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1985

GENERAL REPORT

ON THE

PUNJAB OIL LANDS

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BY

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ERRATA

IN THE

REPORTS ON THE PUNJAB OIL LANDS.

<i>Page 2, line 12, and in many other places, for</i>	<i>Asphalte</i>	<i>read Asphalt.</i>
" " " 8,	" Buttiol	" Buttiot.
" " " 12,	" Chhotta	" Chhota.
" " " 18,	" Dhuddow	" Dhuddur.
" " " 31, (last of section)	" mommeeai	" moomeesai.
" 4, " 2,	" of (Aluggud)	" at Aluggud.
" " " 17,	" and slope	" and northern slope.
" " " 19,	" oil chhota	" oil of Chhota.
" " " 12, from bottom	" 1000	" thousand.
" 5, " 13,	" ceralites	" ceratites.
" 8, " 25 and 26	" in different	" in a different.
" " " 30,	" S	" ess.
" 10, " 15 and 16	" test at	" test it at.
" " " 24,	" places	" place.
" 12, " 22,	" work	" works.
" " " 7, of section 5	" 13	" 30.
" 14, " 16,	" Verchère	" Verchère (or Verchere).
" " " 17,	" Part III	" Part II.
" " " 25,	" Sudkul	" Sudkal.
" 15, " 14,	" begins	" belongs.
" 17, " 18, from bottom	" Tulbeeun	" Tulheeun.
" " " 15, " "	" reached	" reaches.
" " " 9, " "	" spring downward	" spring. Downward.
" 18, " 13,	" oil also	" oil ; also.
" " " 24,	" direction ; 28	" direction 28.
" " " 15, from bottom	" Tulbeeun	" Tulheeun.
" 19, " 9,	" 100	" hundred.
" 21, " 17, from bottom	" copping	" capping.
" 22, " 2,	" rocks	" rock.
" " " 5,	" cale	" calc.
" " " 24,	" nodulon	" nodular.
" " " 30,	" six-inch long	" six inches long.
" 23, " 1, of yield table	" 1500	" 500.
" " " 5, and 2 from bottom	" on	" in.
" 24, " 1,	" week by	" weekly.
" " " 5,	" to be	" will be.
" " " 2, from end of section 6	" yard, probably	" yard probably.
" " " 11, from bottom	" but, from	" but from.
" " " 10, " "	" direction is	" direction it is.
" 25, " 5,	" outer-crops	" outcrops.
" 26, " 5,	" the asphalte	" the oil or asphalt.
" 27, " 3,	" rills	" rolls.
" 28, " 1, of section 5	" earth of any	" earth or any.
" 29, " 1,	" Book	" Books.
" " " 1, from bottom	" well south	" well. South.
" 30, " 9, from end of section	" sand lime	" sandy lime.
" " " 5, " " " "	" 3	" 8.
" 30, " 2, from bottom	" north 86° north	" north 86° east.
" 32, " 5,	" east, and flows	" east, flows.
" " " 9, from end of section 3	" Chhotta	" Chhota.
" 33, " 12,	" lie, not	" lie not.
" 36, " 1,	" on Aluggud	" on the Aluggud.
" " " 8, from bottom	" encrimite	" encrinite.
" 37, " 2, of section c	" ridge, mentioned	" ridge mentioned.
" " " 6, from end of section 4	" feet bed	" foot bed.
" 38, " 11, and many other places	" Chhotta	" Chhota.
" 39, " 2,	" springs downward	" springs. Downward.
" " " 3, from end of section 3	" nummulitic	" nummulite.
" 42, " 2, of section b	" springs downward	" springs. Downward.
" " " 3, from end of section 3	" about it	" above it.
" 45, " 1 and 6	" Dhuddow	" Dhuddur.
" " " 2, of Dooma Report	" which form	" which forms.
" ii " 12, from end of report	" scale, perhaps	" scale perhaps.
" 20, " 3, of section 5,	" Runneeal	" Tulheeun.
" 27, " 3, of section table	" 16	" 10
" 30, " 6,	" 64	" 74.

In the table on page 4 all the numbers of the columns should have the word *about* before them.

In the table on page 27 the footings 113, 17 and 13 should have the word *about* before them ; the gaps " 50 " and " 30 " should be set in the outer column with the footings, to show that the sections are continuous.

BENJAMIN SMITH LYMAN.

Calcuttta, 9th December 1870.

GENERAL REPORT
ON THE
PUNJAB OIL LANDS;
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BENJAMIN SMITH LYMAN,

Mining Engineer, Public Works Dept. of the Government of India.

1. SITUATION.
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1.—SITUATION.

The oil lands of the Punjab all lie between north latitude $32^{\circ} 31'$ and $33^{\circ} 47'$, and east longitude $71^{\circ} 22'$ and $73^{\circ} 9'$; say within a space of 102 miles long east and west, by 88 miles wide north and south, with Rawul Pindee two miles inside the eastern edge, and eleven miles inside the northern edge. Outside of these limits no lands can properly be called oil lands, although around Murree, and perhaps elsewhere, the lime rock is in many places impregnated with bitumen, and sometimes even has small drops of tar in it large enough to be seen.

The north-easternmost oil spring is the one near Rutta Otoor, 11 miles north by east of Rawul Pindee; the next so-called oil spring is in the first

Cheerpar Mountain near Runneal, and eight miles south-west of Pindee; then comes the oil spring in the Seel River at the mouth of the Bussala near Moorut, and $10\frac{1}{2}$ miles south-west by west of Pindee; then the Loondeegar asphalte and oil, also near Moorut, and 14 miles south-west of Pindee; the Gunda oil wells, 23 miles west of Pindee; the Chhurrut old oil boring at Chhurrut village, and 28 miles west of Pindee; the Boraree old oil well near Chhurrut, and $28\frac{1}{2}$ miles west of Pindee; the Jafir old oil boring near Jafir, and 29 miles west of Pindee; the Dulla asphalte between Boota and Buttiol, and $38\frac{1}{2}$ miles west of Pindee; the Punnoba oil springs at Punnoba (Kohat District) near Shekh Khan, 25 miles east of Kohat, and 67 miles west of Pindee; the Aluggud asphalte and rock tar, on the Aluggud brook (Bunnoo District), ten miles and a half south of Eesa Khêl, and 124 miles south-west by west of Pindee; the Chhotta Kutta oil springs near Jaba (Bunnoo District), 10 miles south-east of Kalabagh, and 59 miles south-west by west of Pindee; the Burra Kutta oil springs, half a mile south-east of the last; the Sadeealee rock tar near Nara (Jhelum District), and 90 miles south-west of Pindee; the Chinnoor rock tar near Murdowal (Shahpoor District), and 83 miles south-west of Pindee; the Hungooch rock tar near Dhuddow and Murkoom (Shahpoor District), and 81 miles south-west by south of Pindee; and the Dooma rock tar near Kubbukkee (Shahpoor District), and 77 miles south-west by south of Pindee.

