ART. XIII.—*Note on the Asphaltum of Utah and Colorado;* by GEORGE H. STONE.

DURING the past year the writer has visited all the known asphalt fields of western Colorado and northeastern Utah, save those situated within the reservations of the Ute Indians, and two other exceptions noted below. It is intended at some future time to complete a map of the asphalt exposures and to publish a more detailed account of them than is possible in this preliminary paper.

Petrography of the Deposits.—The following named classes of deposit are represented:

1. *Asphaltic sand-rock*, known also as sand-asphalt and bituminous rock. This is the most abundant of all the asphaltic deposits. It consists of a sandstone the grains of which are in contact with each other and the spaces between the grains are wholly or partly filled with asphaltum. The proportion of asphalt varies up to about 15 per cent by weight and 27 per cent by volume Of course sandstones will contain different proportions of asphalt in their inter-granular spaces since those spaces depend on the sizes and shapes of the constituent grains and often on the presence of other cementing substances. When a bituminous sandstone contains more than about 15 per cent of asphalt, it may be assumed that it has not been under pressure of superincumbent rock sufficient to cause the grains to come in contact with each other.*

The thickest stratum of fully charged rock that I have seen was near 40 feet in thickness. Usually the strata of high grade rock are not more than 4 to 10 feet thick and they alternate with lower grade or barren strata of sand-rock, and sometimes with marls, shales or limestones. Hence the amount of rich rock,—"pay rock"—has often been enormously over-estimated, no account having been made of the poor strata. This is particularly the case with some of the published accounts of the asphalt beds of the valley of Ashley Creek, Utah.

2. *Bituminous Shales or Marls.*—Black or blackish marls or shales cover large areas both in Colorado and Utah. The richer layers have the smell of asphalt, though like Wurtzilite, they are difficultly soluble. The specimens examined by me

* The analyses of the California bituminous rock given in Seventh Annual Report, Wm. Irelan, Jr., State Mineralogist, Cal., 1887, pp. 51–53, show from 1·10 to 8 per cent of fixed carbon, and of volatile carbonaceous matter from 9·40 to 46·20 per cent, with small proportions of lime, etc. An asphaltic sand containing so large a percentage of asphalt as afforded by some of these analyses would probably have been produced by a relatively small quantity of sand being washed or drifted on to an outflow of soft asphalt.

yield no paraffin, or at most a mere trace to solvents and boiling water, and a considerably larger proportion after destructive distillation. They approach cannel coal in composition, but contain a very large proportion of ash, so that none of them contain more than 10, or perhaps 20 per cent of carbonaceous matter. The richer layers are commonly known in western Colorado as "oil rock," and burn readily with a bright, furious flame, leaving pieces of shale having the same size and shape as they had before being burned. These facts indicate that in their natural state these bituminous shales (they all contain so much lime as to be more nearly marls than shales) are asphaltic rather than paraffinic rocks. The richer layers are seldom more than 4 feet thick and are found in the midst of low grade rocks (shales, marls, and limestones). At one place I noted ten of the rich layers each two to four feet thick, distributed at intervals through about 400 feet of rock.

3. *Bituminous Limestones.*—Limestones and marls constitute a large part of the Tertiary rocks of the region under discussion, i. e. of the asphalt-bearing formations. Almost all the limestones are somewhat bituminous, and some strata will burn like the shales. They are colored from gray to yellowish-brown, light color, rather than blackish like the bituminous shales. Usually they do not contain distinct fossils, but are often oolitic, pisolitic or coarser concretionary, i. e. they are semi-crystalline. Fetid layers are not rare, and some of them are particularly offensive. Cavities in the bituminous limestones are often filled with hard asphalt, in some places taking the form of Wurtzilite, in other places Uintaite. The color of the Uintaite varies from the deepest black to brown and even gray-brown. The lighter colors are found in the centers of the lumps or in the cavities less open to the air. I have found asphalt in five classes of cavities in these limestones.

