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CLASSIFICATION OF THE LOWER PERMIAN ROCKS OF KANSAS

By

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Part I

CLASSIFICATION OF THE "LOWER PERMIAN" ROCKS OF KANSAS

By Raymond C. Moore and Maxim K. Elias

Part II

STRATIGRAPHY OF THE BIG BLUE SERIES IN NORTH-CENTRAL KANSAS

By Maxim K. Elias

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Bigelow limestone ~~formation~~

Crouse limestone member

Blue Rapids shale member

Funston limestone member

Speiser shale ~~formation~~

Chase group

Wreford limestone ~~formation~~

Threemile limestone member

Havensville shale member

Schroyer limestone member

Wymore shale ~~formation~~

Kinney limestone ~~formation~~

Blue Springs shale ~~formation~~

Barneston limestone ~~formation~~

Florence limestone member

Oketo shale member

Fort Riley limestone member

Holmesville shale ~~formation~~

Towanda limestone ~~formation~~

Gage shale ~~formation~~

Winfield limestone ~~formation~~

Stovall limestone member

Grant shale/ member

Cresswell limestone member

Luta limestone member

Sumner group

Odell shale ~~formation~~

Nolans limestone ~~formation~~

Krider limestone member

Paddock shale member

Herington limestone member

Pearl shale ~~formation~~

Donegal limestone ~~formation~~

Hollenberg limestone member

Newbern ~~Sand Springs~~ shale member

Strickler ~~Carlton~~ limestone member

Wellington shale ~~formation~~

Buckeye ~~Bonaccord~~ shale member

Carlton ~~Farmer~~ limestone member

CLASSIFICATION OF THE "LOWER PERMIAN" ROCKS OF KANSAS

By Raymond C. Moore and Maxim K. Elias

INTRODUCTION

Purpose of Report

Determination of the characters, thickness, and order of succession of the rocks that occur in different parts of Kansas is a primary function of the State Geological Survey. Such important features as the topography of the land surface, the nature of soils, commercial utilization of rock materials, and in many cases the quality and quantity of underground water supplies are dependent on the physical and chemical characters of the rocks. Directly or indirectly these are subjects that concern every inhabitant of the state, for they affect the environment in which he lives.

One of the first steps in geologic study of a region is the grouping together of like kinds of rock and classification of these in an orderly fashion according to their arrangement. The characteristics of each unit or group of strata should be observed, the thickness and distribution of these units at the surface determined, and their relation to topography, soils, economic utilization, or other subjects investigated. Special types of geologic or engineering work dependent on the rocks may be carried forward. For purposes of scientific study, also, involving the correlation of rocks in one region with deposits in distant areas, knowledge of the sequence of strata and the nature of their contained organic remains is necessary. Included here is the decidedly practical and important matter of recognizing various rock layers underground in deep drilling for oil and gas, or in some cases for water. Determination

forward in connection with the mapping of the state for the new geological map of Kansas, and in the course of this work certain new elements that ~~have an important~~ bearing on classification of these rocks have been observed. In part they require a modification of previously accepted classificatory units.

Acknowledgments

In expressing acknowledgment of the work of others, the writers wish first to pay tribute to the early investigators of the "Lower Permian" rocks of Kansas, whose field work and writings have laid the ground work for much of the later studies. That this early work was well done is indicated by the comparative stability of the classification that had previously been developed, and by the absence of serious misidentifications of strata in different parts of the Kansas region. Chief among these early workers are G. C. Swallow, second state geologist of Kansas, who was among the first to announce conclusions as to presence of Permian rocks in Kansas, though deposits of that age were not yet known elsewhere ~~which was also the first~~ in the United States; C. S. Prosser, who carefully studied and measured many sections of the ~~so-called~~ "Permian" rocks and defined several of the formational or group units in this part of the section; and J. W. Beede, who contributed both important stratigraphic information and investigation of fossil invertebrates. In later years the work of G. E. Condra, state geologist of Nebraska, and his associates, particularly J. E. Upp and Busby of the Nebraska Geological Survey, have been most important in recognizing and defining the finer very persistent stratigraphic subdivisions of the "Permian" rocks in the northern Mid-Continent region. N. W. Bass, of the United States Geological

Survey and the Kansas Survey, has made a valuable study of the "Permian" rocks of southern Kansas. Special mention may be made of the assistance of Doctor Condra who has collaborated with the senior writer in certain field investigations bearing on correlation and classification of some of the rocks of the Big Blue series.

THE PERMIAN PROBLEM

Although, generally speaking, the Permian is definitely accepted in geology as the closing period or epoch of the Paleozoic era, a more precise definition and limitation of this time unit still presents one of the most difficult problems in geologic chronology. The difficulty is due partly to the very diversified nature of the sediments and embedded fossils which are classed as Permian and it is due partly to the scarcity in many places and in parts of the section of marine fossiliferous beds. No one region contains fossil-bearing marine deposits representing ~~more than a fraction~~ complete duration of what is generally classed as Permian time. Another kind of difficulty has arisen from errors introduced in the definition of the type Permian.

Definition of the Type Permian

The "Permian system" of Murchison, de Verneuil and Keyserling was designed to include everything between the top of the Carboniferous system and the base of the Triassic rocks, the type locality of the system being established in the area east of the City of Perm on the western slopes of the Ural Mountains. Here the supposedly lowermost Permian beds (marls, dolomites, shales, and sandstones) rest upon a series of grits, and conglomerates which the originators of the term Permian erroneously considered as equivalent to the

Millstone grit of the Carboniferous of England. This error was subsequently discovered by Russian geologists (Pander, Möller, Karpinsky and Tschernyschew) who found that the marine, mostly ammonoid faunas of the beds (now known as Artinskian) supposedly equivalent to the Millstone grit, indicate for these beds an age younger than the youngest beds of the Carboniferous as generally defined. Accordingly, these geologists began to regard the Artinskian as transitional beds that belong between the Carboniferous and the Permian and they applied to them the term Permo-Carboniferous. Later, the Russians added the Artinskian beds to the Permian, thus extending the original use of Permian to include these ammonoid-bearing Artinskian grits.

In the type region of the Permian, the Artinskian is underlain by a series of calcareous marine deposits called Uralian. According to Tschernyschew, the highest beds of the Uralian contain Schwagerina, a fusulinid which many American geologists regard as an exclusively Permian form. This led Beede and Kniker[1] and sub-

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[1] Beede, J. W., and Kniker, H. T., Texas University, Bull. 2433, 96 pp., 1925.

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sequently various others to extend the lower boundary of the Permian farther down so as to include in it the beds containing Schwagerina. According to ~~recent~~ revisions ~~of the determined stratigraphic succession in Russia and its classification by Russian geologists, it appears that Schwagerina occurs abundantly in the lower beds of the Uralian, and not where Tschernyschew placed it, although its presence in the uppermost Uralian beds can not be considered finally disproved. This occurrence of Schwagerina in~~ by G. Frederichs and his associates, in west-central Ural Schwagerina appears not in the upper but in the lower beds of the Uralian (or in the Gzhelian); according to Sokolskaya the genus Schwagerina occurs about in the middle of the Uralian, referred to the Uralian, while Ruzencev observes in Southern Ural abundant Schwagerina in the Sakmarian, that is directly below the Artinskian and suggests that the Sakmarian is added together with the overlying Artinskian to the Permian.

~~the lower Uralian (not yet supported by published illustrations or detailed descriptions) creates no difficulty for those who place the lower boundary of the Permian below the Artinskian, since it is~~ advocated by Grabau and Schuchert that the whole Uralian should be added to the Permian (Grabau, Schuchert). It is perhaps a desirable thing to unite the Uralian with the Artinskian and Permian, as originally indicated in Permian districts, in a single geologic system, but it is needful to point out that at the present time the term Permian has no definite and generally accepted meaning even for the area where it is supposed to be typically developed.

We must take into account, furthermore, that several definitions other than that based on the type exposures in the western Urals have been proposed for the lower boundary of the Permian system. These have been and still are followed by many prominent geologists. Thus, German geologists tend to define the lower boundary of the Permian as belonging at the base of the Rotliegende of Germany. The tendency to consider the base of the Permian as belonging at the first appearance of Schwagerina has already been mentioned. The International Carboniferous Congress (1927) at Haarlen, Holland, suggested acceptance of the definition of the beginning of Permian time as coinciding with the first appearance of ~~the~~ Callipteris conferta. J. P. Smith advocated definition of the beginning of Permian on the basis of the first appearance of primitive meddlicottid ammonites (Uddenites). We believe that probably none of these suggested additional definitions of the base of the Permian will precisely coincide either with the base of the Permian in the original sense or of the Artinskian, or of the Uralian in the type region of these divisions in Europe.

Evaporite deposits are chiefly confined to the upper part of the Big Blue series. The salt beds are remarkably thick and pure, measuring about 400 feet in total thickness between Hutchinson and Kingman. The salt is in part interbedded with shale. Because of their solubility, the salt beds are not exposed at the surface in any part of the state, but they have been recognized throughout a large area in deep drilling. Gypsum occurs in the lower part of the Big Blue series in northern Kansas and in the upper part in central Kansas.

The Cimarron, or red beds division of the "Permian", is chiefly characterized by the red color of the formations, both shale and sandstone. Limestone is conspicuously lacking, but there are some thin persistent beds of dark bluish dolomite. The shales are clayey or sandy and grade laterally in many places into sandstone. The sandstones are commonly cross-bedded, irregular in thickness, and nonpersistent. Gypsum and anhydrite occur in parts of the red beds section, being identified at the surface in southern Kansas and widely reported in drilling in the western part of the state. Fossils are rare or lacking in most of the Cimarron deposits.

