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THE PETROLEUM FIELDS OF UTAH

BY *Dr. James E. Talmage.*

THE interest recently aroused and at present manifest with increasing intensity in the probable existence of oil accumulations in Utah and contiguous territory is sufficiently explanatory of the local desire for information regarding the occurrence of oil in general and the value of this natural product.

By "oil" in the sense in which the term is here used is meant the naturally occurring liquid commonly designated as petroleum. Chemically this substance consists essentially of a mixture of various hydrocarbon compounds, which, as the name indicates, are composed of the elements hydrogen and carbon. Of these hydrocarbons there are probably innumerable varieties depending upon the different proportions in which the elements are united or upon the varying arrangement of the constituent atoms.

Hydrocarbon compounds occur in nature as solids, liquids, and gases, and each of these classes may be produced from the constituent elements in the laboratory of the chemist. Solid and semi-liquid hydrocarbons occurring in nature are generally classed as bitumens, including the mineral waxes, also ozocerite, gilsonite, wurtzellite, elaterite and asphaltum, all of which are solid at ordinary temperatures; and maltha or mineral tars. But beside these there are viscid liquids, comprising petroleum proper, and naphtha, as also the many varieties of natural gas.

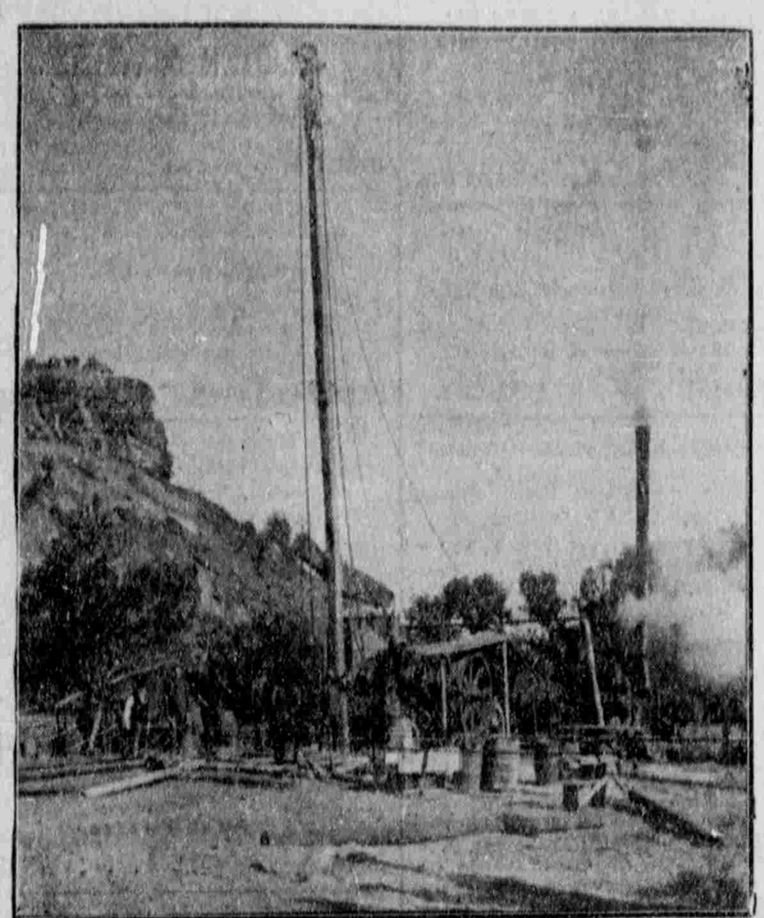
Petroleum, also known as "rock-oil," from the fact that it may be obtained by distillation from certain shales and other bituminous rocks, and as "coal oil" from the belief once general that it is a product of the natural distillation of coal, is a dark colored liquid, usually deep-red or brownish when viewed by transmitted light, and greenish when seen by reflected light. It has been found so limpid and clear as to be suitable for illuminating purposes without artificial distillation or other refining treatment; but usually it occurs as a dense thick liquid containing a large proportion of heavy oils, which are separated in the refinery and are used as lubricating oils and for fuel. As a rule the products of the eastern oil fields are rich in illuminating oils and poor in lubricating material; while the opposite condition is characteristic of oils from the western parts of the United States.