1. In small irregular or somewhat amygdaloidal cavities in fine granular limestone and having no visible outlets.
2. In fractures that cross the strata for only a short distance (gash veins of the miners).
3. In deep fissures (true fissure veins).
4. In caves or channels of subterranean streams, in which the asphalt was brought in after the stalagmitic growths were completed or nearly so.
5. In the interior of shells, or in the cavities found in the centers of concretions and nodules contained in the limestone.

The limestone yields on destructive distillation several per cent of volatile and combustible carbonaceous matter. In all cases unless in the fissure veins and stream caves it is evident that the asphalt must have been derived from the country rock, i. e. a bituminous liquid oozed out of the limestone into the cavities. Since the limestone is of a light color, this liquid must have acquired its dark color during the process of being changed into hard asphalt. This conclusion is confirmed by the lighter color of the least exposed asphalt. Evidently the bituminous matter that is now in the rock is not in the condition of ordinary black asphalt, but the liquid which oozed out of the rock was capable of being changed into such asphalt, hence the bituminous limestones may well be classed with the asphalt-producing rocks.

The rather light color of some of these masses of hard asphalt, which have all the properties of Uintaite except the deep black color, suggests the question whether the color of asphalt be not due to disseminated fixed carbon, in a state approaching charcoal, the product of partial oxidation, more than to the natural color of the hydro-carbons proper. I began some experiments and analyses to determine this point, but the work is incomplete.*

4. *Outflow or Overflow Asphalt.*—Under this class are here included all forms of asphalt that have oozed out of the rock that originally contained them. Some of these had the black color before, others have acquired it since the outflow. I leave it as an open question whether these oils were true asphalts before acquiring the black color.†

Mineralogically the outflow asphalts present the same difficulties of classification as do the petroleums. There are perhaps a dozen different grades in Utah and Colorado that might be described as distinct minerals by those on the alert for new species. The more important generic terms (they are all generic rather than specific) are the following: 1. Maltha, asphaltic tar, brea, mineral tar or pittasphalt. Here are included the viscous liquids. In Utah they all have an aromatic odor and black color. By degrees they harden to a solid, sometimes tough, waxy or horny, sometimes brittle. The

* Mr. S. H. Gilson, of Salt Lake, informs me that he has obtained by distillation of the limestone out of which a mass of Wurtzilite had oozed, a dark yellowish tarry material that closely resembles and appears to be identical with the distillate from the Wurtzilite.

† That the lighter constituents of petroleum can be changed to more viscous oils by protracted exposure to oxygen, appears to have been proved by experiments made some years ago by W. P. Jenney. The same conclusion is enforced by the hardening of the brea of California, also by the finding of asphalt in cavities in the Devonian and Silurian petroliferous rocks (see Report of Professor Edward Orton on the Trenton Limestone as a source of Natural Gas and Petroleum in Ohio and Indiana. Eighth Ann. Report Director U. S. G. S., 86–87). Such asphalt cavities have been observed by Shaler, Newberry, Linney, Orton and others. In the present state of the argument it is permissible to assume as a working hypothesis that the harder asphalts were derived from the softer or pittasphalts, and they in turn from more liquid bitumens. under exposure to the air or perhaps to aerated waters. How much this is quantitatively due to oxygen or other chemical agencies, and how much to evaporation of the lighter compounds, remains to be determined

hardened outflow is known as outflow or overflow asphalt. The maltha is found in small pools, or spread over the ground and often penetrates the spaces between the broken rock of the talus or sub-soil in a complex network of stringers, small veins and sheets. 2. Uintaite or Gilsonite. A brittle, easily soluble and fusible mineral. 3. Wurtzilite, a shining, tough mineral, fusible and soluble with great difficulty.*

Geological Age of the Deposits.—A fissure vein of wurtzilite is reported to be found in a region where none of the U. S. geological maps show rocks later than the Jurassic or early Cretaceous, and the same is true of one area of asphaltic sandrock. I have not examined these deposits and leave their age an open question. All the fields of sand asphalt that I have visited are plainly of Tertiary age. Most of them are in the Green River beds, some may be in the upper part of the Wasatch, and the thick beds found in the Ashley valley appear to be near the base of the very late Tertiary formation marked on Hayden's maps as Uinta and on that of Dr. C. A. White, (Ninth Ann. Report Director U. S. G. S., 87–88) named Brown's Park. The black asphaltic or bituminous shales (marls) are of Green River age. The bituminous limestones, so far as I have observed them, are of Green River and some perhaps are of Upper Wasatch age. The outcrop of the fissure veins of uintaite and some of the wurtzilite are in the Brown's Park rocks and therefore these veins were opened and filled after the Brown's Park epoch—obviously in case of outflow asphalt we have to determine not only the date of origin of the tarry bitumen but also the date of outflow. These fissure veins will be referred to again.

