone, yellow-gray, powdery; crust of *Crurithyris* at top; fusulinids, bryozoans, and brachiopods	0.5-0.7
70.	Shale, gray, limy	0.4
69.	Limestone, light-gray; small fossil fragments	0.35
68.	Shale, brownish-gray; bryozoans, corals, crinoid fragments, *Lissochonetes,* and shark teeth	0.8
67.	Limestone, yellowish-gray, "oatmeal" rock; fusulinids	0.5
66.	Limestone, light-gray, flecked with white, one massive bed	1.3
	Salem Point shale member (7.1 feet)	
65.	Limestone and shale, gray, nodular, cross-bedded	0.5
64.	Shale, greenish-gray; upper part clayey; limy with thin limestone beds in lower middle part; black streak approximately 1 foot from base	6.6
	Burr limestone member (12.05 feet)	
63.	Limestone, gray, upper 0.35 foot crystalline, lower part soft, silty, and laminated; mud cracks on upper surface	1.4
62.	Shale, medium dark-gray to greenish-gray	3.5
61.	Limestone, medium light-gray, upper 0.6 to 0.8 foot more massive, lower part slabby and laminated	2.0
60.	Shale and limestone, gray; upper half calcareous; lower mostly powdery laminated limestone	0.8
59.	Limestone, medium-gray, weathers slightly tan, yellow shale break 0.3 foot from top, even platy beds, "flagstone"	1.9
58.	Shale, gray, limy; pelecypods and small discoidal algal colonies	0.3
57.	Limestone, Portland cement gray; flattened fossil fragments and clams	0.8
56.	Shale, gray, calcareous; clams	0.4
55.	Limestone, light-gray; *Aviculopecten* and *Myalina*	0.5
54.	Shale, dark-gray; clams	0.15
53.	Limestone, medium-gray; clams	0.3
	Legion shale member (8.1 feet)	
52.	Shale, black, papery	0.3
51.	Shale, with platy limestone in upper middle part, dark-gray; lower part is darker, well-bedded to drab; black shale 0.75 foot from base; upper part fossiliferous, brachiopods especially abundant	7.8
	Sallyards limestone member (2.55 feet)	
50.	Limestone, light-gray, crystalline, hard; clams	0.25
49.	Shale, drab; *Aviculopecten* and other clams	0.5
48.	Limestone, gray to drab; clams	0.7
47.	Shale and limestone, gray; upper half mostly shale, lower mostly limestone; clams	0.7
46.	Shale, gray, calcareous	0.1
45.	Limestone, light-gray, platy, partly light-gray limy shale; clams	0.3
	Roca shale (16.75 feet)	
44.	Shale, slightly calcareous; contains sparse clams	0.7
43.	Shale, middle part covered; upper 2 feet is greenish-gray, blocky, and limy; lower 3 feet dark to purplish-gray and contains limy nodules	8.75
42.	Limestone, gray, impure, nodular	0.2-0.3

41. Shale, dark-gray, limy; nodules more abundant in lower part 1.7
40. Limestone, gray, impure, nodular 1.0-1.5
39. Shale, red, clayey 1.3
38. Limestone, gray, nodular .... averages 0.5
37. Covered interval 2.0

Red Eagle limestone (12.85 feet)

Howe limestone member (1.5 feet)

36. Limestone, medium dark-gray, weathers brown and yellow, somewhat laminated; a spergenite of foraminifers; ostracodes in upper part 1.0
35. Limestone, gray, soft 0.5

Bennett shale member (10.6 feet)

34. Shale, yellow and gray, somewhat limy in upper part; abundant fossils especially in lower and middle parts, largely *Chonetes* and echinoid spines 3.85
33. Limestone, nearly white, locally weathers pinkish-yellow, chalky, brecciated, cavernous; crinoids, brachiopods, and gastropods 5.15
32. Limestone, buff, granular; fusulinids 0.8
31. Shale, gray, variable thickness; bryozoans .... averages 0.8

Glenrock limestone member

30. Limestone, dark-gray, hard, massive; *Osagia*-like algae 0.75

Johnson shale (20.9 feet)