The Pennsylvanian-"Permian" Boundary

The so called "Permian" rocks of the northern Mid-Continent region lie parallel to and apparently conformable upon the Upper Pennsylvanian strata. Because of this fact and because the faunas collected from the Big Blue strata are only slightly different from those of Upper Pennsylvanian rocks as commonly classified, some geologists hold that there is no valid ground for differentiating these higher marine strata from the lower, all being

included under the term Pennsylvanian.[5] On the basis of the distribution of fossils regarded as indicating Permian time,

[5] See Ulrich, E. O., Geol. Soc. America, Bull., vol. 22, p. 376, 1911. Pl. 26 opp.

the lower boundary of the "Permian" has been variously placed at horizons from the Wreford limestone to the base of the Americus limestone. The somewhat arbitrary decision of the United States Geological Survey and concurrence of the Nebraska and Kansas Geological Surveys, however, has long stabilized the lower boundary of the Permian at the base of the Cottonwood limestone. On the basis of studies by J. W. Beede of the fusulinid genus Schwagerina and other fossils, the Oklahoma Survey since 1914 has adopted the base of the Neva limestone as the boundary between Pennsylvanian and "Permian".[6] As previously noted, Beede,[7]

[6] Beede, J. W., Okla. Geol. Survey, Bull. 21, 37 pp., 1914.

[7] Beede, J. W., Science, n. s., vol. 29, pp. 637, 752, 1909; Jour. Geology, vol. 17, p. 718, 1909.

in 1909, had concluded that the Permian should be regarded as including the Elmdale shale, which would place the boundary at the top of the Americus limestone, about 120 feet below the Neva. Moore,[8] in 1932, after extended studies of lithologic and faunal

[8] Moore, R. C., Guidebook, Sixth Ann. Field Conf., Kan. Geol. Soc., p. 88, 1932.

characters, concluded that the beginning of "Permian" conditions was located at least as low as the base of the Americus limestone,

and because this is a prominent mappable horizon the base of the "Permian" in Kansas was tentatively lowered to this position.

Recent investigations have brought to light evidence of the existence of large channel sandstone bodies that appear to have significance as to location of the boundary between Pennsylvanian and "Permian". These sandstones occur in a constant stratigraphic position and are distributed from southeastern Nebraska to northern Oklahoma.[9] The channels occupied by these deposits

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[9] Moore, R. C., and Moss, R. G., Permian-Pennsylvanian boundary in the northern Mid-Continent area: Geol. Soc. America, Proc. 1933, p. 100, 1934.

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were made by erosion of Upper Pennsylvanian strata to a depth locally of about 125 feet. Before normal sedimentation was resumed the depressions were filled by conglomerate, sandstone and sandy shale. The indication of physical discontinuity thus observed is comparable to that which defines the boundaries between the series now recognized in the Pennsylvanian section of Kansas. Study of these latter disconformities indicates that a crustal disturbance that is profound in geosynclinal regions may only be recorded in a stable platform area, like that of which Kansas is a part, by cessation of sedimentation accompanied by local erosion and by subsequent channel-sand filling. Thus, the large channel sandstone bodies that have been discovered at a horizon not far below the Americus may be interpreted as indicating a physical break between the rocks that are undoubtedly Pennsylvanian and those that have been regarded as Permian. The position of this

"super-formation" rather than as a "subsystem", and therefore, is not necessarily set apart from adjacent strata by other than lithologic characters. The stratigraphic contact between two groups may be a conformable one and it may be parallel to stratification planes for a long distance or transect these planes obliquely. In other words, contiguous groups may be wholly different in age or on the other hand they may be partly or wholly of the same age.

There are two rather clearly defined main subdivisions of the "Permian" rocks in Kansas: (1) the dominantly non-red, rather highly fossiliferous succession of limestones and shales called Big Blue, below, and (2) the dominantly red, mostly unfossiliferous sandstones and shales called Cimarron, above. Parts of both of these subdivisions are marine and parts of both are apparently nonmarine. The Big Blue and Cimarron deposits represent different types of environment that existed in part contemporaneously as is shown by tracing the Big Blue strata southward in Oklahoma into Cimarron type of red beds. Because of this laterally gradational relationship of the red and non-red "Permian" deposits and because the contact between Big Blue and Cimarron in any given vertical section seems to be conformable, it appears that the subdivisions called Big Blue and Cimarron might be classed as groups rather than as series. On the other hand it is quite possible that there is actually a stratigraphic break between the Big Blue and Cimarron deposits of such character as to indicate their proper classification as series. In this case the southern red beds equivalents of the Big Blue limestones and non-red shales

Definition of Formations

Formations are the essential units of the geologic column, as subdivided stratigraphically, and they are also the fundamental units of geologic mapping. Some of the factors that apply to definition of geologic formations are difficult to evaluate ~~in some cases~~ and there are many so-called "formations" as described in the literature that are wholly arbitrary groupings of strata. It is agreed that lithologic characters are the most important in defining the formation, for it is chiefly desirable to segregate and to map the kinds of rocks that have similar physical characters. The boundaries of a formation as defined by one geologist should be clearly recognizable and useful to other geologists.

The succession of alternating limestone and shale deposits that comprises the lower "Permian" section of Kansas offers an interesting problem in stratigraphic classification. What are the lithologic units that should be ranked as formations? It is clearly undesirable and indeed impossible to differentiate each individual limestone stratum or unbroken succession of limestone beds as a limestone formation, and it likewise is undesirable to designate each separate shale unit as a shale formation. These alternating limestones and shales are mostly much too thin. One may segregate parts of the section that are dominantly composed of limestone, however, and class them as limestone formations. The parts consisting mainly of shale may be classed as shale formations. Subordinate shale beds in limestone formations and subordinate limestone beds in shale formations may then be classed

as members or lentils depending on their prominence and persistence. In general, this has been done and it is desirable to retain such a classification.

Having made these observations, there remains for us merely to inquire as to the desirability or propriety of the respective segregations of beds that have been made in the past. Are the groupings of limestone beds to make limestone formations "natural" groupings? Are the shale formations of previous classification well defined or do they represent, at least in part, arbitrary residues of strata between the selected limestone formations? Is there any guide as to the proper classification of successive strata? Study of these questions indicates that most of the previously defined limestone formations of the Kansas Lower "Permian" section are acceptable without change of boundaries, but it appears that a number of limestone subdivisions of previously defined shale formations should be elevated to the rank of formations. A guide to a more natural and therefore a more practically useful stratigraphic classification of the Lower "Permian" rocks is afforded by recognition of the existence of a definite cycle of sedimentation that is repeated again and again in this part of the section.

Relations of Formations to Cyclothems

Proposed revisions of formation units in the Big Blue series are designed to conform to our present knowledge of the cyclic character of sedimentary conditions and at the same time to serve practical needs of field mapping and the recognition and correlation of beds in deep wells. As soon as we recognize the cyclic

DESCRIPTION OF STRATIGRAPHIC UNITS IN THE LOWER PERMIAN SECTION OF KANSAS

Big Blue series [1]

~~(Named by F. W.~~ (Cragin, 1896) ~~revised by R. C.~~ Moore and ~~R. C.~~ Moss, 1934)

1896, Big Blue series, Cragin, F. W., Colo. College Studies, vol. 6, pp. 3, 5. Includes beds from base of Neosho shale [equals base of Morrill limestone] to top of "Geuda salt measures" [top of salt beds in Wellington]. ---- 1902, Prosser, C. S., Jour. Geology, vol. 10, p. 704, Includes beds from base of Wreford limestone to top of Wellington shale. ----- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, ~~2d ser.~~ (2), Bull. 6, p. 7. Includes beds from base of Cottonwood to top of Wellington shale. ---- 1932, Moore, R. C., and Condra, G. E., Guidebook, Sixth Ann. Field Conf., Kan. Geol. Soc., Classification chart. Includes beds from base of Americus limestone to top of Wellington shale. ----- 1934, Moore, R. C., and Moss, R. G., (Geol. Soc. America, Proc., 1933, p. 100.) ~~Mss.~~ Includes beds from base of Indian Cave sandstone and of Towle shale (base of Admire group) to top of Wellington shale.

[1] Following the practice in paleontologic taxonomic literature the name of the author of stratigraphic terms is given with the date of introduction. If the original author's definition has been changed, his name is placed in parentheses and the name of the author of the revised definition

(1) Wolfcampian Series

The Wolfcampian series includes most of the rocks formerly included in the "Big Blue" series but excludes the rocks above the Nolans limestone. ~~Most of the rocks included in the Wolfcampian series were included in the Big Blue series, which are now included in the~~

1917, Big Blue group, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 110. Includes beds from base of Cottonwood limestone to top of Wellington shale. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 54. Same.

Type locality, named from Big Blue River valley, north-central Kansas.

The strata classed under the term Big Blue series are characterized by prominence of limestones and associated marine strata, many of which are highly fossiliferous, and by the relative unimportance of red sediments. In these respects the Big Blue rocks are decidedly unlike those called the Cimarron series, which consist mainly of unfossiliferous red beds. The boundary between Big Blue and Cimarron divisions of the Kansas "Permian" has been rather uniformly drawn, in terms of definition at least, at the top of the Wellington shale. It is thus intended to divide red strata above from dominantly non-red beds below, but the presence of red zones in the upper Wellington ~~and the probable gradational nature of the contact both vertically and in a horizontal direction toward the south~~ indicates that the boundary between these series is not a very precise one. Because of the known southward gradation of the non-red beds into red beds, it is probable that the line of demarcation drawn on basis of color is not at a constant stratigraphic plane. This difficulty, however, affects

northern Oklahoma more than Kansas. Owing to the fact that both the upper Wellington and the lower Cimarron consists of weak strata, outcrops in the vicinity of the boundary are few and rather poor. It is difficult, therefore, to map the contact in detail.

The lower boundary of the "Big Blue" series has been variously drawn, depending mainly on changing ideas as to the boundary between "Permian" and Pennsylvanian rocks in the Kansas section. It was originally placed by Cragin at the base of the† Neosho formation (which corresponds to the base of the Morrill limestone as now defined[13]), was subsequently shifted to the base of the Wreford limestone by Prosser, and later (Moore and Haynes, 1917) to the base of the Cottonwood limestone. Tentative change of the lower boundary of the "Permian rocks" to the base of the Americus limestone (Moore and Condra, 1932) and more recently (Moore and Moss, 1934) to the unconformity recognized just above the Brownville limestone has occasioned corresponding extensions of the application of the term Big Blue series.