The Bituminous Rocks and Coal Beds.—In one place in the Ashley valley a coal bed about two feet thick has an underclay a few inches thick, and that rests directly on the asphaltic sand rock. The coal is a fair specimen of the Tertiary coals of the region. It is free burning, not caking, and no bitumen

* For a full description of Uintaite and Wurtzilite and their relations to albertite, grahamite and elaterite, see article by Professor W. P. Blake. Proceedings of American Institute of Mining Engineers, Feb. 1890. I have recently learned of a locality where the wurtzilite is said to soften under heat so as to be drawn out into strings that tend to shorten. This grade is very near elaterite in behavior and perhaps is identical with it. The Ute Indians have camped on almost all the uintaite and wurtzilite in this country. The valley of the DuChesne River, also those of the Lower White and adjacent parts of the Green River, are crossed by numerous fissure veins of these minerals, though wurtzilite is more often found as an out-flow product in the talus and scattered drift than in fissures. Both wurtzilite and uintaite are found in a great variety of situations. It is uncertain whether the hardening of the outflow into one or the other of these minerals is due more to original differences in the chemical composition of the outflows or to the physical conditions under which they hardened after the outflow. I have not heard of both minerals being derived from the same outflow. So far as at present known the facts seem to indicate that they are derived from malthas of different chemical composition.

has invaded it or its under-clay from the asphalt layer. The coal abounds in lumps of yellow, partially mineralized rosin, just like most of the softer coals of the mountain region.

In the Wasatch and Roan Mountains I have in several places found coal seams up to eighteen inches in thickness with the bituminous Green River shales and limestones both above and below them. Here the conditions for the formation of coal and asphalt rocks alternated.

Both the bituminous rocks and the coal beds are substantially conformable to the bedding, and both are somewhat lenticular.

A few years ago, Mr. C. A. Ashburner proposed as a basis of classification of coals the ratio of fixed carbon to volatile carbonaceous matter. As I understand it the term "fixed carbon" does not assume that all the carbon thus designated exists in the coal as carbon uncombined with hydrogen, etc., but refers to the residue after destructive distillation. It remains to be determined how far this test will apply to the asphalt. In western Colorado and Utah we find in the carbonaceous minerals all proportions of fixed carbon from one or two per cent in the maltha up to eighty-seven or more in the anthracite. The soft asphalts grade by insensible degrees into the hard asphalts (at least in their physical characteristics) and these in turn into jet, the cannel coals and bituminous shales, and these again into the caking coals, etc. Dana's Text-book of Mineralogy approves the theory that coals are chiefly composed of oxygenated hydro-carbons. In the Rocky Mountain region not only must a scientific classification of the coals take account of the oxygen contained in the different coals, but the industrial classification must do the same also. Many coals of this region when once inflamed will continue to burn for a long time even when protected from the air. This accounts for the long distances the lignites often burn under ground. On East Salt Creek, Col., the burning coal produced a layer of slag of unequal thickness up to twelve feet and the country shows the action of hot waters much like a volcanic region. Several places are known where the coal adjacent to the once burning coal has been changed to a natural coke, and as we go backward from the former fire the coke passes by degrees into the unaltered caking coal.

Origin of the Asphalt.—When the facts as to the Utah and Colorado bitumens are thoroughly collated and discussed, they will throw considerable light on the mooted questions as to the origin of petroleum, asphalt, gas, and other subterranean hydrocarbons. Most other areas were marine, while these deposits were made in the sediments of the extensive lakes which in Tertiary times extended from the Rocky Mountains several hundred miles westward. These rocks will therefore present conditions somewhat different from those of marine beds.