Crude petroleum is refined by distillation and other treatment, from which a wide variety of products result, ranging from the volatile benzine and gasoline, through the different grades of kerosene with varying qualities of inflammability, to the vaselines and solid paraffin waxes. As a by-product, several varieties of paraffin oils are obtained, and the final residue left in the retort is a black porous coke, not essentially different from the coke resulting from the distillation of coal.

Those products are analogous in composition and properties to the natural occurrences, which have been in part already noted.

As to the ultimate origin of petroleum and the exact process by which the oil is found in the laboratory of nature, little can be said with certainty, though in a general way we may have a partial understanding of the matter. It has been conclusively demonstrated that coal is altered vegetable matter. All the many varieties of coal, though differing widely from one another, afford evidence of their vegetable origin; and the natural process of change transforming woody tissue into coal has been investigated, and to a certain extent can be imitated by artificial means. This transformation is not a process of decay in the ordinary sense of the term; it may be described as a partial decomposition, followed by a recomposition among the constituents, the change taking place only when the vegetable matter is kept out of contact with air and in the presence of fresh water.

In a somewhat analogous manner organic matter, either plant or animal tissues or both, if buried away from the air but associated with salt water, is known to undergo a process of change resulting in the formation of one or more of the petroleum series of hydrocarbon minerals. The bodies of fish and other marine animals have been found in a fossilized state in the vicinity of oil-bearing rocks, the animal substance being in many instances almost completely bituminized. This has led to the supposition that fossil fish are the chief source of natural bitumen and petroleum.



San Rafael Oil Company's Property, South of Price, Utah

There is little reason for specifically naming fish bodies in this connection, as any organic matter appears capable of such transformation under favorable conditions; though marine fossils are probably the main source of supply, for, as stated, the association of petroleum and salt water is so general as to warrant the inference that dilute brine, such as sea water, is requisite in the process of formation. Doubtless the bodies of land animals and plants would undergo the bituminizing change if buried in marine sediments, but such an occurrence would be exceptional. Land and fresh-water plants and animals are found fossilized in river and lake sediments, in bogs and marshes, or occasionally in brackish-water deposits as in river deltas and bars; but only by accident would they be carried out to sea and be deposited with the marine sediments.

It is therefore to the salt water forms of life we look as the probable source of the series of bitumens represented by petroleum and its allied substances.

Attention has been of late directed to the tiny plants known as diatoms, as petroleum producers. These plants are so small as to be distinctly visible only under a powerful microscope, but they exist in such numbers as to constitute when in a fossilized state, extensive formations. Those diatomaceous deposits are known as infusorial earths; they consist of the silicious shells or skeletons of the tiny plants, the organic substance having disappeared through partial decomposition. Diatoms abound in both fresh and salt water, and extensive marine deposits of their shells are known. Chemical investigation has shown the ready manner by which oils allied to petroleum may be produced from the diatom substance, and the possibility of such a process taking place in nature is apparent. However, there is danger in being too definite in our assumption as to the particular source of this product of chemical change; though we are justified in the belief that organic matter of some kind is the material from which petroleum and other hydrocarbons are derived, and that the transformation is effected in connection with marine sediments. It was once supposed that petroleum is a product of coal distillation, and as already stated, the common name "coal oil" is traceable to this assumption. True there is a marked similarity between petroleum and its derivatives and the products obtainable from coal by chemical treatment. But there appears in nature no common or necessary association of coal and "coal oil," and, moreover, the oil is often found at a lower geological horizon than that at which the coal occurs. Furthermore, the rocks in which oil occurs are not such as bear evidence of the effects of intense heat.

DR. JAMES E. TALMAGE.

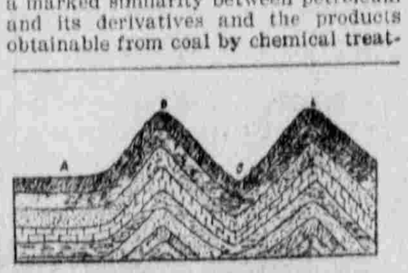


Fig. 1. Horizontal and folded strata.
A. Horizontal layers in the position in which they were deposited as sediments.
B. Arches or anticlinal folds.
C. Troughs or synclinal folds.

But, whatever the ultimate source may be, our present interest lies rather in the mode of occurrence of the oil, and in learning the means by which we may recognize and reach the petroleum accumulations.

