A LITHOLOGIC INVESTIGATION OF THE SCHROYER LIMESTONE IN GEARY, POTTAWATOMIE AND RILEY COUNTIES, KANSAS

by

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INTRODUCTION

Purpose of this Investigation

The purpose of this investigation of the Schroyer limestone was three fold. The first was to determine the lithologic character and distribution of the abundant chert beds. The second purpose was to develop a theory of origin for the chert beds. The third was to study the petrography and distribution of the oolitic limestone occurring in places at the top of the Schroyer limestone.

Area of Investigation

This analysis of the Schroyer limestone covers the outcrop area in Riley, Pottawatomie, and northern Geary counties, Kansas (fig. 1). The area of Riley, Pottawatomie, and Geary counties was chosen because it had a close proximity to Manhattan, Kansas, and Kansas State University. The area of study was limited to these counties by time and economics.

Structural Associations

The area of investigation is approximately the southern half of the Irving Syncline (fig. 1). The syncline is flanked on the west by the Abilene Anticline and on the east by the Nemaha Anticline. Although all three of the features are primarily pre-Pennsylvanian structures, dips of 4° can be measured on the flanks of both the Abilene and Nemaha Anticlines. The dips in the surface rocks may be the result of Permian and Post-Permian structural movements, primary dip or differential compaction.

Explanation of Fig. 1   Index map showing area of investigation and structural features.

A. Nemaha Anticline
B. Irving Syncline
C. Abilene Anticline

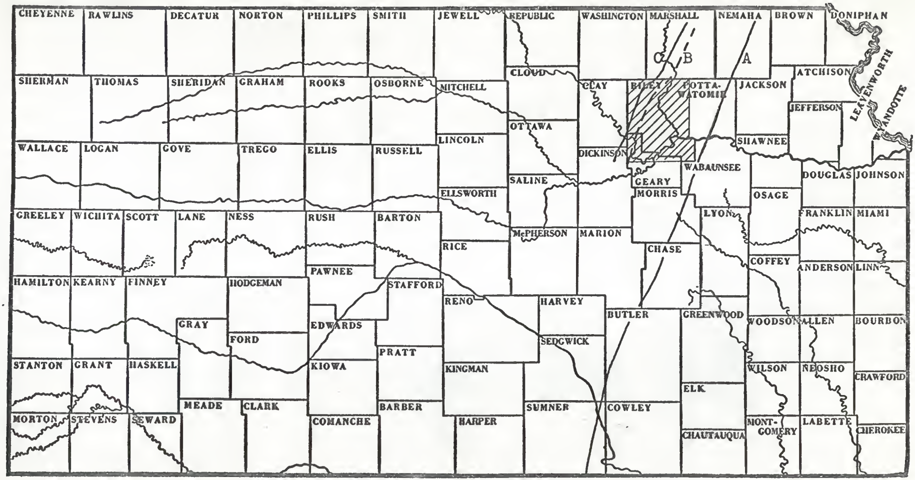


Fig. 1 Index map showing the area of this investigation.

Review of the Literature

The Schroyer limestone was first described by Meek and Hayden (1860). They described a section which occurred at Fort Riley. The Wreford formation was named by Hay (1893) from exposures near Wreford in Geary County. It remained for Condra and Upp (1931) to subdivide the Wreford formation into the Threemile (Fourmile) limestone, Havensville shale, and the Schroyer limestone. Twenhofel (1919) did the only extensive work on the origin of chert in the Wreford formation and concluded that the chert was of early diagenetic origin. Elias (1937) wrote the first paper dealing with the environment of the Lower Permian of Kansas. Jewett (1941) made the first detailed geologic map of Riley and Geary Counties. Jewett also described all rock units outcropping in Riley and Geary Counties. Mudge (1949) increased the detail of Jewett's work and also described all rocks outcropping in Riley County. Hattin (1957) did extensive work on the Wreford formation throughout its entire Kansas outcrop length. Hattin investigated the cyclic lithologic character of the Wreford formation.

Investigation Procedures

The Schroyer limestone in the area investigated crops out on hillsides, in creek banks, and in road cuts. The outcrops were measured only if a complete section was exposed. The outcrops were measured to the nearest one tenth of a foor. Care was taken to note color, fossils, staining by noncarbonate minerals and the lithology and distribution of the chert beds.

Samples were taken of the limestone and chert beds and examined by binocular microscope before they were sectioned. Selected samples were then cut and etched with dilute hydrochloric acid. The etched sections were then examined by means of a binocular microscope to determine the type and degree of silicification of fossil fragments. Thin sections were also made of selected samples to study the texture and composition of the limestone, and the contact between the chert beds and the surrounding limestone.

Samples of different chert beds were prepared and analyzed by x-ray. The chert samples were ground by mortar and pestle. These ground samples were then pass through a 270 sieve, the portion which passed through the sieve was used for analysis. The prepared sample was then mounted in aluminum slides. Mounting was done by pressing the powder into a rectangle cut in the slide. The aluminum slide was placed on a glass slide and the powder was packed in from one direction only. The object was to obtain a completely random orientation of the granules on one side of the slide.

When the slide was completed it was mounted in the x-ray. The equipment available was a Phillips X-ray Diffractometer and could start at 90° and rotate the sample to 0°, however, because minerals which would give high reflections at angles between 60° and 90° are not normally present in chert, the rotation was started from 60°. The X-ray operates on the reflection principle. X-rays are aimed at the slide. When the X-rays strike one of the planes in the crystal lattice of the substance being examined they are reflected. The reflected X-rays are received and their intensity plotted by geiger counter on a continuous graph which gives both the intensity of the reflected waves and the angle of rotation at which the reflection occurred. The wave length of the x-rays and the angle at which the reflection occurred can be used with Bragg's equation to solve for the distance in Angstroms between the planes of the lattice. Given the distance between the planes of the lattice, a search through the National Bureau of Standards tables for the same intensities of reflection and the same distance between lattice planes will reveal the names of the minerals present. Table 1 is an analysis which was obtained on a sample of chert from the basal chert bed in Section 22, Township 9 South, Range 7 East. It should be noted that the calcite reflection was less intense than the quartz. On the graph obtained from the sample, the quartz at an intensity of 100 gave a reflection twice as intense as calcite at an intensity of 100, indicating that quartz was the prevalent mineral in the sample.

Table 1. Typical values obtained with x-ray analysis of chert.

Angle	Angstroms	Intensity	Lattice Plane hkl	Mineral
20.78	4.2709	35	100	Quartz
26.57	3.3519	100	101	Quartz
29.40	3.0354	100	014	Calcite
36.00	2.4926	14	110	Calcite
36.48	2.4609	12	110	Quartz
39.60	2.2739	18	113	Calcite
		12	102	Quartz
40.22	2.2402	6	111	Quartz
42.58	2.1214	9	200	Quartz
45.70	1.9835	6	201	Quartz
47.52	1.9117	17	108	Calcite
48.50	1.8754	17	116	Calcite
50.08	1.8198	17	112	Quartz
54.83	1.6729	7	202	Quartz
55.30	1.6598	3	103	Quartz
56.58	1.6252	4	121	Calcite
57.54	1.6004	8	212	Calcite
59.92	1.5424	15	211	Quartz

General Description of the Schroyer Limestone

The Schroyer Limestone is the uppermost limestone member of the Wreford formation. The Wreford formation is in turn the basal formation of the Chase Group, which is in turn Wolfcampian. The type section is "about 1¼ miles below Schroyer" in Marshall County. (Condra and Upp, 1931, p. 32)

The general description of the Schroyer limestone as given by Jewett, (1941, p. 70), is:

> "The Schroyer limestone is mostly flinty, but contains generally a bed of non-flinty limestone, which crops out more prominently than the rest of the member. The bed containing no flint lies at or near the top and is commonly about 3 feet thick. The thickness of the member is about 18 feet."

The only discrepancy between Jewett's description and the sections measured by the author was in thickness. The maximum thickness measured in the field was 16 feet. The overall average, however, was considerably less, 10.5 feet. The variation between the thickness measured by the author and the thickness given by Jewett is attributed to disagreement as to the location of the base of the Schroyer.