Many of these are places where only very small and unimportant traces of oil or asphalte are found, yet they are well known to the inhabitants of the country for miles around, so familiar do they become in tending their flocks with almost every foot of ground in the mountains. As careful inquiry from them has brought to light no other traces even of oil, it is pretty certain that none such exist, except possibly a few quite insignificant ones.

The oil is commonly called by the natives "muttee ka têt" (earth oil), and at Jaba it is said "gunduk ka têt" (sulphur oil); the rock tar or blackened oil is called at Aluggud and at Jaba "kalapani;" at Sadeealee, "leleera;" at Hungooch and Dooma, "leloora;" the solid asphalte is often called "momeeai," sometimes "meemeeai."

2.—LAY OF THE LAND.

The River Indus flows south-south-westerly from the northern edge of the region described to its south-western corner, falling in that space from about 800 feet above the sea to about 650. It is joined midway by the Sohan, which comes to it with a general west-south-westerly course from near Rawul Pindee, where its waters are about 1700 feet above the sea. The Jhelum River runs (about 700 feet above the sea) south-westerly across the very south-eastern corner past Pind Dadun Khan. The Koorum empties into the Indus on the west just south of Eesa Khêl. A dozen miles north of Pindee are several parallel high ridges that run in a north-east and south-west direction on the edge of the Rawul Pindee and Huzara Districts. A dozen miles west of the meridian of Pindee these ridges die away; and half a dozen miles south of their end begin the Choor Hills, that run first westerly, and then west-north-westerly to the Indus, and are perhaps continued beyond in the hills of Punnoba; but these run south-westerly, and then west-south-westerly, and soon west again, and there are several parallel ranges south of them for 25 miles. At Moorut, near the Bussala and Loondeegar oil places, begins a ridge some 3100 feet high above the sea, called the Khairee Moorut (often called Gibraltar in Pindee), which runs south-westerly for about 20 miles and dies away. Half a dozen miles east of Moorut are three or four parallel north-east and south-west ridges of 200 or 300 feet high, called the Cheerpar Mountains, running nearly to the meridian of Pindee. Along the southern edge of the region the Salt Range, rising in places even to 5000 feet above the sea, runs at first west-south-

westerly, then about the middle of the southern edge, which it just crosses, it turns sharply north-north-westerly to the Indus a few miles below the mouth of the Sohan, and continues the same course, and a more northerly one on the west of the Indus, until it meets the east and west ranges already mentioned. In the south-western corner the Kafirkot double range, with the Aluggud Valley between, rises to 2200 feet above the sea, and runs southerly west of the Indus and south of the Koorum. The country south and south-west of the Salt Range is flat, and about 700 feet above the sea ; the country north of the Salt Range between the mountains and hills already mentioned, and a few other small parallel ones, is comparatively flat and from 1200 feet above the sea on south and along the Indus to 1800 feet on the north-east ; of course the streams cut valleys in this comparative plain, making it a rolling country. The smaller narrow valleys as far south as the Sohan, even near its mouth, and this river, also show a striking parallelism to the general course of the mountain ranges on either side.

3.—GEOLOGY.

a. Structure.—Almost all of the mountain ranges already mentioned seem to be formed of rocks that lie in saddle form, and most of the ranges have several such parallel ridges. The Cheerpar Mountains, however, are quite small, and, as they seem to have but one dip, are perhaps formed by only one half of a saddle. The Salt Range has also been said by some to have on its southern edge a northerly dip, as if the southern half of a saddle were wanting, but this survey did not lead to an examination of that part of the range. The rocks, then, of the oil region, lie in waves, the tops of the waves in certain places forming mountain ranges ; but in the greater part of the region, both the tops of the waves and the hollows between them are covered over with nearly level layers of much newer rocks, of old alluvial age. Where the streams have cut down through these alluvial rocks, the older steep dipping rocks form ridges, and give to the smaller valleys the parallelism that has been already noticed. For a dozen or two dozen miles north of the Salt Range the dip of the older rocks, beginning with a steep dip, on the south, becomes quite gentle, and then nearly or quite level ; so that the old alluvial rocks, if they rest upon them, are conformable to them, whereas further north these alone remain level, while the lower rocks have a steep dip, and the unconformability is striking. The axes of the saddles run south-westerly on the eastern edge of the region, westerly in the middle of it, then north-westerly, and northerly on the western edge ; but in the north-western corner, south-westerly and then westerly. The dips are commonly quite steep, sometimes reversed as far as 70° , and seldom less than 45° , except along the northern side of the Salt Range near Dooma (6°), Hungooch ($26\frac{1}{2}^\circ$), Chinnoor and Sadeealee, and at Aluggud (25°).

b. Rock Beds.—The following seems to be the section downward of the old alluvial rocks as exposed along the Seel River near Moorut :—

Concretionary lime rock or travertine	...	...	...	..	about 100 feet
Coarse brown pebble rock	...	...	...	...	" 3 "
Soft brown sand rock	...	...	...	...	" 30 "
Coarse brown pebble rock	...	...	...	...	" 2 "

In all " 135 feet

In the banks of the Indus for a dozen miles above Mukhud and as many below it a much greater thickness of these older alluvial rocks seems to be exposed, including several thick but not persistent layers of very coarse (6-inch) pebble rock, varying sometimes very rapidly from a thickness of 100 feet in one bed to three separate layers of six feet.