In some particulars the occurrence of oil is very similar to that of underground waters; in other respects there are striking and important differences between the two. Thus, we know that water accumulates in porous rocks even at a considerable distance beneath the earth's surface, under favorable conditions. The essential conditions are that the porous beds shall be roofed and floored by rock that is impervious to water, thus confining the liquid and preventing its escape either upward or downward. The porous beds may become thoroughly saturated with water, holding the same much as a sponge would do; and if the water-bearing strata are inclined upward so as to give considerable elevation or "head" the confined water in the lower parts will be under great pressure and will push forth with force if the impervious roof stratum be pierced, as by a natural fissure or by an artificially driven pipe. Water escaping from such a natural fissure constitutes a fissure spring; a pipe driven through the upper confining layer and permitting the escape of the water, is an artesian well. If the edges of such water-bearing strata as have been described are exposed on a hillside for example, the water will escape as a "seep" or dribble, or as a regular hillside spring.

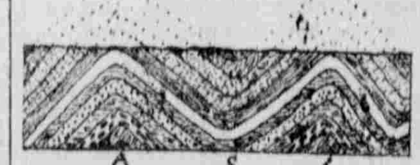


Fig. 2. Folded and eroded strata.
S. S. Surface after erosion.
A. Anticlinal fold.
S. Synclinal fold.
Dotted lines above surface indicate former extension of strata, now removed by erosion.

Now, in the same way petroleum occurs in porous rocks confined by impermeable layers, and in the same way the oil escapes as natural springs or through pipes driven down to the porous oil-bearing rock strata.

But the analogy between water and oil occurrences will not hold in all particulars. The water supply is perennial, and by drainage the porous strata may be kept constantly saturated, so that it may be drawn upon with little danger of exhausting the reservoir. Oil occurrences, however, are the accumulations of ages, and when tapped are speedily drained, with no probability of the supply being replenished except by a repetition of the slow process of geological accumulation. The same may be said with respect to natural gas. It is therefore improbable, and as shown by experience, practically impossible that any one supply of either of these natural fuels will be permanent. However, an isolated oil reservoir is of unlikely occurrence, in a region of oil accumulation there will usually be found numerous small areas of oil-saturated rocks, each of which is in a measure an independent reservoir of the fluid.

The surprising force with which the oil gushes forth when such a reservoir is first tapped is proof of the high pressure under which the liquid has been confined, and the diminishing volume tells of the rapid exhaustion of the supply. The pressure is partly hydrostatic, that is, due to the "head" or liquid columns extending to higher levels, but it is surely largely due to the expansive force of the imprisoned gases. Some of the best wells in the Pennsylvania field have delivered at first over 120,000 gallons per day, but such a yield is phenomenal and but temporary. After the flow under natural pressure has entirely ceased, pumping has been resorted to, and to this operation a single well may continue to respond for years but it will finally run dry.

The geological structure best suited to the accumulation of oil is as indicated—that of porous layers encased above and below by impermeable beds. The commonest materials constituting the oil-bearing strata are sandstones, conglomerates, and cavernous limestones, and the usual layers above and below are compact shales and clays. It is essential, however, that the rocks shall not have been greatly disturbed; therefore, we fail to find oil in great mountain ranges where the strata have been tilted and broken, and in consequence metamorphosed by the heat and pressure to which they have been subjected. If such rocks were charged with oil before the uplifting and fracturing incident to mountain formation, the fissured strata would have allowed the escape of volatile liquids, and gases and only the solid hydrocarbons would remain. Gentle folding of the strata appears rather to facilitate the accumulating of oil in certain parts, but extensive disturbances of the strata promote the escape of the liquid.

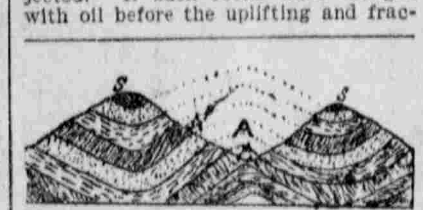


Fig. 3. Folded and eroded strata.
A. Anticlinal valley.
S. Synclinal hills.
Dotted lines above the surface show the former extension of the layers before erosion.