~~The thickness of the Big Blue series ranges from about feet in to feet in . Deep well records in western Kansas indicate that the average thickness of the series in this part of the "Permian" basin is about feet.~~

[13] In accordance with recommendations of the Stratigraphic Code (Geol. Soc. America Bull., vol. 44, p. 423, 1933) obsolete stratigraphic terms are here designated by a dagger (†).

but was progressively shifted by successive workers to the base of the Hartville limestone member of the Bottle of Coin Flowers to the base of the Workpark, the Base of the Cottonwood, the Base of the Americans and more finally recently (1934) was placed by Moore and Moss at the unconformity recognized just above the Brownsville Limestone (Moore, 1940)

(3)

(2)

The total thickness of the ~~Big Blue~~ Wolfcampian series for central Kansas is about 1,400 feet, ~~not counting~~ exclusive of the basal Indian Cave channel sandstone, ~~which is up to 100 feet thick~~ (see p. 35).

The ~~Big Blue~~ Wolfcampian series, as here defined, is subdivided into ~~four~~ three groups, ~~from the top downward: Sumner, Chase, Council Grove,~~ and Admire, which in upward order are designated Council Grove, Chase, and ~~Sumner~~.

14pN

Admire group

~~(Named by G. I.~~ (Adams, 1903) ~~revised by R. C.~~ Moore and ~~C. E.~~ Condra, 1932)

1903, *Admire shale, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 53. Includes beds between top of Emporia limestone (name erroneously applied to beds now recognized as Maple Hill to Grandhaven limestones) to the base of the Americus limestone. ----- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 114. Includes beds between Emporia and Americus limestones. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 106. Same. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 48. Same. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 43. Same.

~~Asterisk (*) indicates names used in a sense different from that now accepted.~~

1927, *Admire shale, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, p. 75. Redefines Admire to apply to beds between base of the Brownville limestone and base of the Americus limestone. Condra notes the following subdivisions of the Admire shale as thus redefined, in upward order: Brownville limestone, Aspinwall shale, Falls City limestone, West Branch shale. Since ~~at this time~~ in 1927 Condra misidentified the bed now called Five Point limestone as Americus, the term Admire shale as here

In northern Kansas,
the Admire group is ~~about~~ 85 to 115 feet
thick, exclusive of the Indiana cave channel
sandstone at its base; the latter being
~~up to~~ 100 feet or more in thickness at ~~some places.~~
~~Dadga, Pottawatomie Co, Kansas.~~

In tributary valley of the Little Nemaha valley SE ¼ Sec. 4, T. 1 N., R. 15 E., abt. 3¼ mi. W. of the S. fork of Nemaha, Nemaha County, Nebraska (communication by G. E. Condra, Oct. 14, 1936).

shale, Morrill limestone, Stearns shale, Eiss limestone, Hooser shale, Middleburg limestone, Easly Creek shale, Crouse limestone, Blue Rapids shale, Funston limestone, Speiser shale.

1932, Council Grove group, Moore, R. C., and Condra, G. E., Sixth Ann. Field Conf., Kan. Geol. Soc., Classification chart. Includes beds from base of Americus limestone to base of Wreford limestone.

Type locality, named from Council Grove, Morris county, Kansas.

In the early work on the Upper Paleozoic rocks of Kansas the Cottonwood limestone was given rather special notice and prominence because of its distinctive lithologic and faunal characters which fitted it to serve as an easily identified datum plane or marker in dividing lower from higher beds. Thus, in 1895, Prosser selected the Cottonwood limestone as the upper boundary of the "Wabaunsee formation". Next above the Wabaunsee, the "Cottonwood formation", was defined to include the Cottonwood limestone below and the Cottonwood shale [Florena] above. The succeeding beds to the base of the cherty Wreford limestone were classed as "Neosho formation" and the prominent

cherty limestones and included shales from the base of the Wreford to top of the Winfield were designated the Chase formation. The name Council Grove was introduced in 1902 to include the beds between the Wabaunsee and Chase. Later studies indicate a lesser classificatory importance of the Cottonwood limestone than was assigned to it by Prosser and other workers, and suggest that the lower boundary of the "Permian" rocks should be placed considerably below the Cottonwood.

The distinguishing lithologic features of the Council Grove beds as first defined, consisting of mainly non-cherty limestones and the shales between them, apply equally well to the underlying beds down to the base of the Americus or Foraker limestone. The first of the very prominent limestones in the "Permian" succession is the Foraker limestone, of which the Americus is the lower part. Accordingly, it seems best to extend application of the term Council Grove to include the beds from the base of the Foraker to the base of the Wreford, rather than to introduce a new term to include the beds formerly classified as upper Wabaunsee. The fact that chert is present in some of the limestones of the Council Grove group occurs locally

1903, Americus system, Smith, A. J., Kan. Acad. Sci., Trans., vol. 18, p. 101.

Type locality, near Americus, Lyon county, Kansas.

The name Americus was given by Kirk[15] to a "system" of "two thin layers of limestone which are about 4 feet apart" and cap the hills north and west of the water reservoir hill at Emporia, Lyon county, Kansas. This "system" made of two limestones was previously designated by Haworth and Kirk[16] as Limestone System No. 11.

[15] Kirk, 1896, p. 80.

[16] Haworth and Kirk, 1894, p. 111.

In view of further reference by Kirk to the locality where the "system is of greatest commercial interest west of the river" (Neosho river) "opposite Americus, in the northwestern quarter of section 9", this latter locality, where the beds of the Americus limestone have been intensively quarried and are well exposed, is considered by the Kansas Geological Survey as the type locality of the Americus. When correlating the beds of the Pennsylvanian system in Nebraska with those in Kansas, Condra[17] assumed that the type locality of the Americus is in the "exposures in the south bank of Neosho river,

[17] Condra, 1927, p. 82.

2 miles west and one-half mile south of Americus, which is southeast of the locality designated by Kirk and where, in the river bank, as subsequent observations by R. C. Moore proved, not the Americus limestone but the Five Point limestone is exposed. It is quite possible that Kirk himself did not realize that another limestone, also a splendid building stone comparable in nearly every respect to the Americus, is developed in close proximity to the latter, and erroneously considered them to be one single limestone. Be that as it may, his description of the Americus "system" as composed of "two different strata"..."separated by 4 feet of shale" corresponds to what is here called the Americus, and not to the Five Point, which here (as well as elsewhere) outcrops as a single limestone separated into three lithologically somewhat different ledges only by horizontal cleavages, and ~~but~~ not by intervening shale.

The geologic section on the south bank of Neosho river 2 miles west and one-half mile south of Americus was studied jointly by R. C. Moore and G. E. Condra in 1929, and its description is given here as recorded by R. C. Moore, see page ____ of this report.

M. K. Elias visited and checked this section in 1934. In the river bank of this locality only Five Point limestone is exposed, projecting as a prominent bench at the top of the bank, while the Americus limestone builds another bench several hundreds of yards south and west of the river on the slopes of the dissected hills. Although the bench which is formed by the Americus in these hills is quite prominent, the large and heavy slabs of this limestone slump down from their original position and the softer, mostly shaly, beds above and below are rarely and poorly exposed. In the banks of the deep ravines on the south side of Neosho valley in the NW. ¼ of sec. 9, about 2½ miles west and one-fourth mile south of Americus, the Americus limestone and the shale below are much better exposed. Here are also located the old quarries from which the building stone has been taken and this is exactly the area as designated by Kirk. The type section of the Americus and underlying beds ~~xxx~~ was ~~xxxx~~ taken in the ravines about in the middle of the NW. ¼ of sec. 9 by M. K. Elias in 1933, see page ____ of this report. Bed No. 14 of this section corresponds in its lithologic characteristics and thickness to the lower limestone of the Americus "system" of Kirk, which was described by the latter as "light buff stone ....about

16 inches thick, very solid and compact" and producing "splendid dimension stone".[18]

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[18] Kirk, 1896, pp. 80-81.

It is of some importance to note that due to the steep gradient of Neosho river, coupled with unusually steep dip of the Paleozoic beds in the area of the type locality of the Americus (about 32 feet per mile in a northwest direction), the outcrop of this limestone directly west of Americus is about 40 feet above the water level of Neosho river, while 1 mile to the southeast it raises to 70 feet, ~~and~~ the Five Point limestone below raises to an elevation 27 feet above the Neosho river water level, ~~or~~ and here ~~the latter~~ appears at about the level of the Americus at its type locality, which is only 1 mile away.

Roca shale formation

(Named by Condra, 1927)

1902, Elmdale formation (part). See under Hughes Creek shale.

* 1927, Roca shale, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, p. 86.

Type locality, Roca, Lancaster county, Nebraska.

The "complete exposure of Roca" at the type locality at Roca and along Warner creek has been taken by Condra "near the center of section 8, south of Warner creek". This complete section of Roca shale is shown here in graphic form on Pl. I, section 23. On section 23a is shown the later and more accurate measurement of Grenola formation taken at about the same locality. From comparison of these two sections, it is quite clear that the Roca, as originally defined by Condra, includes the Legion shale and the Sallyards limestone, which he and Busby name now and propose to include as members of the Grenola formations. At the same time, however, they fail to redefine the Roca shale.

22 Condra, 1927, p. 181.

23 Condra and Busby, 1933, pp. 12-13.

Insert (B) for p. 61 (B)

(restricted), G.E. Condra, G.E. and Busby, C.E., The Gressola formation, Nebr. Geol. Survey, paper No. 1, p. 7.

Does not include Legion Shale and Sallyards Limestone which are considered part of the overlying Gressola formation.

1935, Condra, G.E., Geologic cross-section, Forest City, Missouri to Du Bois, Nebraska, Nebr. Geol. Survey, Paper No. 8, p. 8. Same.

From the standpoint of uniform application of rules of nomenclature throughout the local Pennsylvanian-Permian section, we ~~suggest that~~ it is proposed To accept the Roca shale ~~be accepted~~ in its original meaning, ~~which includes~~ including in it the Sallyards limestone and Legion shale, leaving in the Grenola formation the Burr limestone, Salem Point shale, and Neva limestone. For detailed arguments in favor of this suggestion see pp. in the chapter on the Grenola formation.