My partial exploration does not yet warrant discussion of all the questions at issue but certain points may here be mentioned.

From Professor Orton's report above cited I extract a few statements of theories.

Dr. T. Sterry Hunt counts limestones the principal source of petroleum and denies that it has been produced by distillation from bituminous shales, while Dr. J. S. Newberry finds in the shales the main source of oil and gas, and vigorously opposes the view that limestones are ever an important source of either. Professors J. P. Lesley, I. C. White and J. D. Whitney favor the theory of the origin of petroleum by the primary decomposition of organic matter, while Dr. Newberry and Professor S. F. Peckham favor theories of secondary distillation. Hunt regards petroleum as indigenous when in limestones, and adventitious in the other rocks, as sandstones and conglomerates.

Since petroleum and asphaltum appear to have so nearly the same origin, it is permissible to discuss them in the same connection, especially as Dr. Newberry has referred the origin of the Utah asphalt to the marine Cretaceous black shales (Fox Hills and Colorado groups).*

Regarding the above stated theories we remark:

1. Certain Tertiary limestones of Colorado and Utah now contain considerable solid bituminous matter and once contained a liquid substance which has oozed out of the rock into cavities where it became changed to hard asphalt. The asphalt occurs as a great number of rather small masses and its aggregate quantity is great. This sort of rock is well exposed in the remarkable cañons of Parachute Creek, Col.

2. Professor Whitney refers the Tertiary bituminous minerals of California to organic matter derived from marine infusorians (quoted from Orton). In the Tertiary lakes of the region under description we might expect there would be drift-wood, many diatoms and fresh-water algæ and possibly infusorians enough to contribute considerable organic matter to the limestones. Irrespective of this source of organic matter, there are great numbers of fossil molluscan shells in the limestones. Hence although the lime rocks are in part non-fossiliferous and in part may be composed of lime precipitated from solution, yet we seem here to find evidence of the presence of organic matter within them sufficient to account for the indigenous origin of petroloidal bitumens according to Hunt's theory.†

3. The black bituminous shales are also to be considered in this connection. Certain layers are quite rich in bitumens.

* Dr. Newberry as quoted by Salt Lake Journal of Commerce.

† This hypothesis is strengthened by the highly probable indigenous origin of the petroleum of the Trenton limestone in Ohio and Indiana. Orton, op. cit.

They are distributed through several hundred feet of shales (or marls) and occasional limestones. Each stratum bears its own proportion of bitumen over large areas. The richer strata are not those nearest the limestones and they alternate with low grade strata. There are no veins or highly bituminized tracts leading from the limestones out into the shales, nor any other field evidence that after deposition the shales were bituminized from the limestones. Indeed these black shales are a very impenetrable rock. When veins of asphalt cross both limestones and shales the asphalt has in no place that I have discovered passed out into the shales and super-charged them.

Certain of the shale strata contain great numbers of imprints of deciduous leaves, water plants and insects, larvæ, etc. The carbonaceous matter of the leaves is not in the form of asphalt, but of charcoal or free-burning coal and contains quite a large proportion of fixed carbon. It is thus proved that certain strata contained a large amount of organic matter. As above noted there are occasional thin coal beds in the midst of the bituminous shales, but they do not contain more than the average quantity of bitumen found in the coals of the period. Evidently the conditions for the production of coal are very different from those that produce oil and asphalt, but the surprising thing is that we do not find the two conditions passing into one another by transitionary steps.

Thus there is no proof that the shales were bituminized from the limestones and the coals have only their indigenous bitumen and volatile carbonaceous matter. So far as I have observed, the richer bituminous shales and asphaltic sand rocks are mostly non-fossiliferous and there is no direct evidence of the former presence within them of undecomposed organic matter, except a few shells in the sandstones, and some silicified and ferruginized wood.

4. If, according to the views of Dr. Newberry, the asphalt of the Utah Tertiary beds was derived from the Cretaceous black shales, then it must have passed upward either as a liquid or as a gas.