Until comparatively recent times the belief was very generally held that oil accumulated in large fissures and subterranean caverns, and that the lucky prospector was he whose drill pierced the roof of such a cistern. This explanation is unsatisfactory when applied to oil occurrences in general though doubtless such cavities as may exist in oil-bearing rocks would be filled with the fluid. The rock strata in which oil is most commonly found—sandstone and conglomerates—are not of the kind suitable to cavern formation; limestone which may also carry oil is frequently cavernous, but the oil accumulations are not contained in large open spaces, but in the small cavities and pores of the stone. Such caverns as may exist would facilitate the local collection of oil, and the oil operator produces cavities artificially by means of explosions fired at the bottom of the well. Into such cavities the oil would percolate from the contiguous rock, and the possible yield would thus be greatly increased.

Besides the general features of geological structure common to all oil fields, there are certain structural details which may be strictly reliable as guides to the local accumulations of oil in one region, but which would be wholly inapplicable to other fields.

The anticlinal theory of oil occurrence, which has attracted wide and growing interest during the last decade, is without doubt a good and sufficient guide to the location of oil pools in the West Virginia fields, and is applicable to some sections of the Pennsylvania region. Prof. Wilbur C. Knight, of the university of Wyoming, has shown that it applies also to oil pools in that state. Briefly stated, this theory holds that the oil has accumulated in the arches or anticlines of the folded strata while the adjacent synclines or troughs are left barren. A word as to the terms here use: Stratified rocks are made up of sediments laid down in layers as a result of the sorting power of water. Under normal conditions these strata are horizontal when first deposited, but by subsequent disturbances they may be tilted and folded in a variety of ways. When the folds are convex upward, so that their crests form arches with respect to the horizontal plane; in other words when the strata on opposite sides of the axis of folding dip away from each other, the structure is called an anticline or an anticlinal fold. On the other hand, when the strata are folded so as to produce troughs—the layers on opposite sides of the axis dipping toward each other, the trough-like fold is called a syncline. The distinction will be rendered plainer by the accompanying diagram. In figure 1, the strata at A are shown in vertical section, in the position in which they were originally laid down. Beyond A the layers are folded, forming anticlinal arches at B and a synclinal trough at C.

Now, as stated, in certain oil regions the petroleum is found in the arches, or crest of the folds, while the lower synclines are barren. This mode of accumulation may be due to the fact that the oil being a volatile liquid, sought the higher parts of the folded beds, leaving the heavier water to accumulate in the lower troughs. Moreover, the rocky layers at the anticlines will be more porous than in the troughs, owing to the fact that at the crests the rock has been submitted to tension or stretching in the folding process, whereas in the synclines the rock has suffered compression.

The fluids contained within any porous bed or series of beds, properly encased by impervious strata above and below would tend to arrange themselves in the order of their specific gravity, water being heaviest would sink to the lowest level; then would come the oil, and above this the gases. These conditions of local accumulation may explain the unequal distribution of oil within the field, and would indicate the futility of boring in a hap-hazard way, anywhere within the oil region. Oil does not exist in the rocks as a continuous bed, like coal, but is concentrated within certain limited areas determined by geological structure.

In the foregoing explanation of folded strata, and in the illustrative diagram (figure 1) the surface appearance is that of anticlinal belts and synclinal valleys. It must be remembered, however, that erosion may produce such changes in the surface configuration as to reverse these conditions, and synclinal hills with anticlinal valleys are not uncommon. Again, the surface may be planed down to a common level, with no topographical indication of folding. Thus in figure 2, the anticline at A and the syncline at S are plainly shown in vertical section, but the surface is practically flat. The dotted lines in the upper part of the figure show the former extension of the folded layers, but all above the surface plane has been carried away by erosion. Such an anticline as that shown in this diagram is spoken of as a broken fold, inasmuch as the true crest of the original arch has been removed. Of course, if the oil-bearing layers were above the present surface, the erosion would have liberated the oil, whereas if the oil zone were below, the liquid would still be imprisoned.

