PETROLEUM AT CONTROLLER BAY.

By G. C. Martin.

INTRODUCTION.

LOCATION.

The Controller Bay petroleum field is located on the north shore of the bay, which is a few miles east of the mouth of Copper River, in longitude 144° to 144° 40′ west, latitude 60° 10′ to 60° 15′ north. The localities at which there are known indications of petroleum are confined to a belt about 25 miles long from east to west and from 4 to 8 miles wide from north to south. (See fig. 1.) This belt is adjoined on the north in part by the Bering River coal field. Its southern border

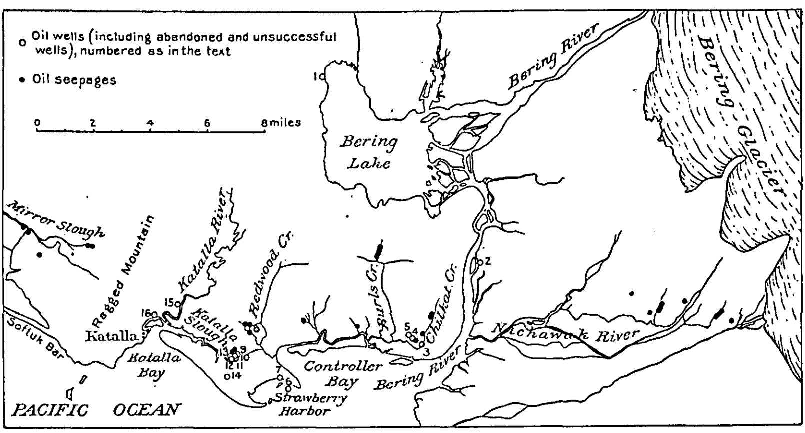

Fig. 1.—Map of Controller Bay oil field, showing position of wells and seepages.

is formed by Controller Bay and the Pacific Ocean and by the alluvial flats on the east shore of Controller Bay. The eastern and western terminations are formed by Bering Glacier and by the Copper River delta, respectively.

OUTLINE OF THE GEOLOGY.

The geology of the region and the occurrence of petroleum have already been described,[a] but more detailed geologic work and further developments have added much to the knowledge which was available

[a] Petroleum fields of Alaska and the Bering River coal fields: Bull. U. S. Geol. Survey No. 225, 1904, pp. 365-382. The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits: Bull. U. S. Geol. Survey No. 250, 1905, 64 pp. Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 128-135.

when these papers were written. A final report on the geology and mineral resources of the region is now in preparation. The present paper contains an abstract of such parts of that report as relate to petroleum.

The general stratigraphic sequence in this region is represented in the following table:

Generalized section of rocks in the Controller Bay region.

Age.	Character of beds.	Thickness.
		Feet.
Quaternary	Fluviatile, glacial, and beach deposits	0-500+
	Marine sands and clays	60
Tertiary	Shales, sandstones, conglomerates, and arkose	12,000+
Paleozoic or Mesozoic (?)	Slate and graywacke with interbedded or intrusive greenstone and other igneous rocks.	

The oldest rocks of the region are the slates and graywackes, with associated igneous rocks, which make up the mass of Ragged Mountain and the low hills west of it and constitute all but the southeastern extremity of Wingham Island. The observed contacts of these rocks with the Tertiary rocks are faults. The amount of metamorphism which these rocks have undergone as compared with the Tertiary rocks, which though in direct contact with them are entirely unmetamorphosed, proves a much greater age for the former and a great unconformity between them and the Tertiary rocks. The lithologic similarity of these older rocks to the Paleozoic or very early Mesozoic rocks at Yakutat, Orca, and Kodiak is suggestive of a corresponding age.

The Tertiary sediments consist of monotonous repetitions of shales and sandstones, with an included mass of coal-bearing arkose, and one or more massive conglomerates. The total thickness, as stated in the foregoing table, is at least 12,000 feet. The structure of the region in which these rocks outcrop is complex, exposures are wanting at many critical points, and neither the lithologic character of the beds nor the fossils which they contain are sufficiently distinctive to make it possible to recognize with certainty the complete stratigraphic succession.