The base of the Schroyer limestone used in this paper is essentially the same as the base described by Hattin, (1957). Hattin excluded from the Schroyer, thin, non-cherty beds of limestone occuring below the basal chert bearing limestone. These beds, which had previously been included in the Schroyer, were excluded on the basis of faunal differences. Field examination revealed another distinctive characteristic. The beds which were previously included in the Schroyer were discovered to be composed of extensively recrystallized Calcite, whereas the chert bearing limestone of the Schroyer are not recrystallized but are composed of fine grained Calcite. The Calcite crystals in the fine grained limestones are 2-5 microns in diameter whereas the crystals in the recrystallized limestone of the Havensville shale are 20 to 50 microns in diameter.

The Schroyer limestone is overlain by the Wymore shale member of the Matfield formation. The Wymore is a varicolored clay shale with few calcareous seams. Green shale overlays the Schroyer in the area of this investigation. The Schroyer is underlain by the Havensville shale member of the Wreford formation. The Havensville in the area of investigation

EXPLANATION OF PLATE I

Fig. 2 The upper non-cherty limestone at section II. 0 to 3.6 feet.

Fig. 3 Schroyer limestone in road cut at section III. Note chert beds from 1.8-2.1 and 3.7-4.0, and nodules at 1.2 on stadia rod.

Fig. 2

Fig. 3

varies from a gray clay shale to a buff colored argillaceous limestone with a few calcareous shale partings. The limestone lenses within the Havensville shale are usually composed of recrystallized Calcite.

LIMESTONE DISTRIBUTION

The thickness distribution of limestone is shown in Plate II. This Plate is an isopach map on the total thickness of the Schroyer limestone. During the field work it was discovered that major thickening and thinning of the Schroyer was due to thickening and thinning of the limestone portion of the unit. The shale portion of the unit does change from an observed maximum of 5.8 feet in Section 1, Township 8 South, Range 6 East, to a minimum of 1 foot in Section 18, Township 6 South, Range 7 East. It should be noted, however, that over most of the area the shale portion of the unit is consistently 2-3.5 feet in thickness. The shale increases in thickness which causes a corresponding decrease in the thickness of the limestone and does not cause major variations in the total thickness variations of the Schroyer.

In observing Plate II, three lobes and one inferred lobe of increased thickness can be seen extending to the eastward from the thickest portion of the unit. As the thickest portion of the Schroyer limestone occurs on and very near the axis of the Abilene Anticline, it is believed that this structural feature may have had some effect on the accumulation of the Schroyer limestone. The lobes which extend toward the east are more difficult to explain. These lobes are believed to represent material which was carried from the west by currents crossing a marine bank located on the axis of the Abilene Anticline. This bank is exposed in a road cut in Section 36, Township 6 South, Range 5 East. The bank consists of 7.5 feet of chalky limestone without bedding planes. The buildup of calcareous deposits on the crest of the Abilene Anticline began before Schroyer time for the entire Havensville shale at this location consists of argillaceous fine grained limestone. The bank buildup stopped at the end of Schroyer time for the Schroyer is overlain at this location by the typical green shale of the Wymore shale. For this buildup to have been initiated, it is believed that minor structural movement would have had to occurred. Uplift would have made the area more inhabitable for lime secreting organisms and made it more probably for the deposition of terriginous sediments to be overshadowed by lime deposits. Twenhofel, (1950) lists seven conditions conducive to the deposition of carbonate buildups. Two of the major ones being: bottom free of large amounts of clastics and topographic highs.

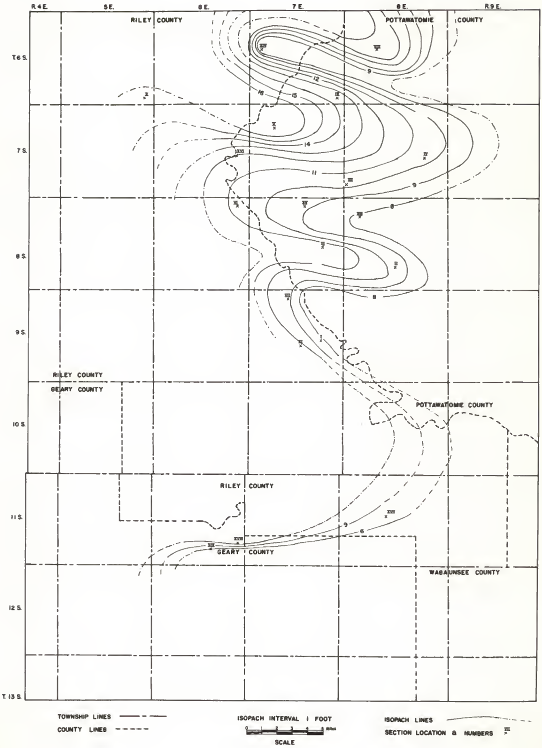
The water along the crest of the Abilene Anticline would have had to have been relatively shallow and the water to the east slightly deeper if currents were to have been effective as erosional agents on the bank. The area east of the anticline had been, at a time previous to the deposition of the Schroyer limestone, a nearly completely enclosed embayment as intermittent beds of gypsum are found in some of the underlying units and commercially profitable deposits occur in the Easly Creek shale at Blue Rapids in Marshall County. Currents across the anticline would have been vigorous if the area east of the Abilene Anticline were nearly shut off from open water to the west by the bank. The currents would carry material eroded from the bank to the eastward forming the delta like lobes to the east of the anticline. A schematic representation of this theory is shown in Plate III.

EXPLANATION OF PLATE II

Isopach map of the Schroyer limestone. Note lobate thickness variations.

PLATE II

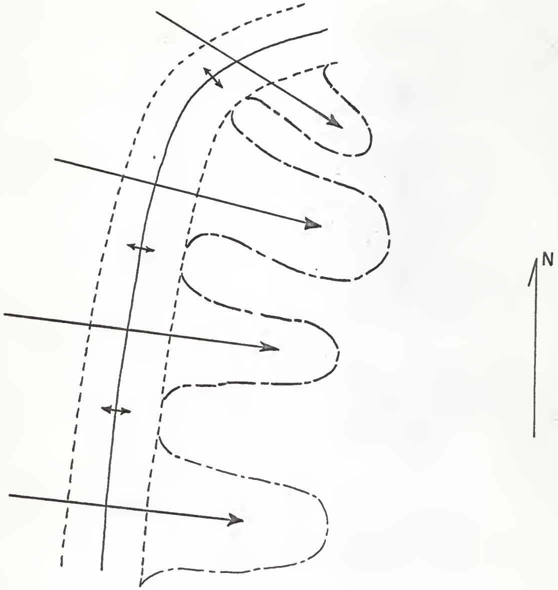
ISOPACHOUS MAP OF THE SCHROYER LIMESTONE



EXPLANATION OF PLATE III

Schematic representation of the theory for the formation of lobate thickness variations in the Schroyer limestone.

PLATE III



Limit of Bank - - - - - - -

Major Current Axes ——→

Axis of Abilene Anticline

Limit of Lobes

Known —-——-

Inferred —-—-

LIMESTONE DEPOSITION

Fine Grained Limestone

General Characteristics-The chert bearing limestone of the Schroyer consists of finely crystalline calsite particles from 2-5 microns in diameter in thin section. The limestone would be called a micrite by Folk (1959) or a calcilutite by Pettijohn (1957). The limestone is dense and becomes sublithographic locally. Vugs lined with minute calcite crystals occur randomly and are responsible for a major part of the macroporosity. The remainder of macroporosity occurs as small fractures randomly oriented. The limestone is thick bedded. The only factor causing bedding planes or a hiatus in deposition of calcite was the amount of clay and silt material being deposited. The chert bearing limestone graded into a calcareous shale at its top and base in most sections measured.

Origin of the Carbonate Material-The crystals of the fine grained limestone are 2-5 microns in diameter in thin section. Purdy (1963, p. 65), gave the crystal size for lime mud forming as the present time on the Great Bahama Bank as from 3-7 microns. As the size of the crystals in both instances are in the same range of size and as the fauna present in the limestone indicates warm shallow water, the chert bearing limestone is believed to have originated as a $CaCO_3$ mud.

An excellent review of the literature dealing with the origin of lime muds is given by Purdy (1963) and Thorp (1955). At the present time the major area of limestone deposition is i n the Carribean region, on the Great Bahama Bank. As this area contains all the components of the Schroyer limestone, except chert, extensive reading was done on the environment on the Great Bahama Bank.

