ON THE

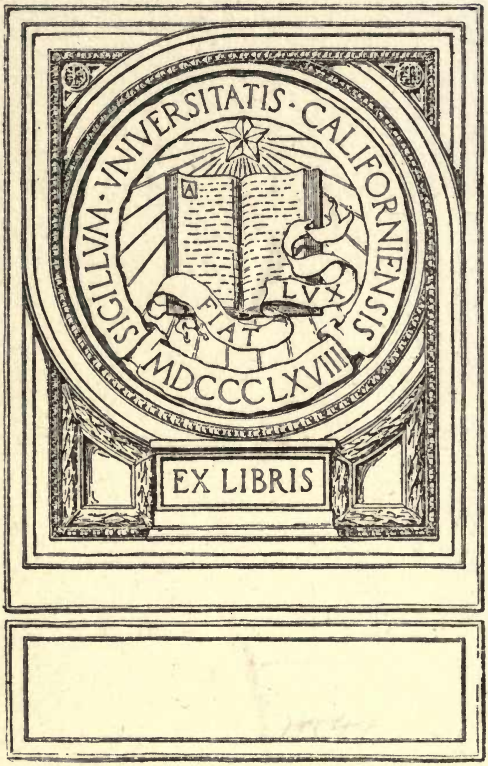
GEOLOGY OF KANSAS.

BY

B. F. MUDGE, A. M.,

PROFESSOR OF GEOLOGY AND NATURAL HISTORY IN THE KANSAS STATE AGRICULTURAL COLLEGE, AND STATE GEOLOGIST FOR 1864.

LAWRENCE:
JOHN SPEER, PRINTER TO THE STATE.
1866.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FIRST ANNUAL REPORT

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To His Excellency, S. J. Crawford, *Governor of Kansas:*

Sir: I have the honor herewith to transmit to you the First Annual Report of the progress of the Geological Survey of the State of Kansas, for the year 1864.

Very respectfully, your obedient servant,

B. F. MUDGE,
State Geologist.

GEOLOGY OF KANSAS.

PART FIRST.

GENERAL PRINCIPLES.

The area of the State of Kansas is 78,418 square miles, or ten times that of Massachusetts, one-sixth larger than Missouri, and about one-third larger than England. The settled portions of the State, embraced within the organized counties, cover 25,000 square miles.

The labors of the first year of a geological survey, under a small appropriation, and over one-third of so large a territory, could be but little more than a general reconnoissance. This allowed so short time to each county that no detailed report of any could be given. On the other hand, the remarkable uniformity of the geological formations, extending even to single stratification, enables us to give the development of each county with sufficient precision to delineate its general geology. No marked disarrangement of the strata has been seen, and from the Coal Measures to the Cretaceous, there is apparently no unconformability. This absence of any geological disturbance accounts, mainly, for the rolling features of the prairies and the almost entire absence of either lakes, ponds or swamps. The few lakes are really but the old beds which the rivers have deserted in forming new channels. Sibley and Silver lakes are examples of this feature. It gives such excellent drainage that we have never seen a swamp which compared with those of the Eastern States, deserved the name. Even the low river bottoms are uncomfortably wet only during the rainy periods. There are no mountains in the State, and no hills that rise very high above the valleys.

The general slope of the country is east, with a slight inclination toward the south. This is seen by the course of the rivers. The mouth of the Kansas river is about 850 feet above the ocean. The rise of the land due west to Manhattan, 107 miles, is very uniform and gradual, and is a little over two feet to the mile;* thence westerly, the rise is similar and but little more rapid. This is shown by the current of the Smoky Hill river, which rises in the western part of the State and flows quietly nearly due east, without any important rapids and but one fall, and that only a few feet.

COAL MEASURES.

The lowest geological formation known in Kansas is represented by the upper portion of the Coal Measures. It is a continuation of the coal field which covers the northeastern part of Missouri, and the southern part of Iowa, and also extends into the Indian Territory south of this State. Like the deposits of those States, the dip of the strata here is to the northwest, passing at a low angle of inclination under the Permian, Triassic and other later stratifications. The Coal Measures cover a larger area of the State than any other formation, being nearly one-third of the whole. The fossils of this epoch are formed over all of the eastern part of Kansas, and exist as far west as Fort Riley.

The line which separates the Coal Measures from the Permian runs rather irregularly in a northeasterly and southwesterly direction. Considering Fort Riley as on the line of average extent westerly, we shall have, (in the width of the State,) the territory of the coal lands 208 miles in length by 107 in average breadth, which gives an area of 22,256 square miles. The extent of the coal regions, in the settled part of the United States, is estimated to embrace about 140,000 square miles. In our calculations we include only the Coal Measures proper, and not the Permian, although the latter belongs to the Carboniferous Age.

* See Appendix.

It will thus appear that Kansas contains one-seventh part of all the coal lands of the United States. We do not, however, intend to be understood that the State contains one-seventh part of the coal, for Pennsylvania has more numerous and thicker working beds. But we shall show, under the head of coal, in Economical Geology, that we have one seam, which, for all practical purposes, is inexhaustable. The question of the area of distribution becomes more important than the quantity to each square mile, when the latter is sufficient for all our wants.

The Coal Measures here have undergone little change, and lie nearly in their natural position. They dip on the average, as before stated, slightly to the northwest. In some parts of the State this inclination cannot be seen, and in some instances there is an anticlinal ridge or dip in the opposite direction. Thus, in Wyandotte county, the strata are nearly level, or have a slight inclination to the southeast. This may be seen by tracing any bed of limestone ten or fifteen miles. The peculiar shale, which is numbered 22 in our section, is seen at the water's edge at Parkville, on the Missouri river; but twelve miles westerly, near the State Penitentiary, at Leavenworth and Atchison it is higher. Most of Jefferson, Leavenworth, Atchison, and the southern part of Doniphan counties, show little variation from a level, and that little is an inclination to the southeast.

Among the greatest angles of dip which we have noticed, is one extending from Lawrence to Lecompton, where, in a distance of ten miles, it is over one hundred feet.

It will be seen that this small disturbance of the strata is very favorable to the opening of coal shafts. No "faults" will be found in the beds, and the probability of reaching the coal at reliable depths at any given point, will be nearly certain. It also gives us a larger area of the coal field, as a higher angle of inclination would soon carry the heads too deep for mining.

This portion of the State also shows a great uniformity in the thickness of the strata. About one-fourth of the whole quantity of the deposit is limestone. South of the Kansas river, the strata show an increase of thickness, particularly in the shales, accompanied with a slight increase of dip. This increase of thickness is very marked in Miami county, as developed by the oil and salt borings.

It is well understood that the extreme upper portion of the Coal Measures does not contain coal of the first quality, or seams of much thickness. Those peculiar favorable conditions of climate, &c., which were so important for the accumulation of vast amount of vegetable matter had begun to change, so that the coal was small in quantity and poor in quality. A fine illustration of this passing away of the peculiarities of the vegetation of the coal period is to be seen in the banks of the Neosho, about three miles below Council Grove. It consists of a stratum of shale, two feet in thickness, full of the remains of the vegetation of the period, but accompanied by a singular commingling of the material with other substances; and the vegetation shows less of the transformation from its original state than that of the true coal beds.

A marked peculiarity of our coal seams is that while the remains of plants are abundantly visible in most every coal stratum, few passably perfect specimens can be obtained. Nor do the shales, above and below the coal, furnish us with any better. Enough can be seen to give the general characteristics of the plants, but scarcely ever can any be found which will designate the species, and, consequently, sufficiently perfect to deserve a place in a cabinet.

SECTION.

The following section of the Coal Measures in Leavenworth county, including 100 feet in the coal shaft and about 200 in the borings connected with the same, will represent very closely the thickness of the strata in the northeastern part of the State, and approximately a large extent south of the same:

No. 32.—10 feet of slope, probably covering shale.

No. 31.—16 feet light gray to buff fossiliferous limestone, sometimes cherty. This is the highest limestone in this vicinity, being the upper bed, near Fort Leavenworth, and from which much of the materials of the

Government buildings have been obtained. This is No. 13 of the Missouri River Section of Prof. Swallow, and is by him, on page 78 of his Geological Survey of Missouri, erroneously put down as No. 1. The first members of his section are not found in the bluffs of the Missouri river in Kansas, or at Parkville, Mo.

No. 30.—16 feet variegated shale, at some places bituminous, varying somewhat in thickness.

No. 29.—3 feet brown, ferruginous, fossiliferous limestone.

No. 28.—18 feet blue and variegated shale.

No. 27.—10 feet blue and gray, coarse grained, fragmentary limestone.

No. 26.—25 feet blue and variegated, calciferous shale. This bed varies in thickness at different points.

No. 25.—10 feet shaly limestone.

No. 24.—8 feet shale and sandstone.

No. 23.—20 feet buff and gray limestone, seen well developed near the landing at Fort Leavenworth, also at Quindaro and various places in Leavenworth, Atchison and Wyandotte counties, just above high-water mark.

No. 22.—4 to 6 feet of bituminous shale. This, with the limestones above and beneath it, forms a well defined geological horizon, easily traced in numerous places in the eastern part of the State, from Kansas river as far north as Doniphan county.

No. 21.—2 feet hard, dark limestone, furnishing larger blocks than any other bed in the northeastern portion of the State, and is much used in heavy work. This lies at the water's edge at Leavenworth and Quindaro.

The above strata can be seen in the bluffs near Leavenworth and other places in the eastern part of the State north of the Kansas river, comprising the highest hills and descending to the water's edge. By the coal shaft at Leavenworth and its borings, sunk under the direction and calculations of Prof. G. C. Swallow and Major F. Hawn, we have a continuation of the stratifications as low as the six feet coal seam; as follows:

No. 20.—77 feet of shale, inclining, near the middle, to sandstone.

No. 19.—4 feet hard, gray and blue limestone.

No. 18.—43 feet blue shale.

No. 17.—13 feet limestone.

No. 16.—24 feet bituminous shale.

No. 15.—5 feet limestone.

No. 14.—13 feet bituminous shale and coal. This is the position of the coal bed which crops out on the Osage river, near where it crosses the State line, and is there about 3 feet thick, and of good quality.

No. 13.—6 feet blue limestone.

No. 12.—15 feet shale.

No. 11.—7 feet hard, gray shale.

No. 10.—20 feet blue and bituminous shale, with a thin seam of coal.

No. 9.—2 feet hard shale.

No. 8.—4 feet hard limestone.

No. 7.—6 feet bituminous shale, and a little coal.

No. 6.—2 feet hard, compact limestone.

No. 5.—7 feet common shale.

No. 4.—2 feet hard shale.

No. 3.—6 feet hard limestone.

No. 2.—15 feet shale.

No. 1.—9½ feet bituminous shale and coal.