The presence of two easily recognized kinds of rock, the arkose and the conglomerate, gives distinctive character to two parts of the stratigraphic column. The arkose is restricted in areal distribution to the region north of Bering Lake, and the conglomerate to the region south of the lake. Between these regions are areas of no outcrops, and none of the beds of either region can be recognized with certainty in the other. The following sections represent the rocks north and south of the lake:

Section north of Bering Lake.

	Feet.
a. Sandstone	500
b. Shale with thin flaggy sandstones and with occasional calcareous concretions	2,000
c. Arkose with many coal beds and with some shale and sandstone[a]	3,000
d. Shale and sandstone	1,000+

Section south of Bering Lake.

	Feet.
e. Conglomerate and conglomeratic sandstones interbedded with shale and flaggy sandstones	3,000
f. Soft shale with calcareous concretions and with a bed of glauconite near the base	2,000
g. Sandstone	1,000
h. Soft shale	500

The succession in each of these sections may be assumed as reasonably correct, although there is a possibility that the thicknesses are too great because of the repetition of the less characteristic beds by faulting. The correlation of the beds of one section with those of the other rests at present on evidence which is incomplete and unsatisfactory and must be regarded as suggestive rather than proved. It is probable that one of two correlations is true. The shale and sandstone (*d*) may overlie the conglomerates (*e*), with a concealed interval of unknown extent between them; or *a* and *b* may be identical with *g* and *h*. In the former case the conglomerates underlie the coal field; in the latter case the coal underlies all or nearly all of the entire region under discussion. The stratigraphic and structural field evidence proves nothing either way, but suggests, as the most probable relation, that the entire section north of Bering Lake overlies the section south of the lake.

The Quaternary deposits form the surface of practically all the low flats of the entire region. They fill all the large valleys to a considerable depth, which in one place is known to exceed 500 feet.

DEVELOPMENTS.

Active attempts to produce petroleum in commercial quantities in this region have been made for the last five years. The first well was begun in the summer of 1901, but no oil was produced and no great depth was reached, as the tools were soon lost and the well abandoned. The next year the same people drilled another well and obtained some oil. Six wells were being drilled in 1903. The following year witnessed the greatest activity that the region has seen, eight wells being in progress. In 1905 and 1906 operations were restricted to two wells.

The result of these operations has been to obtain one well which yields a moderate amount of oil, another well which is capped, but in

[a] The Kushtaka formation of earlier reports.

which the oil has at times a considerable pressure, and two more wells in which an unknown amount of oil stands near the top of the casing.

Drilling has proved to be very difficult and expensive and the results are not as encouraging as had been hoped. These facts, together with the uncertainty as to the amount of territory which one concern may legally control, and the equally great uncertainty as to the conditions of the market, have led to a suspension of some of the more active operations.

The petroleum obtained in the region, both from the seepages and from the wells, is all a high-grade, light-gravity, refining oil, with paraffin base and high content of naphthas and burning oils. The character of the oil has already been described[a] by the writer and no new information is available.

OCCURRENCE OF PETROLEUM.

SEEPAGES.

GEOGRAPHIC DISTRIBUTION.

It may be seen from inspection of the map (fig. 1) that the seepages all occur within a long, narrow belt extending from the edge of the Copper River delta to Bering Glacier, a distance of about 28 miles from east to west. The belt is very narrow, not exceeding 4 miles at the widest known point, and is parallel to the north shore of Controller Bay, which has the same east-west direction as the larger aspect of the shore of the Pacific Ocean between Copper River and Yakutat Bay. The seepages at Cape Yaktag[b] are also reported to lie on a line having the same direction as this and practically coinciding with it in extended position. Several of the smaller groups of seepages, such as the group on Redwood Creek and at the head of Katalla Slough, and those in the valleys of Burls and Chilkat creeks, and in the Nichawak region, have a distinct linear arrangement, each extending in a direction of about N. 15° E. These lines coincide with the directions of the valleys in which they occur, and the relationship suggested is that either the position of the valley and that of the line of seepages are due to the same cause or that the former is the cause of the latter.

