

REVIEW OF GEOLOGY OF KANSAS.

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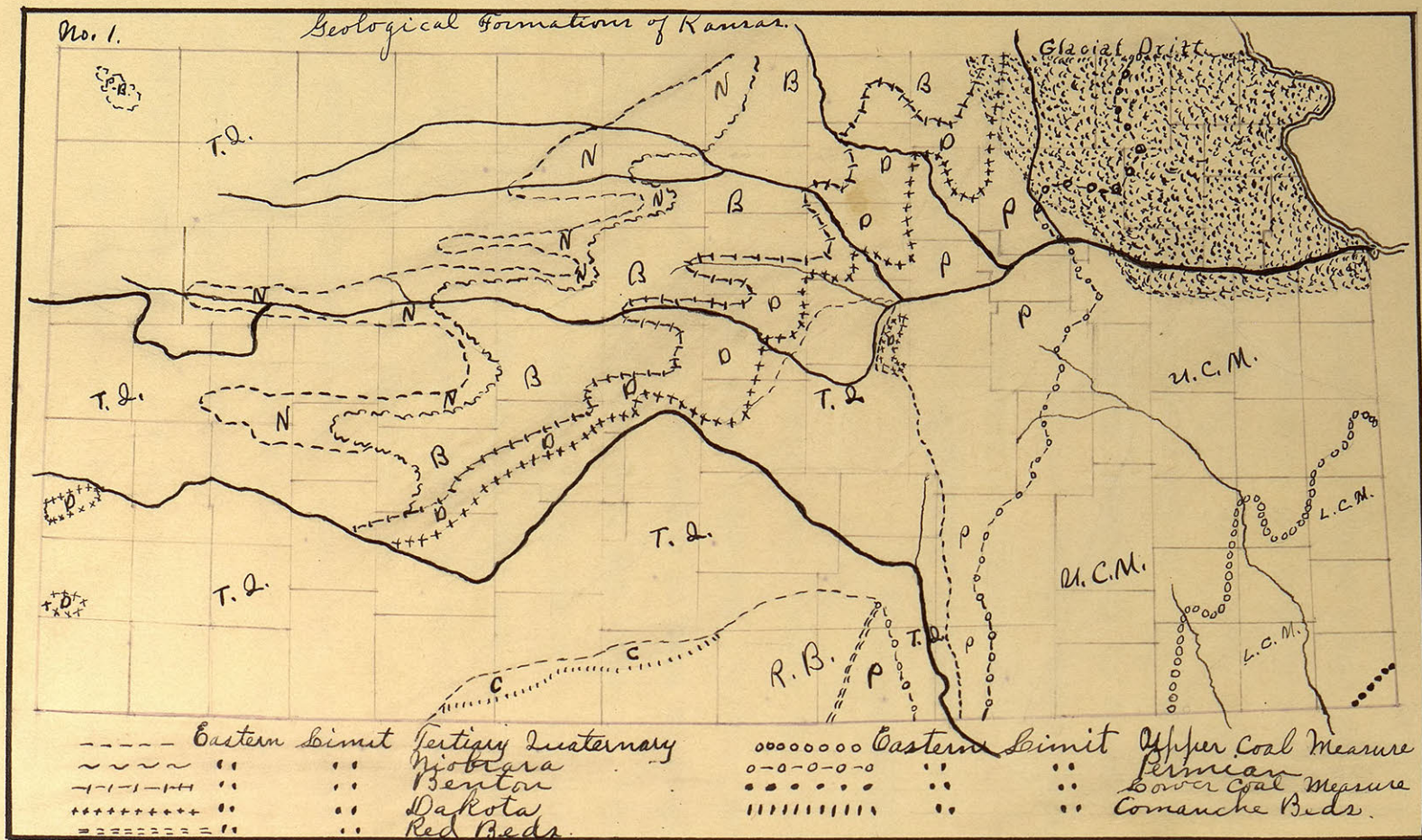
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## I. Introduction.