29. Shale; upper approximate 1 foot black to brownish, remainder gray, blocky; approximately 1 foot of platy limy beds about 4 feet from top 11.4
28. Limestone, buff, weathers brownish, platy, conchoidal fracture 1.8-2.0
27. Covered interval 7.5

Foraker limestone (43.2 feet)

Long Creek limestone member (7.7 feet)

26. Limestone, yellowish-gray to medium-gray, slightly granular; ripple-marked upper surface 0.5
25. Shale, gray, limy 0.5
24. Limestone, yellow, granular 0.5
    (Locally units 24, 25, and 26 are nearly solid limestone)
23. Covered interval 1.5
22. Limestone, gray and yellow, deeply weathered 0.5
21. Limestone, drab-gray, granular, massive; *Osagia*-like algae 0.8
20. Limestone, yellow, granular, massive 1.2
19. Limestone, gray, slabby 0.5
18. Limestone, yellow, granular; *Osagia*-like algae 1.7

Hughes Creek shale member (23.35 feet)

17. Shale, dark-gray; abundant fusulinids 0.95
16. Limestone, ashy gray, soft, weathers into rounded-off outcrop; abundant fusulinids 2.5
15. Shale, gray, limy; fusulinids 1.0
14. Covered interval 4.5
13. Limestone, gray, blocky; fusulinids 1.3
12. Covered interval 8.45
11. Shale, dark-gray, abundantly fossiliferous; fusulinids and brachiopods 4.65

Americus limestone member (12.15 feet)

10. Limestone, ashy gray; fusulinids 0.6
9. Shale, gray; fusulinids 0.15
8. Limestone, bluish-gray; crinoid fragments and brachiopods 0.7
7. Shale, yellow, soft 0.3
6. Limestone, gray, hard; fossil fragments 0.3

5. Shale, dark bluish-gray, limy in basal part; abundant fossils especially *Dictyoclostus* 5.9
4. Limestone, gray, platy; brachiopods 2.0
3. Shale, black or dark-gray; brachiopods 0.7
2. Limestone, dark-gray, crystalline, "deer track" impressions on upper surface; fusulinids and brachiopods 1.5

Hamlin shale
Oaks shale member
1. Shale, dark to black .... exposed 1.5

(14) *SE¼ SE¼ sec. 6, T. 20 S., R. 9 E., Chase County, Kansas. Along Bloody Creek.*

Thickness, feet

PERMIAN—Wolfcampian
Grenola limestone (20.35 feet exposed)
Salem Point shale member
34. Shale, gray, flaky .... exposed 1.0

Burr limestone member (7.75 feet)
33. Limestone or shale, yellow-gray, platy 1.85
32. Shale, gray and yellow 2.85
31. Limestone, brown and gray, platy; clams in lower 0.2 foot 2.0
30. Shale, gray 0.05
29. Limestone, bluish-gray, mottled; clams 1.0

Legion shale member (9.5 feet)
28. Shale or shaly limestone, gray; abundant fossils especially brachiopods and bryozoans 2.0
27. Limestone, gray, soft; fossils as in unit 28 .... 1.0
26. Shale, mostly gray, some bluish and yellow, flaky 6.5

Sallyards limestone member
25. Limestone or limy shale, gray, more shaly in middle part; abundant clams 2.1

Roca shale (18.7 feet)
24. Shale, dark-gray 0.25
23. Limestone, bluish-gray, impure, platy to shaly, locally massive, locally weathers as shale 1.95
22. Covered interval 5.1
21. Shale, greenish-gray, slightly nodular 3.5
20. Clay, dark bluish-gray, blocky 0.5
19. Shale or limestone, nodular, blocky 0.5
18. Shale, red and green, red prevalent in upper middle part 1.2
17. Limestone, gray, nodular, very uneven top; calcite cleavage faces on fractured surface; small high-spired snails 0.4–1.0
16. Shale, gray 0.1
15. Limestone, Portland cement gray, silty 0.8
14. Shale, gray; contains limestone stringers 0.5
13. Covered interval 3.3

Red Eagle limestone (18.6 feet exposed)
Howe limestone member (2.7 feet)
12. Limestone, light-gray, banded, weathers light-gray, more or less crystalline, pitted; uneven upper surface; ostracodes and foraminifers 1.0
11. Limestone, brownish-gray, "pepper and salt"; foraminifers 0.5
10. Limestone, gray to yellowish, somewhat slabby, earthy, uneven contact with unit 11 .... 1.2