The environment of deposition of lime muds on the Great Bahama

Bank is given by Purdy (1963). The water is clear and warm. Both the pH and Eh are near normal. The salinity on the bank varies slightly but never increases or decreases far from normal. The water depth varies but the maximum depth for the occurrence of $CaCO_3$ mud is 120 feet. The water is relatively calm in the areas of muddy bottom with the mud facies changing to oolite facies when the turbidity increases. This is essentially the environment in which the fine grained limestone of the Schroyer is believed to have been deposited.

The origin of the lime muds of the Great Bahama Bank cannot be fully explained. The mud is considered to form in any of the following ways: the physical disintegration of the limestone source area, the reduction of shell material by bacteria, direct precipitation from sea water, and the action of algae (Purdy, 1963). The physical disintegration of source area occurs when wavos strike a cliff or when streams erode limestone and deposit it as a clastic deposit.

The reduction of shell material by bacteria is a process which is constantly occurring. The bacteria remove the organic material in shells. The bacterial destruction of a pelecypod shell is given here as an example. The death of a pelecypod means the beginning of bacterial reduction of organic parts. Bacteria remove the part of the shell known as conchiolin which acts as a cement for the lamellar layer of the shell (Moore, 1952, p. 402), and its removal allows the lamellar layer to disintegrate into fine needle like fragments. The needle like fragments contribute to the formation of lime mud.

The direct precipitation from sea water and the action of algae are interrelated. Direct precipitation from sea water occurs when sea water becomes trapped on a shallow platform. Evaporation occurs and the water becomes over saturated with calcium bicarbonate. Add to the evaporation, the loss of CO_2 from the water by wave action and the action of algae and the precipitation of $CaCO_3$ is increased.

As the predominating process for the formation of the lime muds of the Great Bahama Bank cannot be determined, it is believed that no single process is probably responsible for the formation of the lower Schroyer limestone. The only process occurring on the Great Bahama Bank which was not thought to be important was the physical disintegration of the source area.

Fauna-The fauna characteristic of the chert bearing limestone is predominantly one of brachiopods, bryozoans, and echinoderms. A great majority of the brachiopods belong to suborder Productacea. The most frequent occurring genera were Dictyoclostus and Chonetes. One genera of suborder Rostrospiracea, Composita, is also common. Bryozoans are common throughout the chert and the surrounding limestone. Fistulopora and Rhombopora, make up fifty percent of the bryozoan fauna with fenestrate bryozoans being the remainder. The fossil remains of members of Phylum Echinodermata consisted of echinoid spines and test plates and crinoid columnals and calyx plates.

Oolitic Limestone

General Characteristics-The upper non-cherty portion of the Schroyer limestone contains varying amounts of oolites. The amount varies from approximately 95% to only a trace. In several sections a distinct zone of oolites occurs within a finely crystalline limestone resembling the chert bearing limestone below;

The individual oolites have recrystallized centers surrounded by not more than two laminations. The centers are mostly fragments of ostracodes and small high spired gastropods. Around the centers composed of ostracodes are laminations which are ellipsoidal when ovserved in two dimensions. Laminations around the small gastropods are nearly spherical. Both gastropods and ostracodes, which compose the nuclei of the oolites, are composed completely of calcite crystals 20-50 microns in diameter, with no shell material remaining. The laminations are composed of cryptocrystalline calcite which is similar to the calcite of the chert bearing limestone.

Origin and Depositional Environment of Oolites-Oolites are mow forming in the carbonate areas of the Carribean Newell et al, 1959; Purdy, 1963; Ginsburg & Lowenstam, 1958). The process which initiates the growth of the oolites cannot be determined. Even though the process which initiates and causes the growth of the oolites cannot be determined, much can be said about the environment in which they are formed.

Purdy (1963, p. 110) commenting on the depth of water over an oolite ridge on the Great Bahama Bank states: "The depth of water overlying the ridge varies from intertidal exposure at low tide to an observed maximum of ten feet. The average depth is less than six feet." Shallow water is not the only factor determining the formation of oolites. Turbulence is the other factor determining the formation of oolites. Ginsburg and Lowenstam (1958, p. 316) relating water turbulence to the occurrence of oolites on the Florida Platform state: "Where the platform is undefended by reefs, many skeletal grains are coated with single oolitic laminations; where reefs are present, oolitically coated grains are found in only a few places behind the reefs on topographic ridges." The two major physical factors determin- the formation and occurrence of oolites are shallow water and high turbulence. The formation of the oolites in the upper Schroyer limestone is considered to have formed in shallow, turbid water.

CHERT DEPOSITION

The Origin of Chert

Because the chert of the Schroyer limestone is considered to be of primary origin, theories on the secondary origin of chert will be discussed briefly. The most widely expounded theories of secondary chert origin are: silicification by hydrothermal solution, silicification by movements of siliceous ground water, the submarine alteration of volcanic ash, and the concentration of silica in sediments during diagenesis. These theories, with the exception of the submarine alteration of volcanic ash, are inadequate for they fail to explain the occurrence of chert beds on a regional scale. The submarine weathering of volcanic ash is not applicable, for the area of this investigation had no proximity to areas of volcanic activity in Permian time. Silicification by ground water has occurred along the outcrop in two forms. Cavities containing quartz crystals are found at several localities in the upper, non-cherty limestone, and in most sections examined, portions of the upper, non-cherty limestone, have been replaced by colorless chert without altering the texture of the limestone.

Proponents of the theory that chert is primary believe chert was deposited in a manner similar to the deposition of other sediments. When conditions were favorable, silica was deposited instead of limestone, just as when conditions are favorable, limestone is deposited in place of shale.

The source of the silica is normal chemical weathering of the provenance. The amount of silica entering modern seas yearly is estimated to be 320×10^6 tons as compared to 560×10^6 tons of $CaCO_3$ (Kuenen, 1950, p. 233). This silica is not, to any great extent carried as a colloid, for silica has been shown by Krauskopf (1956 & 1959), and Siever (1957), to go into true solution as monosilicic acid, H_4SiO_4. Inorganic

Precipitation of silica occurs when fresh water, high in dissolved silica, enters a marine environment. If silica were carried by water as a colloid, instead of in true solution, the precipitation of silica could be explained solely by the action of electrolytes. As silica goes into true solution, the problem of precipitating inorganic silica becomes much more comples than precipitation of a colloid. Precipitation from a saturated solution is spontaneous if more solute is added to the solution. It is difficult, however, to imagine a sea saturated with dissolved silica in the Permian owing to organisms secreting siliceous tests, but it seems probably that the dissolved silica content of Permian seas was much higher than it is in modern seas, 0.1 to 8.0 parts per million. (Siever, 1957, p. 833) The increase of dissolved silica in the Permian is based on a diminished number of organisms secreting siliceous tests. Diatoms had not evolved and only one suborder of subclass Radiolaria contributed significantly to Paleozoic sediments. (Jones, 1956, p. 50)

Inorganic precipitation of silica from an undersaturated solution is a complex process. Maximum inorganic precipitation of silica from undersaturated solutions requires small amounts of colloidal silica, suspended particles in the water, and the electrolytic action of sea water. Explaining the presence of colloidal silica in water it should be remembered that silica is primarily carried in solution. It seems significant, however, that the time required for a colloidal particle of silica to be dissolved in the time interval of one week. (Krauskopf, 1957, p. 13) Therefore, any colloidal particles of silica acquired by a stream a week before entering the sea will enter the sea as a colloid. The presence of these colloidal particles initiates the precipitation of more colloidal particles. (Krauskopf, 1957, p. 22)

The action of electrolytes neutralizes the negative charge on colloidal silica. The neutralization of charge is required to permit the colloidal particles of silica to coagulate into a gel. Little of the Schroyer chert was precipitated as a gel, for the action of suspended solids prohibits gel precipitation (Bien, 1959, p. 28). Neutralization of charge allows the colloidal silica to be adsorbed on suspended solids and settles to the sea floor. The suspended solid could be calcite, Fe_2O_3, kaolinite, montmorillonite, or $Al(OH)_3$ (Bien, 1959, p. 29).

Primary or Secondary Chert

The chert of the Schroyer limestone is believed to be of primary origin. The following discussion will explain the criteria used in developing this theory.

The chert present in the Schroyer occurs predominately in beds, however, sparse nodules are present. The nodules occur in most exposures as discontinuous beds. The fact that the chert occurs in an orderly fashion, and not as random nodules, was one of the mahor factors that indicated the chert of the Schroyer limestone was of primary origin.