This, according to all observations made in the southeastern part of Kansas, as well as in Missouri, as contained in Prof. Swallow's Report of that State, is the position of the thickest and best seam of coal in the State. It varies in thickness from five feet to six feet nine inches. The coal shaft at Leavenworth was commenced in 1863 or '64 to reach this coal bed. To test the situation of the underlying rocks at Leavenworth, boring was first instituted, which verified the geological calculations so closely that an open shaft, eight feet in diameter, was immediately commenced, and by August, 1864, was sunk 100 feet. The labor was then discontinued till September, 1865, and is now renewed.

This Section is a guide to all the northern and eastern part of the State, wherever it may be desirous to sink a shaft for coal. Nos. 21, 22 and 23 can easily be traced, near the waterline of the Missouri river, and in the low ravines twenty miles west of it; and from them the position of the higher strata of limestone can be obtained without much trouble. As we pass south of Johnson and Douglas counties the strata are found to thicken, so that, at the same geological horizon, the depth of the coal seam No. 1 will be greater, the farther south any shaft may be sunk.

For the present wants of the greater portion of our population, coal shafts at Atchison, Leavenworth and Lawrence, by the aid of our various railroads, will yield a ready and cheap supply of fuel. But as population and the consumption of coal increases, coal mines will probably be sunk in all parts of the 22,000 square miles of the Coal Measures of the State.

PERMIAN.

This formation, so little represented in North America, is found well and clearly identified in Kansas. The characteristic fossils have been described by Meak, and Hayden, and Prof. G. C. Swallow. The extent of the area of this epoch, however, has not yet been clearly marked out, but is quite extensive; and future labors are necessary to obtain a full knowledge of its character, or the territory covered by it. The thickness of the Permian was placed, by Prof. Swallow, from observations made during our survey in the valley of Blue river, at 567 feet. Farther west, Major F. Hawn found it to be greater, placing it, according to his section, made in the Smoky Hill valley, 820 feet. See Rocks of Kansas, p. 5.

It consists mostly of calcarious and arenaceous shales and beds of limestone. The latter are frequently quite impure, but, sometimes, massive magnesian limestone is found, which furnishes an excellent building material.

TRIASSIC.

This epoch, and probably the Jurassic, are represented by a belt of territory crossing the Republican and Smoky Hill valleys, the extent of which is not fully known. The fossils, within it, are very scarce and poorly preserved, which renders it difficult to trace the outlines of the formations. The most important indications of animal life which have been found are Ornithichnites, or foot-prints of birds in sandstone. We found but one slab, and that contained only four impressions. The locality from which it was obtained was about fifty miles northwest of Fort Riley, in T. 6, R. 1, east of the sixth principal meridian, on the top of a sandstone bluff, about one hundred and twenty-five feet above the Republican river. The slab was much weathered, which injures the distinctness of the minor markings. There are two species, both three-toed and liptodactylous, and new. They belong to the long-legged waders, the foot-prints of which have been so frequently found by Hitchcock, in the Connecticut sandstones. The length of the tracks are: the larger, five and a half inches, and the smaller, three and three-fourths. Those interested in a detailed scientific description, will find it in an article published in the American Journal of Science and Arts, Vol. XLI., No. 122. We could find no other tracks in the vicinity, yet it is most probable that they will be found in other places, as the deposit has a long extent in a northeasterly and southwesterly direction.

We cannot speak with confidence in relation to the geological age of the strata which contained the foot-prints, as we found no other fossils near the locality, except silicious wood. A few miles distant we discovered some impressions of exogenous leaves, which we suspected were in the same geological horizon as the tracks, but were unable, at the time, to verify it. We are inclined to place the deposit as high up as the Lias.

The beds of sandstone were much changed from their normal condition, principally caused by the presence of oxyde of iron. The stratification is not regular, much of it showing an oblique deposit, with other indications of shoal-water, at the time the tracks were made. When other foot-prints are found, it will become interesting to institute a comparison between the age of the Connecticut valley deposit and that in which these are found. It will throw light on both.

CRETACEOUS.

The Cretaceous Formation is represented rather largely, but no definite examination has been made to show its extent, as it lies mostly beyond the settlements. Chalk is said to have been found within it. In fact, one specimen was shown us, obtained on the upper waters of the Solomon, which had all the fine, loosely-grained texture of true chalk, and we have good reason to believe that an abundance of the article will be found. So far as our knowledge extends, there appears to be a closer resemblance between our Cretaceous and the English than any other in the United States.

DRIFT.

The materials of the Drift epoch, in this State, consist of stones, gravel and sand, usual in other parts of the United States, but in less abundance. The larger stones attain the size of true boulders, being sometimes ten feet in length, and weighing ten or twelve tons. The most frequent are a metamorphic, stratified, quartzite rock. The metamorphic action has been very thorough, giving the boulders a hardness equal to common quartz, and on that account they are frequently known under the name of "hard-heads." They cannot fail to attract the notice of most persons, as they are so unlike any other rock that may be found in ledges, or in the stratified deposits of Kansas. The original stratification of these metamorphic boulders, is shown in the various shades of pink and purple bands, which give many of them a neat, ribboned appearance. The characteristics of the stratification are so much destroyed that no clevage exists in the course of the layers. Sometimes they are dotted with white quartzy pebbles, which were rounded and water-worn before the original stratification. The large boulders are usually angular, and not much worn by water. In this respect there is a strong contrast between them and the small pebbles, indicating different starting points at the time the Drift agency commenced. The pebbles, usually, are also of different materials.

Next to the quartz rock, boulders of green-stone are the most frequently found. A few of granite and sienite are also seen, but seldom as large as those of metamorphic quartz or green-stone. They are also more water-worn and less angular.

Associated minerals are rather rare in the Drift, though cornelian, homblende, feldspar, and, sometimes, agate are found. The deposit is not deep, seldom being seen over two feet, and more frequently only a few inches. The large boulders are found as far south as 38 deg. and 50 min., or ten miles south of the Kansas river, while the small pebbles may be seen twenty-five miles farther, as low as 38 deg. and 30 min. of latitude. The large boulders are found quite numerous in the Potawatomie reserve, on both sides of the Kansas, frequently numbering fifty to the acre. They lie on the tops of the bluffs and high prairies, more frequently than in the lower lands. We noticed one near Mill creek, in Wabaunsee county, on a high bluff about two hundred feet above the valley, which weighed fully eight tons. Some still larger, including one of green-stone, are to be found near Oskaloosa. They are found, more or less abundantly, in all parts of the State above the latitude named.

The original deposit from which these metamorphic boulders were brought, in the great Northern Drift period, is unknown; but their marked appearance is so peculiar, that when the country to the north shall be examined by any geologist who has seen them here, they can be easily identified. Owen, in his Geological Report of Wisconsin, Iowa and Minnesota, has identified the nearest metamorphic rock, on St. Peter's river, Wisconsin, four hundred miles from the most southern boulders in our State. Also, on the western shore of Lake Superior, and Lake of the Woods, from seven to nine hundred miles distant. In Europe, larger boulders than these have been transported, by drift agencies, over more distant points than a journey from Lake of the Woods to Kansas river.

No marks of grooving, stria, or other glacial action has been seen by us on any ledge in the State. The limestones, which crop out in every county, show no disturbance such as a glacier would make. The fragments of the strata in the bluffs or hillside always lay so uniform as to show that nothing but the present quiet agents has aided to drop them even a few feet from their original position. Only in one instance have we noticed a boulder with the marks of stria upon its surface, and that was under such circumstances as showed that they must have been made before it left its northern home. The whole circumstances show that however strong may have been the action of glaciers in drifting these eratics across the country in other places, they could have owed their present position in Kansas only to icebergs.

LOESS, OR BLUFF.

This is well represented in the eastern part of the State, particularly on the banks of the Missouri. At Wyandotte, south of the city, it is nearly one hundred feet in thickness. Extending westward, it grows thinner, and at fifty miles the deepest deposits are not over thirty feet. Still farther west, it almost entirely disappears. It is the same formation so extensively seen in the Missouri and Mississippi valleys. Sir Charles Lyell, in his visit to the United States, decided that it was the same as the Loess of the Rhine, but the fossils do not show a perfect identity between the two formations.

It consists of thick beds of fine, brown marl, often heavily intermingled with clay, so much so as to be used in the manufacture of brick. Its color is owing to the presence of peroxyde of iron. Mingled with the more recent vegetable mould, it forms a rich soil.

To this formation belongs a part, at least, of the bones of the Mastodon, which have been frequently found in the State. A few years ago a part of a large jaw bone, containing three teeth, was fished from a stream near Osawatomie. It was sent to Ohio, and all trace of it is lost; but from the verbal description of those who saw it, the bones must have belonged to the Mastodon. A large tooth was shown us, which was found near Emporia. It was the sixth molar tooth from the lower jaw of the *Mastodon giganteus*, and belonged to a large and old individual. The three anterior ridges were worn through the enamel, and the last down to its base. The os femoris of another, found near Manhattan, is in the cabinet of the State Agricultural College. The smallest circumference of the shaft measures fourteen inches. Both extremities of the bone are gone, but it still measures thirty-three inches in length. Originally, it could not have been less than thirty-eight or nine inches, which would indicate that the entire skeleton measured about eighteen feet in length and twelve feet in height.

We hear of several other instances of portions of the skeletons being found, especially in the western part of the State. This animal, with the elephant, must formerly have been a common tenant of our valleys.

ALLUVIAL.

The Alluvial deposits in Kansas are so similar to those of the other Western States, that no particular description becomes necessary.

The river bottoms are usually broad and level, but well drained. The thickness varies from five to fifty feet. In various places in the valley of the Neosho, unaltered wood has been found at the latter depth, in the sinking of wells. The material of this alluvium, on the surface, is very rich in vegetable matter, and, in many places, furnishes a nourishing soil throughout its whole thickness. In some cases it is, in part, composed of modified drift. At the salt well in Brown county, a metamorphic boulder was found fifty-two feet below the surface.

The humus or vegetable mould of the high prairies is from one to three feet in depth. It is the usual development of the prairie features, so common in the other Western States. It is the same fine, black, rich loam, which has become noted as the most fertile soil in the world. No better exposition of its richness, in Kansas, can be given than to refer to the Agricultural Report of the Patent Office, since Kansas became a State. According to that high authority, in 1865 it was the fourth of the Western States in the production of wheat to the acre. In 1863 it stood with Missouri at the head of the list, and in 1862 and 1864 it ranked entirely at the top of the list. This shows the character of this Alluvial better than any description.

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PART SECOND.

ECONOMICAL GEOLOGY.

COAL.

In a State where, to a great extent, prairie covers the surface of the country, the question of fuel becomes of the first importance. Not only is a cheap and abundant supply material for domestic purposes, but it is equally necessary to drive the steam engine for the manufacture of the hundreds of articles in daily use. In this respect Kansas is amply supplied. In almost every settled county, coal, of varied quality, is found near the surface; and, as we have already shown, the Coal Measures, with good workable seams, underlie about 22,000 square miles of the eastern portion of the State. As much of our coal field is the cropping of the upper measures, it follows that most of the *surface* coal, in all but the southeastern part of the State, will lie in thin seams and be of an inferior quality.