RELATIONS TO KINDS OF ROCKS.

The oil of the seepages reaches the surface through a variety of rocks. (See pp. 93–95.) The seepages west of Katalla are associated with metamorphic rocks, the oil coming to the surface either through the joints and bedding or cleavage planes of the slate and graywacke or through surficial deposits which probably overlie such rocks. The

[a] Bull. U. S. Geol. Survey No. 250, 1905, pp. 57–58.

[b] Locally known as Cape Yakataga.

presence of petroleum in rocks of this character is somewhat unusual and worthy of notice. Similar occurrences of small quantities of oil in metamorphic rocks are known in California and Washington, where the oil is considered to have migrated into the metamorphic rocks subsequent to their alteration. A similar explanation may account for the Alaska occurrence. The writer would suggest as a possible explanation that the metamorphic rocks, which are known to be separated from the Tertiary shales by a fault, are overthrust upon the shales along a fault plane of low hade, and that the oil at the seepages west of Ragged Mountain is coming through the metamorphic rocks from underlying shales.

The seepages at the head of Katalla Slough and on Redwood, Burls, and Chilkat creeks are all in the soft shales, which have previously been called the Katalla formation (*f* of section on p. 91). Those between Redwood and Burls creeks are associated wth conglomerates of presumably higher position (*e* of the section). Such of the seepages of the Nichawak region as have been seen by the writer are in shales which closely resemble those referred to above. The Cape Yaktag seepages are said to be in Miocene sandstones and shales.

RELATION TO THE STRUCTURE.

The position of the seepages with reference to the structure is somewhat vague and uncertain. Those west of Katalla are on steeply folded rocks in which the structural features have not been determined. The group on Redwood Creek and Katalla Slough is apparently in close proximity to a fault. The Burls Creek and Redwood Creek groups are each near the axis of an anticline, the Redwood Creek anticline being probably broken near or west of its axis by a fault. The seepages between Burls and Redwood creeks are on monoclinal conglomerates. The general structure of the Nichawak region has not been determined, but the rocks have steep dips and are probably closely and complexly folded. The Yaktag region, which has not been visited by the writer, is said to have an anticline near and parallel to the coast, north of which the rocks have a monoclinal northward dip. The seepages are said to occur on the north flank of the anticline, parallel to and not far from its axis.

DESCRIPTION OF THE SEEPAGES.

Petroleum seepages and gas springs are very numerous in many parts of the oil belt, and at some of them the flow of oil or of gas is large.

Several large oil seepages were seen by the writer on the banks of Mirror Slough, near the mouth of Martin River. The petroleum comes to the surface from the clay and mud of the valley floor, and a large amount has accumulated in the pools on the swampy surface and in the soil. The nearest outcrops of hard rock are sandstones or graywackes, probably the same as those on Wingham Island and in Ragged Mountain, and if so of pre-Tertiary age. It seems almost certain that the oil came from these rocks. Seepages were also seen near the head of Mirror Slough at the base of Ragged Mountain. The oil here reaches the surface from the soil, which is underlain either by glacial drift or by talus or landslide débris. The underlying rocks are probably the slate or graywacke referred to above. Another seepage about 1 mile south of this point, in the canyon immediately north of Bald Mountain, was visited by the writer. The oil was here seen oozing in small quantities directly from the joints and bedding planes of the steeply dipping slates and graywackes.

Oil is reported to have been seen in large amounts at the time of the earthquake in September, 1899, on the surface of the water of the small ponds and the creek at the south end of Katalla. The surface material consists of rock débris, largely from Ragged Mountain, underlain by the soft shales previously described as the Katalla formation.