1. Did the asphalt originate in a liquid that passed from the black shales upward? It is admitted that the black shales contain more or less petroleum, though in general these shales afford only thin films of oil. This may, however, be due to the petroleum having drained off to lower levels during the upheavals incident to the elevation of the mountains. From the top of the Fox Hills rocks to the lowest of the Tertiary asphalt beds there intervene 3000 feet or more of Laramie and Wasatch rocks, mostly sandstone, with thick strata of shales, marls and limestones, also several coal beds, and a very impenetrable iron-cemented sandrock. If a liquid passed up through

these rocks it may have been either by a general diffusion through the inter-granular spaces, or it may have been along fractures or fissures.

Now the coal of this region is no more bituminous than the Laramie and Tertiary coals of other coal fields outside of the asphalt area. The Laramie sandstones of the asphalt area are just like those found outside that area. Nobody has yet reported even one deposit of bituminous rock of Laramie age. It is incredible there should have been any general diffusion of liquid bitumens through so great a thickness of various kinds of rocks, without some of the bituminous matter remaining in those rocks, even after they have drained for ages. Moreover, I do not see why such a supposed ascension of petroleoids should be confined to the area of the Tertiary lakes instead of being spread over all the extensive area covered by the black shales. At Florence, Colo., most of the oil is said to be contained in a stratum of sandstone situated in the midst of the black shales, and if the overlying shale and the Laramie rocks have been sufficient to keep down the oil without a general diffusion into the Laramie sandstones, how could happen such an enormous upward diffusion in the region of the Tertiary lakes?

On the other hand, it may be urged that the oils of the marine black shales passed up along great fissures. The Tertiary lakes in question lay along the southern base of the Uinta Mountains and eastern base of the Wasatch. It is the conclusion of Powell, King and others that the Uinta uplift began at the close of the Laramie period and continued through Tertiary time. Great fissure veins of Uintaite now cross the region south of the Uinta Mountains and the Yampa plateau. The fissures cut down through the Brown's Park, Bridger and Green River beds, and nobody knows how much deeper. The fact that they are situated within 30 miles of where a great mountain range was pushed up to say nothing of the Wasatch uplift to the west, makes it highly probable they go down to profound depths and intersect the marine Cretaceous shales. Did the asphalt or any portion of it come up through these fissures? The details of an hypothesis to this effect would be about as follows: The petroleum of the black shales passed up through the fissures and floated on the surface of the water of the lake. Here it gradually oxidized or at least thickened, acquired a black color and became tarry asphalt. The wind blew it upon the sandy shores where it penetrated the sand. Off shore the mud contained in the water became entangled in the asphalt and sunk, carrying its sticky burden with it.* And even if we assume the indigenous origin of the bitumens

* See description by Dr. Joseph Leidy of the action of the mud of the Schuylkill River, on gas tar. Orton, op. cit.

of the limestones or certain layers of the shales, we may also assume that a part of the bitumens originated as above described, or in some other way from the upward passage of oils through the fissures.

Such an hypothesis certainly accords with some of the facts. The rocks now dip from the Roan Cliffs northward to the DuChesne and White Rivers. The marginal portions of the rocks that were laid down in the Tertiary lake of this region have been removed by erosion. This is the region where a non-conformity would be exposed.* While, then, we do not know with certainty that the rocks at the southern margin of the Tertiary lake near the present course of the Green river dipped northward at the time this lake began to exist, yet it is a very natural supposition that they did so, and that it was owing to an uplift toward the south that the lake was formed. If reservoirs of oil existed in the black shales, a northward dip would tend to prevent their escape southward. And since the supposed fissures would let in the water from the lake as well as let out the oil, it is easy to account for the oil rising to the surface of the lake. The intermittent depositing of the asphalt could then be accounted as due to alternate opening and closing of the fissures, such as would be possible during the great Uinta uplift, or to other accidents of sedimentation.