A notice of the surface coal, as it is found in various places, will illustrate this subject. In Republic county, the highest, geologically, being above the true Coal Measures, we find the lignite variety. The thickest seam which came under our observation measured twenty-eight inches; but the middle portion was much mingled with a clay shale, and the upper nish a cheap article, at fair profits, should be at least four feet in thickness.

There are two seams of coal in our State which combine a uniformity in quality and thickness over all those mentioned. The first is seen cropping out on the banks of the Little Osage, in Linn and Bourbon counties, near the Kansas and Missouri State line; and thence in various places in a southwesterly direction across the State into the Indian Territory. It also crosses Missouri in a northeasterly direction, and is mined at Lexington, on the Missouri river. It is a good article of bituminous coal, better, on the average, than the other seams described. Above the strata of coal is about two feet of shale, which is overlaid by a bed of hard limestone that affords an excellent roofing for the mine. The other, and in all respects the most important coal bed, crops out in the center of Cherokee county, crossing Cow creek near its principal forks, and thence running at the surface in a southwesterly direction across the State into the Indian Territory. It measures, in several places where it has been slightly worked, five feet six inches to six feet nine inches in thickness, and averages about six feet. The coal, I am informed, has been taken from Cherokee county to Granby, and other places in Missouri. The bed extends in a northeasterly direction across Missouri, to the northern part of that State. The seam is the same that is wrought at Boonville and near Hudson, on the Chariton, and at both places is about six feet in thickness.* In this State, as in most places in Missouri, it is of excellent quality. In Cherokee county it appears in the open prairie, where there is but little overlaying soil. This is first removed, and the mining is in the open air. Where it is so deep beneath the surface as to require drifting, it is overlaid by shale sufficiently hard to afford a fair roofing.

The last two seams are the best in quality and most persistent in thickness and uniformity of character of any in the State. These, with all the strata of the Coal Formation in Kansas, dip on an average of about three feet to the mile toward the northwest, and are seen as far west as Manhattan and Fort Riley, where they disappear under the more recent

*See Missouri Report, by Swallow.

formations. Consequently, these coal seams underlie the whole of the eastern part of the State to that extent. In fact, every geological indication shows that they lie, conformably, farther west, in a position nearer to the surface than many of the coal beds in England, which are there wrought to supply that country with fuel. These two seams, we hesitate not to say, will hereafter supply the State with coal to the neglect of all others; and perhaps the Osage seam will be ultimately disregarded, and only the thick Cherokee bed worked. They are but a little over one hundred feet apart, in a vertical position; and when once a shaft from the surface has penetrated the strata to the former, the economical inducements will be strong to go an additional hundred feet to the latter, and work in a bed of coal six feet in thickness, instead of one-half as much. The advantages of working in a thick seam, instead of one that is thin, is very apparent. On a vein that is twenty inches thick, in drifting, a man does well to obtain twenty bushels a day. On one thirty-six inches, he can procure sixty to seventy bushels, and if it is six feet he can obtain two hundred bushels. Where the bed is less than four feet, he must spend a portion of his time in removing the shale above or below, in order to make space sufficient to mine the coal, and the removal of this shale is more than his labor on the bed. In addition, the machinery recently invented for mining coal cannot be used to advantage unless the coal is over four feet in thickness.

The objections to deep mining, after the shaft is once opened, is more apparent than real. A man can work as comfortably three hundred feet below the surface as at thirty. The cost of raising the coal three or five hundred feet is very small on each ton. The greatest apparent objection is the trouble which may occur from the influx of water. This, however, is not so great as in many other States. About one-fourth of the total thickness is limestone, and the other three-fourths are shales. The great proportion of the latter is composed of clay,* which does not allow water to penetrate freely. Those who have been obliged to dig deep wells in Kan-

* These clay shales are frequently improperly called soapstone. The latter substance is not found in the State.

sas know how slowly the water percolates these blue shales, and how moderate is the supply in artesian borings. This feature, which is objectionable in wells is favorable in mining. Should any seam of sandy shale allow a free flow of water, it can be closed around the shaft by cement masonry without much expense.

The first cost of the shaft is the only serious item. The price at Leavenworth, by the first contract, was $10 per foot, or $1,000 for one hundred feet of vertical depth. The high price of labor in 1864, made this a loosing business for the contractor. The latter contract is about $17 per foot.

To supply a population of only 5,000 with fuel, it will be cheaper to expend $10,000, or even $15,000 in shafting and machinery to mine a six foot seam of coal, than to work a thin one at the surface. Few are aware of the immense quantity of coal in a bed of this thickness. A few figures will explain it. A seam of coal six feet thick and one mile square, contains 6,000,000 tons of coal, of twenty-eight bushels to the ton. In other words, every farm of a quarter-section, in the eastern part of the State, has under it, in this coal seam, 1,500,000 tons. If we compare the relative value of coal and wood, the result is quite interesting. One ton of coal has been variously estimated as equaling from one and a half to two cords of good dry, hard wood for heating purposes. Take the former figure; then 6,000,000 tons of coal are equal to 9,000,000 cords of wood, or an acre of this coal seam is equal to 14,062 cords of wood. We thus find, if all Kansas, (78,000 square miles,) were covered by a forest affording one hundred cords of wood to the acre, that 557 square miles, or less than sixteen townships of the six foot coal seam, would equal the whole forests of the State. Who can say that our State is deficient in fuel?

It has been found, from statistics, that the consumption of fuel, (aside from that used in manufactories and by steam engines,) is equal to one ton to each inhabitant. On this basis, Leavenworth would require less than 25,000 tons per annum. Allow the city to cover four square miles of territory, and this coal seam at six feet in thickness will supply 24,000,000 tons of coal from under its streets and lots, so that the supply, for all practical purposes, is inexhaustable. We must recollect, too, that rivers do not affect the strata below, and that the coal may be mined under the Missouri river as easily and safely as anywhere else.

Considering the quality and abundant quantity contained in this heavy seam of coal, we cannot too strongly urge all capitalists not to waste their money in endeavoring to procure coal from the thin surface seams. None of them can supply a *cheap* fuel. Let companies be formed in all the large cities to open a shaft at each important point. It will not only supply as cheap fuel for domestic purposes, but steam engines can be supplied at so low a rate that manufactures would soon spring up among us. Coal ought not, when capital and competition engage in this enterprise, to sell in our towns for more than a dime per bushel.

We are informed by several gentlemen of reliability, that there is an extensive bed of lignite coal in the western part of the State, about 125 miles from Fort Riley. It is of the kind found near Richmond, Virginia, and was there mined, during the rebellion, to over a thousand feet. It crops out in a northeasterly and southwesterly course, across the Republican, Solomon, Saline and Smoky Hill rivers, and is represented as being formed in a heavier bed than those in the eastern part of the State. Future geological investigations are necessary to determine the extent and value of this deposit of coal. But enough is known to settle the question that that portion of the State is not deficient in fuel.

LIME.

Good lime is furnished from beds in various parts of the State, and is so common that no particular notice is necessary. We believe every county in the State is furnished with an abundance of this most useful article. The numerous stone houses built from limestone, which may be seen in every town and city, show the quantity and quality of the material. The sections taken in the various portions of Kansas, show that nearly one-fourth part of the strata of the Coal Measures is made up by this stone.

MARBLE.

Marble is but a nice variety of limestone, which has a fine, soft, uniform grain, and is susceptible of a higher polish than the common variety. The best marble is found either in the older formations or in that portion of the more recent which has been subject to igneous action. Our lime strata which furnish the best marble, do not yield large blocks. But, in many cases, slabs may be obtained for all purposes ordinarily required for internal uses or ornaments. They take as high a polish as most of the American marbles, which are found in the markets of our large cities. We have seen specimens from Fort Scott, Mapleton, Garnett, Burlingame, Lawrence, Doniphan county, and other places, which compare favorably with the same article from New England and New York. They are of various dark shades, seldom either white or black. The best which we have seen polished was from the hydraulic lime stratum near Lawrence. This is of various shades of buff, sometimes inclined to brown, often taking a fine mellow tinge which is truly beautiful. No attempt has yet been made to work these various beds, but there is good reason to conclude that, practically, the marble may be applied to any purpose in which the article is used. Undoubtedly, there are many other places in the State where as good marble can be found as at those named. As the wealth of our population increases, there will be a growing demand, which our home quarries can easily supply, without sending beyond the bounds of the State.

HYDRAULIC LIMESTONE.

Hydraulic cement, "cement," or "water lime," is much used in our State. "Roman cement" is a nice variety of the same article. Hydraulic limestone, or that kind of limestone which contains the usual elements necessary to make good cement, is found in various parts of the State. The English Roman cement is made from nodules of magnesian limestone, called Septaria, which are found disseminated through the London clays. These Septaria, like the magnesian limestone, are composed mainly of lime, magnesia, silica and alumina.

In Kansas they are found in numerous places. We noticed many on the banks of the Marais des Cygnes, in Linn county, in Douglas and Wyandotte counties, &c. The purest which came under our observation were at Burlingame, and at Grasshopper Falls, about three miles northwest of the town. They are usually dark brown and of uniform texture, but in a few from Burlingame and Douglas we found the sulphuret * of lead and zinc. They are usually small, weighing from two to ten pounds, but those in Linn county measured thirty inches in diameter. In all the localities they originated in the clay shales. Strata of hydraulic lime are, however, found so frequently in our State, and more easily obtained and worked, that it is not probable that these Septaria will be used, unless their quality should be found superior to the other hydraulic limes.

A bed of brown hydraulic limestone was worked, about eight or ten years ago, by the late Dr. F. Barker, at his farm four miles northwest of Lawrence. Not being familiar with the manufacture of the article, he probably did not succeed as well as a person of experience. Still he made a good cement, which was used by various builders at Lawrence, for cisterns and other similar purposes. Many of the cisterns are still in use, with the cement in good condition. They show a durability which compares favorably with the best Kentucky cements now sold in our State. Dr. Barker was intending to pursue the business more systematically and extensively, when his death closed the operations. No one has worked the bed since his decease. His experiment, so far as it was tried, was perfectly satisfactory, and the stratum has all the qualities of a good hydraulic cement. Should capitalists develop this branch of our resources, it would undoubtedly be a source of profit to them, as well as a benefit to the State. We are now using cement brought from Louisville, Kentucky, a distance, by water, of 750 miles, when as good an article can be manufactured as cheaply here, and the cost of transportation, a large item, could be saved. An additional advantage would also be gained in having the cement ready for use as soon as it is made, as it is well known that it loses its

* Sulphides.

best qualities rapidly after leaving the kiln. Vicat, the best authority on hydraulic lime, says that a larger stock should never be made than is wanted for immediate consumption; otherwise it soon becomes an inferior article.