Numerous and copious seepages are to be seen at the head of Katalla Slough. The oil impregnates the soil very completely at many points and has accumulated in large amounts on the surface, but these accumulations are chiefly of oil and are not residues, as at the California brea deposits. No outcrops are near, but the underlying rock is almost certainly the soft shale referred to above, and probably has a steep dip.

On the west slope of the valley of Redwood Creek, about 1½ miles northwest of the mouth of the creek and near a well, oil can be seen coming directly from soft fissile iron-stained shales. The shale has been broken into small angular fragments and recemented by ferruginous material. This condition is common at or near seepages in these shales, but we do not know whether it is a surface condition connected with erosion or whether it indicates crushing of the rocks at a depth below the surface during the process of folding or faulting. Here, as at many other seepages, sulphur springs are associated with the oil. Another seepage was seen near the headwaters of Redwood Creek.

It is reported that oil may be seen at low tide in the beach sands on the north shore of Strawberry Harbor. The rocks in the vicinity are sandstone and shale, probably belonging much higher in the stratigraphic column than the soft shale at the seepages previously described.

There are several seepages along the wagon road which leads from the head of Katalla Slough to the mouth of Bering River. Two of them are located about a mile and a half west of Burls Creek and close to the road. The amount of oil at one of these is large. The nearest visible rock is steeply dipping conglomerate, which outcrops a few feet away, but the oil can be seen only on the surface of the soil, the direct source not being visible.

The upper part of the valley of Burls Creek contains many seepages at which the oil oozes directly from steeply dipping shales that here contain a large amount of glauconitic grains, making the rock green. Large calcareous concretions are abundant, and many of them take the form of septaria nodules with calcite fillings. Organic remains are frequently seen in the concretions. The soft shale is also rich in organic material, some beds being so dark as to suggest in appearance impure coal. No coal was seen by the writer in the vicinity or anywhere else in these rocks. The rocks seem to be very strongly impregnated with oil in this locality and seepages are numerous, but large surface accumulations are rare. Broken shale recemented by ferruginous material was seen here as on Redwood Creek.

Some seepages with considerable surface accumulation of oil were seen along the edge of the tidal flat close to the wagon road halfway between Burls Creek and the mouth of Bering River. Outcrops were absent in the immediate vicinity, but fragments of shale indicated the presence of such rock.

Several seepages have been reported from Chilkat Creek. The largest one seen by the writer is in the west bank of the creek, 1½ miles above the forks of the wagon road. The oil reaches the surface through soft brecciated shale with a steep westerly dip. The seepage is associated with a black sulphur spring.

Many seepages have been reported in the group of hills centering around Mount Nichawak. Those seen by the writer were small, but the oil issued directly from the rock, which is shale resembling that at the seepages west of Bering River. Others are reported to be located on the banks of a small lake that is said to be covered at times with oil.

Other seepages have been reported from various parts of the Controller Bay region, but they have not been seen by the writer. Reference should be made to those in the vicinity of Cape Yaktag, about 75 miles east of Controller Bay. The amount of oil is said to be very large, the flow being continuous from several of the seepages, one of which has been estimated to yield several barrels of oil per day. The oil is said to come directly from the rocks, which are shales and sandstones of Miocene age, and to come from a line of seepages located along the crest of an anticline parallel to the coast.

Inflammable gas comes to the surface of the water in large amounts in several places. The largest of the "gas springs" seen by the writer are in Mirror Slough and in Katalla River. The former is sufficient to furnish a large continuous flame. The composition of the gas is not known. It issues from the mud on the bottom of the slough.

POSITION AND DESCRIPTION OF WELLS.