The following seems to be the section downward of the portion of the older rocks that contains all the oil found in the Punjab :—

Soft gray sand rock estimated by some writers as much as 10,000 feet of (Aluggud) more at any rate than	100 feet.
Red and greenish gray clays, with a few layers of brown sand and pebble rock (Aluggud, Jaba, and whole northern side of western part of Salt Range), about	700 "
Coarse (up to six-inch) pebble rock, perhaps sometimes wanting (Aluggud)	40 "
Brown sandy lime rock, with productus and other fossils; in some places becoming merely soft gray sand rock, with the oil of Aluggud brook (Aluggud)	40 "
Soft gray sand rock (Aluggud)	100 "
Brown and gray shales (Aluggud)	180 "
Aluggud group	1,150
Gray sand rock, with a few layers of pebble rock, and near the bottom some dark red shales, and with gray shale; tar of Dooma, Hungooch, Chinnoor, and probably Sadeealee near the bottom (Jaba and slope of Salt Range)	700 feet.
Blue gray lime rock, with nummulites, echinoderms, and other fossils; oil Chhota Kutta and Burra Kutta (Jaba) near the top; and oil of Rutta Otoor, Dulla, and Punnoba near the bottom, about	1,100 "
Jaba group	1,800
Red sand rock and shales (the whole at Punnoba, the lower part at Gunda)	500 feet.
Brown sand rock and shales, with nummulites, oil of Gunda, and perhaps Cheerpar (Gunda, Chhurrut, Boraree)	100 "
Gray lime rock, with nummulites and gray shales, with some red shales near the bottom; oil of Chhurrut, Boraree, and perhaps Bussala and Loondeegar (Gunda, Chhurrut, and Boraree)	190 "
Red shales, salt, (Gunda, Chhurrut, Boraree), perhaps more than	60 "
Gunda group	850
In all	3,800 feet.

As nummulites abound from the lime rock of the Gunda group up to the top of the lime rock of the Jaba group, all these rocks probably belong to the so-called nummulitic age, although the Gunda rocks seem to hold the place of rocks that in the Salt Range have commonly been assigned to a much older age. It should also be stated that the Gunda rocks may prove on more complete examination not to underlie the Jaba group, as here considered to be the case; but the absolute determination of this point was immaterial to the objects of the oil survey, and would have taken too much time for it to be on the whole desirable.

A like uncertainty exists in regard to the position of the lower 360 feet of the Aluggud group with reference to the Jaba group. The upper sand rock and clays (in all 800 feet) of the Aluggud group are undoubtedly the same that are found for many miles along the Salt Range at a distance of about a 1000 feet above the Jaba lime rock; and the sand rock and shales of the bottom of the Aluggud group much resemble the sand rock and shales from 700 to 1000 feet above the Jaba lime rock. The chief cause of doubt in the matter is the occurrence of the fossil productus, and perhaps other fossils (as certain terebratulæ and spirifer) in the Aluggud lime rock,—fossils which are universally reckoned far older than nummulites, and have given rise to the belief that this rock was carboniferous. In case it be carboniferous, there is a wide gap below the red and greenish gray clays, where at least the whole Jaba group should be together with 350 feet of gray sand rock and shales above it (to be seen at Jaba), in all over 2000 feet that would be quite missing at Aluggud, all thinned out and disappeared within a distance of 30 miles (from Jaba), and that would be almost incredible. There would also seem to be no

rocks below the Jaba lime rock in the Salt Range, though so near, that would correspond in appearance to the lower rocks of the Aluggud group. Indeed, those rocks below the Jaba lime rock, although from their fossils they have hitherto been reckoned oolitic, carboniferous, or older in age, resemble rather the Gunda rocks (with some variations not to be wondered at in a distance of 75 miles); but the Gunda rocks are full of nummulites. It seems absolutely necessary to admit either that the productus and its accompanying fossils are found in rocks far newer than the carboniferous, or else that the nummulites are found in rock much older than the tertiary. Possibly it will turn out that both these admissions must be made, and that all these rocks belong to an age between the carboniferous and tertiary.

Doctor Fleming reports finding in what he calls carboniferous lime-stone (not the rock at Aluggud, but of like age with it in his opinion), ceralites, and "fossils bearing a considerable resemblance to belemnites," both of later age than the carboniferous. There is also found in the pebble rock just above the Jaba lime rock, and apparently quite conformable with it, pebbles of a pink or flesh-colored lime rock that answers to Doctor Fleming's description of some of the carboniferous lime rock of the Salt Range, and in these pebbles are found nummulites.

The thousand feet of greenish gray sand rock and shales above the Jaba lime rock (at Jaba), and the red and greenish gray clays above that (both at Jaba and Aluggud), and the gray sand rock (called by some writers 10,000 feet thick or more) above that, have all hitherto been reckoned as of Sivalik age, without, however, the evidence of fossils. To the positive determination of that point this survey had no occasion to devote any time, and has no light to throw upon it. It is, however, clear that the steeply dipping rocks found at Gunda, Chhur-rut, and at some other points, although they have been called Sivalik, cannot be so, for they abound in nummulites, to say nothing of the reasons for believing them to be even older than the great nummulitic lime rock of Jaba. As the mistake has therefore been made of supposing the Gunda group to belong to the sand rocks above the red and greenish gray clays, it is quite possible, to say the least, that the thickness of these upper sand rocks may prove to be after all much less than the unusual one of 10,000 feet. On the northern side of the Salt Range near Dooma, south-west of Tullagung, the red and greenish gray clays, and the sand rocks over them, dip very gently (about 5°) northerly, and the dip grows more and more gentle northward until it is nearly or quite level. At some point not yet determined, but probably south of Tullagung, the sand rocks pass below the pebble and sand rocks of the older alluvium; and these last keep a nearly level dip throughout their extent northward, while the so-called Sivalik sand rocks probably share the steeper dip of the lower rocks that is clearly shown by the valleys just north of the Sohan, as well as by the course of the Sohan itself. The out-crop of these sand rocks, then, just north of the Salt Range, with a very gentle dip, cannot probably be more than some 15 miles wide at most, and their thickness so exposed can hardly be more than 3000 feet. It is barely possible, however, that this exposure may not show the whole thickness.

It would seem, then, from the section that what (the Aluggud lime rock) has until now been thought to be below the Jaba lime rock, is really above it, while what (the Gunda group) has been thought to be above the Jaba lime rock, is really below it. This matter is, however, quite unimportant with reference to the oil lands; for it must be borne in mind that the oil-bearing beds found at different points in the section are only very locally so, commonly for a distance of only a few yards or scores of yards, rarely, as on the Aluggud brook, for 500 yards or more, or, as at Jaba, for half a mile or more. Beyond these narrow limits the same beds are often seen in their out-crops to be quite barren of oil, and in other cases the absence of any discovered spring is commonly proof enough (in a country so minutely explored as this has been by the natives) that the beds can yield no oil. Not only therefore is it necessary to

study each place separately for itself, but it is quite needless to trace out thoroughly the out-crop of each of these beds with the hope of finding oil by borings here and there all along it, or with the idea of boring say from any point in the Jaba group down to the oil-bearing beds of the Gunda group. Such a random attack upon even a bed that is known to be oil-bearing at some one place, though it might possibly prove successful, would have in its favor scarcely one chance in a thousand million.