Bennett shale member (14.9 feet)
9. Shale, gray, limy 0.5
8. Shale, yellow and gray 1.0

7. Limestone, yellowish-gray, earthy	0.25
6. Shale, gray; abundant bryozoans, brachiopods, and echinoid spines	4.25
5. Limestone, light-gray to nearly white; lower 0.7 foot shaly and slabby; fusulinids in lower 1.4 feet	6.0
4. Shale, yellow, black in lower part, silty	0.7
3. Limestone, brownish-gray, phosphatic; contains scales, teeth, abundant conodonts, and *Orbiculoidea*	0.2
2. Shale, light-gray to dark in lower part, blocky	2.0
Glenrock limestone member	
1. Limestone, gray, blocky, jointed	exposed 1.0

(15) *NW¼ SE¼ sec. 24, T. 21 S., R. 9 E., Chase County, Kansas. In Atyeo oil field.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (17.75 feet)	
Howe limestone member	
21. Limestone, light-gray, weathers gray to slightly yellow, more or less earthy; mostly algae and small foraminifers	1.5
Bennett shale member (15.5 feet)	
20. Shale, yellow, clayey; *Composita* and *Dictyoclostus*	1.55
19. Shale, drab, clayey	5.8
18. Shale, gray and dark, more or less banded, darker gray toward base; abundant bryozoans, echinoid spines, sparse crinoid fragments, *Chonetes*, *Neospirifer*, *Meekella*, *Wellerella*, productids	5.05
17. Limestone, medium- to dark-gray, massive; white fossil fragments	1.35
16. Shale, dark-gray, nearly black, upper 0.7 foot harder than remainder, lower part fissile; *Crurithyris* and *Orbiculoidea*	1.75
Glenrock, limestone member	
15. Limestone, gray, dense, impure, lithographic; part massive and brecciated-appearing; laminated; lower part slabby	0.75
Johnson shale (18.15 feet)	
14. Limestone, sandy, and thin beds of shale; brown, limonitic grades into	0.6
13. Shale, brown, clayey and carbonaceous, wavy-bedded	0.4
12. Shale, grayish-blue to dark-gray in lower part, nodular, noncalcareous	0.75
11. Shale, light-gray, orange-pink zones in lower part, calcareous, stands out on outcrop as two lawyers with softer lower middle part	1.1
10. Shale, upper part green, lower gray, four light and dark bands	3.7
9. Limestone and shale, mostly limy shale; locally 0.6 foot of limestone stands out on weathered outcrop; locally algal (?) material weathered into "boxwork"	1.2-5.0
8. Limestone, light-gray, weathers to lighter gray, impure, nodular, locally only a light band in shale	0.3-0.6
7. Shale, light- and dark-gray bands, lower half is bluish-gray; contains lenses of satin spar gypsum in middle part and sparse gypsum in upper part	6.0
Foraker limestone (13.25 feet exposed)	
Long Creek limestone member (11.45 feet)	
6. Clay and gypsum, nearly solid celestite in lower part; nearly pure gypsum in upper part	0.6

5. Shale, yellow and gray	1.1
4. Limestone, light-gray; upper part slabby, earthy to granular; part laminated; lower part weathers as nearly white shale; many vugs of barite and pyrite, veins of chalcopyrite	5.15
3. Limestone, light-gray to yellow, platy; contains nodules of pyrite	1.25
2. Limestone, light- to medium-gray, lower part darker and mottled, middle part suboölitic	3.35
Hughes Creek shale member	
1. Shale, dark to nearly black, limy, hard; sparse fusulinids in upper part; lower part packed with fusulinids; lacy bryozoans, crinoid fragments, *Chonetes,* and *Composita* exposed	1.8

(16) *Near Cen. N½ sec. 33, T. 23 S., R. 10 E., Greenwood County, Kansas. In Thrall oil field, near Thrall post office.*