In accordance with the suggested acceptance of the Roca shale in its original sense, the Sallyards and the Legion may be considered members or beds of the Roca formation, ~~We suggest that the Sallyards limestone be considered a bed within the Roca formation;~~ the shale below ~~it may~~ the Sallyards limestone To be designated as lower Roca shale and the shale above it as upper Roca shale, ~~the latter~~ corresponding to the Leginn shale of Condra and Busby.

The lower ~~part of the~~ Roca shale is composed of green shale mainly unfossiliferous accompanied by ~~with the addition of some~~ minor amounts of red shale. Above the Sallyards limestone ~~bed~~ the shale is bluish-gray. ~~While the lower Roca shale is unfossiliferous,~~ the Sallyards usually contains pelecypods ~~occasionally~~ in place accompanied by brachiopods. The upper Roca shale is bluish gray and also contains Brachiopods ~~with addition of a few~~ and pelecypods. ~~are common in the upper Roca.~~

Insert (C) (C) for p. 64

* 1934. Moore, R.C., Elias, M.K., and Newell, N.D., Pennsylvanian and "Permian" rocks of Kansas, chart published by the State Geol. Survey of Kansas. Does not include Legion shale and Sallyards limestone which remain in Roca shale as originally defined.

(3)

Grenola limestone formation (redefined)

G.E. C.E.

(Named by Condra and Busby, 1933)

1933, Grenola formation, Condra, G. E., and Busby, C. E., Neb. Geol. Survey, paper No. 1. — 1935, Condra, G.E., Geologic Cross-section, Forest City, Missouri, to Sutton, Nebraska, Nebr. Geol. Survey, Paper No. 8. Same.

Type locality, Grenola, Elk county, Kansas.

Precisely the type locality, at which the described section was taken, is in the ravines and creeks north and south of Highway No. 160 west of Grenola, distance 4 to 5 miles from town.[24]

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[24] Condra and Busby, 1933, p. 9. The writers donsider it somewhat confusing for future identifications and correlations to regard as a "cotype locality" the outcrops of this formation at the American Legion Golf Club southwest of Manhattan, as suggested by Condra and Busby. Although this section, as well as any other well correlated outcrops, may be of considerable help in the study of fossiliferous zones of the formation, it appears best not to regard it as a "cotype" or supplementary type locality because of its great distance (125 miles) from the type locality of the Grenola at Grenola.

The Grenola is defined as a formation "composed of the limestone and shales between the Roca and Eskridge shales".[25] "The top of the Grenola formation is marked by the Eskridge....which is below the well-known Cottonwood limestone and has a thickness of 23 to 40 feet or more. The base...is marked by the Roca shale formation, which, in the north, consists of olive-colored shale, some mudstone and one or two subzones of red shale. The red shale thickens markedly in southern Kansas and northern Oklahoma, leaving thin zones of gray shale above and below. The Grenola, therefore, is well set off by the red shales in the Eskridge and Roca..."[26] To this is added that it is highly fossiliferous in contrast with the Eskridge, which has few fossils, and the Roca, which "is practically nonfossiliferous". With the acceptance of the Roca in its original sense, as suggested in this paper, the last remark will no longer hold.

[25] Idem., p. 8.

[26] Idem, pp. 7-8.

Comparison of the type section of the Roca shale, as originally described by Condra,[27] with the description of the Grenola formation from near Roca, as given now by Condra and Busby,[28] indicates clearly that the Sallyards limestone and the

[27] Condra, 1927, p. 181.

[28] Condra and Busby, 1933, pp. 12-13.

Legion shale were originally included in the Roca shale at its type locality.

It appears that the chief reason for the inclusion by Condra and Busby of these two units in the new Grenola formation is the fossiliferous character of the Sallyards and the Legion, which makes them a part of a "complete cycle" which is believed to be formed by the members of the Grenola formation.[29] The writer[s]

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[29] Idem, p. 24.

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quite agree that the members of the Grenola belong to a single (though complex) marine cycle, but they do not consider that the cycle is complete within the Grenola beds alone. As is discussed in the chapter on the cycles of the Big Blue and demonstrated through the cyclic analysis in the geologic sections, the complete cycle of the Big Blue begins and ends with red shales, and though the limestone beds, generally speaking, represent the deepest marine facies of the cycle of sedimentation, the gray and green partly calcareous shales which flank the limestones from above and ~~from~~ below also represent marine sediments, although deposited at lesser depths. These shales are sparingly fossiliferous, containing usually pelecypods and corneous brachiopods, and only the red shales are entirely unfossiliferous.

Although the cyclic analysis is now accepted by the Kansas Geological Survey as an important controlling factor in the revision of classification of the Mid-Continent Late Paleozoic formations, the limitations of the intermittent

limestone and shale formations is still considered best to be based on lithologic grounds, the limestone formations comprising the thick and solid limestone beds with minor interstratified shales, and the shale formations being composed of thick shales with the occasional presence of minor limestone and mudstone beds. The principle of division of the series into limestone and shale formations was consciously or unconsciously always applied by geologists engaged in field work in eastern Kansas, as this is the only practical classification for mapping of these beds. The cyclic analysis, as now developed, permits control of the uniformity of application of established rules of grouping of the selected thick limestone beds into limestone formations and selected shale beds into shale formations throughout the series.

In the particular problem of whether the Sallyards limestone bed and the Legion shale bed should be added to the Grenola limestone formation above or to the Roca shale formation below, the decision must conform with similar cases in the other cycles of the series. Observations by J. M. Jewett and ~~the writer~~ A. K. Elias in the Big Blue established the presence of very fossiliferous calcareous zones with some minor limestone and mudstone beds in the uppermost parts of the shale formations below the Wreford, Barneston, Winfield and other limestone formations of the series. In all these zones the predominant fossils are pelecypods with

appreciable addition of some particular brachiopods: Derbya, Juresania, and others; thus the fossils of these zones are essentially the same as the fossils of the Sallyards and ~~the~~ the Upper Rock Legion. If the latter two are added to the limestone formation (the Grenola), then the fossiliferous zones beneath the generally accepted basal limits of the Wreford, the Barneston and others should be also removed from the shale formations and added to the respective overlying limestone formations (the Wreford, the Barneston and others). A suggestion to this effect was actually made by J. M. Jewett (oral communication to R. C. Moore) prior to the appearance in press of the "Grenola formation" paper. The writers ~~and Moore~~ consider that such delimitation of these limestone formations is not desirable ~~from~~ for the following reasons:

(1) The addition of the underlying fossiliferous, but essentially shaly, zones to the limestone formations does not constitute any improvement from the standpoint of cyclic classification, because neither with nor without these fossiliferous zones do the limestone formations represent any complete marine cycle (as was erroneously supposed by Condra and Busby).

(2) With the failure of gaining anything in the direction of a scientifically better classification, there seems to be left no other advantage that would warrant the addition of the calcareous but essentially shaly zone to the overlying

limestone formations. The practice of the mapping of the limestone formations in the field shows that by far the best (which means the commonly exposed and easiest to identify) boundary for differentiation between the limestone and shale formations (as well as between limestone and shale members) is the change from the thick, hard and solid limestone beds to the predominantly shale beds with only a few thin limestones. The thinner and less resistant to erosion limestones and mudstones of the type to which the Sallyards limestone belongs are comparatively rarely exposed and certainly never build any benches or sub-benches along the slopes, while the overlying solid limestones often form continuous "rim rock" on the slope or at the crest of hills.

(3) The problem in question may be considered from a third standpoint, and this is the relation of the surficial and underground classification. When we compare the boundaries of the interbedded limestone and shale (mostly "red shale") formations, as accepted on detailed correlation charts like that by B. Kellett,[30] we conclude that the shale formations in the underground correlations are much thinner than the corresponding shale members of the surface and in most cases in the Big Blue series are limited to the red shale zones of the surficial outcrops. Thus it appears that even slightly calcareous shales of the surficial

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[30] Appended to the Guide Book, 6th Ann. Field Conf., Kansas Geol. Soc., 1932.

(4)

Grenola limestone - Neva limestone member (redefined)

(Named by C. S. Prosser, 1902)

1866, Beds Nos. 82-84 ("Cotton rock" and "Drybone limestone"), Swallow, G. C., Prel. Rept., Kan. Geol. Survey, p. 16.

1894, System No. 12, Haworth, E., and Kirk, M. Z., Kan. Univ. Quart., vol. 2, p. 113 and pl. 4, fig. 3.

1896, Dunlap limestone, Kirk, M. Z., Kan. Univ. Geol. Survey, vol. 1, pp. 81, 83. The name Dunlap is applied to "system No. 12" of the preceding papar, which is much too briefly described as two limestone beds separated by about 20 feet of shale. Probably the Dunlap of Kirk corresponds to the Neva limestone in the broad sense as accepted by Condra and Busby (1933) and followed in this paper.