This stratum is quarried near the top of the bluffs west of Lawrence, for building stone. It yields slowly to the crumbling influence of the atmosphere, and we think will not be found a first class stone for external purposes. It takes a good polish, and makes a pretty marble for mantle-pieces and other ornamented articles. Its color varies from buff to brown, and in many cases gives a fine, mellow shading, equal to the buff Italian.

This bed of hydraulic limestone extends across the country over Leavenworth and Atchison counties, and also southwesterly, nearly, if not quite, to the southerly bounds of the State, and probably it will be found to retain good cement properties in the whole of that extensive area.

The analysis of various limes used in the manufacture of cements, shows quite a difference in the relative proportions of the elements, though producing an equally good article. As the art now exists, a practical test in the kiln and cistern is of far more importance than the analysis, and it is to be hoped that the subject will be thoroughly tested on this bed in various places, so that all our large cities may be supplied from their immediate deposits, without loss or cost from transportation. A very fair, but not critical, test may be made by placing the hydraulic limestone in the upper part of a common lime kiln, and giving it a uniform but lower degree of heat than in the burning of the common limes.

GYPSUM.

Gypsum, or sulphate of lime, commonly called plaster of Paris, or "plaster," is found in numerous places in the State. A bed from four to ten feet in thickness crosses the valleys of the Big Blue and Little Blue rivers, from four to seven miles above their junction. It is seen in the banks of both streams, and has been struck, by sinking wells, at various points between the two rivers. It is of uniform grain and purity, and much resembles the best of the Nova Scotia gypsum that is imported into the ports of New England, and used by the farmers of those States. It has been used in the internal finish of several houses in Marysville, and was found to operate as well as the Eastern plaster, making a nice, white "hard finish" to the walls. When carefully prepared, this coating is very smooth, and may be washed as easily as marble, which it much resembles.

Another bed was traced from near the mouth of the Saline river, on the southerly side of the Smoky Hill, in an easterly direction, more than ten miles. At the point first named, it consists of several strata, from a few inches to two feet in thickness, interstratified with clay shales. Some of these seams consist of beautiful fibrous gypsum, varying from white to pink, and quite pure. At Gypsum creek the bed is massive, amounting to sixteen feet in thickness. Some of it assumes the selenite variety, and other portions contain imperfect imbedded crystals. This deposit is a portion of Nos. 6 and 7 of Meak and Hayden's section of this part of the State.

We are informed that the same deposit is found at other points within twenty miles, even thicker than at the localities named. Gypsum is also found in the vicinity of the salt deposits, on the Solomon, Saline and Smoky Hill rivers.

In the arts, gypsum is applied to a hundred purposes, particularly in taking casts, in stucco work and other ornamental designs for furnishing nice buildings. But more practically it is used by the farmer as a fertilizer, and in this respect it will be invaluable. While it is excellent for crops in various ways, its great worth, to the Kansas soil, consists in its hygrometic quality, or virtue as an absorbant and fixer of certain volatile matters which are useful in plants; and particularly in retaining moisture in a condition that renders it available to the roots of plants; and thus counteracting the drying and evaporating effect of the sun and winds. This is an important quality, which our farmers will readily appreciate, especially in those portions of the State which are liable to drouth. It retains the moisture to such a degree that a crop, particularly of roots, manured with it, will sometimes be saved when an adjoining field will be dried up. Even a single bushel of the powder, on a quarter of an acre of land, will show a decided improvement in the crop. Its effect can usually be seen for several years after it is used.

ALUM.

We have noticed the presence of alum in quite a number of places in the State. At Zeandale it is found in small crystals; also, at several points on Mill creek, in Wabaunsee county. In the eastern part of T. 4, R. 10, west, it is found in connection with a seam of lignite coal. It is associated with native sulphur. A similar deposit is seen on Chapman creek, in T. 11, R. 2, east, about twenty miles west of Fort Riley, with the additional associate of salt-petre or nitrate of potash. It is also found in various places on the southern side of the Smoky Hill, from Salina eastward, over a tract of fifteen or twenty miles in extent. It exists in a sufficient quantity to make a commercial commodity, whenever capital and labor shall become more abundant in our State.

In England, alum is manufactured from alum slate and analogous minerals, in which it becomes necessary to calcine and pulverize the material before the alum can be extracted. But in our deposits the article is so free that the manufacture will be much more easy and economical.

FREESTONE, OR SANDSTONE.

This is found in various beds scattered in most every county. The buildings in Leavenworth, Lawrence and other places attest to its neatness and uniformity of grain. The synagogue, at the former place, shows its good qualities for ornamental carvings.

Aside from its uses as a building material, its adaptation to other domestic articles makes it important. We have seen numerous grindstones made of it, which gave a good, sharp grit. There is such a great diversity in its characteristics in this respect, that great care should be taken in selecting the best; but, when this is done, as good whetstones and grindstones can be made here as are brought by our merchants from St. Louis.

METALS.

So far as we have examined the area of Kansas, the prospects are not flattering that it will ever become a mining State. The geological character of its formations is not favorable for metalic products. But as all our observations have been confined to the eastern half, future investigations on the western frontier may prove more favorable.

Iron.—This metal is found in most all geological formations; but in Kansas, so far as our examinations have extended, the quantity is limited. At a few points some ore has been found. About four miles southwest from Garnett, in Anderson county, is rather a singular deposit of iron ore. It lies above the lime strata, in the open prairie, and is a good article, and of a fair degree of purity. No attempt has been made to develop its extent.

The range of sand rock bluff, two miles west of Clifton, near the borders of Clay and Washington counties, furnishes a large quantity of iron ore. Some portions of the ledge contained but a small percentage, while at other points large quantities contained from twenty to thirty percentage of iron. It is easy of access and mining, masses of it laying loosely on the surface. But the great obstacle in its practical use, is the scarcity of fuel in that vicinity. Timber is not abundant, and the surface coal is of an inferior quality. The iron ore, consequently, cannot be considered as of much practical value.

We have been shown a specimen of the brown hematite iron ore, from the western part of the State, of very superior quality, and containing nearly sixty per cent. of iron. Should the deposit prove extensive and easy of access from our proposed railroad, it would be valuable, even were it necessary to transport fuel to the locality.

Lead.—The usual ore of lead, from which most of the lead of commerce is obtained, is the sulphuret or sulphide. It occurs most abundantly in the Silurian formation. The principal deposits of the United States and Great Britain are found in it. In Missouri, lead exists in the lower part of the Coal Measures. As all the territory of Kansas thus far explored by any geologist shows no rocks so old, the prospect for any paying quantity of this metal in the State is small.

The indications of lead in the vicinity of Potosi, in Linn county, however, deserve a passing notice. Lead has been known, for more than twenty years, to exist there. At Mine creek may be seen excavations which are said to have been made in mining for this ore. Judging from the trees that have grown over the debris thrown out from these excavations, it is probable that the operations were carried on about twenty-five years ago. "Tiff" (calc spar) oxide of manganese, zinc blende and small cubes of sulphuret of lead, are found in the vicinity. We examined the location carefully in the spring of 1864, and were compelled to arrive at the conclusion that the appearance of the deposit was against the probability of lead being found in paying quantities. Since that time some small shafts have been sunk, with no profitable result, although some lead was obtained.

Gold, Silver, &c.—The origin of gold and silver lies in the Igneous rocks, and are only found in the stratified deposits when they have undergone changes consequent upon subterranean heats. As we have yet found no changes of this kind in Kansas, it is useless to expect to find the precious metals in our State. What the western portions will develop we cannot say; but we are sure that the eastern, or settled parts, contain no gold or silver bearing rocks. This is a sufficient answer to all inquiries from those who think they have found traces of these metals in Kansas.

Tin.—Frequent reports have been in circulation that this, usually rare mineral, is found here. Several fine specimens of rich proxide of tin have been, on several occasions, produced by the Indians. As their statements concerning them were, in some cases, not true, it still remains an unsettled question whether they originated in the State. A specimen was presented to Gen. Hugh McGee, of Leavenworth, which, on analysis, proved to be a proxide, containing 76 per cent. It was said to have been found on the banks of the Smoky Hill river.

The geological locality of tin is similar to that of the precious metals, but more restricted in its range. It has been found mostly in veins traversing granite, gneiss, mica-slate and other metamorphic rocks. Until we find these, or some eruptive rocks breaking through the recent strata, we must conclude that it is not native to Kansas. The western portion of the State, however, is so far a geological terra-incognita that it is possible that some local igneous action may have brought tin to the surface. The question is the more important, as none is now found in the United States in sufficient quantities to pay for working.

PETROLEUM.

Petroleum, or mineral oil, is seen in numerous places in the State. The Indians have long been in the habit of collecting it from the surface of springs, and using it for medicinal purposes. It is found most abundantly in Wyandotte county, and the border counties southward as far as the Indian Territory. At Baxter Springs, in the south part of Cherokee county, it is said to be found in considerable quantities. At no point in the counties named is it seen in more than a thin film on the surface, but it is found at so many different places, that it is reasonable to suppose that a large body may exist below. The nature of the clay shales which compose a large portion of the deposits for seven or eight hundred feet below the surface, would not readily allow it to come up, if it were there. Should it be found in paying quantities it is probable that it will be below the Coal Measures.

The oil that is found on the surface of the springs is no criterion of its character in the fountains far below; for the lighter and best products evaporate rapidly as it comes to the influence of sun and air. In a short time, only the heavier elements and impurities remain. This will account for the bitumin ("pitch") found in many places, particularly in Miami county.

It is seen in many places in the State, but not so often as in the border counties named. We have noticed it in Brown, Atchison, Leavenworth and Riley counties, and in the salt territory.

Every one familiar with the history of the oil business is aware of the uncertainty of the results in boring for petroleum. Not one well in ten, even in Pennsylvania, has proved a success. Yet the rich returns of the fortunate wells fully compensate for the loss on the others, and the balance of the enterprise is favorable to the public, although some individuals lose by the operation.

The result of our observations in Kansas is, that the indications are sufficiently strong to justify the expenditure of capital to test the quality of the oil, which certainly does exist to some extent. No one should invest in the business more than he could afford to lose without embarrassment. The question cannot be considered as settled without numerous borings to a depth of eight hundred or one thousand feet.

SALT.

While Kansas is relying for its supply of salt on New York, Michigan and Saginaw, there is an abundance of that article within the State, sufficient, if well developed, to supply the whole valley of the Mississippi, even were its population ten fold greater than at present.