	Thickness, feet
Permian—Wolfcampian	
Roca shale	
10. Shale	
Red Eagle limestone (15.7 feet)	
Howe limestone member	
9. Limestone, gray; profuse tiny low and high-spired gastropods, tiny clams, ostracodes in upper part; lower part light-gray with some tan, sandy appearing, massive; sparse poorly preserved microfossils	1.1
Bennett shale member (14.1 feet)	
8. Shale, yellow to buff, calcareous or dolomitic	0.6
7. Shale, mottled olive-gray and tan, thin-bedded to blocky; sparse bryozoans and echinoid fragments	9.6
6. Limestone, light-gray, beds 0.5 foot thick and less; fusulinids, echinoderm fragments, and brachiopods	2.7
5. Shale, gray, weathers tan, thin-bedded; sparse fragments of *Orbiculoidea*	1.2
Glenrock limestone member	
4. Limestone, medium-gray, weathers tan to buff, uneven upper and lower surfaces, chiefly algal material; algal colonies weather free at top; fusulinids, ostracodes; *Orbiculoidea* in top crust of bed	0.4–0.5
Johnson shale (3.5 feet exposed)	
3. Shale, gray to tan, thin-bedded, soft; contains limy nodules	2.0
2. Limestone gray, weathers tan, platy, silty	0.2
1. Shale light tannish-gray, nodular to thin-bedded and platy exposed	1.3

(17) *SW¼ NW¼ sec. 11, T. 26 S., R. 8 E., Greenwood County, Kansas. In Sallyards oil field.*

	Thickness, feet
Permian—Wolfcampian	
Grenola limestone	
Sallyards limestone member	
Roca shale	
8. Shale, not studied in detail, measured along highway one-half mile east	10.9

Red Eagle limestone (11.4 feet)	
Howe limestone member	
7. Limestone, light-gray, banded; spergenite of abundant algal material, small snails, ostracodes, echinoid spines; sparse *Composita* and *Aviculopecten*-like clams	0.8-1.0
Bennett shale member (9.3 feet)	
6. Limestone, yellow-brown, silty	0.3-1.4
5. Shale, gray, weathers tan, calcareous	2.0
4. Shale, light-gray, some shaly and silty limestone in middle part; stony bryozoans, echinoid fragments, corals, *Chonetes*, and *Composita*	5.9
Glenrock limestone member	
3. Limestone, light-gray, hard, massive; large and small fusulinids, echinoderm fragments, bryozoans, *Hustedia*, *Ambocoelia*, and *Wellerella*	1.0-1.1
Johnson shale (3.5 feet exposed)	
2. Shale, dark olive-gray to tan, blocky	0.5
1. Shale, gray and brown mottled; contains small soft limy nodules; thin-bedded to blocky	exposed 3.0

(18) *NE¼ SW¼ sec. 30, T. 27 S., R. 9 E., Greenwood County, Kansas. About 1 mile north and 5 miles east of Beaumont.*

	Thickness, feet
PERMIAN—Wolfcampian	
Red Eagle limestone (11.5 feet exposed)	
Bennett shale member (8.7 feet exposed)	
5. Limestone, light- to brownish-gray, hard, massive, brecciated in middle part; contains sparse gray chert; brachiopods, crinoid fragments; abundant fusulinids in lower and upper parts	exposed 8.0
4. Limestone, gray; red-brown fragments of *Orbiculoidea*, sparse echinoderm and brachiopod fragments, and abundant fusulinids	0.6
3. Shale, gray to brown; sparse *Orbiculoidea*	0.1
Glenrock limestone member	
2. Limestone, light-gray, weathers light-gray to light yellowish-tan, locally massive, locally slabby, cherty; abundant fusulinids, sparse echinoderm and brachiopod fragments	2.8
Johnson shale	
1. Shale, largely covered to a cherty zone in Foraker limestone	11.4

(19) *W½ sec. 3, T. 31 S., R. 8 E., Cowley and Elk Counties, Kansas. In creek bank and Santa Fe Railway cut.* Measured by George J. Verville.