1902, Neva limestone, Prosser, C. S., Jour. Geol., vol. 10, p. 709. Two limestones about 4 feet each separated by about 2 feet of shale, occurring below Elmdale and Eskridge shales. ---- 1902, Beede, J. W., Kan. Univ. Scil Bull., vol. 1, p. 180. The name Neva limestone is proposed by Prosser and Beede, who worked in close cooperation, for "a massive bluish-gray limestone" consisting "of a lower and upper massive limestone,

each one a little over 4 feet in thickness, separated by 2 feet of shales, with a total thickness about 10 feet." Prosser identified the Neva with beds Nos. 82-84 of Swallow's section (1866, Prel. Rept., Kan. Geol. Survey, p. 16) and also considered that the Neva "represents the upper stratum of Haworth and Kirk's 'limestone system No. 12' (1899, Kan. Univ. Quart., vol. 2, p. 112), to which 'system' Kirk later applied the name 'Dunlap limestone'" (1896, Kan. Univ. Geol. Survey, vol. 1, pp. 81, 83). ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 54. Adams uses the Neva in the sense as introduced by Prosser and Beede. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 2 and 6. The Neva is used in the original sense and is applied to two limestone beds about 4 feet thick each, separated by a 2 foot bed of shale. A brief description of the Neva at the type locality is given and a measured section of this limestone and some beds above is given for the locality east of Strong City. This locality was re-measured by M. K. Elias and is considered as a supplementary type locality for the Neva. ---- 1908, Haworth, E., and

Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 115. ---- 1914, Beede, J. W., Okla. Geol. Survey, Bull. 21. For the first time in the literature the Neva is applied to a larger thickness of beds (though still within the Neva as now accepted) than originally defined for the limestone in central Kansas. At Hooser, Cowley county, Kansas, the Neva is considered to be 20 feet thick and at Grainola, Osage county, Oklahoma, it "has thickened to 25 feet or more". The Neva in these localities contains a considerable amount of chert. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 107. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 49. ---- 1925, Beede, J. W., and Kniker, H. T., Texas Univ., Bull. 2432, pp. 30-32. Schwagerina kansasensis from the Neva at Hooser, Kansas, is described. ---- 1927, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, pp 87. The Neva is used in the original sense. It is recognized in southern Nebraska as a member with a thickness varying "from 6 to 11 feet or more". At Douglas, Nebraska, the member is composed "of two comparatively heavy limestones separated by a thin shale", with a total thickness of 6 feet

8 inches. ---- 1927, Moore, R. C., and Landes, K. K., Kan. Geol. Survey, Bull. 13, fig. 8 on p. 16. The Neva is used in the original sense, as two beds of limestone separated by a thin bed of shale. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 55. The Neva is used in the sense as recognized for southern Kansas and northern Oklahoma by Beede in 1914, with a total thickness "of 22 feet, in the northeastern part of Cowley county, and 28 feet in the southeastern part". ---- 1932, Guidebook, Sixth Ann. Field Conf., Kan. Geol. Soc. Section by R. C. Moore on p. 17. The Neva in T. 26 S., Greenwood county, Kansas, is applied to two limestones (3 and 3.5 feet thick) separated by 11 feet of calcareous and sandy shale, the total thickness of the Neva being 17.5 feet. Note: Condra and Busby recognize 17 feet thick Neva limestone at Sallyards, Greenwood county. Section by Neb. Geol. Survey on p. 73. About 26 feet of limestones and shales are recognized as "Neva limestone" in T. 2 N., Richardson county, Nebraska, but this section is now interpreted by Condra and Busby as Neva limestone in part only (the upper 17 feet), while the lower beds of the section

are feferred to the Salem Point shale (7 feet) and upper part of the Burr limestone (3.6 feet thick; the total Burr is 10 feet thick). Compare Condra and Busby, 1933, p. 14. ---- 1933, Condra, G. E., and Busby, C. E., Neb. Geol. Survey, Paper No. 1. The Neva is applied to 17 feet of interbedded limestones and shales outcropping in the vicinities of Neva and Elmdale, Chase county, Kansas, where the Neva was originally described as about 11½ feet thick limestone with a 2 to 3 foot shale interval in the middle. The Neva is made the upper member of the Grenola formation, the latter consisting of Neva limestone, Salem Point shale, Burr limestone, Legion shale and Sallyards limestone, and ranging from 30 to 47 feet thick. The Neva is considered to be "about 20 feet thick", but at Burbank, Osage county, Oklahoma, the thickness is given as 26½ feet. (Beede gives 25 feet for the Neva at Grainola, Osage county, Oklahoma.)

insert (A)

1903, Not Neva limestone, Crevecoeur, F. F., Kan. Acad. Sci., Trans., vol. 18, p. 124. This limestone which, according to the writer's observations in the field, corresponds to the Dover of the present classification of the Kansas Geological Survey, was erroneously identified as the Neva. This in turn resulted in erroneous referance of the Onaga flora to the Elmdale formation, as misidentified by Crevecoeur and quoted by D. White (U. S. Geol. Survey, Bull. 211, pp. 87, 115 and elsewhere in this paper).

Type locality, at Neva, Chase county, Kansas.

The Neva is named "from Neva, a station on the Atchison, Topeka and Santa Fe Railroad between Strong and Elmdale", Chase county, Kansas. The name was proposed by Prosser and Beede in 1902[31] for a "massive bluish-gray limestone" consisting "of a lower and upper massive limestone, each one a little over 4 feet in thickness, separated by 2 feet of shales, with a total thickness about 10 feet". Prosser identified the Neva with beds No. 82-84 of Swallow's section,[32] and also considered that his Neva limestone

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[31] Prosser, 1902, p. 709; Beede, 1902, p. 180.

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[32] Swallow, 1866, p. 16.

"represents the upper stratum of Haworth and Kirk's 'limestone system No. 12'[33], to which 'system' Kirk later applied the name 'Dunlap limestone'"[34]. For the type locality of Neva, Prosser indicated the exposure at an "anticlinal fold to the northeast of Neva, a station on the A. T. and S. F. R. R.", but in his description of the limestone he gives a section measured between Strong and Elmore about 5 miles east of the above mentioned "anticlinal fold".

[33] Haworth and Kirk, 1894, p. 112.

[34] Kirk, 1896, p. 81.

Personal examination by ~~the writer~~ M. K. Elias of Prosser's two localities did not leave any doubt that the same limestone is exposed in the two, and that the eastern exposure permits measurements of a much more complete section of the Neva; thus it should be considered the true type locality of this limestone or at least its supplementary type locality. The section measured by the writer is given on p. ____.

The name Neva became widely accepted in the scientific literature, while Kirk's name Dunlap was not used. On the other hand, the original narrow meaning of Neva was lost and recently it has become a practice to call Neva a much larger system of limestones interbedded with shale, that about corresponds to the Dunlap of Kirk. Strictly speaking, therefore, the name Dunlap, which was proposed earlier than Neva and originally embraced the formation which we now call Neva, should be revived and used instead of Neva. To do so was the intention

of Condra, as revealed by him, but upon communication with the U. S. Geological Survey he was advised "that the name Neva should be continued because it had gained general recognition". Thus, he retained the name Neva and did not re-instate the name Dunlap, but the Neva is applied by Condra and Busby not in the strict original sense, but in the sense as later applied by Beede (1914) to southern Kansas and Oklahoma outcrops, which expands the application of the name to include some limestone beds directly above the original Neva (compare sections 1, 2, 3a, and 4 on Correlation Table I). At one time the writers deemed it advisable to restrict the name Neva to its strict original sense and use it only for the two prominent limestone beds for which it was originally intended by Prosser and Beede. This, however, would not be practical, as the correlation of the Neva outcrops in Kansas and Nebraska shows (see Pl. ____) that different beds of the Neva or Dunlap formation become hardest and most prominent in different parts of these states. ~~(This variability in the prominence of the beds that constitute the thick [illegible] the 30 feet of Neva renders some difficulties in using it for structural mapping).~~ Thus, the redefinition of the Neva limestone member, as proposed by Condra and Busby, is here accepted.

[35] Condra and Busby, 1933, p. 8.

~~Definition and description. In the present use of the name Neva this is an essentially limestone formation 20 to 30 feet below the well-known and~~

(3)

(4) Beattie limestone - Cottonwood limestone member

C. S.
(Named by/Prosser, 1895)

1866, Fusulina limestone (No. 80), Swallow, G. C., Prel. Rept./Kan. Geol. Survey, p. 16.

1895, Cottonwood limestone, Prosser, C. S., Geol. Soc. America, Bull., vol. 6, pp. 40, 44. ---- 1895, Prosser, C. S., Jour. Geol., vol. 3, p. 698. ---- 1897, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 151-155, 161, 164-165, 168, 175. ---- 1897, Prosser, C. S., Jour. Geol., vol. 5, pp. 5-10. ---- 1898, Beede, J. W., Kan. Univ. Quart., vol. 7, pp. 231-233. ---- 1899, Keyes, C. R., Am. Geol., vol. 23, pp. 310-311. ---- 1900, Keyes, C. R., Iowa Acad. Sci., Proc., vol. 7, p. 95. ---- 1902, Beede, J. W., Kan. Univ. Sci. Bull., vol. 1 (9), p. 181. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 55. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 2 and 6. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geologist, vol. 36, pp. 83-111. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 115. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 111.

Classes as member of the Council Grove formation. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 55. Same. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 59. ---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 15.

Insert (A)

1895, Cottonwood formation (part), Prosser, C. S., Jour. Geol., vol. 3, pp. 697, 800. Includes Cottonwood limestone and overlying +Cottonwood shales (now called Florena shale). ---- 1895, Prosser, C. S., Geol. Soc. America, Bull., vol. 6, p. 40. Same. ---- 1896, Haworth, E., Kan. Univ. Geol. Survey, vol. 1, p. 165. ---- 1897, Prosser, C. S., Jour. Geol., vol. 5, pp. 5-10. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 193. ---- 1903, Smith, A. J., Kan. Acad. Sci., Trans., vol. 18, p. 102.

1895, Not Cottonwood shale, Prosser, C. S., Jour. Geol., vol. 3, pp. 700-702, 800 and later authors. See under Florena shale.

1896, +Cottonwood Falls limestone, Haworth, E., Kan. Univ. Geol. Survey, vol. 1, p. 164. ---- 1896, Hall, J. G., Kan. Univ. Geol. Survey, vol. 1, pp. 105-106. ---- 1896, Knerr, E. B., Kan. Univ. Geol. Survey, vol. 1, p. 143. ---- 1900, Beede,

(4)

Beattie limestone - Florena shale member

(Named by C.S. Prosser and J. W. Beede, 1904)

1895, Cottonwood shale, Prosser, C. S., Jour. Geol., vol. 3, pp. 700-702, 800. ---- 1895, Prosser, C. S., Geol. Soc. Am., Bull., vol. 6, p. 39. ---- 1896, Haworth, E., Kan. Univ. Geol. Survey, vol. 1, pp. 164-165. ---- 1897, Prosser, C. S., Jour. Geol., vol. 5, p. 7. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 194.

1895, Cottonwood formation (part). See under Cottonwood limestone.

1902, Garrison formation (part), Prosser, C. S., Jour. Geol., vol. 10, p. 712. Includes beds between top of Alma (Cottonwood) limestone and base of Wreford limestone. Contains Florena shale member (= "Cottonwood shale") at base and Neosho shale member above. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 56. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 2, 3 and 6. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geol., vol. 36, p. 83. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 117. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3,

p. 111. Garrison limestone and shale are member of Council Grove formation. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 55. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 62.