### General Description of the State.

The State of Kansas lies between  $49^{\circ}38'$  and  $102^{\circ}$  W. longitude and  $37^{\circ}$  and  $40^{\circ}$  N. latitude, and has an extent of about 400 miles in length, and 200 miles in breadth, embracing an area of about 82,080 square miles, or 52,572,160 acres. Its average altitude is about 2,375 feet above sea level. The large streams flow to the south and east, with a gradual fall of about seven to eight feet per mile. Nowhere in the state can there be found a water fall of any great height. The principal rivers are: the Kansas or Kaw, Arkansas, Solomon, Republican, Big Blue, Smoky Hill, Saline, and Verdigris. Kansas has no mountains. Between the river valleys, which are formed by erosion, the surface is that of a gentle, rolling prairie with a few steep hills and bluffs. The soil of the state, both prairie and bottom, is the same fine, black, rich, loam, and only differs in thickness.

## II. Surface Geology.

### a. General Stratification & Origin of Strata.

By Stratified rocks, we mean rocks which are formed in successive layers, of the same or different kinds of materials, and varying greatly in thickness, depending upon the amount of material deposited at the time of the formation. Stratified rocks are generally deposited under water. We all have noticed the weathering and wearing away of our soils, and the materials carried away to the sea by our rivers. If we could examine a section taken from the bottom of the sea, especially shallow parts of the sea near the coast, we should find that the materials are formed in this stratified condition. In the different layers, would be found materials of different kinds. It is quite easy for us to see how these different materials came to be there. All of our great rivers passing through the country gathered

all sorts of materials from the different rocks over which they passed, and carried them to the sea; and here, as the current slackened, these particles gradually settled to the bottom, and formed this great mass of material. Now it is also easily seen how this soft, loose material is changed into a solid state when we consider the great pressure under which it is placed. So from these few observations we draw our conclusions as to the probable formation of our rocks:

1. The time of formation must have been great; owing to the amount of material deposited.
2. That at one time the ocean covered all the land, for the lands are underlaid with sedimentary rocks.
3. That there has been some special action upon the sediments to change them from a earthly strata to stony rocks.
4. That the land was formed by an upheaval of the sea bottom.
5. That the inclination or dip of the strata was produced by a bending or rupturing of the strata during this upheaval.
6. That there must have been a force inconceivably great exerted in the moving of this great mass of material. Since Kansas rocks are stratified, we are naturally led to believe that they were formed according to the same conditions by which all other stratified rocks are formed.

b. Kinds of Strata and their Outcrop.

1. Permian. (Division of Paleozoic Era or Primary formation)

The Permian series extends across the state to Nebraska on the north, and Oklahoma on the south. It is bounded on the east by the outcropping cotton wood limestone. The Permian strata pass under the Red-beds in the southwest and under the Quaternary marlites in central Kansas and under the Dakota sandstone at the north west. Its total thickness is from 800 to 900 feet. For exact locality of Permian see Map I. The strata consists chiefly of limestone and shales. About

130 feet from the base of the Permian, is a large stratum of limestone. Several layers of this consists of soft, white limestone, which is very valuable as building stone. The total thickness of this stratum is 40 feet. Other layers consist of large and small concretions of flint. Seventy (70) feet above this bed of building stone, is a stratum about 20 feet thick holding flint, while still 100 feet above this, is another of a similar character. The names of these are given them from the localities where they are well exposed as: Strong Flint, at Strong City; Florence Flint, at Florence; Marion Flint, at Marion, etc. The strong Flints are crushed and used for ballast. A very valuable building stone is found in the Ft. Riley limestone bed, which lies about 25 feet above the Florence Flints. In the upper portions of the Permian, are found beds of salt and Gypsum, which are mined in central Kansas. The Permian of Kansas afford no coal, tho borings have been made many times in various parts of the state. The strata are very persistent and uniform, which will account for the fact that the bluffs are much more steep and bold in the Permian than in the other strata. A remarkable illustration of this feature of the landscape is seen in the hills of Riley County.

(1) Cimarron Series or Red-Beds.