The wells in which oil has been obtained in this region are so few that they throw little or no light on the problem of the occurrence of oil. It will be shown in the following pages that a flow of oil has been obtained in one well (No. 10, fig. 1) and less quantities in three others (Nos. 5, 8, and 13). These four wells are close to seepages and are on the outcrop of the shales which have been referred to as the Katalla formation. They are all on lines of seepages having a north-northeast to south-southwest direction, and are all on the steeply dipping northwest flanks of anticlines and possibly on or near lines of faulting. It is unfortunate that no other wells have been drilled in similar positions on the structural lines alluded to above. Such wells might not be successful, but they would test the possible theory that the above-mentioned lines have something to do with the distribution of the oil.

The net result of the drilling has been to show the existence of moderate amounts of oil in at least part of the territory. The wells are neither numerous enough nor deep enough to determine the outline of the pools and the area of productive territory. They have demonstrated the difficulty and expense of drilling and the need of ample resources and careful management. The existence of oil in remunerative quantities has neither been proved nor disproved. The evidence from the existing wells, like that of the seepages, is sufficient to warrant further testing, if it be done intelligently and carefully and by companies strong enough to exploit large areas on a scale which permits of wholesale economies, and also strong enough to risk their capital on what must certainly be regarded as a speculation rather than an investment.

The following list contains an account of each well that has been drilled in the district. The numbers refer to the geographic location of the wells, as shown on the accompanying map (fig. 1, p. 89).

1. West shore of Bering Lake. The surface rocks are sandy shales, presumably underlying the coal-bearing rocks. Dip 12° to 35° NW. Well begun in 1905. Work interrupted by accidents to machinery. Depth several hundred feet.

2. East shore of Bering River. Begun in 1903. Abandoned at depth of 580 feet without reaching bed rock because of difficulty of sinking casing through the mud.

3. Chilkat Creek. Drilled in 1904 to a depth of several hundred feet. No information available.

4. Edge of tide flats 1 mile west of mouth of Bering River. Drilled in 1904 to a depth of several hundred feet.

5. Edge of tide flats a short distance northwest of No. 4. Drilled in 1904 to a depth of several hundred feet. Oil now stands near top of casing. Small but continuous flow of gas. Amount of oil not known.

6. Strawberry Harbor. The derrick was built on piling about 1,000 feet offshore. Casing sunk deep into the mud in 1904 without reaching bed rock.

7. Strawberry Harbor. Drilled several hundred feet in 1904 without obtaining oil.

8. Redwood Creek. Drilled to a depth of several hundred feet in 1904. Oil now stands about 20 feet below the top of the casing. Quantity not known.

9. Near head of Katalla Slough. Drilled to an unknown depth in 1904. No oil, so far as known.

10. Near head of Katalla Slough. Drilled in 1902 to a depth of 366 feet, where a flow of oil was obtained. Drilled to 550 feet in 1903 without further results. In 1904 this well was pumped for fuel at the other wells of the same company. It is now capped, the oil oozing around the casing.

11. Near head of Katalla Slough. Drilled in 1901 and abandoned because of loss of tools.

12. Near head of Katalla Slough. Drilled in 1903 to an unknown depth.

13. Near head of Katalla Slough. Drilled in 1904 to an unknown depth. Now capped, the oil squirting at times in strong jets from the casing.

14. Between head of Katalla Slough and Cave Point. Drilled in 1903 to 1,710 feet and abandoned because limit of outfit was reached.

15. Katalla River. Casing sunk to a depth of 280 feet in 1903 without reaching bed rock.

16. Near Katalla. Two holes have been drilled in 1904 to 1906 on this site, a depth of about 1,500 feet having been reached. Work is still in progress.

PRINCIPLES GOVERNING THE OCCURRENCE OF PETROLEUM.

The four great problems of the geologic occurrence of petroleum are the origin of oil, the movements of oil in the rocks, the stratigraphic and structural distribution of the existing accumulations of oil, and the determination of the location and area of valuable accumulations from the known facts of surface geology.