4.—OIL, TAR, AND ASPHALTE.

a. Mode of Occurrence.—The oil is in all cases in the Punjab of a dark green color when fresh, but turns black in drying or in becoming tar or asphalte, and the tar that melts in the sun from the asphalte is also black. At the Chhota Kutta and Burra Kutta (Jaba) main oil spring there is green oil to be seen that has freshly come from the rock, but it soon mixes with the black partly dried tarry oil that surrounds it.

At Rutta Otoor, Dulla, Punnoba, Chhota Kutta, and Burra Kutta (Jaba), and partly at Aluggud, the oil (or asphalte) comes from the cracks in beds of lime rock ; in all other cases in the Punjab it oozes from sand rock or sandy shales, sometimes perhaps calcareous. In almost all cases the natural springs are at points where brooks cross the out-crop of the oil-bearing beds, and lay them bare ; but the Gunda wells are in a little plain between the head of two brooks ; the Aluggud oil comes partly from the face of a claiiff high above the brook ; and the Loondeegar asphalte is on a gently sloping hill side ; not to speak of the trifling Cheerpar oil that comes from the roof of a small cave in the face of a cliff 70 feet above the plains.

In nearly all cases where liquid oil is found, it seems to flow with water from the rock, and in the springs is found floating upon it. In the Gunda boring No. 1, however, very little water is now found to come with the oil from the rock ; and at Aluggud (where the so-called oil is, much of it, merely tar melted by the sun from a secondary or wash deposit of asphalte), although the tar is commonly found floating upon water in small holes in the bed of the brook, the two liquids did not come together from the rock. The water in this case is probably merely the common rain or spring water of the brook, protected from drying up by the layer of tar above it. The presence of some of the water in the other springs may be accounted for in the same way, and in some oil springs at certain seasons the presence of water may all be due to this cause.

The water that accompanies at least a part of the oil at the oil springs of Chhota Kutta and Burra Kutta (Jaba) is highly sulphurous, and it is possible that sulphur water may likewise be found at some of the other oil springs (more particularly at Punnoba), but the presence of sulphur is not noticeable in them.

The brook water near the oil springs of Punnoba is strongly salt (in the dry season), and there are traces of salt near the Chhurrut and Boraree oil wells, as also near the Chhota Kutta and Burra Kutta (Jaba) oil springs ; but near the other oil springs very little or no salt is to be found.

Perhaps no point regarding rock oil is more commonly or more widely misunderstood than its mode of occurrence. Most men seem to be possessed with the idea that the oil has come to the place where it is found from a great depth below. Many believe that the oil is flowing hither or thither through vast fissures in the deep rocks, or fills large cavities or reservoirs in the bowels of the earth, whence it issues to the surface by small cracks at the springs above, and that you only need to bore deep enough there to tap these reservoirs, and get an indefinitely large supply. Even some professed geologists imagine that the oil has come to the rocks in which it is now found from the natural distillation of bituminous shales or coal below it. What is more strange is, that really eminent men of science have maintained that the oil is formed by the chemical reactions of certain purely mineral bodies in the interior of the earth, basing

their views upon the established fact that similar products may be made by chemists from mineral bodies which may be believed to exist in the interior of the earth, and also on the well-known presence of oil near mud volcanoes. How much simpler and more natural than any of these far-fetched opinions is the now well established fact, that the oil was first formed, and has always remained in the same rock beds from which it now issues, and that it first came from the slow decomposition of plants and animals buried in the rock as it formed, just as marsh gas (kindred with oil) is formed by the slow decay of vegetable matter at the bottom of ponds. Plants that grow on the ground in the air, having woody fibre, would in case of burial and slow decomposition leave bituminous coal, which, under favorable circumstances, might lose its bituminous or oily part without losing the woody part, and would then become anthracite. But plants that grow in the water (such, for example, as sea weeds of all kinds down to the most delicate and microscopic), having no woody fibre, leave in such a case only oil or bitumen (including gas), and a like result would come from the slow decomposition of the flesh of animals, which in some cases might have been buried in vast quantities, though seldom probably comparable to the accumulations of weeds that are found even now-a-days in the sea. It is not, however, to be supposed that the plants or animals that gave rise to the oil in a thick bed of rock were all buried at once; the burial was in most cases probably very gradual, going on from year to year as the rock itself was formed by the gradual dropping of sand or mud to the bottom of the sea. The frequent presence of salt in beds of rock near the oil is therefore not to be wondered at, for they may likewise have been formed, not merely at the bottom of salt sea water, and therefore naturally salt themselves, but may have been formed in a shallow bay or temporarily closed inlet, where the sun's heat so dried up the water as to leave layers even of crystallised salt. The presence of sulphur with the oil is of a piece with its presence in coal or other organic remains.

Mud volcanoes owe their eruptions merely to the oil gases that are buried under a covering of mud, and push their way out from time to time. The cases of fissures filled with oil that have seemed to some the channels by which the oil rose to the surface from the lowermost depths of the earth, and have seemed to others the vast reservoirs from which the springs above are supplied, are much rarer and more insignificant in size than is commonly thought. Of the thousands of oil wells in the world, scarcely a dozen (if so many) have each yielded a hundred thousand barrels of oil from such a source. Yet a hundred thousand barrels would not fill a fissure 200 feet long by 150 feet deep and half a foot wide; and it is more likely that a fissure of that capacity would be longer or deeper, and only an inch or two wide, and still more likely that such a yield would come from a net-work of much narrower cracks or seams in the rock. It is unlikely that such open fissures would extend to any great depth where the beds of hard rock are thin and separated at short distances by soft shales or clays (as is the case, for example, in the Gunda group of rocks). A deep fissure, extending far below the oil-bearing bed, would be very sure to cross rocks containing water, as all porous rocks do below the drainage level of the region, and below the effects of the sun's drying power. This water would of course tend to fill the fissure, and the oil would float upon it; so that the hope of striking such an oil-filled cavity at a considerable depth below the oil-bearing bed is not justifiable.

