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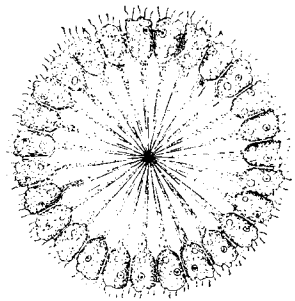
Natural Gas and Oil in Iowa

Charles Rollin Keyes

the form of a shallow polygonal calyx. Each was united to the center of the sphere, the point at which growth began, and from which it proceeded outward along radial lines, by a slender thread of protoplasm which was also inclosed in a delicate chitinous sheath. The colony was free, and doubtless moved through the water with the graceful rolling motion that characterizes colonies of *Uvella* and *Synura*. The movements of the still more beautiful and much more familiar *Volvox globator* will convey to users of the miscroscope a correct idea of a mode of locomotion I fancy they might have witnessed, without the aid of the "tube," in all the sheltered covers of the Upper Silurian period where Cerionites congregated. It is probable that the skeleton was chitinous rather than calcareous. It was flexible enough to undergo extensive deformation without breaking, and exposed parts were frequently decomposed before the entire structure was embedded.



Ideal section of Cerionites (original).

The zoological position of *Cerionites* is less clear than the structure of its skeletal parts. It is scarcely probable, however, that the zooids that inhabited the delicate chitinous thecæ, attained the rank of *Hydrozoa*. It seems more probable that they were rather gigantic *Protozoa*. At all events I know of nothing to render such a view improbable. Some of our modern protozoa are about as large as the smaller individuals of *Cerionites*. Individuals of the genus *Noctiluca* are often a twentieth of an inch in diameter, and the gigantic *Actinosphæria* to which I called attention in the *American Naturalist* for 1890 (Vol. 25, page 934), are even larger. Many of the *Protozoa* secrete a chitinous case or lorica. Many, as *Uvella* and *Synura*, live in spheroidal colonies in which the individuals are attached by bands of more or less modified protoplasm, to the center of the sphere, and in *Synura*, each zooid is contained in a separate membranous sheath which takes the form of calices here conceived to have been present in *Cerionites*. Figures 12 and 13, plate i of Kent's *Manual of the Infusoria*, representing *Megosphæra planula*, approximate very closely the figures that must be made to express my conception of a living colony of *Cerionites*. The figure accompanying this paper is simply an attempt to represent diagramatically an ideal section of such a colony.

NATURAL GAS AND OIL IN IOWA.

BY CHARLES ROLLIN KEYES.

During the past decade no geological question has awakened more popular interest than that of the possibility of finding natural gas and petroleum within the limits of the State. In a number of places shallow borings have yielded from time to time sufficient quantities of natural gas for local use. At some of these places the citizens are kept constantly in a feverish state of expectancy which is ever ready to

burst beyond all reasonable bound at the slightest provocation There is scarcely a county in the State where the problem has not been agitated to a greater or less extent. Some have even gone to considerable expense in testing but without success.

The excitement occasioned by the discoveries of gas and oil in Pennsylvania, Ohio and Indiana was second only to that of gold in California. The rapidity with which the new fuel was utilized everywhere is fresh in the minds of many. The complete revolutions wrought in the various industries are familiar to all.

With gas and oil in abundance in the neighboring states; with a close similarity of geological formations; with an expectant people already testing in different parts of the State, the question naturally arises: What are the probabilities of obtaining these substances in Iowa?

Before attempting an answer, however, it may be desirable to review briefly the conditions of a successful flow. These conditions fall under two heads:

(1) The Origin.

(2) The Accumulation.

Origin.—The different theories concerning the origin of natural gas and mineral oil need not be considered in detail here. Nearly all geologists now believe that organic matter buried in the rocks at the time they were laid down is the real source of petroleum; some regarding it as a kind of distillation through means of moderate heat; some, as the result of decomposition.

Manner of Accumulation.—Contrary to popular opinion petroleum is a widely distributed substance. The well known dolomites of Chicago contain large quantities. Orton has shown that the Waterlime formation, of Ohio, which is a compact magnesian limestone having a thickness of 500 feet in places, contains not less than 2,500,000 barrels of oil to the square mile. This is rock through which the oil is disseminated so as to be perfectly unavailable; yet, if it could be gathered into one place that contained in only three townships would equal nearly 260,000,000 barrels, or the total amount obtained from the Pennsylvania and New York oil field up to the year 1885. Now, in Iowa there are doubtless rocks as rich in oil as the Ohio Waterlime. The Lower Carboniferous limestones in the southern part of this State are good examples.

With oil almost universally distributed, what are the conditions of its accumulation in quantities of commercial value? For the financial success of an enterprise of this kind four conditions must be fulfilled. The absence of any one of them can only result in failure. There must be:

(1) A suitable receptacle or reservoir to allow the oil and gas to accumulate.

(2) A non-porous cover to retain these substances.

(3) A particular geological structure or arrangement of strata.

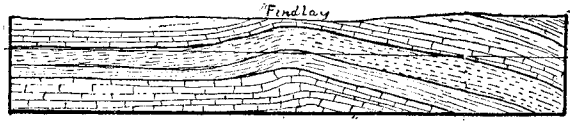
(4) A pressure sufficient to force the oil and gas to the surface.