This group is a division of the Permian. The name of this formation was given to it from the fact that the country underlaid by it is of a conspicuous red color. This gives the landscape a striking appearance, particularly if seen in some bold bluff or cliff. The nearest comparison which could be made would be a landscape in color of red brick dust. This formation consists mostly of sandstones and shales, in which is also found rock salt. Above the salt shales, are red sand-stones after which shales of variegated color predominate for 100 feet in which are found layers of satin spar, selenite, and other forms of Gypsum. Above these shales, is the main Gypsum beds. Succeed-

ing the massive Gypsum are bright red shales and sandstones. An investigation at several localities west of Medicine Lodge river show that the Red-Beds have at least a thickness of 600 feet. This is thot to be a very low estimate.

2. Cretaceous. (Part of Mesozoic Era or secondary formations).

(1) Comanche Series.

All the cretaceous deposits studied south of the Arkansas river will be referred to the Comanche series, with the exception of a few outcropping Dakota. The Comanche Series naturally divides itself into two divisions: the Cheyenne Sandstone, and the Kiowa Shales

The Cheyenne Sandstone, or lower formation, is composed principally of a rather coarse-grained, friable sandstone generally of yellowish gray or whitish color, but frequently found striped with various other colors. The exact thickness is not known, but it varies probably between 40 feet and 55 feet. The out cropping of this formation is usually quite rugged. The layers have been firmly cemented together, but on account of the friable nature of the sandstone, they are easily upon by the erosive agents, and as a consequence they have been carved into pillars, chimney works and many other striking shapes and forms. This formation is very beautiful and affords interesting study.

The Kiowa Shales of the upper formation rests upon the Cheyenne Sandstone. The thickness of this formation varies greatly, but it probably does not exceed 150 feet. The material which composes this formation is mostly shales, and hence it is called Kiowa shales. A thin, hard stratum composed largely of calcareous materila mixed with Gypsum, is generally found at the bottom. Above this is found the very black, thin, argillaceous shales with occasionally thicker layers; while above, these change gradually into those that are coarser and of a bluish black or grayish color.

For exact location of the Comanche Series, see Map. I.

### 3. Upper Cretaceous.

There are four principal divisions of the Upper Cretaceous represented in Kansas, which are, in their order: the Dakota, Benton, Niobrara and Ft. Berre. These will now be briefly discussed separately, in the order of their occurrence.

#### (1) Dakota.

The area covered by this group can also be seen on Map. I. There are no well marked lines of division of this group, but for the sake of discussion, it will be divided into two groups: the Lower and Upper.

The Lower Group is composed of alternate layers of red and white sandstone and argillaceous and arenaceous shales. Small traces of lignite and layers of sandstone are found in the lower shales. Gypsum crystals are usually found near the middle of the bed. The remainder of the lower group consists of alternate layers of shales and sandstones. The sandstones are by far thicker than the shales.

The Upper Group contains some lignite, but is confined to certain localities. It rests upon the gray or white sandstone in the last upper layer of the sandstone group. It varies in thickness from 6 to 26 inches. The lignite is mined, and used for fuel in Republic, Mitchell, Lincoln, Russell, and Ellsworth Counties. A bed of shales very highly saliferous rests directly upon the lignite. It varies in thickness from 15 to 30 feet. From the disintegration of these shales, salt marshes have been formed in many localities. Above the saliferous shales, is a bed of shales containing large quantities of Gypsum crystallins. The bed varies in thickness from 10 to 20 feet. Above these Gypsiferous shales there occurs a thin layer of sandstone, varying in thickness from 8 to 12 inches, which serves to mark the line of separation between the Dakota and the Benton Groups.

#### (2) Benton.



The area occupied by this group can also be seen on Map. I.

The Benton may be divided into two main groups: the Lower, or Limestone; and the Upper, or Shale.

The Lower or Limestone Group is again divided into five principal Horizons namely: Bituminous Shales, Lincoln Marble, Flagstone, Inoceramus, and Fence Post. This will now briefly, be taken up separately and discussed.

The Bituminous Shales forming this horizon vary in thickness from 20 to 40 feet. They are of a dark blue color, and slaty in structure. In some places they extend upward toward the next horizon, and gradually change color from blue to yellow.