It has been maintained by some that a given oil-bearing bed yields most abundantly at the point where it forms the top of a saddle, because the oil is pushed upward through the pores and fissures of the rock by the water below, and because too the fissures would be most numerous at this point. Certain oil regions have been pointed to as confirming this view, by the fact that most of their wells are near the top of a saddle of the rocks. The real cause of this fact seems, however, to be merely that at a greater distance from the top of the saddle the oil-bearing bed is at a greater depth from the surface, and that boring into it is therefore less practicable. However true it may be that water in a fissure would have the oil floating upon it and so push it upward until some

obstruction was met, it is highly improbable that such pressure would cause the oil to pass through the pores of the rock, and give up its place in them to the water. Indeed, if such action took place even slowly, the steeply dipping rocks of the Punjab would no doubt, ages ago, have had all their oil thoroughly pushed out at their out-crops by the water rising from below.

As the oil was formed from materials gathered in the rock when this was lying flat at the bottom of a sea, it is clear that the position or shape of the oil-yielding part of the bed can have in general no reference to the present shape of the ground, hills or valleys. But it is possible that the part of the oil-bearing bed, which now lies high above the drainage level, may have lost some of its oil by drainage and by the drying effect of atmospheric influences ; and this would account for the fact that almost all the Punjab oil springs are found just at the place where a brook crosses the out-crop of the bed, that is, at the lowest drainage level. The wells at Gunda even, which seem an exception, may be at the lowest point where the oil-bearing part of the bed crops out. Still, such a draining away and drying up of the oil must be extremely slow, and it is very likely that it has deprived of most of its oil only a narrow strip along the out-crop on the hill sides.

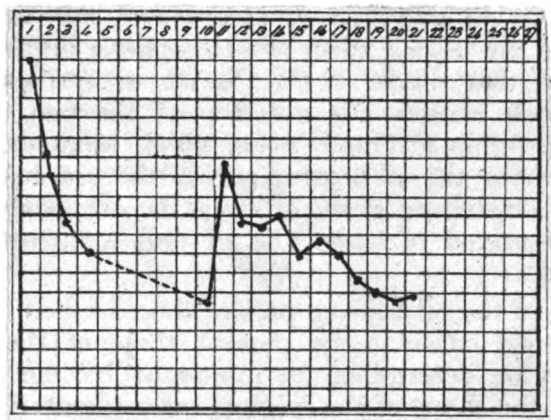
The outline of the oil-bearing part of the rock bed below the out-crop has of course no reference either to the present shape of the surface or dip of the rocks, and can only be determined by numerous borings or trial pits. As the outline depends on the shape of the original mass of materials (plants or animals) that formed it, and that upon the currents of the sea or winds, of the storms, or barriers of the shore, or depth of the bottom, it would not be possible to infer the shape of one deposit from the shape of another at a distance, especially if in different bed of rock of a different age, as is almost always the case in the Punjab. The shape (in plan) of the original mass of materials for the oil in still-water, leaving the influence of the shore and bottom out of account, would probably be circular, but a current in the water or a storm would tend to lengthen this shape to an ellipse, and the shore or bottom might give this an *S* shape, or otherwise irregular shape.

The length of the deposit along the out-crop may be known, at least roughly (for example, as great or little) by the absence of oil springs or noticeable traces of oil along it, even where well exposed and at low points of drainage. For this reason among others it is desirable to study out more or less exactly the course of the out-crop near a spring of oil. Whatever shape the original mass of oil-forming materials had, the present line of out-crop would plainly be as likely to cross it in one part as in another ; the portion on one side of the line is that which has been swept away by the rains and rivers that have scooped out the hollows in the present surface ; the other portion still lies underground. As the out-crop line is as likely to pass on one side of the centre of the original oil-bearing part of the bed as on the other, the width of the underground part at right angles with the out-crop may be taken as probably something like the half of the length of the out-crop.

b. Yield.—The chief yield of oil has been at the Gunda wells, where boring No. 1, and the dug well in which it is, have yielded all the oil, with perhaps a trifling exception. From the 8th of April 1870 to the 22nd October 1870, the whole yield here has been about 1963 gallons, or an average of ten gallons a day ; but from the 29th June to 1st August, 33 days, no oil was taken owing to the caving in of the well ; and in general none was taken on Sundays, and three other days were lost, making the average for the days that oil was taken, $14\frac{1}{2}$ gallons a day. The yield at the beginning of boring work (8th April) was about five gallons a day ; on the 28th of May the yield was about fifty gallons, the greatest yield of any one day. From that time until the caving in the decrease in the daily yield was almost continuous, to about ten gallons a day. On the 1st of August the yield was again 10 gallons a day, but on the 10th of August a fixed pump had been put into the bore hole, and the yield rose to 30

gallons a day. From that time until the 22nd of October the daily yield has again gone with some fluctuations down to 10 gallons a day. The yield in gallons in each full week of gathering the oil from 30th May to 22nd October was about 180, 120, 97, 80 (55, 128, 98), 94, 99, 79, 88, 79, 66, 58, 59; in the weeks "55, 128, 98," one day was lost from the work each week besides Sunday.

A drawing to represent these variations of yield shows that the yield at the end of this year (1870) will probably be about 35 gallons a week, and that



by the middle of next year it will be hardly a gallon a day, and that the whole future yield will be about a thousand gallons or one-half of the past yield since the boring was begun, making about 3000 gallons in all that the well will have yielded. These results are a good illustration of the character of the yield of oil wells in general, greatest at first, then rapidly diminishing; after that diminishing more and more slowly until the yield finally becomes too small to pay for pumping. The curve representing this decrease is clearly a parabola.

The yield at all the other places is from natural springs. At the Chhota Kutta (Jaba) springs the oil yield is perhaps three quarters a day; at the Pun-noba springs two quarts a day; at the Burra Kutta (Jaba) springs three pints a day; at the Rutta Otoor spring half a pint a day; at the Bussala springs one gill a day; at the Loondeegar, Chhurrut, and Boraree places a mere trace;—at all the rest no oil proper at all, making the whole oil yield of the springs perhaps seven quarts a day. Of asphalt there is at Loondeegar perhaps 1000 cubic yards, or 1500 tons; at Aluggud brook 350 cubic yards, or 550 tons; at Gunda 15 cubic yards, or 19 tons; at Chhurrut 15 cubic yards, or 19 tons; at Boraree brook six cubic yards, or seven and a half tons; at Dooma one-half cubic yard, or two tons; at Dulla half a cubic yard, or five-eighths of a ton; at the other places none at all to speak of, making in all perhaps 1388 cubic yards, or 2098 tons, capable at a rough guess of yielding as much gas as 700 tons of crude oil, that is, something more than 15 million cubic feet. Of rock tar there is at the Aluggud brook perhaps 100 gallons; at Dulla, Sadeealee, Chinnoor, Hungooch, and Dooma, scarcely more than mere traces; and at the other places none at all to speak of.

c. Out-crop.—The Gunda group of rocks seems to crop out all along the southern edge of the Choor Hills, and most likely also on the northern edge and further east to the southern edge of the hills at Rutta Otoor. They probably also appear here and there in the whole region between the Choor Hills and Khairree Moorut, and on the south-eastern side of the Khairree Moorut as far south as the Sohan River. South of this river, as well as in most of the country north of it, they seem to be covered up by rocks of older alluvial age, and only to reappear on the southern edge of the Salt Range.