	Thickness, feet
PERMIAN—Wolfcampian	
Grenola limestone	
Sallyards limestone member	
6. Limestone, dark-gray, platy to irregular-bedded, coarsely crystalline; pelecypods common	4.0
Roca shale	
5. Shale, red, green at top and base; contains numerous knoblike algal growths in upper part	14.7

Red Eagle limestone (19.6 feet)
Howe limestone member
4. Limestone, buff, chalky, sugary texture, massive, many small foraminifers and gastropods 2.5
Bennett shale member (16.9 feet)
3. Limestone, gray, weathers gray to buff, coarsely crystalline; massive to thin irregular beds; lower part somewhat nodular; jointed 16.6
2. Shale, gray, silty to mealy; contains red-brown fragments of *Orbiculoidea* 0.3
Glenrock limestone member
1. Limestone, gray, silty, nodular; fusulinids 0.2

(20) *Sec. 21, T. 32 S., R. 8 E., Cowley County, Kansas. Cut on Kansas highway 38.*

Thickness, feet

PERMIAN—Wolfcampian
Red Eagle limestone (20.7 feet exposed)
Howe limestone member
27. Limestone, speckled gray, tan, and brown; spergenite of shell fragments, ostracodes, bryozoans, gastropods, echinoid fragments, fusulinids .... exposed 2.8
Bennett shale member (17.4 feet)
26. Limestone, tannish-gray, uniformly fine-grained 6.4
25. Limestone, light- to medium-gray, dark-brown fossil molds, massive, hard, part brecciated; sparse bryozoans, fusulinids, ostracodes, foraminifers, abundant brachiopods and echinoderm fragments 5.1
24. Shale, gray 0.1
23. Limestone, gray, hard, fine to medium crystalline; sparse bryozoans, abundant brachiopod and echinoderm fragments 3.8
22. Shale, tan to gray 0.2
21. Limestone, medium-gray; brachiopods 1.0
20. Limestone, medium-gray, hard, crystalline 0.6
19. Shale, gray to nearly black, very thin-bedded; small fusulinids and red-brown fragments of *Orbiculoidea* 0.2
Glenrock limestone member
18. Limestone, grades laterally into limestone nodules interbedded with shale; contains a few glauconite grains; sparse echinoderm fragments, very small fusulinids, ostracodes, gastropods, foraminifers, and brachiopods 0.5
Johnson shale (30.3 feet)
17. Shale, light-gray and tan, underclaylike 0.4
16. Shale, gray, thin-bedded; nodular to limy siltstone interbedded with tannish-gray to dark-gray thin-bedded shale; upper part contains bryozoans, crinoid fragments, *Nucula* and other clams, sparse snails, *Ambocoelia*, *Chonetes*, abundant *Linoproductus* and *Juresania*, and abundant ostracodes 4.6
15. Siltstone, light-gray, weathers creamy gray 0.1
14. Conglomerate, shale and limestone pebbles 0.3
13. Shale, olive and tan; contains carbonized plant fragments .... averages 0.2
12. Limestone, "boxwork," yellow-brown and greenish, grading laterally into gray siltstone 0.4-1.0

11. Shale, olive and tan, upper part blocky with small white limy nodules, lower part thin-bedded	3.6
grades into	
10. Shale, olive and tan	4.5
9. Shale, maroon in upper part, green in lower, blocky	2.9
8. Mudstone, greenish-gray, weathers into small nodules	1.1
7. Limestone, pinkish-gray, hard, dense, sublithographic; contains small veins of clear calcite and green clay; tiny snails	0.7
6. Shale, gray to olive, dark-green in lower part, blocky	2.7
5. Limestone, gray to light-tan, weathers deep golden-brown; tiny snails and clams	1.2
4. Siltstone, light-gray to light-cream, limy, and light-gray limy shale; *Nucula* and other clams, and snails	1.4
3. Siltstone, gray to tan, weathers cream to tan	2.2
2. Shale, yellowish-brown to gray, upper part clayey; contains abundant limy nodules in lower part	3.4
Foraker limestone	
Long Creek limestone member	
1. Limestone, light- to medium-gray, weathers yellowish-brown, fine-grained, massive, hard, fossiliferous; contains sparse gray to black chert nodules ... exposed	3.6

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ORTHOGRAPHY AS A FACTOR IN STABILITY OF STRATIGRAPHICAL NOMENCLATURE

By

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CONTENTS

ABSTRACT

The problem of divergent spellings of stratigraphic names is discussed, as illustrated by examples in which (a) all usage follows "erroneous" spelling, as in Bennett versus Bennet, (b) usage is divided, as in Kimmeridge versus Kimeridge, and (c) effects of differences in language are a factor. Suggested rules are given for procedure judged best suited for stabilizing nomenclature.