The Lincoln Horizon rests directly upon the Bituminous Shales. It consists of from two to five layers of hard flinty limestone, intercalated with shales. The whole group reaches a thickness of 15 feet, but no single layer exceeds a thickness of six inches. It is of a bluish gray color, and is easily eroded.

The Flagstone Horizon rests on the Lincoln Marble. It consists of three or four layers of limestone with shales between. The group has a thickness of about 10 feet but no layer exceeds 8 inches in thickness.

The Inoceramus Horizon rests on the Flagstone, and the average thickness of the group is from 4 feet to 5 feet. It usually contains from 3 to 4 layers, and the layers are about 6 inches in thickness. The bed resembles a mortar bed into which shells have been thrown.

The Fence Post Horizon are the upper most of the lower group. They get their name from the use to which the stones are put. They are used quite extensively for fence posts. In the two countries alone Mitchell and Lincoln there are now 50,000 of these posts in use. Their average thickness is 9 inches.

The Upper or Shale Group consists of two Horizons: the Ostrea,

and the Blue Hills. The total thickness of this Group is about 250 feet.

The Ostrea Horizon lies directly upon the Fence Post Shales. It consists of a bed of argillaceous shales, and is often from 100 feet to 150 feet in thickness. On account of the great number of shells in this horizon, the soil formed from it is very productive. There is, however, a tendency for this to form what we call a "Hard Pan" subsoil which prevents the storing of water.

The Blue Hill Shales, unlike the Ostrea is loosely coherent. This forms a kind of soil we call "Gumbo". Its maximum thickness is 100 feet. They are dark blue in color.

(3) Niobrara.

The Niobrara overlies the Benton, and forms a belt along the Tertiary. Their extent can be seen on Map. I. Its total thickness is from 350 to 400 feet. It has been divided into two groups: the Lower or Ft. Hayes Limestones; and the Upper or Smoky Hill Chalk.

The Septaria beds tie on the upper layer of the Benton Group. It marks the division line between the Niobrara and Benton. It is composed of sphere shaped nodules, which are often hollow having their cavity lined with a crystalline substance, usually calcite, which varies in color from a dark wine to that of a transparent. These are quite often gathered and placed in museums or used for lawn ornaments.

The Ft. Hayes Limestones extend continuously along the banks of the Smoky Hill River, from the mouth of Hack-Berry Creek to the western line of Ellis County. Its total thickness is from 50 to 60 feet. It rests upon the Septeria and upper shale beds of the Benton.

The Smoky Hill Chalk rests upon the Ft. Hayes limestone, and reaches a thickness of 300 feet. They vary in color from a light blue, thin lavender, yellow, and buff, to light red. Erosion has produced many peculiar shapes and forms in this chalk Section.

(4) Ft. Pierre.

The Ft. Pierre rests directly upon the last layer of the Niobrara in northwestern Kansas. The upper shales are dark blue in color, argillaceous, chaffy, and loosely textured. The next layer is usually of a rusty yellow color. Its thickness reaches about 200 feet. There is but little of this group found in Kansas.

4. Mississippian Series.

The area covered by the Mississippian rocks is confined to the southeast corner of the southeast county of the state, as can be seen on Map. I. It contains an area not exceeding 45 square miles; yet this area, small as it is, owing to the vast amount of zinc and lead which it produces, is of great economic importance to the state. The rocks of this Series are composed of limestones and cherts irregularly interbedded with shales appearing in some localities. The chert, however, is the most productive of the ores. From investigation, it is that that the Mississippian underlies the greater part of the coal measures of Kansas. In order to get a complete knowledge of this formation it is necessary to study it outside of the state owing to the small area here exposed.

5. Coal Measures.

The coal measures of Kansas extend over the eastern part of the state, covering about one fourth the entire area, See Map. I. They are composed of a heavy mass of rock almost 3000 feet thick. The strata are composed of alternating beds of limestone, sandstone, and shales. The limestones have a strong resemblance tho by close examination they can be distinguished. The lower layers, being the older, are darker in color, more dense in appearance, finer in texture, more substantial and more highly crystalline than the upper formations.