Now the fissures that are at present exposed are of very late age, being made after the latest rocks were formed in this basin, and after the lake was drained by the Green River, and when the Uinta and Wasatch uplifts were far advanced. It is possible that they are the continuations upward of fissures made in earlier Tertiary time, or we may suppose there were earlier fissures that were at the last covered by the Brown's Park rocks. The present fissures are filled with hard asphalt that once was evidently liquid, and indeed the asphalt grows softer as we go down in the veins and in places is somewhat viscous, even quite near the surface. Where I have examined these veins there is no sign that this liquid has passed out into the wall rock and charged it. The only asphaltic rock exposed in the country bordering the fissures is of very low grade, and there is a very large amount of this impoverished rock in that region. There are no known fissure veins in the country where the asphaltic sand rock is rich. Thus there is no field evidence of the passage of asphalt outward from the fissures, but strong indications that the sand rocks were drained of their maltha to fill the fissures.†

* Such a non-conformity exists at the Grand Mesa east of Grand Junction, Colo., where the Tertiary beds overlie the Laramie.

† At two places in the Ashley valley there are very rich areas of sand asphalt at the foot of slopes of natural dip, as if the maltha had flowed down the slopes

If asphaltic tar as such rose in fissures and sub-aerially poured out over the ground or penetrated the pores of the adjoining sediments, we ought to find the richest areas nearest the fissures. But if oil or asphalt rose to the surface of the lake and then was driven far and wide by the winds and waves, the larger masses of asphalt might be far away from the fissures. The bedding and other structural phenomena would be the same whether this rose from the marine shales through fissures, or was derived from the primary decomposition of the organic matter buried in the sediments of the lake.

The fact that the asphalt was not formed till a considerable depth of Tertiary rocks was laid down, favors the hypothesis that it was derived from organic matter contained in the Tertiary beds. However I leave the matter open; though it must be admitted that thus far I have discovered no field evidence of the passage of oils or bitumens upward from the Cretaceous marine shales to form the asphalts of Tertiary time.

2 Was the asphalt derived from gas brought up to the surface? Professor Orton in the work cited well states the chemical objections to the theory of synthesis of more complex compounds from gas. However it is not my purpose to enter into a general argument, only to note the bearing of the facts discovered in Colorado. There are gas springs on the lower White River. In some places the gas is said to be accompanied by a trace of petroleum, but there is no proof that the one is derived from the other, and there is no deposit of asphaltum forming around the place. I find no field evidence that the asphalt under description originated in gas coming to the surface from below. The surface rocks at these gas springs are the very lowest of the Green River and uppermost of the Wasatch.*

5. Near the Utah line, on the head-waters of West Salt Creek, Col., is a field of sand asphalt which contains concretionary masses of the sand rock cemented with lime and iron, from the size of cherries up to four feet in diameter. The concretions are very compact and impenetrable and are free from asphalt, while the surrounding rock is thoroughly charged

(through the pores of the sand) before it became so hard as at present. In one place a large field of the asphaltic sand rock has been laid bare by erosion. The bed dips about 15°, and under the heat and force of gravity has flowed bodily like a glacier, so as to dip down the sides of ravines of erosion a short distance. Some have described this as over-flow asphalt The flow is not equal throughout the mass, but is more active along certain lines of fracture, so that the upper surface looks like an exposure of basaltic columns, while the prisms are marked one from the other by depressions one to four inches deep that are in some cases partly filled by true out-flow asphalt that has oozed out of the sand. As a body this is a mass of sand cemented by viscous asphalt and having a sort of plastic flow, the units of motion being the prisms except at the prismatic lines where the units are the sand grains.

* Prof. A. Lakes of Golden, Colo., like myself, found no oil at these gas springs.

with it. The concretions must have had their intergranular spaces filled with cement before the asphalt penetrated the pores of the sand around them.

A few miles farther west I found an asphaltic sand rock much cross-bedded. Alternate layers about half an inch thick contained more and less asphalt so that the rock was crossed by darker and lighter bands. The size of the grains of sand was so nearly uniform in the different layers that it did not seem probable some of the layers were originally more porous than others. A better interpretation is that the layers were charged from the surface during deposition of the rock, and the same causes that produced the intermittent deposition charged the layers unequally.

While here asphaltization was probably cotemporaneous with deposition, in the case of the concretionary rock above-mentioned, asphaltization did not take place till after the cementing of the concretions. Geologically this may not have been long. At Thistle, Utah, a sand rock containing molluscan shells is charged with asphalt which has also filled the interiors of the shells. Here the time of asphaltizing is not certain.