The contact between the chert and the surrounding limestone is sharp. The sharpness of the contacts can be seen macroscopically and in thin section. The sharpness of the contact was best illustrated in the field by the difficulty incurred in trying to obtain a sample which would show the chert limestone contact. The chert and the limestone almost slways parted along their contact. The contact should be a gradational one if the chert was of secondary origin.

The chert beds are continuous over an area of approximately 900 square miles. Various types of secondary chert deposition are not conducive to creation of bedded chert; volcanism could produce these cherts as a secondary deposit, but lithologic characteristics deny a volcanic source of SiO_2.

Beds of chert can be seen in a few exposures, notably section III where a chert bed diminishes to a bed of nodules, then to sparse nodules, all with the same relative location within the limestone in which they are contained. The characteristics of the limestone do not change over these areas, therefore, the change must have been caused by deposition of the chert.

The chert beds migrate vertically through the limestones and shales of the Schroyer. Several localities have chert beds in shales. Where the chert is present in shale, differential compaction can be seen around irregularities of the chert beds. Differential compaction could not have occurred unless the chert was nearly lithified before the shale was compacted.

The chert and the limestone almost always have different faunal characteristics. Brachiopods are conspicuous by their absence, except as small fragments, in chert while they comprise one of the major faunal assemblages of the limestone. The great majority of fossils in the chert are in small fragments, but many fossils occur in the limestone with entire shells. In general, where the limestone is very fossiliferous, the chert contains only sparse fossil fragments, and where the chert is fossiliferous, the limestone contains only sparse fossils.

The factors in this discussion taken separately could not be used to indicate a primary origin of chert. It is thought, however, that the combination of factors can lead to no other conclusion. The chert of the Schroyer limestone is of primary origin.

Summary of the Origin of Chert in the Schroyer Limestone

The beds of chert in the Schroyer limestone appear to have been formed by the inorganic precipitation of silica carried in solution. The precipitation was caused by the combined effect of small amounts of colloidal silica, the presence of electrolytes (sea water) and the adsorption of colloidal silica on suspended solids. Calcite and Fe_2O_3 were the predominate suspended materials. The presence of Fe_2O_3 was indicated by a test with KCNS on powdered chert. This test is most widely used in soil testing as a test for ferric ions. The presence of calcite in the chert was indicated by tests with HCl and by X-ray analysis on finely powdered chert.

The beds of chert were deposited as the front of mixing between fresh and salt water migrated over the area during monor transgressions and regressions in Schroyer time. The thickness of the chert beds is proportional to the rate at which the front of mixing migrated over the area. The slower the transgression or regression, the thicker the chert bed. When the transgression or regression was too fast, a bed of chert nodules was deposited in contrast to a chert bed which was continuous.

The precipitation of a gel may have been responsible for the chert in some areas. Liesegang rings are present in the chert at Section XI. Field examination, however, indicates that the rings are a weathering phenomena rather than the result of the rythmic precipitation of a gel.

Lithology and Distribution of Chert

The chert of the Schroyer limestone occurs predominately in beds from 0.1 to 1.75 feet thick. Nodules are completely dominated by bedded chert and where nodules occur, they lie along a plane parallel to the normal bedding planes.

The chert beds all have similar characteristics. They are varying shades of gray and contain fossils from unidentifiably small fragments to fistuloporid bryozoan fragments 0.5 inch in diamenter and 2.0 inches long. Their contacts with the overlying and underlying limestone is sharp. An attempt to break a piece of rock showing the contact between the limestone and chert from the outcrop usually ended in failure when the chert and limestone separated along the contact. Most of the chert beds contain nodules which differ from the surrounding chert by some characteristic such as color, fossils, or liesegang rings.

The distribution of the chert in the northern two thirds of the area studied is shown by panel diagram in Plate IV. This diagram shows a vertical migration of the chert to the west-northwest. The vertical migration, considering the mode of origin of the chert, indicates a regression of the sea to the west-northwest. To the west and north of sections XI, III, XII, and IV the shale and limestone sections above the uppermost chert bed increase markedly in thickness. The thickening of the limestone and shale in this area is in the axis of the Irving Syncline. (See figure I) The fact that the thickening above the chert occurs in the axis of the syncline may indicate structural movement along the Abilene and Nemaha Anticlines. However, it is believed that the evidence is insufficient to substantiate structural movement.

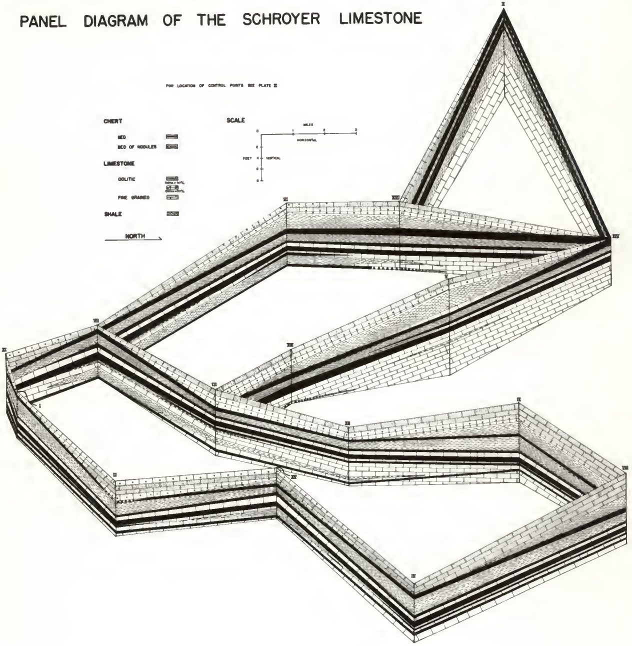
The total chert in the Schroyer thins slightly to the west. The maximum thickness of chert occurs where the limestone is thin. As the limestone thickens toward the west, the chert thins from a maximum accumulative thickness of 2.8 feet in section XIII to a minimum of 1.2 feet in section X. Plate VI is a map which shows the limestone/chert ratio. The map also shows the 2 foot isopach on the total chert thickness. The 2 foot isopach approximately follows the limestone/chert ratio line of 3. This indicates that the variation of the limestone/chert ratio is the effect of both increased limestone thickness and decreased chert thickness.

EXPLANATION OF PLATE IV

Panel diagram of the Schroyer limestone. Note the vertical migration of the chert to the west and north.

PLATE IV

PANEL DIAGRAM OF THE SCHROYER LIMESTONE



EXPLANATION OF PLATE V

Fig. 4 Dark chert nodule within a chert bed. Polished section has been etched with dilute HCl showing that fossil fragments have not been silicified. Note fracture along which movement has taken place in lower left hand corner. X2

Fig. 5 Liesegang rings in highly weathered chert bed. X2

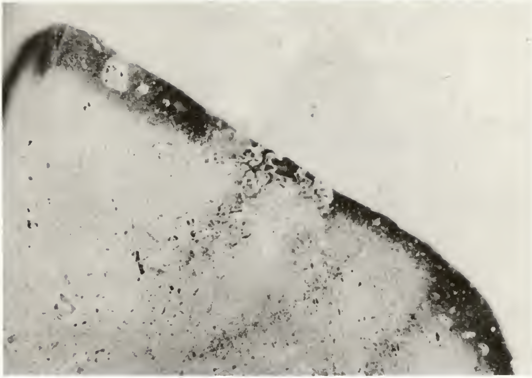


Fig. 4

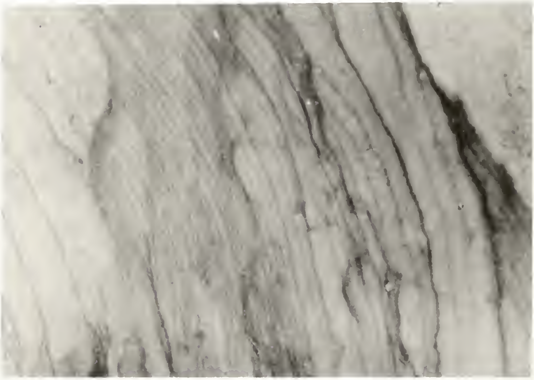


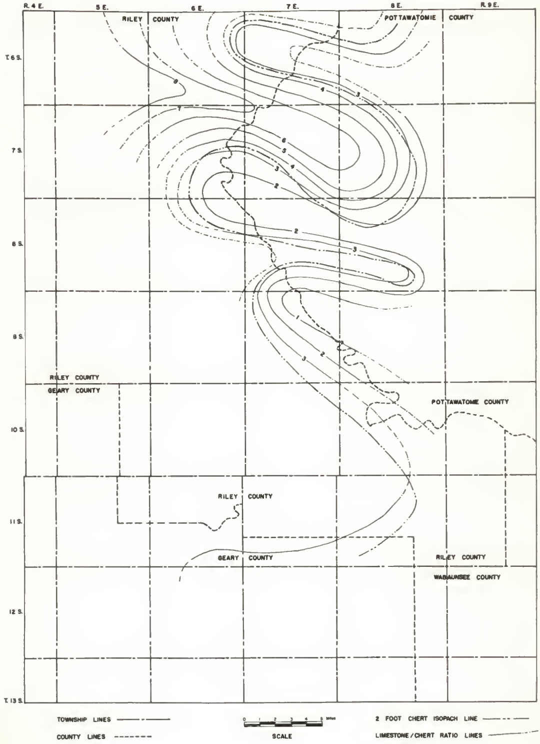
Fig. 5

EXPLANATION OF PLATE VI

Limestone/chert ratio map of the Schroyer limestone. Also shows 2 foot chert isopach line. Note lobate nature of variations.