INTRODUCTION

Unnecessary and undesirable in stratigraphical nomenclature seems to be the emendation of names which have become well established in geological literature on the ground of some difference in spelling of the stratigraphic name and the place name of the chosen type locality. The origin of such discrepancies (fortunately few in number) is diverse and by no means all are due to error. It is even true that accustomed spelling of place names is changed with lapse of years, or locally adopted spelling may differ from that accepted officially. As in zoological and botanical nomenclature, a name is a designation which must be different for each recognized unit and in order to avoid confusion, it should be employed uniformly by all workers as applied to any specified unit.

Although certain appropriate rules have been formulated for construction of stratigraphic, zoologic, and botanic names, basically they are merely handles designed to provide precision, uniformity, and stability. A name is a name, and whenever a name is given scientific application, it is obvious that no two different entities should bear the same name (homonyms) or that a single entity should bear two or more different names (synonyms). This is a sound principle for stratigraphical nomenclature, as in other fields.

STRATIGRAPHIC NAMES AFFECTED BY USAGE

Bennett versus Bennet.—The study by O'Connor and Jewett (1952) on the Red Eagle formation in Kansas has brought to notice divergence in spelling of the name Bennett, as applied to one of the members of the Red Eagle, and the locally recognized name of the type locality, Bennet, Nebraska. This place is a small town located in sec. 10, T. 8 N., R. 8 E., approximately 18 miles southeast of Lincoln, Nebraska. O'Connor and Jewett report that the spelling Bennet appears on the local post office, railway station, and highway signs at the town limits. Accordingly, they raised the question: Should the stratigraphic name Bennett shale be changed to Bennet shale? Publication of the spelling Bennett for this place on the base map of Nebraska (U.S. Geol. Survey, 1921), and adoption of it by Condra (1927, p. 86) in the original definition of the rock unit are presumed to represent errors which should not be perpetuated. Is this an acceptable view? Alternatively, can geological usage of Bennett be continued properly or wisely, given knowledge that the place of origin of the name is differently designated? It is firmly my judgment that usage of Bennett as applied to this shale in many reports published during the 25 years since introduction of the name by Condra should be recognized as establishing it in such manner that for stratigraphic nomenclature the term is not subject to change. So far as known, the designation Bennet shale or Bennet member of the Red Eagle formation has appeared in print nowhere. Accordingly, the Kansas Geological Survey proposes to continue usage of Bennett for this division of Lower Permian rocks in the mid-continent region. The general rule derivable from consideration of the Bennett versus Bennet example may be formulated as follows:

Stratigraphic names established by uniform usage in several publications shall not be subject to change of spelling, whatever the origin of these names or the advocated reasons for change of orthography may be. If question is raised as to what constitutes "several," it is evident that no satisfactory answer can be given. Also, if attempt is made to define usage in terms of years, difficulty is encountered equally, for a 10- or 20-year period during which only one or two references to a given stratigraphic name appear in print, establishes 100 percent uniformity of usage for the period, provided spelling of the name is identical with that in the original publication. Surely, no need exists for a legalistic approach in formulating and applying a general rule of the sort here given. Geologists undertake to have common sense, and if someone wishes to discard common sense, no police authority is available to arrest him.

A stratigraphic name is merely a name. It is useful to know when, where, how, and why it was first employed because this has bearing on precise definition and understanding of the term. It is needful also to take account of usage subsequent to the date of original publication, because stability is measured by uniformity. If in several publications issued during a span of years accordance in usage is complete, surely no reason at all exists for upsetting adopted practice, and if the accordance is nearly but not quite complete, effort should be directed to suppressing minor divergent usage. Then, discrepancies in names of the sort here discussed are unimportant; essentially they have historical interest only.