The Jaba lime rock ("nummulitic lime-stone of the Salt Range") appears not only all along the Salt Range, but is probably the material of the

Khairee Moorut, Choor Hills (including the hills of the Punnoba), and the hills about Rutta Otoor.

The Jaba sand rock (just above the lime rock) crops out all along the northern slope of the Salt Range, and perhaps is also to be found among the steep dipping rocks north of the Sohan and near Khooshialgurh, on the western side of the Indus. The upper part of this sand rock, just below the red and greenish gray clays, seems to be the same as the oil-bearing rocks of the Aluggud brook also, skirting with its out-crop the eastern edge of the valley.

d. Working.—It would be hopeless, as already hinted, to bore or dig for oil along these out-crops, except very near to the places where oil springs, or at least asphalt deposits, are known. Indeed, the first borings should be as near as may be to these, not more than a few yards distant; and if they should prove successful, the oil-bearing bed may be tested in the same way to a greater and greater distance. As the bed near the surface may have been somewhat affected by ages of natural drainage and of atmospheric influences, it is desirable to test at some depth, and to bore rather to the dip from the springs than along the out-crop, although this not to be altogether neglected when the springs give encouragement. Still in boring to the dip it would not be well to make the first boring more than from fifty to a hundred feet deep, for the expense of such a shallow boring is less, and so is also the risk of striking the bed outside of the oil-bearing part of it. Other borings may afterwards be made still further to the dip, as well as to the right and left on the same level, that is, along the strike. It is commonly easy to measure the dip near the spring with exactness enough to fix upon the places of a boring that would pass through the bed at a depth of from fifty to a hundred feet. After one or more borings are made, the dip will be still better known from them, so as to be a guide for other borings.

As the specific gravity of porous sand rock is about one-fifth less than that of quartz, it is plain that about one-fifth of the bulk of the rock is taken up by pores or empty spaces between the grains of sand. One cubic foot of oil, then, or say eight gallons, would fill the pores of five cubic feet of such sand rock, and 3000 gallons (the whole past and future yield of Gunda boring, No. 1) would in the same way saturate in round numbers 2000 cubic feet of rock. Capillary attraction, however, would prevent more than perhaps a tenth of the whole amount of oil in the rock from draining into a boring, but this proportion would depend on the coarseness of the rock. Only that part of the rock next the boring would, however, be fully drained at first, while that at the outer limits of drainage would be drained infinitely little; the average amount of drainage, then, would be perhaps only one-twentieth of what is in the rock. The 3000 gallons then would drain from twenty times 2000 cubic feet, or say 40,000 cubic feet, or 2000 square feet of a bed (like that at Gunda), 20 feet thick, that is, a circle about 50 feet in diameter. According to this the wells should not be nearer than 50 feet apart upon the oil-bearing bed; but something more might be allowed for the possibility of draining to a greater distance by reason of exceptional seams in the rock here and there; and if the rock seemed on trial to be rich in oil, intermediate wells might finally be placed half way between those of the first set, so as to drain more thoroughly the less perfectly drained part of the rock. After a season of rest, the better drained portions of the rock would tend to fill up partially again from the less drained portions.

It would not be well then to put the borings, at least at first, nearer to each other than some 50 or 100 feet, because not only does each bore-hole drain the rock more or less to some 25 feet or more all around it, but the exploration of the limit and yield of the oil-bearing part of the bed will go on more rapidly if the holes are not put too close together. It is better to bore than to dig shafts through the rock, partly because it is cheaper, especially for a mere exploratory test of the bed, and partly because the very explosive gases given out by the oil render the digging of a shaft of any depth highly dangerous, and the gases are likewise very dangerous to the life of the laborers who breathe them.

in large quantity. Even artificial ventilation of such pits might well prove insufficient to remove these dangers.

As to the yield of future borings it is clear from what has already been said of the nature of oil deposits, that it must be quite impossible to make anything better than the very roughest guess. The bore-hole may hit upon a portion of the deposit where the rock is much fissured or coarsely porous, so as to give a very large yield, or it may fall quite outside of the deposit. The yield of a natural spring, however, gives some little clue as to whether the yield of borings is likely to be great or little, although the spring may in running for ages have now nearly run dry, that is, drained all the oil from the adjoining rock, or the small cracks in the rock through which the spring is fed may have become so clogged as to allow only a very small yield compared with that of a bore-hole. As the bore-hole passes through the whole thickness of the oil-bearing bed, the yield of course is likely to be greater (other things being equal) the thicker the bed is. The oil-bearing bed at Chhota Kutta and Burra Kutta (Jaba) seems from the place of the different springs to be about 100 feet thick; the bed at the Aluggud brook seems to yield oil through a thickness of some 50 feet; that at Punnoba 20 feet; at Gunda 20 feet; at Rutta Otoor 15 feet; at the Bussala River 12 feet.

The order in which the different places deserve to be tried by boring, taking the oil-yielding merits of each into consideration, is this: Gunda, Chhota Kutta, Aluggud, Punnoba, Burra Kutta, Rutta Otoor, Bussala, Loondeegar (at the asphalte). The other places do not deserve trial at all, except possibly Chhurrut and Boraree, which however derive their chief importance from the unsuccessful trials made there last year by Mr. Fenner.

But considering also the distance of each place from the points to which the oil is destined, and from the head-quarters of superintendence, the order of trial would be somewhat different. If the oil be destined to the Rawul Pindee Gas Works alone, the trial would perhaps best be made in this order—Gunda, Rutta Otoor, Chhota Kutta, Burra Kutta, Bussala, Punnoba, Aluggud, Loondeegar.