The "buffalo licks" or "tramps" so common in most every county of the State, in most cases owe their origin to the presence of the salt brine, even when it does not appear in the shape of springs at the surface. Numerous wells in various counties, sunk for fresh water, have produced only salt. These cases have occurred at Mound City, Marmaton and Emporia, as well as frequently among the farmers on the prairies. At Osawatomie a case of this kind has been turned to practical benefit, producing an excellent article of salt. The brine, in this instance, was met at a little over 100 feet from the surface. So satisfactory has been the result of the well, that a new company has been formed, which is sinking a larger artesian bore, hoping to obtain a larger supply of brine.

The valleys of the Verdigris and Fall rivers have salt springs which supply part of the local demand, though no exertions have been made to develop the supply. The water from open springs or wells only being used, which is much diluted by the surface streams. No attempt has been made to test the full strength or supply found at any considerable depth. So numerous are the indications of brine at various places, that future efforts will undoubtedly furnish a large quantity of salt from that part of the State.

At Walnut creek, in Brown county, is a large and good spring, which is now occupied by the Leavenworth Salt and Coal Oil Company, and promises to be the most productive in the eastern part of the State. From a series of pumpings made in our presence, we found the supply of brine sufficient to manufacture one hundred bushels of salt every twenty-four hours. The spring is an open well about fifty feet deep, and evidently much diluted with surface water. The strength of water was about double that of the ocean, yielding one bushel of salt from one hundred and seventy-five gallons of brine. The company are now sinking an artesian boring, to go below the influence of surface water.

A very large deposit of crystalized salt exists south of the great bend of the Arkansas river, in which it lies in beds from six to twenty-eight inches in depth. In one instance, two Government wagons were filled in a few minutes, without being moved. The salt is so compact as to require a hatchet to cut it. These deposits are undoubtedly caused by the drying up of salt ponds or salt branches of the Cimmaron river. But this is situated so far from the settled portions of the State, or any regular route of transportation, that at present it is of no practical value. A railroad toward that region would make it of vast commercial importance.

The great supply of salt which is to meet the demand for Kansas and the neighboring States, lies at various points in a tract of country about thirty-five miles wide and eighty long, crossing the Republican, Solomon and Saline valleys. The signs of the deposit are seen in numerous springs, but more frequently in extensive salt marshes.

A description of one of these marshes will be good for large numbers of them, as they are very similar in their formation and appearance. Take that in T. 4, R. 2, west of the sixth principal meridian, in the Republican valley, about seventy-five miles northwest of Fort Riley. It is sometimes called the Tuthill marsh. The valley here is wide, gradually rising to the high prairies, so common in that part of the State. The marsh covers nearly one thousand acres, more or less impregnated with saline matter. About one-third is entirely void of vegetation, which the brine will not allow to grow. It is perfectly level, and at the time of our first visit was as white as a wintry snow field, with a crust of crystalized salt. The marsh is of recent Alluvial formation, composed of sand and loam, from twenty to thirty feet in thickness, brought down by the wash from the high prairies, which rise gradually on three sides. In this alluvium, at various depths, are found the bones of buffalo, deer and antelope, who have probably made this a resort for salt for long ages past, as they are seen to do at the present time. Underlying this is the Triassic rock, which in Europe furnishes so much salt that it is termed the Saliferous system.

The incrustation of salt is frequently three-eighths of an inch in thickness. This is scraped up and used, in its natural state, for salting cattle, &c.; but, for domestic purposes, it is melted by being mixed with about twenty gallons of water to a bushel of salt, when the mechanical impurities, sand, &c., readily settle. The salt is again returned to a solid state by evaporation. The marsh, after scraping, produces a second crop of salt in from five to seven days of dry weather, and after repeated scrapings during the past three years, yields as full a supply as at first. The brine exists in nearly equal quantities and strength in all parts of the marsh, and can be obtained by boring a few feet, or digging pits. No definite salt spring shows itself at the surface, but the supply must come from numerous points below, though coming from one great central reservoir or salt bed. According to the observations of Mr. J. G. Tuthill, who lives near, and has made borings in over one hundred different places, to a depth of twenty or thirty feet, there is a very uniform supply and strength of brine. The water preseved for analysis was obtained by me by a boring made at random. It was found at four feet from the surface. The density, by the salometer, was 24 deg., (6.16 Baume, or specific gravity of 1.0421,) with the thermometer at 60 deg. This should give a bushel of salt for one hundred and thirty gallons of the water, (not counting the impurities,) which is three times the strength of the ocean. It was taken at our second visit, immediately after a heavy rain, which must have diluted the brine.

The marsh receives the drainage of the valley slope, about two miles in width and five miles from the north, and, consequently, the brine as it comes from the source below, must be constantly weakened by so large a body of surface water. That from the north comes down in a stream ten or fifteen feet wide, and about a foot in depth, in a sluggish current and, when near a clump of trees at the north end of the marsh suddenly disappears, and is not again seen till it reappears below the opposite part of the valley, toward the Republican river. A part of this stream, in its subterranean course, may pass unmingled with the salt water; but a large portion must percolate into the loose soil occupied by the brine, and help to dilute what would otherwise be a very strong solution. Every indication tends to the conclusion that by an artesian boring brine can be obtained equal to the strongest now used in any part of the United States. Scarcely any other spring east of the Mississippi gives so strong a brine at the surface. The extent of the marsh also shows that the main source of the salt cannot lie far below. It is a fair inference that the strength of the brine is in proportion to the extent of ground affected.

The soil of this and the adjoining valleys affords excellent farming land, and good fresh water is obtained as soon as the borders of the marsh are passed.

The other salt deposits on the Republican and Solomon rivers and their tributaries, are similar to that above described; extending across the country in a southwesterly direction. The Indian troubles prevented us from visiting those on the Saline river, but from reliable information, from various quarters, they must be as good as any we have visited.

The large quantity of salt, within the tract designated, is evident from the fact that the waters of the Solomon and Saline are so impregnated as to have a saline taste from points eighty miles above their entrance into the Smoky Hill river. The waters of the latter, when the stream runs low, also shows the presence of the brine. The supply of salt sufficient to meet this daily and hourly amount thus carried down must be immense.

STATE SALT SPRINGS.

The twelve State springs lie in this territory, and call for a brief notice.

Spring No. 1 is in S. —, T. 10, R. 6, west of the sixth principal meridian, and covers several springs in the valley of Salt creek, a branch of the Solomon. The indications are not so good as in other places within four miles. The location is so far from any great traveled route that the spring cannot be of practical benefit for many years. Springs Nos, 2, 3 and 6 are good, but are located on Salt creek, above No. 1, and farther from the settlements; and for that reason cannot at present be made available. They are in T. 8 and 9, of R. 8. Springs Nos. 4 and 5 are in T. 13, of R. 1 and 3. By some singular oversight in the location, neither of the two contain any salt spring, or salt deposit of any kind.

Springs Nos. 7, 8, 9 and 10 are all in one large salt marsh, in S. 20, 29, 30, 31 and 32, T. 4, R. 5, and S. 5, 6, 7 and 8, T. 5, R. 5. The marsh covers about three thousand acres, and is so similar to the Tuthill marsh, first described, that no further description is necessary. The brine is found in all parts of the marsh at a few feet below the surface, with equal indications of quantity and strength. They are about seven miles from the Republican river, and nine miles from the projected route of the Union Pacific Railway, Eastern Division. The location is excellent, and springs are valuable. About six miles east of these are Springs Nos. 11 and 12, occupying a salt marsh in S. 7, 8, 17 and 18, T. 5, R. 4, and cover an area of three hundred acres, which, like the other marshes, is void of vegetation. It is, in nearly every respect like the Tuthill marsh, with every indication of a large supply of brine. The nearest point of the Republican is one mile, and the line of the proposed railroad is within four miles.

These springs are all leased by the State, and the six last named will soon be in operation. Could those first named be re-located it would be an important gain to the State. At the time of their location, the commissioners were not allowed to select springs beyond the first guide meridian west of the sixth principal merdian, as the public lands were not surveyed west of that line; while one-half of the salt territory lies there. The whole of that region is now surveyed, and could Congress be induced to allow these springs to be re-located, they could be selected in the Saline valley, within ten miles of the proposed railroad and the road of the present overland express. This is the more important, as salt is now carried over this route to Denver, and the manufacture would be on the nearest point to that market.

The geological position of the salt deposits of the world, in this connection, becomes important. It has been found in the Tertiary formation in Lower California, on the Colorado river, Greece and Western Asia. In the Permian, in parts of England, Ireland and Russia. In the Coal Measures, in Kansas, Valley of the Kanawha, Western Virginia, and at some places in Ohio, Pennsylvania and Michigan. In the Devonian, in Russia, Pennsylvania and Ohio. In the Upper Silurian, in the celebrated Onondaga Salt Group, New York. But the greatest deposits are in the Triassic, the most of the beds of rock salt being found in this formation. In Germany it occurs in the Muschelkalk, or middle of the Triassic. In Ireland, England and France in the Upper Triassic. The celebrated salt mines near Cracow, in Poland, are in the Triassic. This bed has been penetrated over 1,200 feet, and is twenty miles wide and over five hundred miles long.* The bed in Cheshire (Triassic) supplies most of England with salt, and a large quantity is sent to the United States. The following section at this mine is interesting:

No. 1.—2 feet of soil.
No. 2.—3 feet of hard-pan.
No. 3.—36 feet of marl and indurated clay.
No. 4.—7 feet of open gravel.
No. 5.—90 feet of marly earth, with seams of crystalized gypsum.
No. 6.—75 feet of rock salt.
No. 7.—30 feet of stone, containing veins of red rock salt.
No. 8.—75 feet of rock salt.

* Knapp's Chemical Technology, p. 248, vol. I.

No. 9.—15 feet of rock salt. This layer contains less earthy matter than those above or below it, and is the only one worked.

No. 10.—180 feet rock salt. A shaft has been sunk to this depth without passing through the strata.

168 feet of rock and earth.
345 feet of rock salt.

573 feet total.

The immense beds of Cheshire and Poland become more interesting to us when we consider that our main salt territory is in the same geological formation.

The purity of rock salt is exceedingly various. While the crystals are sometimes entirely pure, the beds are so mingled with foreign substances as to be of no value until the salt is dissolved and purified, and then returned to a solid form. In many instances fossil infusoria enter abundantly into its composition.

We are not aware that rock salt is found in paying quantities in any part of the United States except at Holston, Va.