These problems are stated above in the order of increasing importance from the point of view of immediate utility. The last problem can be solved in either of two ways—by expensive practical testing with the drill or by the solution of the first and second problems, together with a complete and accurate knowledge of the areal geology of the region in which the occurrence of oil is suspected. In the present condition of our knowledge the practical method is the only certain solution of this problem. But all knowledge gained in this way, as well as all facts concerning the geology of the oil-bearing rocks, leads us nearer to the solution of the other problems, and hence hastens the time when we can determine within reasonable limits the presence of oil from our knowledge of the manner in which oil originates and accumulates. The first and second problems are consequently the problems of greatest ultimate importance and should, in a public geologic investigation, be given at least equal weight with the other or immediate commercial problems.

Petroleum occurs in rocks of practically all ages from the oldest Paleozoic to the Recent. All known productive bodies of oil are in rocks of sedimentary origin, such as sandstones or sands, shales or clays, limestones, and conglomerates. Minute quantities of oil have, however, been seen in volcanic or other crystalline rocks.

The origin of petroleum may be explained according to one of two theories. The oil may be of organic origin, having been derived from animal or vegetable matter which was associated with the mineral constituents of the rocks at the time they were deposited, or it may be of inorganic origin, having been formed by the chemical action of water on the formerly unoxidized mineral constituents of the rocks. The prevalent scientific opinion is in favor of the organic theory for the origin of the larger and more widespread accumulations of petroleum.

The movement of petroleum in the rocks is controlled by four factors—the direct action of gravity, capillary attraction, the presence of water, and gas pressure.

The effect of the direct action of gravity is to cause oil to go down as far as the rocks are porous, dry, and not too warm for the oil to exist as such. It will sooner or later be stopped in this downward movement by an impervious stratum (either a bed of close-textured rock or a bed filled with water), and will then move laterally along the upper surface of that stratum to its lowest point, where it will accumulate.

The effect of capillary attraction is to cause the oil to be diffused throughout the rocks in all directions, provided the rock is dry and of the right texture to permit capillary movement. The directions in which it will move will be controlled by the distribution of porous rock and will be modified by the other factors here discussed.

The presence of water causes an upward movement of the oil. The essential conditions for such movement are a porous rock containing both water and oil and a lower limit beyond which the water can not go. The water, because of its greater density, seeks a lower level than the oil and forces it upward until either the demand of all the water for space is satisfied or the oil is checked in its upward movement by an impervious stratum. In the former case the oil rests on the surface of the water in a state of equilibrium; in the latter case it is confined under pressure with a potential upward force.

Gas pressure tends to drive the oil in any unblocked direction. The requisites for oil movement caused by gas are the presence of gas, either in a contiguous body to the oil or being given off from or within the oil, and an impervious bed above the gas through which it can not pass. The gas then tends to accumulate on the upper surface of the oil and to force the oil downward in the direction of least resistance, which may either be vertical or have a lateral component. The oil would already have been in the lowest available space, and so further downward motion implies the displacement of water. The motion continues until there is equilibrium between the expansive pressure of the gas and the hydrostatic pressure of the water. The oil is then confined between these forces and will escape under pressure at the first opportunity.

The most favorable conditions for the occurrence of petroleum over large and regular areas are the following:

1. A large and widely distributed original source of oil-yielding material.
2. Thick, extensive, and regular porous beds in which the oil can move freely and accumulate.
3. Impervious beds above and below the porous beds.
4. Small angles of dip and fairly regular structure.
5. Absence of deep fracturing or of irregularities of structure.
6. Absence of water in the rocks if the oil-bearing beds are synclinal; or presence of a moderate amount of water if they are anticlinal.

Such conditions are favorable to the occurrence of petroleum in large, regular, and easily outlined pools, to moderately large production and long life of the wells, and to a large degree of certainty in oil prospecting.

These conditions probably nowhere exist in their entirety, at least not over any broad area. Some of the Mississippi Valley and Appalachian oil fields come nearer to satisfying these conditions than any others in North America. It is very evident that few of these conditions are met in the Controller Bay region, and therefore nothing will be gained from further comparison with regions in which simple structure predominates.