The boring No. 1 at Gunda yielded for six months an average of about 11 gallons a day. It would seem, then, that for the supply of the Rawul Pindee Gas Works (100 gallons a day) about nine such wells would be needed at a time. But as boring No. 1 will probably go on yielding something (a trifle at least) for nine or 12 months longer, making its future yield about 1000 gallons more, or 3000 in all in the course of 18 months, its whole yield will probably be about one eighteenth of the whole amount needed for the Gas Works in the 18 months. It would need, then, but one such new well every month to keep up a supply of 100 gallons a day; but that supply would not begin until a number of wells were at work; indeed 18 of them, if they were sunk only so fast. But if the oil be allowed to accumulate at first, without being used, to the amount of about 4000 gallons, or for about the four first months of the yield of such a series of wells, then the series would yield enough to keep up the supply until the full number of wells come to yielding all together. But as the very possible failure of some attempted wells and other delays must be provided against, a stock of oil should also besides be on hand before beginning its use, enough to last say three months; or else, what is about the same thing, three wells of the afore-mentioned whole yield of 3000 gallons each should have been bored before reckoning the series as begun, which, after storing up 4000 gallons, is to yield regularly the desired supply. If then the boring of the wells should go on regularly once a month, and each should yield as much as the first one is yielding, it would take four months after the finishing of the fourth well (that is, until the eighth well has been bored) before it would be at all safe to begin the use of the oil, in other words, before an uninterrupted supply of 100 gallons a day could be counted upon with any reasonable likelihood.

It seems quite likely (to make a very rough guess) that the Chhota Kutta oil lands would yield 30 such wells; the Burra Kutta 20; the Aluggud

20 ; the Punnoba 20 ; the Gunda 5, and the Rutta Otoor, Bussala, and Loondeegar, all together 5, making 100 in all. Yet so uncertain is the matter that it might well turn out that Chhota Kutta alone would yield more than 100. And it would not be very astonishing if a single well here should yield 100 times as much as the Gunda boring No. 1, that has been taken as the standard ; for although the limits of each little oil district are very narrow, the yield of single wells within those limits might be very large, since a well draws its supply from so short a distance around it. Still the rough guess just given does not seem wild either in over-rating or in under-rating the prospects of the places.

A supply of 100 gallons of oil a day may then be counted on with some likelihood for 100 months, or some eight years. Although the supply may well prove to last much longer, it may also prove to be much less ; and uncertain and probably small as it is, it would hardly be worth while to put up Gas Works for its use. As, however, the Gas Works have already been put up, it may on the whole (rather than remove them to another place where gas material is more abundant) be best to make the needful borings, and use the oil while it lasts. When the rail road reaches Rawul Pindee, other gas material may perhaps be got from a distance.

The asphalte seems to be enough in quantity to supply as much gas as a 100 gallons of oil a day for three or four years, lengthening out the term of the Gas Works to 12 years. To use the asphalte alone, the present retorts of the work would probably be too small, but it is quite likely that the asphalte could be dissolved again in a small quantity of the rock oil, and so used in combination with it in the present retorts. At the same time the pebble and sand could be separated from the asphalte after it has been reduced to the liquid form by dissolving in the oil.

As the oil all belongs to the class of heavy oils, it would be (like Rangoon oil) especially well suited for lubricating purposes, and it may well be that its most profitable use will be in that way, particularly after the rail road is finished to Rawul Pindee.

5.—SHIPMENT.

The Rutta Otoor oil spring is 13 miles by road from Rawul Pindee, the first mile only a bridle path, the rest passable for carts, and eight miles of it a good metalled road. The Bussala oil spring is 11 miles by road from Rawul Pindee, two miles and a half of which are a bridle path, the rest nearly or quite passable to carts. The Loondeegar asphalte is 16 miles by road from Rawul Pindee, about six miles a mere bridle path, the rest passable for carts. The Gunda wells are about 13 miles by a wagon road, mostly good, from Rawul Pindee. The Punnoba oil springs are 87 miles by road from Rawul Pindee ; the dozen miles next the springs are not passable for carts, but the rest are. The Aluggud asphalte is $145\frac{1}{2}$ miles by road from Rawul Pindee, of which distance about 10 miles are quite impassable for carts, but the rest is nearly or quite passable for them. The Chhota Kutta and Burra Kutta (Jaba) oil springs are 102 miles by road from Rawul Pindee, the first dozen miles or so quite impassable for carts, and the rest perhaps so in places. If the hire of a camel be taken as eight rupees a month, and his load 50 gallons of oil, and a march as about a dozen miles, the carriage of a gallon of the oil by camels from each of these places would at least cost as follows : Rutta Otoor and Bussala $2\frac{1}{2}$ pies ; Loondeegar, 3 pies, Gunda, $7\frac{2}{3}$ pies ; Punnoba, 1 anna $5\frac{1}{4}$ pies ; Chhota Kutta and Burra Kutta (Jaba), 1 anna $7\frac{2}{3}$ pies ; Aluggud, 2 annas $3\frac{2}{3}$ pies.

6.—REPORTS AND MAPS.

A special report has been written upon each of the places where oil, tar or asphalte is found, and geological and topographical maps have been made for the Rutta Otoor, Bussala, Loondeegar, Gunda, Chhurrut, Boraree, Dulla, Punnoba, Aluggud, Chhota Kutta, and Burra Kutta oil lands. It was not

thought worth while to map the other places, and even some of these derive their chief importance much less from their own merits than from the boring and digging that were formerly done at them.

The report for each place treats specially of the situation ; the lay of the land ; the geology, both the structure and the rock beds ; the oil, its mode of occurrence, yield, out-crop, and working ; salt, sulphur or any other minerals found near the oil ; the shipment ; and finally the books and papers that speak of each place. The aim has been to make the reports as full as may be, without giving needless and confusing details, and to give not only the observed facts, but the inferences drawn from them, without, however, giving mere inferences as observed facts. All the reports, though final, have by requirement been wholly written in the jungle, as it were, and are therefore defective of course in some points where a reference to books and collections would be needed.