The number of gallons of brine requisite to make a bushel of salt, from springs at the surface, can be seen by the following table:

Kanawha, Virginia,	350
Montezuma, New York,	600
Conemaugh, Pennsylvania,	300
Sciota, Jackson county, Ohio,	700
Shawneetown, Illinois,	280
Harris's Springs, Missouri,	265
Blythes's Springs, Missouri,	340
East Saginaw Salt Company, Michigan, at 70 feet,	2,600
Scribner's, Grand Rapids, Michigan,	392
Sea water, Nantucket,	350
Great Salt Lake,	30
Brown county, Kansas,	about 200
Taylor's Spring, Verdigris, Kansas,	200
Tuthill Salt Marsh, Kansas,	130
Wells after boring from 100 to 1,500 feet:	
Kanawha, average,	77
do best,	32
Onondaga, average,	34
do best,	30
East Saginaw Salt Company,	30
Montezuma, N. Y.,	50
Zanesville, Ohio,	95

Grand River, Arkansas	80
Muskingum, Ohio,	50
Pomeroy, Ohio, at 1,200 feet,	56
Prussian Minden, at 2,515 feet,	165
Rodenberg, Germany,	130
Schonebeck, Germany,	112
Cheshire, England,	25 to 22

MANUFACTURE OF SALT.

The most usual method of making salt, in this country, is by boiling the brine in iron kettles, holding from eighty to one hundred gallons each. A "block," consisting of about sixty, connected so that the brine can flow from those nearest the fire-grate to those more distant, placed in two rows, is the usual arrangement at Onondaga, New York. One fire-grate is sufficient for thirty kettles. After being settled in large cisterns, the water is run into the kettles over the fire, and then flows from one to another, as it becomes boiled down, till saturation and crystalization take place in those nearest the smoke-stack. In the early part of the process the impurities settle in the bottom of the kettles, and form a "pan" so solid that a cold-chisel is required to remove it. Formerly it was the custom to allow the fires to go out once a week, in order to remove this solid mass, which would become an inch thick. This is called bittern. To obviate this, a false bottom or loose inner lining is placed in the kettle, with a handle rising in the center. As the impurities settle, the false bottom is taken out and the "pan" is easily removed without stopping the fire. In the kettles nearest the fire the bittern settles most freely.

As the brine passes into the kettles most distant from the fire, it ceases to boil, till, in the last, the temperature falls to 190 and even 160 deg. As it crystalizes, it is taken out and allowed to drain thoroughly, when it is ready for the market. A block at Onondaga yields forty-five bushels of salt to a cord of good wood. But this is when the brine is very strong, requiring the evaporation of but thirty-five gallons of water to the bushel. Where coal is cheap, as in Kanawha valley, the process by boiling is carried on to great advantage. In that valley, when borings were made, in some instances so copious a supply of gas rushed up that a simple contrivance was made to convey the jet under the boilers, and that saved, in a great degree, the expense of fuel. As some accidents occurred in its use, and fuel is abundant, the use of the gas has been nearly discontinued.

Another method of manufacturing salt is by *graduation.* In this case, high, narrow frames are erected, and the spaces between the open walls filled with thorn bushes or other fagots. The brine is pumped into cisterns placed on the top of the frames, and allowed to trickle slowly down over the fagots, which thus give a large evaporating surface. The brine is allowed to fall five, six or even eight times, according to its strength. As the graduation houses are from thirty to fifty feet high, this operation requires much labor or steam power. A loss, too, occurs (about 12 per cent.) from small drops of brine being blown away. At Nauheim, a glass placed six hundred feet distant was found incrusted with salt. As Kansas is liable to strong winds, this method will not be found advantageous. Should any one desire to try it, he will find it more fully described, with plans and diagrams, in the Patent Office Report for 1857, in Knapp's Chemical Technology, Vol. I., and Ure's Dictionary of Arts, Manufactures and Mines, Vol. II., either of which will give the reader a full idea of the details of the method.

But the best method of manufacturing salt, particularly for Kansas, is by solar evaporation. In this process, the brine is first placed in large and rather deep vats and allowed to settle. The mechanical impurities are thus readily precipitated. The water is then drawn into shallow vats, and as the process of evaporation goes on, portions of the chemical impurities are precipitated. This is owing to the fact that sulphate of lime, and some other substances, are held in solution more firmly and in larger quantities, in weak brine than in strong. In this way frequently three-fourths of the impurities of weak brines are thrown down before the salt begins to assume a solid form. The brine is next drawn into crystalizing vats, where it takes the solid form, but in coarser crystals than in boiling, and is, at Onondaga, for that reason, called "coarse salt," and the boiled called "fine." For table and dairy purposes, it is first ground.

This method of making salt is extensively used in the south of France, the West Indies, and on the coast of the United States. At the salt works of New York, about one-sixth part is made by solar evaporation. It always makes a *better article*, and at Onondaga commands from five to twenty per cent. higher price. The objection to it is that it requires more capital and more time. But, notwithstanding these disadvantages, the cost of making at New York and at Saginaw, Michigan, is not over two-thirds as great for solar as for boiled salt. If solar evaporation is the most economical method in New York, where fuel is cheap and the climate cool and moist, our climate must contribute a decided advantage over Eastern manufactories. At Onondaga, the number of days in the year on which rain falls is one hundred and twenty-two, while the records at Fort Riley show only sixty-eight. The salt territory is even dryer than at Fort Riley. Again, Onondaga and Saginaw are situated about three degrees of latitude farther north, giving a long winter, during which no solar salt can be made, and but little except during the summer months. While here, owing to our well known dry and mild climate, evaporation goes on during most of the year. Blodgett, in his Climatology of the United States, says that the amount of rain in our salt territory is about three-fourths that of New York. But a very great advantage in evaporation is gained in the peculiar dryness of our winds, which can be fully appreciated only by those who have traveled in that part of the State. Buffalo meat, when hung in the summer air, will readily cure without salt. All these causes combined will undoubtedly give an evaporating power three times greater than New York; or, in other words, an ordinary vat or "cover," 16x18 feet, which at Onondaga gives fifty bushels of salt a year, will give us one hundred and fifty. Solar evaporation must then be the most profitable method of manufacturing salt in Kansas. One objection which is raised to solar evaporation is that chloride of calcium will penetrate the wooden vats, even when no crack is visible, and carry with it a portion of salt. It will even penetrate through many kinds of earthenware. As this, however, has a tendency to purify the salt, it nearly compensates for the loss. But the chloride of calcium, by the analysis of the salt, is not found at the Tuthill marsh, and, if found at other points, exists in very small quantities; so the objection does not have much weight when applied to the manufacture of salt in Kansas.

A large portion of the cost of the vats in New York and Michigan is in the sliding covers which are used to protect the brine from rain. At Turk's Island, the south of France and many other places, where solar evaporation is the method employed, no covers are used, as the loss from an occasional rain is not equivalent to the additional cost of preparing the roofs. The amount of rain in our salt territory is only three-fourths as much as at Onondaga, and it may be found to be economy to use open vats only.

The number of "covers" in New York, in 1864, was 43,200, spread over an area of several hundred acres. Should it be found unnecessary to employ them here, a large reduction of capital in carrying on the business will take place. This reduction would probably be sufficient to bring the capital employed in solar evaporation on an equality with that used in the manufacture by boiling.

All brines and salt contain more or less impurities,* such as corbonate of lime, sulphate of lime, sulphate of soda, chloride of magnesium, chloride of calcium, &c. One great object in the manufacture of salt is to free it (or the brine) from these ingredients.

The following table will show the percentage of impurities in the *water* of various springs before boiling, and of the *salt* after boiling:

	Water.	Salt.
Tuthill Marsh, Kansas,	17.09	2.55
East Saginaw Salt Company, Mich.,	23.80	
do do do do do 2d well,	18.66	
Great Salt Lake,	9.36	1.11
Warm Spring, near Great Salt Lake,	20.17	7.05
Sea Water, average about,	23.00	4.00
Onondaga, average of five wells,	5.51	

*In all cases where this word is used, it is intended to include all solid substances other than salt or chloride of sodium.

Kanawha, do three wells,	. . . .	21.55	3.15
Schonebech, Prussia,	. . . . . .	7.07	2.19
Dieuye, France,	. . . .	15.13	1.91

By comparing these results, it will be seen that while all brines, during evaporation, precipitate a portion of their ingredients before they do the salt, and thus aid its purity, different springs vary in this most important characteristic. Other things being equal, weak brines precipitate a larger proportion than strong.

Different substances have a different point of solubility, according to the strength of the brine, being usually more soluable in weak. But their proportion is a constantly varying ratio, dependent on the combinations. Thus, sulphate of lime (gypsum) is most soluble in brine, standing at 12 deg. of the salometer, but combined with other substances may be equally soluble when it is stronger. It will be seen that the brine from the salt marsh precepitates 83 per cent. of its impurities by evaporation.

Various methods have been practiced to remove these impurities. Lime was formerly used, in small quantities, in settling the brine, but as this has a tendency to unite with the chlorine of the salt, and form chloride of calcium, (one of the worst and most unhealthy impurities,) it has now nearly fallen into disuse. Alum, in small quantities, is also sometimes used, and found to be far better, for while "limed" salt and "alumed" salt were placed side by side in the same store house, the former would absorb water from the atmosphere, and become caked almost as hard as stone, while the latter would remain dry and uncaked. This ability to remain dry and loose is one of the best practical tests of the purity of salt; for while pure salt does not absorb water from the air, but remains dry, impure salt absorbs moisture freely, which, in its turn, attracts dust and any light particles of matter. This absorbent power is owing to the presence of the chlorides of magnesium and calcium, which are both remarkably deliquescent. There is another method of purifying salt, considered as good as by the alum process, and as possessing some advantage over it. This is to mix a small amount of common clay with the brine in the settling tanks. This carries a portion of the impurities to the bottom without any chemical union, and in this respect it is preferable to all other purifiers. These three methods have all been thoroughly tested at Onondaga, and so fully has the experience settled the question, that the superintendent, for 1852, says that "the public interests would be promoted by the entire prohibition of the use of lime." He adds, also, the following significant remarks: "It has long been known that if brine is allowed to stand exposed to the air for some days, it needs no other preparation." Large reservoirs, for the latter purpose, could be made at small cost, of clay, which is abundant near all our springs and marshes.

No refining process is used at Turk's Island, or most of the West India Islands.

The cost of making the salt, per bushel, and presenting it to the market at various points, is interesting to manufacturers:

At Valencia, Spain,	.04
At Berre, France,	.05
In the West Indies,	.08 to .12
At Mazatlan, Mexico,	.12
The above are by solar evaporation.	
Kanawha, Va.,	.17

The Saginaw, Michigan, enterprise gives the following items as the cost, at that place, per barrel, by artificial heat, in 1863:

Labor,	.20
Wood,	.35
Barrel,	.35
Packing,	.04
Nails, &c.,	.02
National tax,	.11
Total,	$1.08
Or, per bushel,	.22
Or, per bushel, without barrels,	.15

Cost, by solar method, for 2,000 barrels:

Labor,	$2,000
Barrels,	6,000
Packing, &c.,	1,500
Interest on capital, at 7 per cent.,	3,080
Total,	$14,580
Per barrel,	.73
Per bushel,	.15

Per bushel, without barrel, ...08½

We are informed that this was more than the cost at Onondaga at that time; yet salt, at this time, is selling for $2 per bushel in many parts of Kansas.