Some of the California, Wyoming, and Colorado oil fields are characterized by complex and broken structure, in this respect being not unlike the Controller Bay region. These western fields show that it is possible for large accumulations of oil to exist in rocks with steep dips, irregular folds, and large faults. They show that the structure does not make it impossible for oil to exist in quantity in the region under discussion, but they show also the difficulties of drilling and of locating the pools in such a field, and demonstrate very clearly the need of careful operating and the risks which are necessarily involved.

OUTLOOK FOR PROFITABLE EXPLOITATION.

PROBLEM OF LOCATING POOLS.

If oil is found in quantity it will almost certainly be in circumscribed areas, and the location and boundaries of these areas will be of the utmost importance in the development of the field. The position, size, and shape of these productive areas can not be foretold in advance of all drilling or at the present stage of development. The wells which have been drilled in this region are so few, most of them are so shallow, and so little oil has been obtained that they give almost no light on the occurrence of oil in the rocks. But if at least one area were outlined wholly or in part by the known position of productive and nonproductive wells it would then be possible to determine the relation of the occurrence of the oil to the geology and from the known facts of the geology to outline other possible productive areas in advance of drilling. For this reason it is of the utmost importance to obtain complete and accurate records of all wells, and to use the information and experience thus gained in locating subsequent wells.

DIFFICULTIES OF DRILLING.

CROOKED HOLES.

Much difficulty has been encountered in keeping the wells vertical, and delay and expense have resulted from the necessity of frequently reaming out the holes in order to straighten them. The crooked holes are the natural result of the steep inclination of the beds, with frequent alternations from hard to soft rocks. Whenever the drill passes from a soft rock to a harder one dipping at a steep angle the drill tends to be deflected and a crooked hole results. This difficulty will always be encountered in this region and will increase the time and cost of drilling. It will, however, become less as the knowledge of the local conditions becomes greater, for the tendency of the drill to deflect can be lessened by drilling slower when the deflecting bed is struck and by special shaping of the tool, and the holes can be straightened more quickly when the drillers have had more experience in the region.

CAVING.

When a well in soft or fractured rock stands uncased too long, the rock caves in, often burying and frequently causing the loss of the tools, and sometimes it is necessary to abandon the well. Much delay has been caused in this way at most of the local wells and it has added greatly to the cost of drilling. It has been impossible on this account to drill several of the wells as deep as they would otherwise have gone. The only remedy is to case the well at the proper time, and when the drillers know better the rocks with which they are dealing they will be able to anticipate the caving and introduce casing at the time when it is needed. Conditions may in this way be expected to improve in the future, and thus the cost will become less and the speed greater and it will be possible to sink wells to greater depths.

WATER.

The rocks of this region are full of water, and consequently large amounts are encountered in all the wells. This is undesirable for two reasons—the pressure of the column of water in the well keeps the oil back in the rocks and prevents it from coming out into the well, and the water reduces the effective weight of the drill and acts as a cushion between the drill and the rock, in both ways reducing the power of the blow. The only remedy is in casing off the water, which can not be done too often without reducing the size of the hole to undesirable dimensions and finally limiting the depth to which it can be drilled without pulling the casing and going back and reaming out the hole.

REMOTENESS FROM SUPPLIES.

The remoteness of this region from a base of supplies increases the cost of labor and of freight, which will be discussed under a subsequent heading, and also increases the time and expense of drilling, by making it necessary either to carry an exceptionally large equipment of fishing and repairing tools and of general supplies or to be subject to delays in ordering special tools from a long distance. Conditions will improve in this respect with better facilities for communication and transportation, and can also be bettered if machine shops and supply depots are established, as they will be if the presence of productive oil territory is shown.

INEXPERIENCE WITH LOCAL CONDITIONS.