Kimmeridge versus Kimeridge.—Similar in some respects to the question of what spelling should be accepted for the Bennett shale is the problem of nomenclature presented in the case of Kimmeridge versus Kimeridge. This pertains primarily to designation of Upper Jurassic strata in southern England. Differences of two sorts, as compared with the Bennett example, are noteworthy: (1) Kimmeridgian (or Kimeridgian) has been adopted very widely for designation of a stage in the standard Jurassic column and thus is found to be employed for indicating the age of rocks throughout the world; and (2) neither Kimmeridge (Kimmeridgian) nor Kimeridge (Kimeridgian) is recognized with such universality as to warrant adoption of one as "correct" and the other as "wrong." Can divergence in spelling of this name yield to complete convergence?

The name Kimeridge was introduced in geological literature by Damon in 1860 (Arkell, 1947, p. 68), reference being made to the exceptionally well-exposed sections of dark shaly fossiliferous beds of the Dorset coast, southern England, near Kimeridge (or Kimmeridge), some 15 miles east of Weymouth. According to Arkell, the town name (and that of the bay on which it is located) was Kymerich in 1293 and by 1774 had become known as Kimeridge. Spelling of the name with one "m" appeared on the official Ordnance map of 1811 and in geological reports published in 1860, 1884, 1888, and 1895 (the last-cited being a memoir of the Geological Survey of Great Britain by H. B. Woodward). As indicated by Arkell (1933, p. 441) and as confirmed by my visit to the locality in the summer of 1951, the town is labeled Kimeridge on highway and other signs. Thus, consistent local usage down to the present day seems to establish Kimeridge as "correct." Kimeridge clay and Kimeridgian (or Kimeridgien, French) were recognized in Haug's (1911, p. 948) classic Traité de Géologie, Arkell's (1933) *magnum opus* on the Jurassic System in

Great Britain, a large monograph by Termier (1936, tab. 25) on parts of northern Africa, and other papers. These facts seemingly furnish strong support for general adoption of Kimeridge and Kimeridgian in geological literature.

In 1892, the Ordnance survey of Great Britain adopted the spelling Kimmeridge (sheet 342) and this was accepted by the Geological Survey of Great Britain in 1898 (Arkell, 1947, p. 68). Since then, Kimmeridge and Kimmeridgian have appeared in hundreds of geological publications, issued in many parts of the world. A representative few of these include Neaverson (1928), Muller (1941), Gignoux (1943), Arkell (1946, 1947), Chatwin (1948), Edmunds (1948), and Moore, Lalicker, and Fischer (1952).

What solution can be advanced to achieve uniformity? Shall effort be made to secure adoption in geological literature of the spelling accepted locally for the type locality during centuries and persisting today? This seems the more logical when we recall that priority in published Kimeridge as a stratigraphic name gives it preference over Kimmeridge. Opposed to this is the fact that overwhelming preponderance of geological usage seems firmly to have fixed Kimmeridge and Kimmeridgian. The best decision seems to be one based on recognition of the separateness of stratigraphic nomenclature, established by custom among geologists, from sources of the names. Thus, without reference to spelling of the place called Kimeridge and how slightly changed spelling gained general acceptance in geological literature, it is judged that the stratigraphical names derived from this locality are appropriately spelled Kimmeridge and Kimmeridgian. A general rule derivable from consideration of this example may be stated as follows:

Stratigraphic names which are spelled divergently in many publications shall be made uniform by adoption of the form accepted by a majority of later workers, whatever may be the local spelling of the type locality or original spelling introduced in geological literature. Acceptance of this rule leads to adoption of Kimmeridge (Kimmeridgian) and rejection of Kimeridge (Kimeridgian).

STRATIGRAPHIC NAMES AFFECTED BY LANGUAGE

A special problem in stratigraphical terminology is introduced by differences in language. What shall be the correct name of a rock unit or time-stratigraphic division based on outcrops at a given place in any country if the place name differs in various languages? Shall these place names be "translated?" For example, widely known Cenozoic rock units named from the vicinity of Piacenza and Villafranca (both in northern Italy) are termed Piacenziano (Italian), Plaisancien (French), Plaisancian (English); Villafranciano (Italian), Villefranchien (French), and Villafranchian (English). Upper Cretaceous deposits named from Maastricht, in southern Holland, are variously designated as Maastrichtien (Dutch), Mastrichter Schichten (German), Maestrichtien (French), and Maestrichtian (English).