The shales likewise are similar in general characters from top to bottom of the coal measures. It is, however, possible to distinguish

between them, tho the age of the various kinds cannot be determined by their positions; for we find those of the same color scattered thru- out the whole strata. It is therefore only by regarding a few of the more minute details that we are enabled to decide as to the age of different shales.

The different kinds of sandstones are more easily distinguished than either those of the shales or of the limestones. Those of the lower coal measures are more firmly cemented, and therefore produce a more valuable building stone than any found in the upper coal measures. These coal measures are very important to the state.

#### 6. Tertiary Material in Kansas.

In Kansas the Tertiary material is composed of gravel, sand, black sand, clay and silt, and a small amount of material usually called "volcanic ash". Each of these will now be briefly discussed separately.

Gravel. - The gravels are pebbles varying in size from about five inches in diameter down to the finest pebbles, grading into sand. They are composed of granite, syanite, posphyry, andesite, ihyolite, basalt and quite often of pure quartz. It was at the first thot that the various kinds of pebbles were restricted to certain localities but later investigation shows that it is more than probable that their location is accidental.

Sand - The sand is similar in character to the gravel, but is more largely composed of quartz, since sand is usually principally pure quartz. The sands of Kansas are, however, badly mixed with other materials from the mountains of the west. The shape of the grain is greatly rounded, which indicates a long and extended travel. As to size, they vary from those as large as the finer gravel down to those which are microscopic in size.

Black Sand. - This material can be found distributed here and

there almost everywhere over the tertiary. It is composed almost entirely of black oxide of iron the greater portion of which is granules of magnetite as can be proven by the application of a magnet. The black sand is greatly mixed with other materials. It is usually found in connection with gold mines, and so quite often those who have found this material in western Kansas have been greatly effected by the belief that there must be gold near by. But this conclusion does not necessarily follow, for since this black sand material is so much lighter than the gold particles they would be very apt to be carried further down the mountain than would the gold. This seems to have been the case here in Kansas.

Clay and Silt - The clay and silt of Kansas vary in character from place to place, and also at different depths. Frequently, small beds of pure clay are found, but as a rule, it is mixed with other materials. There has, however, been a small quantity of clay found in Kansas which has a quality equal to any known, with the exception of a slight tinge in color which was caused by decaying organic matter; but generally the clay seems to indicate the absence of organic matter of any kind.

Volcanic Ash - This material exists in small quantities through the tertiary of Kansas. This substance, when closely examined, seems to be composed of irregularly outlined thin flakes which resemble glass in many respects. Its color is variable, passing from a nearly pure white to various shades of white and buff. It is quite often found well stratified. It is usually found covering only a small area in one place, rarely more than a few acres, and there seems to be no connection in its distribution whatever. This material has not been sufficiently investigated to allow any definite conclusion to be drawn regarding its nature, origin, or mode of deposition.

Mortar Bed. - Mortar beds are found in many localities. They

are composed simply of clay, sand and gravel materials, cemented together, usually with calcareous cement.

#### Origin and Mode of Formation of the Tertiary.

It can be stated with certainty that the greater part of the Tertiary materials have come from the Rocky Mountain region of the West. Portions of the mountains have been dry from a very early geological time, and the different erosive agents have worked upon them, producing the ordinary products of decomposition of crystalline rocks, such as sand, pebbles, etc. At first, the elevation of the mountains were slight, which gave an opportunity for the material to accumulate in great quantities, but when the elevation of the mountains became greater, and the drainage system well established, this large mass of material moved eastward and covered this large area.

Much dispute has risen as to whether the Tertiary materials of Kansas were formed by lake or by river deposits. When we come to examine the positions of the sand, gravel, and clay of the Tertiary all over Kansas we find that it corresponds much better to river than to lake deposits; the irregularity of formation succession, the limited lateral extent of the beds of clay, gravel and sand, the steepness of the cross-bedding plains all correspond to river deposits, but not to lake deposits.

It is quite probable that in different localities there existed for a considerable time, small lakes which would form some lake deposits. But when we consider the Kansas Tertiary as a whole, we find that the greater part of this material has been river deposits, while a relative small amount has been of lake deposite.