PLATE VI

LIMESTONE / CHERT RATIO OF SCHROYER LIMESTONE



CONCLUSIONS

The following conclusions relative to the deposition of the Schroyer limestone seem justified:

1. The chert beds of the Schroyer limestone appear to be primary deposits. Their deposition occurred at the fron of mixing between fresh and salt water. The deposition was probably from an undersaturated solution by a complex process of association and mutual reaction of electrolytes, suspended solids and small amounts of colloidal silica.
2. The chert beds and the limestone beds in which they are contained were deposited in relatively shallow water, less than 120 feet.
3. The oolitic, noncherty limestone was, by all indications, deposited in shallow turbid water. This water was probably brackish, indicated by the abundance of gastropods and ostracodes.
4. The vertical migration of the chert beds within the Schroyer limestone as shown in plate III shows regression of the sea way to the north and west, placing the shoreline to the south and east.
5. Indications are that the climate may have been subtropical. Hattin (1957, p. 104) made the following statement about the climate during the deposition of the Wreford formation. "Broad-leaved-conifer and seed-fern fossils indicate that a warm climate prevailed during Wreford deposition." The amounts of chert present in the Schroyer limestone indicates that an abundant supply of silica was needed. Rankama and Sahama (1950, p. 272) commenting on the relative abundance of materials dissolved in river water state:

> "In tropical regions the salinity of the river waters is remarkably low because there the rivers drain through leached tropical forests and have not very much access to fresh rocks. Consequently, the amount of sulfate is relatively low, whereas iron and aluminum are usually rather

abundant and silica is expecially high. The great abundance of silica is evidently due to the lateritic decomposition essential to tropical and subtropical regions, which includes the removal of much silica as the most essential feature."

The abundance of dissolved silica in subtropical streams, therefore, seem to have been the source of silica for the chert of the Schroyer limestone. The reason for concluding that the climate was subtropical instead of tropical was: the dissolved solids in streams increases the farther the streams are removed from the tropics. To obtain a silica content which in relation to the dissolved $CaCO_3$ could be considered high enough for the source of the chert beds the climate would have had to have been at least subtropical.

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APPENDIX

Section I

Road cut in the SW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 23, T. 9 S., R. 7 E., Riley County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone	
Limestone, gray, weathers brown and buff, fine grained, sparse brachiopod fragments	0.7
Chert, gray, weathers light gray, no fossils	0.6
Shale, gray weathers tan, thin bedded, unfossiliferous, limestone 0.2 feet thick 0.5 feet from base, gray weathers buff, numerous cavities filled with calcite crystals	1.8
Chert, gray, weathers light gray, unfossiliferous	0.4
Shale, buff, weathers tan, thin bedded, unfossiliferous	0.3
Limestone, buff, weathers buff, fine grained, crinoid columnals, calyx plates, echinoid spines and sparse brachiopod fragments	0.4
Chert, dark gray, weathers light gray, small fossil fragments common	0.2
Limestone, buff, weathers buff, fine grained, crinoid columnals, calyx plates, echinoid spines, and sparse brachiopod fragments	0.8
Chert, dark gray to light gray, weathers light gray, dark gray occurs as nodules in light gray bed, nodules unfossiliferous, light gray has abundant fossil fragments; gray limestone nodules weather in negative relief	0.9
Limestone, brown, weathers buff, fine grained, few _Dictyoclostus_ sp. molds, no remnants of shell material	1.5
Chert, light gray, weathers light gray, liesegang rings prominent on weathered surface, unfossiliferous	0.2
Limestone, brown, weathers buff, fine grained, platy unfossiliferous	0.3
Total thickness	8.1

Havensville member Wreford formation

Section II

Road cut in the SE$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 28, T. 9 S., R. 8 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone	
Limestone, light reddish gray, weathers buff, recrystallized, oolites common, abundant ostracodes and small high spired gastropods	0.9
Limestone, buff, weathers buff, recrystallized, oolitic abundant small high spired gastropods weathering in relief, unit weathers honeycombed	2.1

Limestone, light reddish gray, weathers buff, recrystallized, oolites sparse, ostracodes common, sparse small high spired gastropods.. 0.9
Shale, greenish buff, weathers tan, thin bedded, thin limestone beds and nodules; Dictyoclostus sp., Chonetes sp., crinoid columnals and unidentifiable fragments............................ 2.2
Limestone, buff, weathers tan, fine grained, unidentifiable brachiopod fragments.. 0.1
Chert, dark gray, weathers light gray, contact with limestone very sharp, sparse fossil fragments.................................... 0.3
Limestone, buff, weathers buff, fine grained, argillaceous, sparse brachiopod fragments.. 0.5
Chert, dark gray to light gray, weathers light gray, dark gray is unfossiliferous, occurs in nodules within light gray bed, light gray has abundant fossil fragments; limestone nodules weather in negative relief.. 0.8
Limestone, dark gray, weathers tan with limonite stains fine grained, sparse fossil fragments.................................. 0.2
Chert, dark gray, weathers light gray, fossil fragments abundant, contact with limestone sharp and irregular....................... 0.2
Limestone, buff, weathers tan, fine grained, argillaceous, Dictyoclostus, Neospirifera, Fenestrillina, Fistulopora, echinoid spines, and crinoid columnals.......................... 0.7
Chert, dark gray, weathers light gray, nodular bed.................. 0.1
Limestone, light reddish tan, weathers buff, fine grained unfossiliferous.. 0.2
Chert, light gray, weathers light gray, nodular bed, abundant fossil fragments.. 0.2
Limestone, light reddish tan, weathers buff, fine grained, unfossiliferous.. 0.2

Total thickness 9.6

Havensville member of the Wreford formation

Section III

Road cut in the NE¼, NE¼, Sec. 23, T. 8 S., R. 7 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone
Limestone, brown, grading to gray at top, weathers brown, recrystallized, sparsely oolitic, thick bedded, weathers blocky, sparse high spired gastropods, ostracodes common upper 0.5 foot.. 2.5
Limestone, gray, weathers tan, fine grained, abundant fossil fragments; made up of 50% subspherical gray chert nodules........ 1.2
Shale, olive gray, weathers tan, thin bedded, unfossiliferous....... 0.9

Chert, dark gray, weathers light gray, sparse fossil fragments...... 0.4
Limestone, gray, weathers buff, fine grained, crinoid columnals, echinoid spines, and numerous brachiopod fragments............... 0.7
Chert, black to light gray, weathers light gray, black occurs as nodules and is unfossiliferous, light gray has sparse fossil fragments; gray limestone nodules enclosed and weather in negative relief.. 0.8
Limestone, gray, weathers buff with limonite stains, medium grained, unfossiliferous, lenticular chert nodules common........ 0.4
Chert, dark gray, weathers light gray, Fenestrillina, Rhombopora, and abundant fossil fragments..................................... 0.3
Shale, buff, weathers buff, calcareous, Composita, Fenestrillina, Dictyoslostus, echinoid spines, and abundant fossil fragments.... 0.3
Limestone, cream, weathers white, fine grained, sparse fossil fragments; chert content varies from sparse nodules at the south end of the road cut to a bed of gray chert 0.3 foot thick at the north end of the cut...................................... 1.2
Shale, olive gray, weathers buff, calcareous, sparse Composita, and fossil fragments.. 1.1
Limestone, gray, weathers buff, argillaceous, fine grained, abundant fossil fragments; fossiliferous chert nodules upper 0.6 foot, quartz filled cavities common.......................... 1.8