Are such divergences of nomenclature unavoidable and are they significant? As regards time-stratigraphic names, it is evident that variations in endings imposed by language differences (as -ian, English; -ien, French; -iano, Italian, Spanish) have no significance. They do not constitute any real alteration. This is not true, however, if the "stem" of the place name is changed, as by alteration of Piacenz- to Plaisanc-, or by modification of Villafranc- to Villefranch-. Even if one grants that no ambiguity exists from citation of the name in these variant forms, the differences seem unnecessary and undesirable. Why not adopt the spelling of any place name in the country of its origin, thus accepting (in English usage) Piacenzan, Villafrancan, Maastrichtian, etc., instead of terms based on translations of place names? Patently absurd would be reference to the Liberty Hall limestone (Ordovician, Virginia) as "calcaire de la Salle de Liberté" (French), or "Freiheitskammer Kalkstein" (German). This is never done, but after all it is not essentially different from less violent linguistic alteration of place names. A general rule based on avoidance of translation may be stated:

Stratigraphic names should employ the spelling of place names in the country of their origin rather than that of equivalent names in other languages.

Application of such a rule naturally does not call for replacement of long-adopted stratigraphic terms based on Latinized place names, such as Lutetian, from Lutetia (Paris), by their equivalents in present-day use. To do this would be absurd. Indeed, the fact that functions of scientific nomenclature are well served by employment of almost any name that avoids homonymy and synonymy is illustrated by the evident distinction between the words Lutetian (time-stratigraphic) and Paris (rock name). Conceivably each might be adopted in stratigraphic nomenclature, being applied to different units without ambiguity or confusion. The terms themselves are not alike even though they are derived from the same geographic feature.

What about correlative place names such as Brussel (Flemish) and Bruxelles (French), Luik (Flemish) and Liège (French), Bâle (French) and Basel (German), Morat (French) and Merten (German), and many similar variations. These are alternative designations accepted in the country to which they belong; one is as correct and official as another. An example of stratigraphic terms based on names in this category is furnished by Bruxellian, well known as a division of Eocene deposits in Belgium. The spelling adopted is uniformly derived from Bruxelles, not Brussel; hence, this has sanction of usage and should take precedence over the slightly different name Brusselian. Because of the close similarity of these French- and Flemish-derived spellings, most geologists would agree that it is very inexpedient to employ both names. It is possible, however, that such a term as Brussel sand could coexist with Bruxellian stage without introducing confusion. Without doubt, names like Luik and Liège, or Bâle and Basel could furnish clearly distinguishable pairs of stratigraphic terms, if needed. Although they refer to the same place, they are virtually as separate as if they belonged in different countries.

It seems to be repugnant to proprieties which take account of national pride that stratigraphic names should be formed, either originally or by translation, on foreign-accepted names. For example, the London clay should be known everywhere and in any language as London clay—not argile de Londres. In other words—

Spelling of stratigraphic names should conform to usage recognized in the country that contains the type locality and it should not be altered by conversion into equivalent but different words in other languages.

The question of transliteration into roman letters of words written in other alphabets, such as Greek, Cyrillic, Persian, and Chinese, and the proper mode of dealing with special letters, such as those in German characterized by the umlaut (ä, ö, ü), Swedish å, or Norwegian and Danish ø—to mention a few—has interest but it is passed over here. It would be appropriate for consideration of the Commission on Stratigraphy of the International Geological Congress.

CONCLUSIONS

Maximum possible uniformity in stratigraphic nomenclature is desirable in the interest of clarity and stability. This uniformity includes spelling of stratigraphic names but does not at all embrace classification of rocks for which the names are introduced. Homonyms and synonyms of whatever origin are to be avoided because inevitably they conduce nomenclatural confusion.

Usage is a more important criterion than priority of publication or the mode of spelling the name of a type locality, when question arises as to choice between different names for the same stratigraphic unit.

Stratigraphic names should not be formed on the basis of translation into a language foreign to the country in which the type locality is placed, or built on a name for such place used in a foreign country if this differs from the locally recognized name. This does not exclude linguistic variation in the nature of endings employed for time-stratigraphic terms, however.

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