We are frequently asked, when a weak salt spring is found at the surface, how far it will be necessary to penetrate into the earth to obtain strong, paying brine. There is no definite rule on this subject, except what is applicable to particular localities. Even in the same locality, various wells meet with brine of different density at the same depth. In most cases, stronger brine can be obtained by boring, provided the supply is reached at a lower level. But a spring at the surface may approach in an oblique direction from a distance, and the boring pass through the upper or diluted portion, and then obtain only fresh water. At Prussian Minden, a very weak brine at the surface, furnished, at 2,515 feet, a bushel of salt to 165 gallons of water. A well in the Muskingum valley, Ohio, which yielded a brine containing a bushel of salt to 600 gallons at the surface, gave a bushel to 50 gallons at 1,000 feet. In the Kanawha valley, springs at the surface giving a bushel of salt to 350 gallons of water, at 750 feet gave a brine yielding a bushel to every 32 gallons, while in the same boring, at a depth of about 1,500 feet there was no increase of strength. A boring at East Saginaw, gave a brine at 70 feet which required 2,600 gallons to make a bushel of salt; but at 639 feet gave a bushel for every 30 gallons of water, the brine standing at 1 deg. in the former, and 90 deg. in the latter case. The Bay City well, at the same place, gave an equally strong brine at 513 feet. The brine at Saginaw is usually strongest at from 500 to 650 feet, beyond which it grows weaker. At Onondaga, New York, the brine averaging 72 deg. by the salometer (35 gallons to a bushel of salt) is found at 310 feet, and after that depth is passed the brine grows weaker. At Liverpool, N. Y., the well is but 100 feet deep. At Pomeroy, Ohio, at 1,200 feet, the brine gives a bushel to 56 gallons.

The most regular increase in boring which has come under our notice, was that of the East Saginaw Company, at a well about three-fourths of a mile northeast of the village, on the banks of the river. It was as follows, viz:

At 90 feet the brine stood at	1° salometer.		At 531 ft. the brine stood at	44° salometer.	
At 102	" " " 2°	"	At 559	" " " 60°	"
At 211	" " " 10°	"	At 569	" " " 64°	"
At 293	" " " 14°	"	At 606	" " " 86°	"
At 487	" " " 26°	"	At 639	" " " 90°	"
At 516	" " " 40°	"			

By these examples from various places it will be seen that no rule exists by which the strength of the brine can be estimated prior to actual test by boring. In the eastern part of Kansas, in the Coal Measures, though good and profitable wells may be found, we cannot expect that any two wells will give brine of the same strength at the same depth. The extensive deposits of the salt group on the Solomon, Republican and Saline rivers, however, give the best reasons to believe that a fixed rule may be found for that geological deposit, similar to that at the Onondaga system. Or, full as probably, a bed of *rock salt* may be penetrated, to which a shaft may be sunk, and the dry salt mined like coal. This idea is favored by the fact that nearly all the large deposits of rock salt are found in the same geological formation, viz: the Triassic. The analysis of the salt from the Tuthill marsh shows the entire absence of chloride of calcium, which is one of the peculiarities of rock salt.

THEORY OF SALT SPRINGS.

The theory of salt springs is this: Below the surface, at various depths, are deposits of salt, either in the form of rock salt or saliferous shales or sandstone, in which the article is more or less disseminated. The surface and subterranean streams of fresh water come in contact with the salt, and are changed to brine. This brine either directly or indirectly rises to the surface. In its course upward it mingles with surface streams or other fresh water, and becomes diluted. On this account the brine, when it issues as a spring, is seldom sufficiently strong for profitable use in salt manufacture. We know of none in the United States which, for anything more than a small local demand, are used in their natural state, or as they are found at the surface. If we can, by any means, bring this saturated brine, before its dilution, to our tanks, we can manufacture a bushel of salt from less than 25 gallons.

This is attempted, and frequently with great success, by boring down below the influence of surface water. The fresh water is kept from flowing in, by tubing, and the brine rises almost to the top of the well.

PURITY OF THE SALT.

An item not to be overlooked in considering the character and value of the Kansas salt, is its relative purity. The analysis of the salt from Osawatomie, made by Dr. C. T. Jackson, of Boston, is as follows, as contained in his letter:

BOSTON, June 28, 1862.

DEAR SIR:—I have made a chemical analysis of the sample of salt sent me by Mr. Chestnut, of Osawatomie, Kansas, and find it consists of—

Chloride of Sodium (pure salt)	97.947
Chloride of Magnesium (Muriate of Magnesia)	0.482
Chloride of Calcium (Muriate of Lime)	0.706
Oxide of Iron	0.500
Sulphate of Soda	0.365
	100.000

The saline spring is uncommonly strong, and with proper methods of manufacture will give an abundance of excellent salt. I remain,

Your obedient servant, &c.,
CHAS. T. JACKSON,
State Assayer.

All of which is respectfully submitted,

WM. CHESTNUT, President.
HENRY D. GILLETT, Vice-Pres't.

A. GOVE, Secretary.

S. N. JORDAN,
CHARLES GALE,
HENRY NEWMAN, } Directors.

This gives about 2 per cent. only of impurities.

The analysis of the *salt* and brine from the Tuthill marsh, made by Prof. C. F. Chandler, of the School of Mines, Columbia College, N. Y., is as follows:

	Salt.	Brine, 100 pts.	Brine, 1 U. S. gal.
Chloride of Sodium	96.689	4.708	2,861.20
Sulphate of Soda	1.959	0.573	348.23
Sulphate of Lime	0.216	0.157	95.41
Chloride of Magnesium	0.300	0.231	140.39
Oxide of Iron		trace.	trace.
Sand and Clay	0.050	0.010	0.61
Water	0.786	94.221	57,327.35
	100.000	99.900	60,773.19

Density of brine, 1.0421—6.16 Baume.
Total saline matter in brine, 5.779.
Chloride of Sodium per U. S. gallon of 231 cubic inches 6.53 oz.

This gives one bushel of solid matter to 110 gallons, or one bushel of pure salt to 130 gallons of brine. The water was taken by me from a boring, within four feet of the surface. The salt, I took from one of fifty *hollow logs*, in which it was being made. The percentage of solid impurities is 2.55, and contains *no chloride of calcium*. No attempt was made to purify the salt, as the parties making it had no previous knowledge of the business. The ordinary market salts of the United States contain from two to six percentage of impurities; a larger portion being nearer the latter than the former standard.

By a recently patented method, a very superior "medicated salt is manufactured at Onondaga, and sold at high prices, under the name of *factory filled*," for table use and dairy purposes. We copy from the report of the Onondaga Salt Springs the analysis:

Chloride of Sodium	97.600
Sulphate of Lime (combined)	1.124
" " (free)	0.227
Sulphate of Magnesia	0.077
Carbonate of Lime	0.162
Water	0.810
	100.00

This gives but 1.60 per cent. of solid impurities. The celebrated "Stoved Ashton salt," of England, contains about the same quantity. They are acknowledged to be the best salts in the world, and are prepared with great care. It will be seen that our unrefined salts are not far inferior.

We give below a statement of the impurities of various commercial salts:

Foreign.	Per cent.
Salz	3.12
Chateau Salins, France	2.12
Sea Salt of St. Malo	4.00
"Common Scottish"	6.45
St. Ubes, best	2.36
" 2d quality	7.21
" 3d quality	11.04
Droitwich, England	3.17
Domestic.	
Kanawha, best of six analysis	1.85
" poorest of six analysis	6.07
" average of six analysis	3.15
Great Salt Lake, (G. H. Cook)	1.11
Onondaga, average	2.59

Salt Marsh, Kansas*	2.55
Osawatomie, "	2.05

Those who are interested in the analysis of salt will find in the New American Cyclopœdia, and in the Annual Report of the Superintendent of the Onondaga Salt Spring, statements of the ingredients found in the salts of the principal sources of the supplies of the world. The reader will be struck with the remarkable purity of all or nearly all of the specimens examined. This is so strongly apparent that the conclusion is irresistible that they are choice selections, and not fair samples of the ordinary commercial article sent to market from the various places named. Thus, fourteen samples of foreign salt, from Vic, France, Cheshire, England, ("fine common," British bay, fishery, rock salt, "common,") from Holland, Auguilla, Curacao, St. Kitts and St. Martins, are found to contain less than 1 per cent. of impurities, and ten of them having no chloride of calcium, and the other four only a trace. Cheshire "extra rough common" has but 1.48 per cent. only. And among the most impure are the stoved salts, viz: Ashton's, 1.71; Noak's, 3.07; and Garston's, 1.59 per cent. If such were the common articles from those places, and at the lowest prices, would the stoved salt be sent out at high prices, and find ready sale as a very superior article? Nine analyses of American salt, from Pittsburg, Onondaga, Saltville, Pa., Texas, Holton, Va., are also found to contain less than 1 per cent. And seven samples from Onondaga are marked as less than 1.65 per cent. If these were an average, or fair samples, would it pay to refine salt, by a chemical process, at several times the cost of the ordinary but better article, as is done in making the "factory filled?" Men do not pay a high price, when they can get a better commodity for less money. We are therefore compelled to come to the conclusion that the cases quoted are to be considered as choice selections, and not average samples of commercial salt. We are satisfied that the ordinary article found in the Kansas market seldom contains less than 3 per centage of impurities.

* The company at Brown county, Kansas, claim that their salt has but 1 per cent. of impurities, but we do not think that statement reliable.

STATISTICS OF SALT.

The amount of salt consumed in the United States, in 1860, was about 30,000,000 bushels, or nearly one bushel to every inhabitant. A larger quantity per head was used at the North than at the South, so that our Western States consume fully one bushel to each individual. As civilization and the arts increase, this per capita is found to increase in a larger ratio. One-half of our national consumption is imported, and, of the domestic product, New York furnishes nearly one-half. During the four years from 1861 to '64, inclusive, she made, on an average, 7,803,870 bushels per annum. New York salt stands first in the market, which arises principally from its uniform character, and this uniformity comes from the rigid system of State inspection, which Michigan and other States would do well to copy.

Michigan, stimulated by a bonus of ten cents per bushel-commenced the salt manufacture by making 20,000 bushels in 1860, which increased to 2,331,780 bushels; and in 1864 replaced New York salt in the port of Chicago alone to the extent of 1,700,000 bushels. Very little salt is made west of the States of Ohio and Michigan, and Kansas should not only replace the salt from those States, but also in the St. Louis market. We have the natural supply, and the railroad facil ities for doing it. The Union Pacific Railway will be completed to our salt territory as soon as the works can be built, and then the Eastern salts should be met half way in transportation. The present consumption in Kansas is nearly 200,000 bushels per annum, saying nothing about the Denver market, which receives its supply from the East. Missouri, Iowa, Kansas, and the adjoining territory, are estimated to consume 2,500,000 bushels yearly, and the amount is rapidly increasing. We can supply all this and more, and thus add millions of wealth to our State. We predict that ere many years Kansas will become one of the first salt-producing States in the Union. Our salt resources appear to be perfectly inexhaustible.