Total thickness 11.6

Havensville member of the Wreford formation

Section IV

Stream bank in the SW¼, NE¼, Sec. 23, T. 7 S., R. 8 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone
Limestone, cream, weathers buff, recrystallized, oolitic, abundant ostracodes upper 0.5 foot.............................. 1.6
Limestone, gray, weathers buff, fine grained, chert beds connected by vertical portrusions, make up 50% of unit........... 1.3
Shale, gray, weathers buff, thin bedded, sparse poorly preserved fossil fragments.. 2.6
Limestone, gray, weathers buff, fine grained, Chonetes, crinoid columnals, and brachiopod fragments............................. 0.2
Chert, dark gray, weathers light gray, unfossiliferous............... 0.5
Limestone, cream, weathers buff, fine grained, Chonetes crinoid columnals; sparse chert nodules near top......................... 0.5
Chert, dark gray, weathers light gray, unfossiliferous, sparse nodules of limestone weather in negative relief................. 1.0
Limestone, cream, weathers brown, fine grained, sparse Fenestrillina, and brachiopod fragments......................... 0.3

Chert, light gray, weathers light gray, abundant small fossil fragments	0.2
Limestone, cream, weathers buff, fine grained, 0.2 foot platy zone in center, poorly preserved fossil fragments	0.8
Chert, light gray, weathers light gray, abundant fossil fragments	0.2
Limestone, cream, weathers buff, finely crystalline, unfossiliferous, chert nodules in lower 0.5 foot	1.3
Total thickness	10.5

Havensville member of the Wreford formation

Section V

Stream bank in the NE$\frac{1}{4}$, SE$\frac{1}{4}$, Sec. 8, T. 7 S., R. 7 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, gray, weathers buff, fine grained except for oolites, oolites grade from trace at base to 90% at top, abundant ostracodes and small high spired gastropods; inclusions of overlying green shale upper 0.4 foot	1.7
Shale, gray, weathers buff, calcareous, thin bedded, sparse poorly preserved brachiopod fragments	3.3
Limestone, gray, weathers buff, slightly argillaceous, fine grained, unfossiliferous, dark gray chert nodules lower 0.4 foot	0.8
Chert, dark gray, weathers light gray, sparse fossil fragments	0.4
Shale, buff, weathers tan, thin bedded, unfossiliferous, limestone nodules upper 0.7 foot, finely crystalline, argillaceous	1.4
Chert, gray, weathers light gray, abundant small fossil fragments	0.3
Limestone, cream, weathers buff, finely crystalline, sparsely fossiliferous	0.5
Chert, gray, weathers light gray, abundant fossil fragments; limestone nodules enclosed, gray, dense, weather in negative relief	0.9
Limestone, gray, weathers buff, finely crystalline, abundant bryozoan fragments	1.4
Shale, buff, weathers tan, calcareous, thin bedded, unfossiliferous	0.2
Limestone, gray, weathers buff, fine grained, no bedding planes, unfossiliferous	5.9
Total thickness	16.8

Havensville member of the Wreford formation

Section VI

Road cut in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 1, T. 8 S., R. 6 E., Riley County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, gray, weathers buff, partially recrystallized, sparse high spired gastropods, abundant ostracodes.......................... 0.6

Limestone, gray, weathers buff with limonite stains, recrystallized, oolitic, weathers honeycombed.................................. 0.5

Limestone, gray, weathers buff, partially recrystallized, sparse small high spired gastropods, ostracodes common................. 0.6

Chert, gray, weathers light gray, _Fistulopora_ and small fossil fragments common.. 0.8

Shale, olive tan, weathers buff, calcareous, thin bedded, crinoid columnals and _Derbyia_ common.................................. 1.3

Chert, gray, weathers light gray, unfossiliferous.................. 0.3

Limestone, cream, weathers buff, fine grained, _Fenestrillina_, _Fistulopora_, _Composita_, _Meekela_ and small fossil fragments....... 0.7

Chert, gray, weathers light gray, fossil fragments much smaller than in surrounding limestone....................................... 0.6

Limestone, gray, weathers buff, fine grained, recrystallized, brachiopods.. 0.4

Chert, gray, weathers light gray, very small fossil fragments....... 0.4

Shale, buff, weathers brown, silty, calcareous, sparse calcareous chert nodules, unfossiliferous.................................. 1.7

Chert, gray, weathers light gray, abundant small fossil fragments... 0.3

Total thickness 8.2

Havensville member of the Wreford formation

Section VII

Road cut in the NW¼, SE¼, Sec. 4, T. 9 S., R. 7 E., Riley County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, cream, weathers buff, fine grained, sparse oolites except upper 0.3 foot which is oolitic, abundant ostracodes and small high spired gastropodes.............................. 0.7

Chert, gray, weathers light gray, unfossiliferous, 25% of bed is made up of dense, gray limestone nodules......................... 1.3

Shale, buff, weathers buff, calcareous, thin bedded, unfossiliferous.. 1.3

Chert, gray weathers light gray, abundant small fossil fragments.... 0.6

Shale, buff, weathers tan, thin bedded, unfossiliferous............. 0.7

Chert, gray, weathers light gray, abundant fossil fragments, dense, gray limestone nodules weathers in negative relief........ 1.5

Shale, buff, weathers tan, thin bedded, unfossiliferous............. 0.7

Limestone, cream, weathers buff, _Fenestrillina_, _Fistulopora_, and fossil fragments.. 0.8

Shale, gray, weathers yellow, heavy limonite stains, calcareous, thin bedded, unfossiliferous.................................... 1.5
Chert, gray weathers light gray, abundant fossil fragments.......... 0.2

Total thickness 9.3

Havensville member of the Wreford formation

Section VIII

Road cut in the SE$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 17, T. 6 S., R. 8 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, gray, weathers buff, oolitic, centers recrystallized, abundance at small high spired gastropods and ostracodes, solution cavities filled with quartz crystals.................... 3.7
Shale, buff, weathers buff, thin bedded, calcareous fossils fragmental and very poorly preserved............................ 2.2
Limestone, cream, weathers buff, fine grained, fossils fragmental... 0.1
Chert, gray, weathers light gray, unfossiliferous.................. 0.7
Shale, buff, weathers buff, thin bedded, calcareous, Derbyia, Dictyoclostus, crinoid columnals, calyx plates, echinoid spines, and abundant fragments.. 0.1
Chert, light gray, weathers light gray, abundant small fossil fragments.. 0.3
Limestone, cream, weathers buff, finely crystalline, Fenestrillina, Fistulopora, Composita, Derbyia, Dictyoclostus and unidentifiable fossil fragments.. 0.7
Chert, light gray to dark gray, weathers light gray, light gray has abundant fossil fragments, limestone nodules enclosed weathering in negative relief.. 0.8
Limestone, light gray, weathers brown, argillaceous, Dictyoclostus, Chonetes, Meekela, and fossil fragments......................... 0.3
Chert, gray, weathers light gray, Rhombopora, and fossil fragments present... 0.2
Limestone, gray, weathers buff, chalky, fine grained, Dictyoclostus, Ambocoelia, Composita, Fenestrillina, and fossil fragments....... 0.7
Chert, gray, weathers light gray, bryzoan fragments and ostracodes.. 0.1
Limestone, cream, weathers brown, finely crystalline, sparse Dictyoclostus, and other fragments.............................. 0.9

Total thickness 12.4

Havensville member of the Wreford formation

Section IX

Road cut in the NW¼, SE¼, Sec. 36, T. 6 S., R. 7 E., Pottawatomie County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, gray, weathers buff, oolitic, weathered surface pitted by solution cavities, ostracodes and small high spired gastropods abundant	2.3
Limestone, cream and gray, weathers buff, platy, abundant ostracodes and high spired gastropods	0.9
Shale, buff, weathers buff, calcareous, thin bedded, unfossiliferous	2.3
Chert, dark to light gray, weathers light gray, liesegang rings on weathered surface of dark gray chert, fossil fragments abundant in light gray chert	0.3
Shale, buff, weathers buff, calcareous, thin bedded, unfossiliferous	2.6
Chert, dark to light gray, weathers light gray, liesegang rings on weathered surface of dark gray chert, fossil fragments abundant in light gray chert	0.3
Limestone, cream, weathers buff, fine grained, sparse echinoid spines and crinoid columnals, sparse dark gray, unfossiliferous chert nodules	0.8
Chert, dark to light gray, weathers light gray, liesegang rings on weathered surface of dark gray chert, light gray chert has abundant fossil fragments	0.8
Limestone, cream, weathers buff, fine grained, sparse fossil fragments	0.2
Chert, gray, weathers light gray, _Fenestrillina_, ostracodes and fossil fragments	0.1
Limestone, cream, weathers buff, fine grained, sparse brachiopod fragments	0.9
Chert, light gray, weathers light gray, abundant fossil fragments	0.1
Limestone, cream, weathers buff, finely crystalline, argillaceous zone 0.6 foot thick at center, _Fenestrillina_, crinoid columnals, and abundant fossil fragments	2.3
Total thickness	13.9