In figure 3 a still more complicated result of erosion on folded strata is shown. The anticlines A are here shown as valleys, while the synclines S are hills. Here as before the dotted lines show the extent of the folds before erosion had removed the upper parts. It is therefore evident that surface configuration is not to be relied upon as a guide to the oil pools; the geological structure of the region is the essential point to be determined. The oil-bearing formations already successfully exploited are found to belong to many different horizons or geological ages. There is therefore no specific period of geological time to be characterized as an oil age. Little or no oil has been found in rocks older than the silurian, but from that age to the comparatively recent tertiary time, oil and hydrocarbons in general have been accumulated. The oil formations of Pennsylvania, Kentucky, and Canada, belong to the devonian age; those of West Virginia and Ohio are carboniferous; in Wyoming, and presumably also in Utah, the oil horizons range from carborniferous to tertiary; but the main deposits are found in the cretaceous division of the mesozoic era. The Pacific coast oil fields are of the tertiary age, as are also the widely famed Burmah fields, and the Baku fields in the neighborhood of the Caspian sea.

It is plainly evident that a region known to be oil-containing must be separately and specially studied to determine the horizon at which the oil-rock occurs, and the particular features of structure favorable to the accumulation of local pools.

Among the oil-producing countries the United States takes first rank; then follow Russia, Canada, Japan and New Zealand. Within our own land, the principal fields are the Pennsylvania-New York region, which, being continuous, may be considered as one field; the Ohio fields, comprising two separate regions; the West Virginia field; the Colorado-Wyoming-Utah field; and the California field.

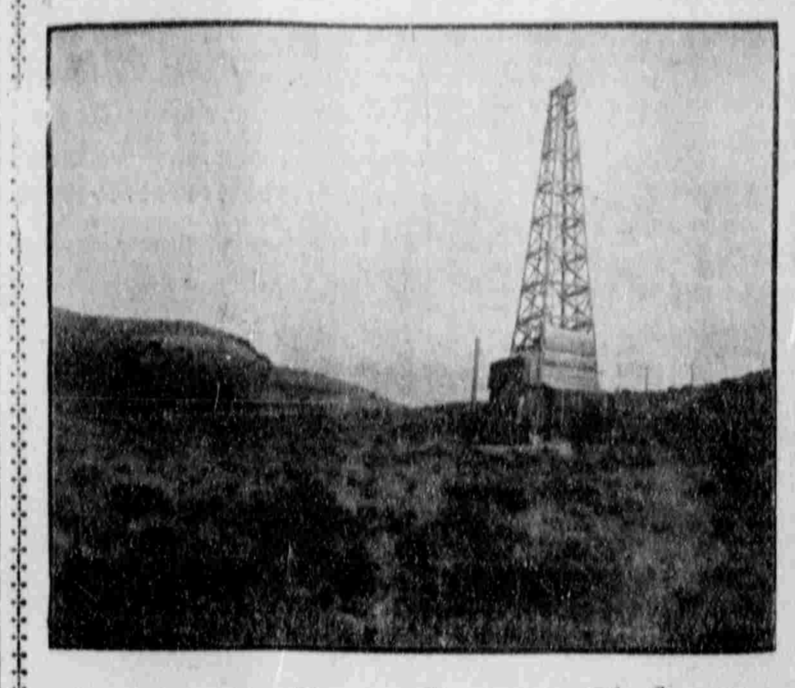
Besides the porous oil rock, from which petroleum is obtained by simple drilling as flowing wells, or as pump-wells, there are other deposits of oil-bearing shales, from which the liquid seldom flows spontaneously, but which may be made to yield richly to distillation treatment.

Before the beginning of the oil industry in the United States, many countries depended largely on bituminous shales for their supplies of illuminating oils; but the rich, and as at first supposed, practically inexhaustible yields from the Pennsylvania-New York and Ohio fields, crippled the shale-distilling industry. Only the richest of such shales were found profitable to work by the methods then in use. Of late years, however, improved methods of distillation have resulted in the revival of shale treatment for oil. This industry is now successfully prosecuted in Great Britain and Australia and elsewhere. The oil so obtained is generally rich in lubricating material, in paraffins both liquid and solid, in addition to the illuminating oils. The distillation of rich shales offers many inducements to capital, as the supplies can be exploited with approximate certainty as to their extent and richness, whereas the spontaneous yield of fluid hydrocarbons is always uncertain. Utah is particularly rich in oil-shale deposits, and excellent products have been obtained from their treatment on an experimental scale. Among the valuable deposits of paraffin-shales already tested are those of Utah county (near Tucker), Juab county, Sanpete county (in the vicinity of Manti and Gunnison), and other deposits in the Uintah basin, south of the Uintah range and east of the Wasatch. From this incomplete list the many extensive deposits of asphaltum sandstones and formations carrying other solid hydrocarbons are excluded.