The difficulties caused by the lack of experience of the drillers with the rocks of the local section have already been alluded to under various headings. They may be summarized as including failure to drill slowly or dress the tools so as to avoid deflecting the drill on hard, steeply inclined surfaces; failure to note the crookedness of the hole and remedy it promptly; ignorance of local caving strata and consequent failure to case in time to prevent cavings; and failure to obtain proper and adequate outfit and supplies.

COST OF LABOR AND TRANSPORTATION.

The cost of drilling has been very largely increased over what it would be in more favored and better established oil fields by the high cost of labor and of transportation of men and freight. Not only are the drillers paid higher wages than they would receive at most localities, but the unskilled labor receives excessive pay. It is highly probable that when conditions become more settled and work is done on a larger and more permanent scale wage conditions will become more normal and transportation charges will be reduced.

SHIPMENT AND MARKETS.

If petroleum is produced in commercial quantities at Controller Bay a new set of problems concerning its disposal will arise. All the petroleum of the region, as far as is now known, is a refining oil of high grade, for which there is a good demand on the Pacific coast. The content of extremely volatile constituents, such as gasoline, is so great that it is questionable whether the oil can be safely shipped in bulk without some refining. There are plenty of good sites for refineries at no great distance from the wells. If a harbor in the vicinity of Katalla or elsewhere on Controller Bay is utilized it will be a very simple matter to transport the oil from the wells to the wharves by short pipe lines on a practically level grade. If no harbor in the immediate vicinity can be used it will be necessary to ship from Orca Bay or elsewhere on Prince William Sound, a distance of about 80 miles westward and across Copper River. The grades to Orca are almost nothing and there will be no difficulties except in crossing Copper River. The distances from Katalla and from Orca to Seattle by the steamer route, "outside way," are about 1,250 and 1,350 statute miles, respectively.

CONCLUSIONS.

The geographic conditions are such as to cause heavy initial expense of prospecting and drilling, but admit of permanent improvements which will make these conditions much better without great engineering difficulties or excessive cost.

The geology is complex and difficult to interpret and does not show definitely the relation of the occurrence of the petroleum to the stratigraphy and structure. The known facts of the local geology are unfavorable to the presence of productive bodies of oil, and indicate that if oil is found in quantity the distribution of the productive areas will be very irregular and difficult to locate.

The surface oil showings (seepages), though widespread and copious, are not conclusive evidence of the occurrence of productive oil pools. They are apparently more promising than any other known facts in regard to the region would indicate. The only safe conclusion to be drawn from them is that they indicate the possibility of productive oil areas in the vicinity.

Operators and investors who may not be familiar with local conditions will do well to be governed by the following suggestions:

1. They should be certain that legal title can be obtained to a sufficient area to make it possible to sink many test wells under widely different conditions, and to expect a large enough probable production to pay for heavy initial expenditures and large permanent improvements.

2. They should have large enough capital to be able (*a*) to purchase in quantity and at low rates; (*b*) to build good roads and other improvements and thus reduce the cost of operating; (*c*) to carry a large stock of tools and supplies in order to avoid costly delays in drilling and to be able to drill deep; (*d*) to procure the best professional advice and good drillers; (*e*) to drill many test wells without hope of immediate profit; (*f*) to market the product in the face of the existing

conditions in the petroleum industry; and (*g*) to afford to lose the investment.

3. The first wells should be located on the strike and at no great distance from producing wells, or down the dip from a good seepage and at such varying distances that the rocks outcropping at the seepage will be encountered at depths ranging from a few hundred feet to the limit (in depth) of drilling.

4. Subsequent wells should be determined in position by the location of existing wells and by the structure. They should be along the strike and close[a] to productive wells, and either not along the strike and at a short distance or on the strike and at a considerable distance from nonproductive wells.

5. Drillers and tool dressers should be obtained from regions where there is difficulty in keeping the holes straight.

6. If oil is obtained it will probably be down the dip rather than up the dip from a seepage, in shallow wells near a seepage, or in deeper wells farther from a seepage.

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[a] The distance should vary with the porosity of the containing horizon.