Havensville member of the Wreford formation

Section X

Road cut in the NE¼, SW¼, Sec. 36, T. 6 S., R. 5 E., Riley County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Chert, gray, weathers light gray, sparse fossil fragments........... 0.4
Shale, buff, weathers buff, thin bedded, sparse poorly preserved fossil fragments.. 1.2
Limestone, cream, weathers buff, fine grained, unfossiliferous...... 0.3
Chert, gray, weathers light gray, sparse fossil fragments, dense, gray limestone nodules weathered in negative relief............. 0.8
Limestone, cream, weathers buff, fine grained, unfossiliferous...... 0.4
Shale, buff, weathers tan, calcareous, thin bedded, unfossiliferous. 1.2
Limestone, buff, weathers buff, fine grained, unfossiliferous, abundant gray chert nodules....................................... 0.25
Marl, gray, weathers buff, thin bedded, unfossiliferous............. 3.5
Limestone, tan, weathers buff, fine grained, chalky, thick bedded, solution cavities in upper 4.0 feet lined with quartz crystals, unfossiliferous.. 7.5

Total thickness 15.55

Havensville member of the Wreford formation

Section XI

Road cut in the NE¼, SW¼, Sec. 22, T. 9 S., R. 7 E., Riley County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, gray, weathers buff, recrystallized unfossiliferous, small veins of calcite crystals.................................. 1.2
Limestone, gray, weathers brown, limonite stains, recrystallized, abundant ostracodes and high spired gastropods, weathers honeycombed.. 1.6
Limestone, light gray, weathers buff, recrystallized, unfossiliferous, impure chert nodules scattered throughout.............. 0.4
Chert, gray, weathers light gray, sparse fossil fragments........... 0.4
Shale, buff, weathers buff, thin bedded, upper bedding planes warped by differential compaction around irregular chert contact, common poorly preserved fossil fragments......................... 1.3
Limestone, gray, weathers brown, fine grained, _Derbyia_, _Meekela_, _Dictyoclostus_, _Chonetes_, _Composita_, crinoid columnals, echinoid spines and test plates, unidentifiable fragments, fossils silicified and weathers in positive relief, 0.4 foot chert bed in center, gray, weathers light gray, sparse crinoid columnals... 1.1
Chert, dark gray nodules enclosed in light gray bed, weathers light gray, unfossiliferous, contact with limestone sharp gray limestone nodules enclosed, weathers in negative relief.......... 0.8
Limestone, cream, weathers brown, crystalline, sparse fossil fragments, silicified and weathers in positive relief............ 0.2
Chert, gray, weathers light gray, fossils fragmental, contact with limestone sharp... 0.2

Limestone, gray, weathers buff, fine grained, crinoid columnals, echinoid spines, abundant fossil fragments, silicified and weathered in positive relief.. 0.5
Limestone, cream, weathers buff, fine grained, becomes argillaceous towards top, abundant Dictyoclostus, and Composita in argillaceous zone, chert nodules present in lower zone................ 0.6
Chert, black to light gray, weathers light gray, most of the chert shows structure similar to liesegang rings...................... 1.2
Limestone, cream, weathers buff, fine grained, fossil fragments recrystallized, small chert nodules in upper 0.3 foot............ 0.7

Total Thickness 10.2

Havensville member of the Wreford formation

Section XII

Stream bank in the NW¼, NW¼, Sec. 31, T. 7 S., R. 8 E., Pottawatomie County, Kansas

Wymore member of the Matfield formation

Schroyer limestone
Limestone, gray, weathers buff, recrystallized, upper 0.9 foot oolitic, abundant ostracodes and small high spired gastropods.... 2.3
Chert, gray, weathers light gray, abundant small fossil fragments... 0.3
Shale, buff, weathers tan, thin bedded, calcareous, unfossiliferous. 1.3
Limestone, buff, weathers tan, fine grained, unfossiliferous........ 0.1
Chert, gray, weathers light gray, abundant small fossil fragments... 0.3
Limestone, buff, weathers buff, fine grained, sparse brachiopod fragments... 0.4
Chert, gray, weathers light gray, abundant small fossil fragments, few fenestrate bryozoan fragments............................... 0.7
Limestone, gray, weathers buff, fine grained, unfossiliferous, nodular bed of chert lower 0.2 foot............................. 0.7
Limestone, cream, weathers buff, fine grained, unfossiliferous...... 2.5
Shale, olive tan, weathers buff, calcareous, thin bedded, vertical tubed of limestone common, unfossiliferous...................... 0.4
Limestone, cream, weathers tan, fine grained, unfossiliferous, sparse gray chert nodules.. 1.3

Total thickness 10.3

Havensville member of the Wreford formation

Section XIII

Road cut in the NW¼, SE¼, Sec. 3, T. 8 S., R. 7 E., Pottawatomie County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, buff, weathers buff, recrystallized, abundant ostracodes and high spired gastropods in upper 1.3 feet, becomes argillaceous lower 0.4 foot	2.8
Shale, olive tan, weathers buff, calcareous thin bedded, unfossiliferous	1.2
Chert, gray, weathers light gray, unfossiliferous	1.0
Shale, olive tan, weathers buff, calcareous, thin bedded, unfossiliferous	1.0
Chert, gray, weathers light gray, abundant small fossil fragments; gray, dense limestone nodules weather in negative relief	1.4
Limestone, cream, weathers buff, fine grained, unfossiliferous, abundant chert nodules	2.0
Total thickness	9.4

Havensville member of the Wreford formation

Section XIV

Stream cut in the SW$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 18, T. 6 S., R. 7 E., Riley County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Chert, dark gray, weathers light gray, unfossiliferous; limestone nodules, gray, dense, weather in negative relief	1.2
Marl, gray, weathers tan, thin bedded, crinoid columnals, echinoid spines and brachiopod fragments, limestone nodules in upper 0.5 foot	1.0
Chert, light to dark gray, weathers light gray, abundant small fossil fragments	0.3
Limestone, cream, weathers buff, fine grained, Dictyoclostus, Meekela, Composita, and abundant brachiopod fragments	0.6
Chert, gray, weathers light gray, ostracodes and fenestrate bryozoans	0.8
Limestone, gray, weathers buff, brachiopod fragments abundant, chert nodules abundant upper 2.2 feet	4.4
Total thickness	8.3

Havensville member of the Wreford formation

Section XV

Stream bank in the SW$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 6, T. 8 S., R. 8 E., Pottawatomie County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, cream, weathers buff, recrystallized, abundant ostracodes and small high spired gastropods in a zone 0.6 foot thick at center.. 2.1

Shale, buff, weathers buff, thin bedded, calcareous, unfossiliferous 0.6

Chert, gray weathers light gray, unfossiliferous.................... 0.4

Shale, tan, weathers buff, thin bedded, unfossiliferous............. 1.2

Chert, dark to light gray, abundant small fossil fragments.......... 0.4

Limestone, gray, weathers buff, fine grained, unfossiliferous....... 0.2

Chert, dark to light gray, weathers light grey, abundant fossil fragments except in dark gray; dense, gray limestone nodules weather in negative relief...................................... 0.7

Limestone, cream, weathers buff, fine grained, sparse brachiopod fragments... 0.3

Shale, buff, weathers tan, thin bedded, calcareous, unfossiliferous. 0.9

Limestone, cream, weathers buff, finely crystalline, unfossiliferous, sparse light gray chert nodules........................ 1.1