#### C. Kinds of Soil and Their Sources.

For convenience of description, we will refer the soils produced from rocks in the same vicinity where they now exist as in-

indigenous soils, and those which have been carried from different localities and deposited by rivers, glaciers, etc., as exotic soils. In the coal measures of Kansas, we find both represented. The glacial soils are found in the north eastern corner of the state as can be seen on Map. I. The remainder of the coal measures are of indigenous soils. Indigenous soils are found by the disintegration of the rocks beneath them. There must be both a mechanical and a chemical action take place in the formation of soils. It is necessary that both should take place in order to produce the best soil, and they usually act together. The chemical action is produced principally by moisture and the atmosphere, but it is also further aided by the decay of organic matter. The chemical composition of the soil depend to a great extent upon the composition of the rocks from which they were formed. The rocks are of three principal classes; limestone, sandstones, and shales, with the latter greatly in excess. In the southeastern part of the state, there is a very heavy bed of Cherokee shales which produces a soil light in color, fine in texture, and in dry weather it breaks up into fine dust along the roadside and in cultivated fields. Such soils are usually called from their color and texture "ashy soils". Extending west from this area is the Oswego limestones. There is a great difference between the soils formed from the Cherokee Shales and those formed from the limestone. The color is changed from an ashy gray to a deep black, and it no longer contains this fine texture but is changed to a more coarse, granular substance. This clearly shows that the soils are extremely different in their composition, and their difference in appearance is easily seen. It often happens that the limestone systems are thin and close together, and their decayed products mix with those of the shales to a considerable extent; but where the shale beds are thick, the soil always possesses that ashy gray color. This description has merely included a

brief sketch as to the most common ways that soils are formed.

### III. Economic Geology of Kansas.

In mineral products Kansas is richer than most of us commonly realize. There are many industries in Kansas producing mineral products quite extensively. Each of these products will now be taken up and discussed separately.

a. Coal - The coal industry of Kansas was stated as early as 1866, on a limited scale, and has increased greatly from that time to this. It is the most extensive mining product of the state. It has been of great value to the state. Neither zinc, lead nor salt smelting could be carried on successfully or profitably in the state, were it not for this fuel. The only kind of coal produced is bituminous, or soft coal. Coal mining is carried on to a greater or less extent in the following counties: Atchison, Bourbon, Brown, Chautauqua, Cherokee, Cloud, Coffey, Crawford, Douglas, Elk, Franklin, Labette, Leavenworth, Linn, Lyon, Montgomery, Neosho, Osage, Shawnee, and Wilson.

b. Gold and Silver - No gold nor silver has yet been discovered in Kansas. There is, however, a company called the "Consolidated Kansas City Smelting and Refining Company", established at Argentine, which refines gold, silver, copper and lead, to a considerable extent. The commercial conditions of the industry are such that it is more profitable to have the refiner situated at this place and the material shipped to it from the different localities. The business of the company has increased from time to time, until it has become the largest refinery in the world.

c. Lead and Zinc - The lead and Zinc areas seem to be quite limited in this state, for the only profitable locality which has been discovered is in the southeastern corner of Cherokee County, covering an area of about 16 square miles. This place, however, produces large quantities of lead and zinc of a very fine quality. This indus-



try has had an interesting history in this state, since the time of its first discovery, in 1876. Its value and importance has been steadily increasing, until to-day it is a very important industry.

d. Oil and Gas. - The oil and gas industry of Kansas has been growing quite rapidly the past few years, and especially has the production of natural gas increased. They are thot to be of organic origin. Both the oils and gas of Kansas are of a fine quality. The oil and gas producing area lies in the southeastern part of the state, and embraces about 85,000 square miles.

e. Gypsum - Gypsum is found quite extensively in Kansas. It is used in the manufacture of, "plaster of paris", and is now being used extensively on walls as "stucco" to take the place of common plaster. The two principal forms in which it occurs are; in the form of rock, and in crystalline grains, looking much like sand. This industry has increased wonderfully within the past few years. Many mills are now in operation producing gypsum, which is sent to many places throughout the United States. The localities where it is most plentifully found are: Blue Rapids, Solomon, Hope, Peabody, Newton, and Medicine Lodge vicinity.