In general the small amount of fine sediment and calcareous, ferruginous or siliceous cements occurring with the asphalt in the pores of the sand rock, favors the hypothesis that the rock was charged with asphalt contemporaneously with or soon after deposition, and before it had time to become cemented into a compact, solid rock. All the richer sand asphalt readily softens under heat, proving it has practically no cement but asphalt. Apparently it is the presence of the asphalt that has kept the other cements out. Moreover I do not see how asphaltization of sediments can in general be so nearly parallel with stratification unless the strata were asphaltized successively before new strata were overlaid.

6. Professor Peckham, as quoted by Orton, says: "It seems to me that the different varieties of petroleum are the products of fractional distillation, and one of the strongest proofs of this is found in the large content of paraffine in the Bradford oil under the enormous pressure to which it has been subjected."

Near the same horizon as the most of the sand asphalt are found some thin seams of paraffine, near the top of the Wasatch Mountains. This ozocerite or mineral wax is extractable with solvents and hot water, and therein is quite different from the paraffine that results from the destructive distillation of the bituminous shales of this region. For the fractional distillation necessary to leave the paraffines as residuum, Professor Peckham postulates considerable heat. In the Wasatch area I have failed to find evidence of local metamorphism or unusual heat. The ozocerite beds were deposited after the upheaval of the Rocky Mountains, and before the rising of the

Wasatch. The heat of these revolutions came respectively too early and too late, and I failed to find volcanoes very near. The fact that hard paraffines result from the fractional distillation of petroleum and from the destructive distillation of coals and asphalts would seem to make it probable the Wasatch paraffines resulted from such distillations. The absence of any other evidence of heat from the locality makes the presence of the paraffines more noticeable. The question arises, why should here be found the waxy paraffines, while all around so great quantities of asphalt were produced in rocks of nearly if not the same age? Evidently a great amount of work remains to be done before we can scientifically distinguish between the processes which severally resulted in the formation of coal, the oily and buttery paraffines, and the asphalts. While studying the subject a theory of a somewhat speculative nature has occurred to me. Paraffines have been found in the turpentine of pines.* Paraffines are among the most stable of the organic compounds. The hypothesis is suggested whether this waxy paraffine of the Wasatch region may not be due to that contained in the turpentine of conifers, and that this is a residuum of primary decomposition, all that remains of the original turpentine, the more unstable substances having disappeared. It is a fact that in the Rocky Mountain region the coal contains a large quantity of partially mineralized resin.†

Now if resin (dried and oxidized turpentine) has so long resisted decomposition and mineralization, it becomes by no means improbable that if a turpentine contained paraffine, that very refractory substance might remain after all the other ingredients had become decomposed and changed either to coal or to petroleoids, or indeed oxidized to carbonic acid. This question is evidently part of a larger question: how far were the hydro-carbons of the carbonaceous minerals formed within the living organisms from which these minerals were derived?‡

* Watt's Dictionary of Chemistry, III Supplement, art. paraffine. Also Roscoe and Schorlemmer, Chem., vol. iii, pt. 1, p. 140.

† According to Messrs. Remington and Gilson of Salt Lake City there is in Utah a bed of fossil resin several feet in thickness. It is still soluble in most solvents of resin, but will no longer unite with linseed oil to form a tough varnish. I have seen specimens of the mineral but have not made a field examination of the deposit and do not know its geological age.

‡ Mr. G. P. Wall, quoted by Orton, p. 500, gives a graphic picture of vegetable matter partially changed to asphalt. The description appears to refer to cellulose and woody fiber. What would become of the more soluble products of the plant, such as the oils, resins, paraffines and other non-oxygenated hydro-carbons? They appear to be able to withstand decomposition longer than the cellular tissues, and would certainly be dissolved in any petroleoid produced from those tissues. Would they simply enter into solution or into a chemical synthesis? These and other similar questions need to be solved before we can trace the relationships of the coals, petroleums, asphalts, fossil resins and acids, hard paraffines, etc.

Colorado Springs, March 3, 1891.