1904, Florena shale, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, p. 3. Name applied for shale formerly called Cottonwood shale, from 2 to 13 feet thick, very fossiliferous. Classed as lower member of Garrison formation. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geol., vol. 36, p. 91. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 111. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 55. ---- 1927, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, pp. 230, 233-235, 237. ----- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 17.

insert (A)

Type locality, Florena, Marshall county, Kansas.

✓ (4)

Beattie limestone - Morrill limestone member

(Named by G. E. Condra, 1927)

1895, Neosho formation (part), Prosser, C. S., Jour. Geol., vol. 3, pp. 764-771. ---- 1896, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 152-157, 164. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 195. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 713. Classes the Neosho as member of Garrison formation; includes the beds below top of Florena shale to base of Wreford limestone. ---- 1903, Smith, A. J., Kan. Acad. Sci., Trans., vol. 18, p. 102 (not Neosho limestone, p. 99). ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 2, 3 and 6. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geol., vol. 36, pp. 83-111.

1896, Neosho shales (part), Cragin, F. W., Colol Coll. Studies, vol. 6, pp. 3, 7.

1902, Garrison formation (part). See under Florena shale.

1927, Morrill limestone, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, pp. 233, 234. ---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 17.

insert (A)

Type locality, near Morrill, Brown county, Kansas

the surficial outcrop the overlying Easly shale is as thick and persistent shale as the Stearns, but in addition it contains an important bed of gypsum and is a very persistent red shale in the well cuttings to the west.

The Hooser shale of the Bader formation is thinner than either the Stearns or the Easly shales. In the surficial outcrops in Kansas and Nebraska some beds of indurated fossiliferous shale, mudstone and limestone are developed near the middle of the Hooser so that in most exposures the Bader formation appears as a system of thin limestone beds interbedded with numerous and mostly calcareous shale, the whole group somewhat resembling the Neva limestone formation (in the present broad understanding of the Neva). In the well cuttings the Bader is usually recognized as a single limestone unit between the Easly shale above and the Stearns shale below. The thickness of the Bader is about 20 to 24 feet.

The Bader formation is sparingly fossiliferous, containing calcareous brachiopods, bryozoans, pelecypods and gastropods. It consists of the following members, named in upward order: Eiss limestone, Hooser shale, and Middleburg limestone.

Bader limestone - Hooser shale member

(Named by G. E. Condra and J. E. Upp, 1931)

1895, Neosho formation (part). See under Morrill limestone.

1902, Garrison formation (part). See under Florena shale.

1927, Lower part "C" of the Easly Creek shale, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, p. 233.

1931, Hooser shale, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 20.

Type locality, Hooser, Cowley county, Kansas.

The Hooser shale was named by Condra and Upp after Hooser, Cowley county, Kansas, the type locality being "Highway cut and ravine just east of Hooser". An explanation follows: "This is the lower unit of the Easly Creek shale as defined by Condra in 1927 when the Easly Creek was erected to include the section between the Eiss limestone and the 'Sabetha' (Crouse) limestone. It is now recognized that this part of the general section represents three members, for which the names Hooser shale and Middleburg limestone are applied to the lower and middle ones and the name

Bigelow limestone formation

(Defined ~~Named by M. K. Elias~~ in this report)

1895, Neosho formation (part). See under Morrill limestone.

1902, Garrison formation (part). See under Florena shale.

Named after Bigelow, Marshall county, Kansas. ~~Type locality, Blue Rapids, Marshall county, Kansas.~~

Type locality, 1 mile north of Blue Rapids, Marshall county, or 8 miles west, 4½ miles north of Bigelow.

The Bigelow formation is composed of the Crouse limestone, the Blue Rapids shale, and the Funston limestone. The formation thus defined comprises all limestones between the important Speiser shale above and the Easly shale below. The Blue Rapids shale contains only a few narrow red bands at the outcrop and is not recognized in well cuttings to the west, where the Crouse and the Funston make a single limestone unit.

Calcareous brachiopods and mollusks are sparingly distributed in the Bigelow formation. The thickness of the formation varies from 34 to 50 feet.

(4)

Bigelow limestone - Crouse limestone formation member

K.C.

(Named by Heald, 1916)

1895, Beds Nos. 12 and 13, Prosser, C. S., Jour. Geol., vol. 3, p. 765.

1895, Neosho formation (part). See under Morrill limestone.

1902, Garrison formation (part). See under Florena shale.

1916, Crouse limestone, Heald, K. C., U. S. Geol. Survey, Bull. 641-B, p. 22. The name is introduced for the upper bed of the Crouse in its present meaning. ---- 1927, Clark, G. C., and Cooper, G. L., Okla. Geol. Survey, Bull. 40 H, pp. 71-74. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 66. The name is used in a broader sense than originally proposed by Heald and includes shale and limestone beds from below.

1927, Sabetha limestone, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, p. 232. The name is applied to a set of beds, the uppermost of which corresponds to the Crouse of Heald.

1931, Crouse limestone (redefined), Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 21. The application of the name in the broader sense as used by Bass is accepted and the Crouse is accordingly redefined and substituted for the Sabetha limestone.

insert (A)

(3)

Wreford limestone formation

(Named by Robert Hay, 1893).

1859, Bed No. 18, Meek, F. B., and Hayden, F. V., Acad. Nat. Sci., Philadelphia, Proc., vol. 9, p. 17.

1866, Beds Nos. 58 to 62, including 4th and 5th cherty limestones, Swallow, G. C., Prel. Rept. Kan. Geol. Survey, p. 14.

1891, Wreford limestone, (Bed No. 5) Hay, Robert, Kan. State Bd. Agric., 7th Bien. Rept., pt. 2, p. 94. Called this Walford limestone (typographical error). ---- 1893, Hay, Robert, Kan. State Bd. Agric., 8th Bien. Rept., pt. 2, p. 104. ---- 1896 (Lower Flint beds), Hay, Robert, U. S. Geol. Survey, Bull. 137, p. 17. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 713. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 56. ---- 1904, Kirk, C. T., Okla. Dept. Geol. and Nat. Hist., 3d Bien. Rept., p. . ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 3 and 6. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geol., vol. 36, p. 83. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 117. ----

1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 112. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 58. ---- 1927, Condra, G. E., Neb. Geol. Survey, (2), Bull. 1, p. 232. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 70. ---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 31.

1895, Strong flint, Prosser, C. S., Jour. Geol., vol. 3, pp. 772, 773, 799. Beds Nos. 1 to 4 only are included in the Wreford as accepted in this report. ---- 1897, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 153-155, 165. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 198.

1895, First flint bed above the Manhattan stone, Prosser, C. S., Geol. Soc. Am., Bull., vol. 6, p. 47.

1897, Strong limestone, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 153, 161, 163, 165, 167, 168, 170.

Type locality, Wreford, Geary county, Kansas.

The Wreford limestone formation was named by Robert Hay after Wreford, Geary county, Kansas. The type locality is the old quarries at Wreford (T. 12 S., R. 5 E.) where "it is now poorly

Insert D for p. 120 (D)

1935, Condra, G. E., Geologic cross-section, Forest City, Missouri to Du Bois, Nebraska; Nebr. Geol. Survey, Paper No. 8, p. 6.

1939, Threemile Limestone [46], Moore, R. C., Elias, M. K. and Newell, N. D., Pennsylvanian and "Permian" rocks of Kansas; chart published by the State Geol. Survey of Kansas.

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[46] see footnote on (D')

since its original publication

46 For some time the name Fourmile was considered by Mrs. Wilmarth ~~inapp~~ inappropriate for use because the name Fourmile Creek is preoccupied for another geologic formation. On account of this the name Fourmile has been changed to Threemile ~~limestone~~ (after Threemile Creek in vicinities of Fort Riley in Kansas) ~~and~~ and appeared in the ~~quoted~~ publication: ~~1934. Moore, R.C., Elias, M.K. and Newell, N.D., Pennsylvanian and Permian rocks of Kansas, Chart published by the State Geological Survey of Kansas, 1936.~~

Now, however, ~~the~~ following the final reconsideration by Mrs. Wilmarth the name Fourmile limestone formation ~~is~~ restored and the Threemile limestone formation becomes its synonym.

(3)

Wymore shale formation

G.E. J.E.

(Named by Condra and Upp, 1931)

1859, Bed No. 17, Meek, F. B., and Hayden, F. V., Acad. Nat. Sci. Philadelphia, Proc., vol. 9, p. 17.

1902, Matfield shales (part), Prosser, C. S., Jour. Geol., vol. 10, p. 714, applied to shale between Wreford limestone and Florence flint. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 57. ----1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 3 and 6. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 118. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 112. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 60. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 73. [illegible]

1905, Matfield formation (part), Beede, J. W., and Sellards, E. H., Am. Geol., vol. 36, pp. 83-111.

1931, Wymore shale, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 37.

insert E

Type locality, Wymore, Gage county, Nebraska.

(4) Barneston limestone - Florence limestone member (Redefined).

(Named by C. S. Prosser, 1895)

1858, Bed No. 14 of Kansas river valley section, Meek, F. B., and Hayden, F. V., Acad. Nat. Sci. Philadelphia, Proc., vol. 9, p. 17.

1866, Bed No. 54 or "third cherty limestone", Swallow, G. C., Prel. Rept. Kan. Geol. Survey, p. 14.

1891, No. 9 of Fort Riley Mil. Res. section, Hay, Robert, 7th Bien. Rept., Kan. State Bd. Agric., vol. 12, pt. 1, p. 94. ---- 1893, Hay, Robert, 8th Bien. Rept., Kan. State Bd. Agric., vol. 13, pt. 2, p. 104.

1895, Second flint bed, Prosser, C. S., Geol. Soc. Am., Bull., vol. 6, p. 48.

1895, Florence flint, Prosser, C. S., Jour. Geol., vol. 3, p. 772, also 773 and 798. ---- 1896, Haworth, E., Kan. Univ. Geol. Survey, vol. 1, pp. 187, 189. ---- 1897, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 157. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 199. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 719. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 58. ---- 1904, Prosser, C. S.,

and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 4 and 6. ---- 1905, Beede, J. W., and Sellards, E. H., Am. Geologist, vol. 36, pp. 83-111. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 119. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 113. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 60. ---- 1921, Fath, A. E., Kan. Geol. Survey, Bull. 7, p. 47. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 76. ---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 42.