As to the prospects of oil development in Utah, I think we are justified in indulging most confident hopes. Considerable yields have been already realized, and boring operations are now in progress in many parts of the state. Undoubtedly many declarations of rich discoveries are extravagant, and the deceiving influence of the "boom" tendency is too plainly apparent to the disinterested observer. Properties have been extolled for their rich contents of oil, and stocks have been offered for sale, with little foundation beyond the unbounded expectations of their promoters; and "oil-prospects" are cried on every side. But with due allowance for these wild schemes, we may rest secure in the knowledge that many honest and conservative men, capitalists and investigators, are diligently working to develop their holdings, and the results are encouraging and assuring. Utah is in sore need of a properly organized geological survey, by which the hidden resources of our young commonwealth may be examined and determined with other and more worthy purpose than that of effecting sales for individual gain.

In the search for oil a careful and efficient geological examination of the region should precede the expenditure of means in useless and hap-hazard attempts in boring and drilling. It is probable that much disappointment and many failures will follow ill-advised ventures, but the results will be in the main of benefit as showing at least what it is best not to do. It has been conclusively demonstrated that our state is rich beyond measure in hydrocarbon deposits of many kinds, though mostly of the solid or semi-solid varieties; and the presence of petroleum is geologically indicated with fair certainty.

Some of the oil shales have yielded as much as eighty gallons of oil to the ton, a considerable proportion of which is of the valuable paraffin class; and such naturally occurring liquid hydrocarbons as have been already obtained are of corresponding richness and excellence. It is not too much to expect that in the near future Utah will take her place as an important oil-producing state.



Property of the Wyoming Illuminating Oil Company, Near Spring Valley, Wyoming.

PRACTICAL DEVELOPMENT. IN UTAH AND WYOMING.

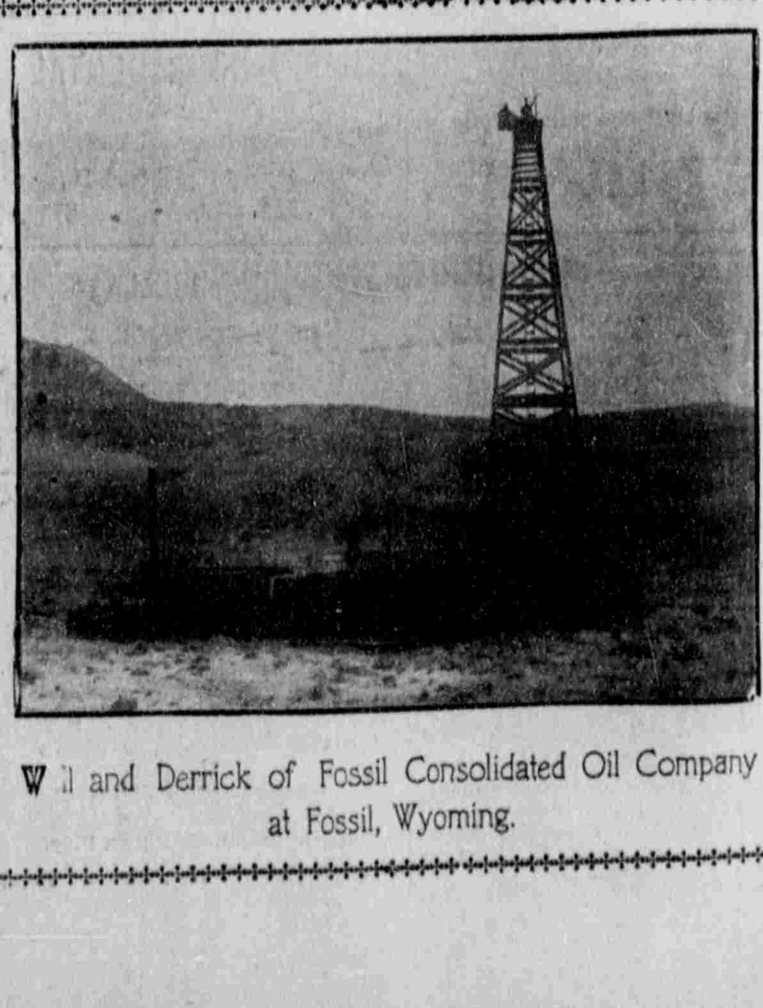
CALIFORNA Pennsylvania, and Ohio no longer have a monopoly of the petroleum output. Utah, Wyoming and Idaho have joined in the procession, and hundreds of investors and an immense amount of capital are being attracted to the newfields in the states mentioned. And it is interesting to note that the amount of money flowing into the above states for investment in the oil fields is increasing as it becomes more and more apparent that Utah and Wyoming, especially, are destined to become one of the greatest if not the greatest centers in the world for the production of petroleum oil. So development work is progressing at an increasing rate, and oil-bearing outfits are being hurried into the fields.