Total thickness 8.9

Havensville member of the Wreford formation

Section XVI

Road cut in the SW$\frac{1}{4}$, NW$\frac{1}{4}$, Sec. 24, T. 7 S., R. 6 E., Pottawatomie County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, cream, weathers tan, upper 1.6 feet recrystallized, abundang high spired and belleraphon gastropods in zone 0.4 foot thick at center, oolites increase from 0% at bottom to 90% at top... 2.4

Shale, light gray, weathers buff, silty, calcareous, unfossiliferous.. 2.5

Limestone, gray, weathers tan, fine grained, dark gray unfossiliferous chert nodules throughout................................. 1.7

Limestone, buff, weathers tan, fine grained, unfossiliferous........ 0.8

Chert, dark gray, weathers light gray, abundant small fossil fragments... 0.6

Limestone, tan, weathers brown, fine grained, argillaceous, unfossiliferous.. 0.7

Chert, gray, weathers light gray, sparse small fossil fragments, few cavities filled with quartz crystals......................... 0.9

Limestone, gray, weathers buff, finely crystalline, <u>Fenestrillina</u>, <u>Fistulopora</u>, echinoid spines, crinoid columnals, and brachiopod fragments, abundant chert nodules............................. 0.9

Shale, buff, weathers yellow, calcareous, thin bedded, unfossiliferous.. 0.3

Limestone, cream, weathers buff, fine grained, unfossiliferous few chert nodules.. 1.2

Total thickness 12.0

Havensville member of the Wreford formation

Section XVII

Road cut in the NW$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 16, T. 11 S., R. 8 E., Rilley County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, cream, weathers buff, recrystallized, oolitic, abundant ostracodes and high spired gastropods, upper 0.3 foot grades into overlying green shale	0.9
Shale, olive, weathers buff, unfossiliferous	0.1
Limestone, cream, weathers buff with limonite stains, oolitic, abundant ostracodes and high spired gastropods	1.4
Shale, gray, weathers buff, calcareous, sparse echinoid, crinoid and brachiopod fragments, limestone nodules occur in upper 1.0 foot.	1.8
Limestone, buff, weathers tan, sublithographic, unfossiliferous, calcareous shale lenses throughout	0.7
Shale, yellow, weathers brown, calcareous, unfossiliferous	0.7
Limestone, buff, weathers buff, fine grained, abundant bryozoan, echinoid, and crinoid fragments	0.2
Chert, dark gray, weathers light gray, unfossiliferous	0.3
Limestono, buff, weathers buff, fine grained, unfossiliferous, chert nodules throughout	0.6
Chert, dark gray to light gray, unfossiliferous, limonite stains on weathered surface	0.8
Limestone, cream, weathers buff, limonite stains on weathered surface, sparse fossil fragments	0.2
Chert, dark gray, weathers light gray, abundant small fossil fragments	0.3
Limestone, cream, weathers buff, fine grained, sparse fossil fragments, chert nodules throughout	1.1

Total thickness 9.1

Havensville member of the Wreford formation

Section XVIII

Road cut in the NE$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 25, T. 11 S., R. 6 E., Geary County, Kansas

Wymore member of the Matfield formation

Schroyer limestone

Limestone, pinkish gray, weathers buff, medium grained, algal colonies common..1.0
Limestone, gray, weathers buff, recrystallized, oolitic, abundant ostracodes and high spired gastropods........................... 0.2
Limestone, gray, weathers buff, recrystallized, oolites present but not abundant, sparse ostracodes................................ 1.2
Shale, olive, weathers buff, unfossiliferous........................ 0.2
Limestone, buff, weathers reddish brown, fine grained, common brachiopod, echinoid and crinoid fragments....................... 0.4
Chert, dark gray, weathers light gray, unfossiliferous.............. 0.7
Shale, olive, weathers buff, clayey, thin bedded, unfossiliferous... 1.3
Limestone, gray, weathers buff, fine grained, platy, sparse fossil fragments.. 0.2
Limestone, gray, weathers buff, fine grained, crinoid and echinoid fragments common, chert nodules throughout........................0.7
Chert, black, weathers gray, unfossiliferous, limestone nodules enclosed weather in negative relief...............................0.8
Limestone, gray, weathers buff, fine grained, silicified Derbyia, Chonetes, crinoid and echinoid fragments, chert nodules common... 0.5
Shale, buff, weathers buff, calcareous, unfossiliferous............. 0.2
Limestone, cream, weathers buff, fine grained, unfossiliferous, abundant chert nodules throughout................................ 1.0
Limestone, gray, weathers buff, fine grained, no fossils............ 0.7

Total thickness 9.3

Havensville member of the Wreford formation

Section XIX

Road cut in the SE¼, SE¼, Sec. 27, T. 11 S., R. 6 E., Geary County, Kansas.

Wymore member of the Matfield formation

Schroyer limestone

Limestone, olive gray, weathers buff, oolites common but not abundant, mostly fine grained, most oolites have silicified centers, abundant ostracodes and high spired gastropods.................. 1.5
Shale, olive tan, weathers tan, calcareous, thin bedded, unfossiliferous.. 0.2
Limestone, cream, weathers buff, fine grained, abundant echinoid fragments, sparse Dictyoclostus................................. 0.3
Chert, dark gray, weathers light gray, unfossiliferous..............0.3
Shale, gray, weathers buff, thin bedded, abundant fossil fragments, limestone nodules in upper 0.4 foot.............................. 1.1
Limestone, gray, weathers buff, fine grained, unfossiliferous, grades vertically into calcareous shale......................... 0.2
Chert, gray, weathers light gray, unfossiliferous................... 0.4
Limestone, gray, weathers buff, fine grained, abundant echinoid, crinoid and brachiopod fragments................................ 0.8

Chert, dark to light gray, weathers light gray, unfossiliferous, limestone nodules enclosed weather in negative relief............ 0.8
Limestone, gray, weathers tan, fine grained, abundant brachiopod, bryozoan and echinoid fragments; dark gray chert bed 0.1 foot thick and center.. 0.6
Limestone, gray, weathers tan, argillaceous, no fossils............. 0.3
Limestone, cream weathers tan, fine grained, unfossiliferous, bed of chert nodules at center.................................... 1.1
Chert, gray, weathers light gray, no fossils........................ 0.2
Limestone, cream, weathers tan, fine grained, stylolites common, sparse echinoid fragments... 0.3

Total thickness 8.0

Havensville member of the Wreford formation

A LITHOLOGIC INVESTIGATION OF THE SCHROYER LIMESTONE IN GEARY, POTTAWATOMIE AND RILEY COUNTIES, KANSAS

by

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B. S., Kansas State University, 1962

AN ABSTRACT OF THE THESIS

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The purpose of this investigation was to examine the lithology of the Schroyer limestone in order to determine whether the chert was continuously bedded, develop a theory of origin for the chert and to find out if the chert maintains its relative vertical position within the Schroyer limestone. An attempt was also made to reconstruct the depositional environment of the Schroyer limestone.

The area of this investigation was Riley, Pottawatomie, and northern Geary Counties, Kansas. Extensive field work was done in the area and 19 complete sections of the Schroyer limestone were measured. Samples were taken from most of the measured sections and examined with a binocular microscope. Selected samples were then sawed, polished, and re-examined under the binocular microscope. The polished samples aided in textural examinations and descriptions which were made. Thin sections were made of selected samples, including the two types of limestone present in the Schroyer limestone and the chert-limestone contact. X-ray analysis was made of some of the chert to determine its constituents. An isopach map and a limestone/chert ratio map were constructed to show variation in lithology and variations in the distribution of lithologies. A panel diagram was constructed to indicate distribution and variation in vertical and lateral position of the different sediments of the Schroyer limestone.

The chert was found to be composed primarily of non-crystalline SiO_2 with minor amounts of calcite in some of the chert. The contact of chert and the surrounding limestones, and in some places shale, was found to be sharp, both macroscopically and microscopically. The sharpness of contact and other criteria indicate that the chert was probably of primary origin. The chert, which was below the upper non-cherty limestone in most sections, was in the upper non-cherty limestone in the western and northern parts of the area investigated. The vertical migration of the chert to the west and north suggests regression of the sea to the west and north during Schroyer time. Regression to the west and north would place the shoreline to the east and south of the area of this investigation. The isopach map delineates lobate thickening to the west. The lobate thickening may be the result of eastward flowing currents across a limestone bank buildup on the crest of the Abilene Anticline. The lobate character of the limestone/chert ratio map is probably a result of thickening of limestone, for the chert thins only slightly to the west.