1895, Not Florence limestone, Prosser, C. S., Jour. Geol., vol. 3, p. 773. ---- 1897, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp.158, 171.

1896, Upper flint beds (Bed No. 9), Hay, Robert, U. S. Geol. Survey, Bull. 137, p. 17.

1934. Florence limestone member (as here redefined) — insert (F)

(4)

Barneston limestone - Oketo shale member

(Named ~~by M. K. Elias~~ in this report)

1859, Bed No. 13, Meek, F. B., and Hayden, F. V., Acad. Nat. Sci. Philadelphia, Proc., vol. 9, p. 17.

1866, Bed No. 55 and upper part of No. 54, Swallow, G. C., Prel. Rept., Kan. Geol. Survey, p. 14.

1891, Bed No. 10, Hay, Robert, 7th Bien. Rept., Kan. St. Bd. Agric., vol. 12, pt. 1, p. 94. ---- 1893, Hay, Robert, 8th Bien. Rept., Kan. St. Bd. Agric., vol. 13, pt. 2, p. 104. ---- 1896, Hay, Robert, U. S. Geoll Survey, Bull. 137, p. 17.

1895, Bed No. 15 of Morris county section, Prosser, C. S., Jour. Geol., vol. 3, p. 773.

~~Type locality, Oketo, Marshall county, Kansas.~~

1900, Beds Nos. 7, 8 and 9, Beede, J. W., Kan. Univ. Quart., vol. 9, pp. 200-201.

1934, Oketo shale member (as here defined) — insert (F

The Oketo shale is named after Oketo, Marshall county, Kansas, where the shale member is exposed in the bluffs of Big Blue river at the railroad depot. The section at this locality was measured by Beede,[52] whose beds Nos. 7, 8 and 9 are considered by the writers to

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[52] Beede, 1900, pp. 200-201.

(4)

Barneston limestone - Fort Riley limestone member

(Named by G.C. Swallow, 1866)

1858, Bed No. 12, Meek, F. B., and Hayden, F. V., Acad. Nat. Sci. Philadelphia, Proc., vol. 11, p. 17.

1866, Fort Riley limestone (Bed No. 52), Swallow, G. C., Prel. Rept., Kan. Geol. Survey, p. 14; Insert (E)

1891, Fort Riley main ledge (Bed No. 11), Hay, Robert, 7th Bien. Rept., Kan. St. Bd. Agric., vol. 12, pt. 1, p. 94. ---- 1893, Hay, Robert, 8th Bien. Rept., Kan. St. Bd. Agric., vol. 13, pt. 2, p. 104. ---- 1896, Hay, Robert, U. S. Geol. Survey, Bull. 137, p. 17.

1895, Florence limestone (part), Prosser, C. S., Jour. Geol., vol. 3, p. 773. ---- 1897, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 158, 171.

1895, "Fort Riley or Florence limestone" (part), Prosser, C. S., Jour. Geol., vol. 3, p. 798.

1902, Fort Riley limestone (part), Prosser, C. S., Jour. Geol., vol. 10, p. 714. Revised application of name as used by Swallow to include thinner-bedded limestones both below (down to the Florence flint = Swallow's 54) and above (up to base

(4)

Holmesville shale ~~formation~~ member

(Named by Condra and Upp, 1931)

1902, Doyle shales (part), Prosser, C. S., Jour. Geol., vol. 10, p. 715. Name applied to shale between top of Fort Riley limestone and base of Winfield formation. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 59. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 4 and 6. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 120. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 113, [illegible]. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 60. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 83.

1931, Holmesville shale, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 43.

insert E

Type locality, Holmesville, Gage county, Nebraska.

The Holmesville shale was named by Condra and Upp after Holmesville, Gage county, Nebraska, the type locality being 1½ miles west and one-half mile north of Holmesville. At the type locality

"the member is composed from the base upward of about 7 feet of gray shale, 1 foot of blocky limestone and 10 or 11 feet of gray, red and gray, argillaceous shale, the combined thickness being about 19 feet".[53] Nothing is said about the limitation of the shale at this

[53] Condra and Upp, 1931, p. 43.

locality either by the Fort Riley limestone below or by the Towanda limestone above and no description of these two limestone members from exposures in Nebraska is given at all in the report.

The writers apply the name Holmesville to the interval between the Fort Riley limestone member in a restricted sense below and the Towanda limestone formation above. The Holmesville shale thus defined consists largely of calcareous shale, mudstone and soft limestone with some soft green and red shale in the upper part. Fossils have been found only in the basal part of the formation where mostly poorly preserved pelecypods (Backewelia) and rarely Orbiculoidea have been collected.

The Holmesville shale is elevated from the rank of member to formation because it is a thick and persistent shale between the Barneston limestone formation below and the Towanda limestone formation

above. The Holmesville is recognized as distinct shale in the well cuttings for some distance to the west.

The thickness of the Holmesville varies from 20 to 35 feet. Juding from the figures as given by Condra and Upp for the thicknesses of the shale in central Kansas, the Holmesville as accepted here is perhaps precisely the same shale formation as originally understood by these authors.

(3)

Winfield limestone formation

C.S.

(Named by Prosser, 1897)

1866, Beds Nos. 40-44, from 1st to 2d chert limestones, Swallow, G. C., Prel. Rept., Kan. Geol. Survey, p. 13.

1895, "Marion flint and concretionary limestone" (not Marion formation), Prosser, C. S., Jour. Geol., vol. 3, pp. 772, also 773, 783 and 797.

1897, Winfield concretionary limestone, Prosser, C. S., Kan. Univ. Geol. Survey, vol. 2, p. 64. ---- 1901, Gould, C. N., Kan. Acad. Sci., Trans., vol. 17, pp. 179-181.

1897, Winfield limestone, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 158, 159, 171, 172, 174. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 715. About 25 feet of cherty limestone and shale, above Doyle shale and below Marion formation. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 4 and 6. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 120. ---- 1909, Beede, J. W., Kan. Acad. Sci., Proc., vol. 22, p. 250. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 113. ---- 1920, Moore, R. C., Kan. Geol.

The following discussion of the problem of classification of the Luta limestone by Condra and Upp presents somewhat similar arguments in favor of adding the Luta to the Winfield formation:

"Whether the Luta should be correlated with the Winfield or with the Marion has not been determined to the full satisfaction of all geologists concerned, nor is it agreed that the member is not a zone of the Cresswell limestone. It seems, however, that it was developed in the cycle which produced the Cresswell, in which the deposition changed from lime to lime and shale, becoming more shaly at the top as a transition to the lower zone of the Odell. Also, it appears that the faunal content is not markedly different from that of the Winfield formation."[58]

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[58] Condra and Upp, 1931, p. 58.

The Winfield is composed of limestones and calcareous shale, the limestones carrying some flint in continuous bands in the Stovall and as scattered nodules in the Cresswell. The fauna throughout the Winfield, except in the upper part of the Luta, consists essentially of calcareous brachiopods (Derbya, Composita, Dictyoclostus, Linoproductus) with almost invariable addition of strong pelecypod elements (Allorisma, Pinna, Myalina and others). Echinoid spines and "collar buttons" and crinoid joints are very common throughout the Winfield. With the exception of its base, where brachiopods are common, the Luta contains pelecypods and gastropods and also corneous brachiopods (Lingula, Orbiculoidea) near its top.

The thickness of the Winfield varies from 21 to 31 feet.

Winfield limestone - Luta limestone member

(Named by Beede, 1909)

1895, Marion formation (part), Prosser, C. S., Jour. Geol., vol. 3, pp. 786-789. ---- 1896, Prosser, C. S., Kan. Univ. Quart., vol. 6, pp. 157-158, 174. ---- 1897, Prosser, C. S., Kan. Univ. Geol. Survey, vol. 2, pp. 64-65. ---- 1900, Beede, J. W., Kan. Univ. Quart., vol. 9, p. 202. ---- 1901, Gould, C. N., Kan. Acad. Sci., Trans., vol. 17, pp. 179-184. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 716. ---- 1903, Adams, G. I., U. S. Geol. Survey, Bull. 211, p. 60. ---- 1904, Prosser, C. S., and Beede, J. W., U. S. Geol. Survey, Geol. Atlas, Folio 109, pp. 4 and 6. ---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, p. 121. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 114. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 61.

1908, Marion beds (part), Wooster, L. C., Kan. Acad. Sci., Trans., vol. 19, pp. 118-121.

1909, Marion stage (part), Beede, J. W., Kan. Acad. Sci., Trans., vol. 22, pp. 248-256.

1909, Luta limestone, Beede, J. W., Kan. Acad. Sci., Trans., vol. 22, p. 251. ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 114. Classed as a member of the Marion formation. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 62. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 93. ---- 1929, Boos, M. F., Jour. Paleontology, vol. 3, p. 241. ---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 57.

Type locality, Luta brook, near Marion, Marion county, Kansas.

The Luta limestone was named by Beede after Luta brook, which is north of Marion, Marion county, Kansas, the type locality being "crusher quarry about 5 miles northeast of Marion, on the Chicago, Rock Island and Pacific Railroad". Here the Luta is a "more or less cellular, soft, gray stone 30 feet in thickness, with siliceous and other geodes scattered through it, and layers of more or less abundant chert concretions".[57]

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[57] Beede, 1909, p. 251.

Condra and Upp apparently redefine the Luta as a much smaller limestone unit than the 30 feet thick Luta of Beede. They state that they found "the thickness of the member at its type locality not to be as great as given by Dr. Beede" and they consider that "the Luta has a thickness of 7 feet or more in central and southern Kansas, reaching a thickness of 18 feet or more at a few places."[58]

[58] Condra and Upp, 1931, p. 58.

According to these authors the contact of the Luta "with the Cresswell limestone is quite even, marked by a change from massive to earthy limestone and at places by the presence of many echinoid spines in the limestone below and their absence or near absence in the Luta. To the south, however, near Winfield and Arkansas City, the Luta becomes quite fossiliferous in its lower part."[59] This

[59] Idem, p. 57.

redefinition of Luta is accepted in this report.