f. The Kansas salt beds are of very great economic value to the state and to the surrounding country. The price of salt per barrel has decreased from \$1.22, when salt was first produced in Kansas to 30 cents at the present time. Kansas supplies about 8.5% of the salt of the United States. The limits of the salt of the United States. The limits of the salt area of Kansas are not exactly known, but the only profitable factories in operation are located in the vicinity of Hutchinson, and at Lyons and Kanopolis. There salt beds are located in the permian formation. The two kinds produced in Kansas are rock salt and evaporated salt.

g. Clays - the clays of Kansas suitable for manufacturing pur-

poses are quite abundant. In the north eastern part of the state, the clay loess abounds and thruout the whole eastern part of the state clay is found quite extensively. West of the coal measures, in the Permian, the clay contains less impurities, and valuable clays are also found in the Dakota, Benton and Tertiary formation. Thus far, the clays of Kansas have not been used for the manufacture of the higher grades of ware, but are used in making tiling, paving brick, pressed brick, common brick, and stone-ware. The clay industry is for the most part confined to the eastern part of the state, for in this locality the fuel is more available and cheaper.

h. Building Stone - Kansas has great quantities of the finest kind of building stone. The two principal kinds are: the sandstones and the limestones. There are few of the dimensions sandstones produced, but the flagging sandstones are produced quite extensively in the south eastern part of the state. The limestone is particularly abundant in the coal measures and Permian areas of the eastern portion of the state, and some few quarries are worked further west in the Benton and Niobrara formations. These stones are usually easily quarried and therefore afford a very cheap and durable building material.

i. Hydraulic Cement - This cement is produced from impure limestone. The limestone is exceedingly compact in texture, fine grained, and dark in color. The only place that this cement has been produced in any great quantities is at Ft. Scott, where at present two factories are in successful operation. Dwing to the improved machinery, this cement can be produced so cheaply, that it is being used in all the large cities to the exclusion of lime mortar in brick and stone work.

Table showing Value of Each Mineral Product of Kansas for 1897.

<u>Name of Mineral Product.</u>	<u>Value for 1897.</u>
Coal	\$3,931,707.00
Salt	417,626.94
clay goods	265,320.27
Gypsum	252,811.00
Limestone	173,000.00
Sandstone	23,180.00
Natural Gas	155,500.00
Petroleum	54,000.00
Hydraulic Cement	64,000.00
Lime (Estimated)	65,000.00
Sand(estimated)	<u>45,000.00</u>
Zinc ore yielding Metallic zinc	\$2,795,683.28
Lead ore yielding Metallic Lead	<u>914,963.89</u>
Zinc Smelting	\$2,755,703.20
Argentine Smelting Output	<u>15,077,048.34</u>
<b>Total</b>	<b>\$26,990,543.92</b>

#### IV. Conclusion.

Kansas, looked at from a geological standpoint, is, on the whole, a very interesting subject of study. The treatment of the subject in this review has been of the briefest order and only those points were given which the writer considered most important for a general knowledge of the different formations of the state, and of their economic importance. We find on comparison with other states, about it that Kansas can hold its place in its geological importance. Many of

the most important strata found in the United States are represented in Kansas. The richest localities of the state in mineral products are the eastern and southern parts. Here are found the coal measures, which produce, oil, gas, building stone and coal, which is the most important mineral of the state. Also the Mississippian series in the extreme south eastern corner produces lead and zinc. The Permian Strata in central Kansas produces gypsum, building stone, and salt. A few minerals are found outside this area, but in a general way, it is safe to say that the eastern half of the state is the richest by far in mineral products.

The geological research, extensive as it has been in Kansas, has not as yet been sufficiently extended to completely explore the state. Many localities still remain unexplored. But a sufficient amount has been done to enable one to get a good general knowledge of the various formations and their relative importance to the state.

Geological facts are slowly obtainable, owing to the many difficulties which arise in carrying out a complete investigation of the strata. The state has authorized the "Universally - Geological Survey" to carry on quite extensive work during the past few years, and before long, the State of Kansas will be well known Geologically.