The Utah oil lands extend from Rich county on the north to the San Juan on the south, between which points immense tracts have been located for oil purposes, so that while Wyoming was exploited at an earlier date, recent discoveries in Utah indicate that this state is not likely to remain of secondary importance as an oil producer. In fact, the highest grades of oil are promised. There are many seepages scattered over the Utah oil belt, yielding a lubricating product valued at from $9 to $15 per barrel, and the market for this class of oil promises to become limitless, because of the application of oil to so many industrial operations as well as to domestic uses.

Utah is rich in oil having a paraffin base and susceptible of being refined into a fine illuminant, and which is therefore a much more valuable product than the oil that is being obtained in Texas and parts of California.

Development has progressed encouragingly in several counties where oil has been found at present in limited quantities, and it is a matter of encouragement that wherever boring is going on oil-bearing sands have been encountered. Wells of special promise are being sunk at Dairy Farm, seventy miles south of this city, there is another eighteen miles south of Colton, a third is located sixty miles south of Price, and others are going down elsewhere. The Green river fields have up to date attracted the most attention, and are included in Grand and Emery counties, 186 miles south of Salt Lake City. The San Rafael company, operating sixty miles south of Price, has acquired 2,000 acres of land, and about $30,000 worth of work has been done up to date. This includes a 10-inch well down over 1,300 feet, oil being found in paying quantities in the second stratum of sand struck at a depth of 657 feet. A heavy flow is promised lower down. The shales and sand penetrated are found to be the same as those found in the Oil City fields of Pennsylvania. The quality is 78 per cent paraffin. The company is operating with a capital of $125,000. The California-Utah company controls about 60,000 acres of land in Emery and Carbon counties, mostly in the vicinity of Green river. Drilling has begun eight miles southwest of the railroad station, the contract being for 2,000 feet, although the company is prepared to go 3,000 feet. Good indications have been discovered. The Uintah company controlling 2,000 acres of land near Colton has two wells. The first well struck oil sands at 180 feet, yielding five to ten barrels per day. The second well is down over 400 feet. Prospectors have found four miles south of the railroad crossing, at the base of the break in a formation, surface oil of dark brown color, pronounced by experts to be a first class lubricating oil, and samples have been refined into heavy white headlight oil. The White Star company encountered oil at 290 feet in their well in Dairy Fork canyon, yielding two-thirds of a barrel per hour, and at 390 feet an amber colored oil of a high grade. The well is being pushed at the rate of nearly seventeen feet per day. There are about fifty companies incorporated to operate in the Utah fields, and between them a great aggregation of capital is being brought in from eastern and western money centers. While the current year has witnessed only good starts, the coming twelve months are certain to see some astonishing developments. As the Green river fields are pretty well taken up, prospectors are striking off into localities hitherto unprospected for petroleum. The San Juan Oil company has taken up fourteen quarter sections of land upon ten of which oil of the finest quality for lubricating and illuminating purposes have been found forty miles west of Bluff City.

The oil is found under a bed of petrified seaweed and shellfish, about 200 feet from the surface, while a magnificent showing is made by sinking an ordinary miner's shaft. The San Juan company has machinery at work, and twenty barrels per day were being taken from the well at last accounts, of oil of a yellowish color. Ohio people have filed on 7,200 acres at the head of White river, 4,320 acres in Tie Fork north of Tucker, and on 3,900 acres near Thistle Junction. L. L. Bettys of California has bought 40,000 acres near Woodside in the Green river district.



Well and Derrick of Fossil Consolidated Oil Company at Fossil, Wyoming.

A San Rafael Oil Spring, with Oil Pool in Shadow at Left and Barrel on Right.