The Luta is the uppermost limestone member of the Winfield. It is usually comparatively soft and flaggy limestone, occasionally fossiliferous. The fauna is mostly molluscan, but brachiopods are also present. The total absence (or rarity, in the south) of echinoid remains helps to differentiate it from the Cresswell limestone below. The thickness of the Luta varies from 2 to 25 feet.

Sumner Group

(Named by Cragin, 1896)

1896, Sumner division, Cragin, F. W., Colo. Coll. Studies, vol. 6, p. 9. Includes beds from top of Winfield limestone to top of Wellington shale.

1902, Sumner stage, Prosser, C. S., Jour. Geol., vol. 10, p. 716.

---- 1908, Haworth, E., and Bennett, J., Kan. Univ. Geol. Survey, vol. 9, opposite p. 77.

1929, Sumner group, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 93.

---- 1931, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 54.

Type locality, Sumner county, Kansas.

The Sumner group was named by Cragin from Sumner county, Kansas, which is the type locality of the group. The sumner group includes the same formations as originally defined by Cragin, from the Winfield limestone formation (but not including it) below to the great series of red beds, the Cimmaron, above.

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60 [2] Also not including Luta which is added in this report to the Winfield.

The lower part of the Sumner up to and including the Carlton limestone (new name) is composed of soft limestones to mudstones interbedded with gray, green and red shale and a few gypsum beds near the top. Next comes a part that consists exclusively of shale interbedded with thick beds of gypsum, which is capped by Banner (Elmo) limestone. This limestone is about at the horizon of the salt beds of Kansas. Judging from the deep well correlations, the thickness of the Sumner in central Kansas is about 700 to 750 feet.

Pearl shale formation (redefined)

(Named by J. W. Beede, 1909)

1909, Pearl shales (part), Beede, J. W., Kan. Acad. Sci., Trans., vol. 22, p. 255. ---- 1931, (part), Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 63. — insert (E)

Type locality, near Pearl station, Dickinson county, Kansas.

The Pearl shale was named by Beede after Pearl station on the Chicago-Rock Island Railroad, in Dickinson county, Kansas, the vicinities of Pearl being its type locality. It is proposed to restrict the name Pearl to the shale between the Herington limestone of the Nolans formation below and the Hollenberg limestone above. The Pearl is, furthermore, elevated from the rank of member to formation, because this shale invariably contains thick red beds in the outcrops and is recognized as a persistent and distinct, mostly red shale in well cuttings to the west.

In the outcrops the Pearl shale is usually made of bluish-gray to greenish shale, generally somewhat calcareous and containing thick maroon bands in its middle part. There are some gypsum

layers in the shale, which are usually leached out at the outcrops. Secondary infiltration of calcite in the form of numerous veinlets and "box-work" is infrequently observed. The thickness of the Pearl is normally about 40 feet.

Donegal limestone formation

(~~Named by M. K. Elias~~ defined in this report)

1895, Marion formation (part). See under Luta limestone.

1934, Donegal limestone formation, near Type locality, Donegal, Dickinson county, Kansas. — insert (F)

The Donegal is the uppermost limestone formation in the Big Blue that contains marine faunas. Above the Donegal a considerable thickness of shale (the Bonaccord) is developed. The Donegal limestone seems to be less consolidated in southern Kansas, where it has not been recognized as yet in surficial outcrops. The thickness of the Donegal varies from 17 to 30 feet.

The Donegal consists of the following members, named in downward order: the Strickler limestone, the Newbern shale, and the Hollenberg limestone.

Donegal limestone - Hollenberg limestone member

(Named by G. E. Condra and J. E. Upp, 1931)

1895, Marion formation (part). See under Luta limestone.

1931, Hollenberg limestone, Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 64.

Type locality, near Hollenberg, Washington county, Kansas.

The Hollenberg limestone is the lower member of the Donegal formation. This is a flaggy limestone, which is usually made of coquinoid layers. The fossils are submicroscopic and consist of foraminifera (exclusive of fusulinids), ostracodes and small gastropods.

The thickness of the Hollenberg varies from 2 to 7 feet.

Donegal limestone - Newbern shale member

(Defined ~~Named~~ in this report)

1895, Marion formation (part). See under Luta limestone.

1934, ~~Donegal limestone formation~~ insert F

Type locality, near Newbern Township, Dickinson county, Kansas.

The Newbern shale is the middle member of the Donegal formation. It consists of shale, somewhat sandy and micaceous and possibly contains some gypsum layers. It is from 13 to 28 feet thick.

Donegal limestone - ~~Carlton~~ Strickler limestone member

(~~Named by M. K. Elias~~ Defined in this report)

1895, Marion formation (part). See under Luta limestone.

1931, Unnamed "limestone 18 to 20 feet above the Hollenberg", Condra, G. E., and Upp, J. E., Neb. Geol. Survey, (2), Bull. 6, p. 63.

1934, Strickler limestone member, Merriam (F)

Type locality, ~~Carlton~~ East of Strickler (Saline county), Dickinson county, Kansas.

The Strickler limestone is the upper member of the Donegal formation. This is a slabby unfossiliferous limestone, which in northern Kansas builds a distinct bench, especially when being reinforced by deposition of secondary calcite (in Dickinson county). Ordinarily the limestone is 1 to 2 feet thick.

Wellington shale formation

(Named by F. W. Cragin, 1896)

1896, Wellington shales, Cragin, F. W., Colo. Coll. Studies, vol. 6, p. 16. Name applied to shale 250 to 450 feet thick, predominantly gray, occurring above Geuda salt measures (which includes salt beds) and below Cimarron red beds. ---- 1902, Prosser, C. S., Jour. Geol., vol. 10, p. 718. Applied to shale above Marion formation and below Cimarron red beds. ---- 1903, Adams, G. I., U. S, Geol. Survey, Bull. 211, p. 60. ---- 1905, Wooster, L. C., Kan. Acad. Sci., Trans., vol. 19, pp. 118-121, ---- 1917, Moore, R. C., and Haynes, W. P., Kan. Geol. Survey, Bull. 3, p. 115, Applied in the sense as accepted by Prosser. ---- 1920, Moore, R. C., Kan. Geol. Survey, Bull. 6, pt. 2, p. 63.

insert (E)

1901, Wellington formation, Gould, C. N., Kan. Acad. Sci., Trans., vol. 17, pp. 179-181. ---- 1929, Bass, N. W., Kan. Geol. Survey, Bull. 12, p. 99, Application extended to include beds down to top of Herington limestone in southern Kansas.

The Wellington shale is a thick formation between the uppermost marine limestone formation of the Sumner group, the Donegal, below and the red beds of the Cimmaron group above. The Wellington is composed of gray to greenish shale with a few thin red bands, some gypsum beds and the principal salt deposits of Kansas, the Geuda salt beds.

The thickness of the Wellington formation estimated in underground of central Kansas is about 700-750 feet. In northern Kansas it contains the prominent nonmarine Carlton (Elmo) limestone member, which separates the ~~Bonaccord~~ Buckeye shale member below from the upper (unnamed) part of the Wellington above.

Wellington formation - ~~Bonaccord~~ Buckeye shale member

(~~Named by M. K. Elias~~ defined in this report)

1934, Buckeye shale member, South of Buckeye and Abilene, insert F

Type locality, ~~Bonaccord~~, Dickinson county, Kansas.

The Bonaccord shale is the lower member of the Wellington formation. It is made of gray to dark-gray shale with only a few red and thin red bands. In northern Kansas it contains several thick beds of gypsum and is about 235 feet thick. In central Sedgwick county of Southern Kansas the following generalized section has been compiled by M. K. Elias from the core drills by the Continental oil company 61/. insert 117

61/ The courtesy of Clark, chief geologist of the Continental oil Co. in permission to study the logs of the core drills is gratefully acknowledged.

Composite section of the Big Blue series ~~for~~ from exposures in the southern part of Kansas

Sumner group

Wellington formation (chiefly from core drills by Continental Oil Company, central Sumner County)

Gray, green and red shale	300 feet
Carlton limestone	
Series of thin li estones interbedded with shale	18 feet
Gray shale with thin band of red and gypsum in lower part	65 feet
Geuda salt	125 feet
Gray shale with thin limestones	150 feet

Donegal limestone formation

Strickler limestone member	2.5 feet
Newbern shale member	
Green and gray shale and sandy shale	34 feet
Hollenberg limestone member	
On the surface usually secondary brownish to dirty-green crystalline rock ("Crystalline limestone" of oil geologists)	3 feet
~~Pearl shale formation~~	~~55 feet~~

Insert (A)

— 1934, Moore, R.C., Elias, M.K. and Newell, N.D., Pennsylvanian and "Permian" rocks of Kansas, chart published by the State Geol. Survey of Kansas. Same.

— 1935, Condra, G.E., Geologic cross-section, Forest City, Missouri to De Soto, Nebraska, Nebr. Geol. Survey, Paper No. 8, ~~" "~~ Same.

→ pp. 6-9 — for p. 26

pp. 8-9 — for pp 31,

p. 7 — for pp. 33, 36, 37, 38, 39 (two times);

p. 6-8 — for p. 43

p. 8 — for pp. 46, 48, 51, 54, 58, 59, 60, 72, 74, 79.

p. 7 — for pp. 84, 89, 93, 97, 101, 102, 104, 105, 108

pp. 6-7 — for p. 110

p. 6 — for pp. 111, 112, 114,

Insert (E)

(E)

1934, Moore, R.C., Elias, M.K. and Newell, N.D. Pennsylvanian and "Permian" rocks of Kansas. chart published by the State Geological Survey of Kansas. Same.

for pp: 34, 122, 123, 125, 127, 128, 137, 141, 144, 146, 152, 154, 156, 158, 160, 163, 164, 165, 167, 170, 173

Laser (F)

(F)

1937, Moore, R.C., Elias, M.K., and Newell, N.D.
Pennsylvanian and "Permian" rocks of Kansas,
Chart published by the State Geological
Survey of Kansas.

for pp. 129, 132, 162, 169, 171, 172, 175

1. Cycles in the Big Blue
2. Contents of water-paper (Circular?)
3. Rock-wool
4. Future scientific articles & personal lists (editorial