The Reservoir is commonly a coarse sandstone, conglomerate or porous limestone. These rocks allow the ready transmission of liquids or gases from one part of a stratum to another.

In order that the gas or oil may be retained within the porous stratum, some close grained rock must overlie it. This impermeable layer is usually found in some shale.

Thus far the origin and conditions of accumulation of the oil and gas are to be found almost everywhere on the globe to a greater or less extent—wherever the stratified rocks are laid down. With all these conditions fully satisfied there is another very important factor—geological structure. The rocks must be tilted.

This causes in the porous rock a movement of the water, oil and gas particles—a free mechanical rearrangement. They accumulate in order of their specific gravity —the water at the bottom, then the oil and then the gas at the top. The particular structure of the earth's crust must be ordinarily an arch or anticline. The structure of the great oil belt at Findlay, Ohio, is as follows:



Cross section of the Findlay region. (After Orton.)

It is readily seen that having arranged themselves according to their specific gravities the gas occupies the central portion of the arch, the water the bottom and the oil a space between. When the top of the dome is pierced gas escapes; when the arch a little farther down is drilled into out flows oil; and if the strata near the base of the bow are penetrated only water appears. The formation of the arch is due to the same causes that elevates the mountains. A section across the Appalachians to the Mississippi river shows sharp folds near the center of the uplift. In passing westward the folds get lower and lower until near the great river the strata are almost horizontal.

General section from the Appalachian to the Mississippi River.

In Pennsylvania and West Virginia some of the anticlines are so sharp that the top of the arches are fractured. If ever any gas had accumulated there it escaped long ago. In Ohio the folds are relatively low. They would not be impressed in existing topography, for erosion obscures geological structure of this kind by leveling the country—the elevations much more rapidly than the lowlands.

The next condition to be considered is the presence of rock pressure, as the Pennsylvania drillers term it. It only needs to be stated that according to the best evidence now at hand the pressure is artesian or hydrostatic and is measured by height of the column of salt water that would rise in any well were water struck instead of gas.*

Such, then, are briefly the conditions, the fulfilment of which are necessary for a successful flow of gas and oil of economic value.

Now, which of these conditions are satisfied within the limits of Iowa? Which are not, if any? What are the prospects of striking either substances under consideration in the State?

It has already been shown that large quantities of petroleum are doubtless disseminated through Iowa's rocks, just as elsewhere—the direct evidence being the actual presence of considerable amounts of hydrocarbons.

There is little doubt but that the porous strata or reservoirs and the shale coverings are present. This is indicated by artesian wells already put down in the different parts of the State, as well as by the succession of the beds observable in the northeastern part of the State.

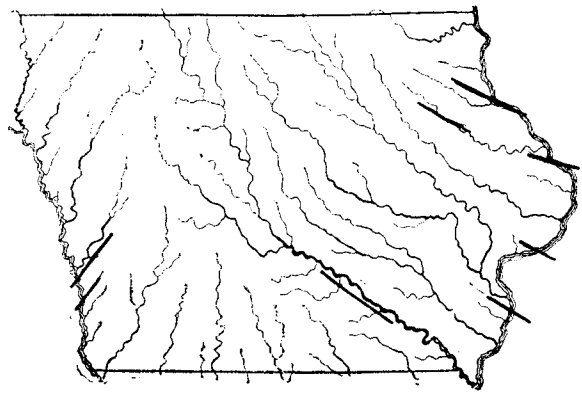
* The preceding remarks on the accumulation of the hydrocarbons are condensed largely from Orton and White who have done more than any other persons to place the oil and gas industry on a scientific basis.

The pressure is sufficient, as is known from several sources.

There remains yet one necessary condition unsatisfied. That is geological structure.

It is well known that the strata in Iowa have a general dip to the southward—the total amount of fall being probably in the neighborhood of 3,500 feet. But the State of Iowa is covered everywhere with a thick mantle of glacial deposits hiding from view the stratified rocks almost entirely. Numerous streams, however, have corraded their channels completely through the drift debris even into the underlying indurated rocks, thus exposing in many places the arrangement of the different layers. It will be sometime before anything like accurate and detailed cross-sections can be made across the State in the direction of the common inclination of the rocks. Yet good progress in this work has already been made.

There is a widespread opinion that the Iowa strata have still their uninterrupted seaward tilt unaffected by deformations of any kind. Such, however is not the case. Although far removed from mountainous districts orographic movements have affected the beds to a slight extent, producing low folds. A number of these low anticlines and shallow synclines have long been known, though rather vaguely. According to McGee, who has indicated recently some of the chief axes in a sketch map of the State, the anticlinals of the eastern part of Iowa trend southwestward. Other folds have been recognized in the central and western portions



Sketch-Map of Iowa, showing Principal Lines of Deformation.

of the State. The extent of this folding is at present unknown, but in some cases it may prove to be very considerable; sufficient perhaps to satisfy the last requirement for a flowing well. It is not then beyond all hope that when, ere long the arching dome of some low anticline is pierced we may yet hear the mighty roar not soon forgotten, or listen to the gushing stream of liquid amber.

IOWA MINERALOGICAL NOTES.

BY CHARLES ROLLIN KEYES.

Pyrite.—Quite recently there have been obtained from limestone cavities in Lee county some small but very perfect pyrite crystals. The faces are brightly reflect-