The abundant supply, our dry climate, and the good market, offer an extra inducement for capitalists to develop this article of daily and hourly consumption.

For an easy and convenient method of finding the strength of brine, instruments are used called hydrometers and salometers. The former, by Beaume, is in common use among scientific men. By simply putting it in any liquid, it shows by a tube graduated from 0 to 100 deg. the density, compared with pure distilled water. By Beaume, saturated brine stands at 26 deg.* The salometer also takes pure water as its standard or 0 point, and pure saturated brine as 100 deg. Consequently, the instrument sinks from 0 to 100 deg., according as the quantity of salt approaches full strength. Thus, brine at 10 deg. by the salometer will give a bushel of salt for every 256 gallons.

The following table, calculated for Beaume's hydrometer, the salometer, percentage of salt and specific gravity, we take the liberty of copying from the Geological Survey of Michigan, (1861) by Winchell. It is at the same time scientific, practical and reliable:

* The specific gravity of pure saturated brine is 1.2046, or about one-fifth part heavier than water.

TABLE,

Giving a comparison of different expressions for the strength of Brine, from zero to saturation.

Salometer.	Beaume...	Specific gravity...	Per cent. Salt......	Grains to 1 pint......	Gallons to 1 bushel....	Salometer.	Beaume...	Specific gravity...	Per cent. Salt......	Grains to 1 pint......	Gallons to 1 bushel....
0	0	1.000	0	0	nfinie	51	13.26	1.095	13.11	1047	46.6
1	.26	1.002	.26	19	2599	52	13.52	1.097	13.36	1070	45.6
2	.52	1.003	.51	38	1297	53	13.78	1.100	13.62	1092	44.7
3	.78	1.005	.77	56	863	54	14.04	1.102	13.88	1115	43.8
4	1.04	1.007	1.03	75	647	55	14.30	1.104	14.13	1137	42.9
5	1.30	1.009	1.28	94	516	56	14.56	1.106	14.39	1160	42.0
6	1.56	1.010	1.54	114	430	57	14.82	1.108	14.65	1183	41.2
7	1.82	1.012	1.80	133	368	58	15.08	1.110	14.91	1206	40.4
8	2.08	1.014	2.06	152	321	59	15.34	1.112	15.16	1229	39.7
9	2.34	1.016	2.31	171	285	60	15.60	1.114	15.42	1252	38.9
10	2.60	1.017	2.57	191	256	61	15.86	1.116	15.68	1276	38.2
11	2.86	1.019	2.83	210	232	62	16.12	1.118	15.93	1299	37.5
12	3.12	1.021	3.08	229	213	63	16.38	1.121	16.19	1322	36.9
13	3.38	1.023	3.34	249	196	64	16.64	1.123	16.45	1346	36.2
14	3.64	1.025	3.60	269	182	65	16.90	1.125	16.70	1370	35.6
15	3.90	1.026	3.85	288	169	66	17.16	1.127	16.96	1393	35.0
16	4.16	1.028	4.11	308	158	67	17.42	1.129	17.22	1417	34.4
17	4.42	1.030	4.37	328	149	68	17.68	1.131	17.48	1441	33.9
18	4.68	1.032	4.63	348	140	69	17.94	1.133	17.73	1465	33.3
19	4.94	1.034	4.88	368	133	70	18.20	1.136	17.99	1489	32.7
20	5.20	1.035	5.14	388	126	71	18.46	1.138	18.25	1513	32.2
21	5.46	1.037	5.40	408	120	72	18.72	1.140	18.50	1538	31.7
22	5.72	1.039	5.65	428	114	73	18.98	1.142	18.76	1562	31.2
23	5.98	1.041	5.91	448	109	74	19.24	1.144	19.02	1587	30.1
24	6.24	1.043	6.17	469	104	75	19.50	1.147	19.27	1611	30.3
25	6.50	1.045	6.42	489	99.7	76	19.76	1.149	19.53	1636	29.8
26	6.76	1.046	6.68	510	95.7	77	20.02	1.151	19.79	1661	29.4
27	7.02	1.048	6.94	530	92.0	78	20.28	1.154	20.05	1686	28.9
28	7.28	1.050	7.20	551	89.5	79	20.54	1.156	20.30	1710	28.5
29	7.54	1.052	7.45	572	85.3	80	20.80	1.158	20.56	1736	28.1
30	7.80	1.054	7.71	592	82.3	81	21.06	1.160	20.82	1761	27.7
31	8.06	1.056	7.97	613	79.5	82	21.32	1.163	21.07	1786	27.3
32	8.32	1.058	8.22	634	76.9	83	21.58	1.165	21.33	1811	26.9
33	8.58	1.059	8.48	655	74.5	84	21.84	1.167	21.59	1837	26.5
34	8.84	1.061	8.74	676	72.1	85	22.10	1.170	21.84	1862	26.2
35	9.10	1.063	8.99	697	69.9	86	22.36	1.172	22.10	1888	25.8
36	9.36	1.065	9.25	719	67.9	87	22.62	1.175	22.36	1914	25.5
37	9.62	1.067	9.51	740	65.9	88	22.88	1.177	22.62	1940	25.1
38	9.88	1.069	9.77	761	64.1	89	23.14	1.179	22.87	1966	24.8
39	10.14	1.071	10.02	783	62.3	90	23.40	1.182	23.13	1992	24.5
40	10.40	1.073	10.28	804	60.6	91	23.66	1.184	23.39	2018	24.2
41	10.66	1.075	10.54	826	59.1	92	23.92	1.186	23.64	2045	23.8
42	10.92	1.077	10.79	848	57.6	93	24.18	1.189	23.90	2072	23.5
43	11.18	1.079	11.05	869	56.1	94	24.44	1.191	24.16	2098	23.2
44	11.44	1.081	11.31	891	54.7	95	24.70	1.194	24.41	2124	23.0
45	11.70	1.083	11.56	913	53.4	96	24.96	1.196	24.67	2151	22.7
46	11.96	1.085	11.82	935	52.2	97	25.22	1.198	24.93	2178	22.4
47	12.22	1.087	12.08	957	50.9	98	25.48	1.201	25.19	2205	22.1
48	12.48	1.089	12.34	979	49.8	99	25.74	1.203	25.44	2232	21.8
49	12.74	1.091	12.59	1002	48.7	100	26.00	1.205	25.70	2259	21.6
50	13.00	1.093	12.85	1024	47.6						

"From this table the properties and capabilities of any brine may be ascertained by knowing its strength as shown by the salometer. Suppose, for instance, the salometer shows 53 degrees. The table shows at a glance that this corresponds to 13.78 degrees of Beaume's hydrometer, a specific gravity of 1.100, and a percentage of 13.62; while a wine pint of the brine would furnish 1092 grains of solid residue, and 44.7 gallons would produce a bushel."

This table is calculated for *pure* solutions of salt. When the strength of the brine is taken by the salometer, the percentage of impurities must be added. Thus, the instrument in the brine at Tuthill's marsh, stood at 23 deg., which gives one bushel to 109 gallons; but, adding 17 per cent. for impurities, shows one bushel of pure salt to every 128 gallons, nearly.

APPENDIX.

The following letter from O. B. Gunn, Esq., who, as Chief Engineer, made the first survey for the railroad in the Kansas Valley, is valuable in showing the relative heights of various places in the northeastern part of the State:

ATCHISON, KANSAS, Feb. 11, 1865.

Prof. B. F. Mudge—Dear Sir: Your favor came duly to hand. * * * The rise from Wyandotte to Fort Riley is as follows, starting from low water in the Missouri river at Wyandotte:

Wyandotte to Lawrence, 39 miles, rise 62.022 feet; average, 1.06 feet.
Lawrence to Topeka, 26 miles, rise 60.04 feet; average, 2.03 feet.
Topeka to Manhattan, 50 miles, rise 120.06 feet; average 2.04 feet.
Manhattan to Fort Riley, 17 miles, rise 54.03 feet; average 3.02 feet.
Total distance, 132 miles; total rise, 297.052 feet; average per mile .2.250 feet.

The foregoing elevations are the surface of the water in each case. The distances are by railroad surveys, and are, probably, not more than two-thirds of the distance which the water actually travels.

Starting from low water in the Missouri river at Atchison, the elevations are as follows:

Water in Grasshopper at Muscotah, 164 feet above the Missouri river.
Water in Big Blue at Irving, 317 feet above the Missouri river.

It is about 60 miles from Atchison to Wyandotte, by water. Assuming that the Missouri river falls one foot per mile, which is not far from the mark, it brings the elevation of Atchison, when reduced to the base of the Wyandotte levels, to an elevation of 60 feet; Grasshopper at Muscotah, (same base,) 224 feet; Big Blue at Irving, (same base,) 377 feet; elevation of Big Blue at Manhattan, (same base), 242.022; rise from Manhattan to Irving, 134.078. * * * * * *

Yours truly, O. B. GUNN.

The following elevations are from explorations and surveys for a railroad route from the Mississippi river to the Pacific Ocean—Vol. XI. They are barometrical measurements, taken at camps, and therefore are not so accurate as those given by Mr. Gunn, but are sufficiently so as to show the total rise in crossing the State westerly, and to show the gradual increase of height. The elevation of the camp above the surface of water is not given. The mouth of the Kansas is about 850 feet above the ocean.

Near Shawnee Mission, Johnson Co., long. 94° 30′	above sea,	991 feet.
Cedar Creek, near Olathe,	" "	1,047 feet.
Tecumseh,	" "	1,234 feet.
Ten miles west of Fort Riley,	" "	1,459 feet.
Mouth of Saline river, long. 97° 40′	" "	1,592 feet.
Mouth of Walnut creek, on Arkansas river,	" "	1,872 feet.
Near Arkansas river, long. 99° 35′	" "	2,004 feet.
Fort Atkinson,* long. 100°	" "	2,330 feet.
Santa Fe crossing of Arkansas, long. 100° 40′	" "	2,431 feet.
Near Arkansas river, long. 101° 20′	" "	2,692 feet.
Near Arkansas river, west line of State, long. 102°	" "	3,047 feet.

The result of all the elevations shows a rise for the first hundred miles of a little over two feet to the mile. For the second and third hundred miles, about six feet to the mile, and for the last hundred miles, about seven feet, or a total rise of 2,200 feet in 400 miles. This shows a very easy grade for a railroad route. Elevation of Fort Scott,† 1,000 feet; elevation of Fort Leavenworth, 896 feet.

*From records of the Fort.

†From the Fort records.

ERRATA.

Page 5, line 17, for "northeastern," read "northwestern."
Page 30, lines 30 and 35, for "proxide," read "peroxid."