The maps of the Gunda, Chhurrut, Aluggud, Chhota Kutta, and Burra Kutta oil lands are based upon a rough survey ; the others, mostly less important, are based upon a very rough survey, and are therefore called mere sketch maps. Each map shows a space of half a mile square with the oil springs in the centre, and by the side of the map are given an upright section of the rock beds and a long section of the basins and saddles. The maps are all on a scale of $\frac{1}{8000}$, or 500 feet to an inch, and show the shape of the ground by contour lines 10 feet apart in level, and the position of the oil-bearing bed of rock by what may be called its contour lines, 100 feet apart in level, and the out-crop by a hatched line. The observed dips are shown by arrow heads, and the number of degrees attached. The basin section is on the same scale as the map, and with the same vertical as horizontal scale, so as not to distort the structure. The rock section is on a scale of $\frac{1}{1200}$, or 100 feet to the inch, so as to make it possible to show a bed of one foot in thickness or even less. The aim has been to make the maps as full and as independent of the reports as possible, and, as in the reports, to state as fully as consistent with clearness, not only the observed facts, but also the inferences drawn from them, yet in such a way that the two classes of statement should not be confounded. The mere guess of one who has been on the ground and carefully studied the matter is of value to those who have not been there, provided it be given as a guess, and not as a positive observation. At the same time, if the original observations are truly given, nothing prevents others from drawing their own inferences independently of the observer's inferences. Of course the rougher the survey has been, the less trustworthy in intricate cases will the inferences be, but that is indicated by the very title of the map ("sketch map" or "map of a rough survey"). In the maps in question it would not have been worth while to make the survey very minute and time-taking, because what is chiefly wanted is a guide in beginning borings, or a proof of the general nature of the geology and structure of the place. They will show not only the probable general course of the out-crops and underground position of the oil-bearing beds, that is, where to look for them, but will show where borings can best be begun. The errors of these indications are in general likely to be greater the farther a point is from the oil springs themselves ; but for other reasons it is desirable to bore at first quite near to the springs, so that the errors are of less importance. The borings themselves as they advance will give more and more exact knowledge of the position of the oil-bearing bed. The maps indeed are not intended as finally accurate statements of the geology, but rather as guides to finding it out, and something on which to base the corrections furnished by further explorations.

7.—BOOKS AND PAPERS.

The Punjab oil springs are spoken of in a "Report on the Salt Range," by Doctor Andrew Fleming, *Journal of the Asiatic Society of Bengal*, Volume XVII, No. 23, November 1848, page 517 ; in a "Report on the Structure and Mineral Wealth of the Salt Range," by Doctor Andrew Fleming, *Journal Asiatic Society, Bengal*, Volume XXII, 1853, No. 3, pages 264 and 265, No. 4,

page 347 ; in "Notes on the Geology of the Punjab Salt Range," by W. Theobald Junior, Journal Asiatic Society Bengal, Volume XXIII, No. 7, 1854, page 669 ; in a "Memorandum on Petroleum in the Rawul Pindee Division," by Colonel R. Maclagan, R. E., Secretary to the Punjab Government, Public Works Department, Supplement to the Punjab Government Gazette, 5th February 1862, pages 23, 28 ; in a "Memorandum on the Results of a Cursory Examination of the Salt Range, and parts of the Districts of Bunnoo and Kohat, with special view to the mineral resources of these Districts," by Thomas Oldham, D. D., Superintendent of Geological Survey of India, Calcutta, April 1864, reprinted in a Supplement to the Gazette of India, 24th August 1867, page 780 ; in a "Report on Petroleum Operations" by A. Fenner, Assistant Engineer, Proceedings of the Government of Punjab, Public Works Department, 17th June 1866, about five pages ; in a "Letter on the Gunda Oil," by Doctor T. E. B. Brown, Chemical Examiner, Supplement to the Punjab Government Gazette for 7th February 1867, (about six pages of foolscap manuscript) ; in a paper on the "Geology of Cashmere, the Western Himalaya, and Afghan Mountains," by Doctor A. M. Verchère, Journal Asiatic Society Bengal, Part III, No. 1, 1867, page 13 ; in a manuscript memorandum, No. 220, by Major C. H. Hall, Deputy Commissioner, 5th February 1868, on file in the Public Works Department at Lahore, one page ; in a "Report on Borings for Petroleum," by A. Fenner, Executive Engineer, Proceedings of the Government of Punjab, Public Works Department, July 1869, pages 2-6 ; in a manuscript "Report on the Jaba Petroleum Springs near Kalabagh," by Lieutenant J. A. Armstrong, Executive Engineer, December 1869, on file in the Public Works Department at Lahore, pages 1-4 ; in a "Note on the Petroleum Locality of Sudkul," by A. B. Wynne, F. G. S., Geological Survey of India, Records of the Geological Survey of India, Volume III, No. 3, 1870, pages 73-74 ; and in a manuscript Report of his last winter's field work in the Salt Range, by A. B. Wynne, F. G. S., Geological Survey of India, on file in the office of the Geological Survey of India at Calcutta, 1870.

Report on the Rutta Otoor Oil Lands, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Rutta Otoor oil spring is 11 miles north by east from Rawul Pindee, and 350 yards north of the hamlet of Rutta Otoor.

2.—LAY OF THE LAND.

The hamlet lies upon a small brook called the Kutta, just in a gap in the most southerly of the several parallel ranges of high hills or mountains that border the Rawul Pindee District on the north next to the Huzara District. The general course of the first range is north-easterly and south-westerly, while the brook here runs for some distance nearly due south. East of the hamlet the ridge is divided in two by a long hollow, with two or three smaller branches. At the northern foot of the northern half of the range, and about 100 yards east of the brook, is the oil spring on the northern bank of a small branch of the brook, about 2000 feet above the sea. A little more than a quarter of a mile north of the spring is another high ridge, likewise cut through by the brook ; and the space between that ridge and the first is pretty flat for a width of say 100 yards near the brook, but rises easterly and westerly to high hills.

3.—GEOLOGY.

a. Structure.—The rocks seem to form a saddle to the north of the oil spring, and a basin to the south of it, with a southerly dip of about 50° near the spring, a southerly one of about 85° at the hamlet, and a northerly one of about 88°, some 50 yards south of the hamlet. It is probable that the axis of the

saddle is not far north of the spring, perhaps 100 yards ; and that the axis of the basin is at the southern edge of the hamlet.

b. Rock beds.—The only rocks exposed about the spring and near the hamlet are a dark gray lime rock, with nummulites and other fossils, belonging therefore to the nummulitic formation. It is probably the same as the so-called nummulitic lime rock of the Salt Range, in which the Kutta oil springs near Jaba occur. There are probably here and there layers of gray or light brown shales between the layers of lime rock. The thickness of this lime rock, including the shales that go with it, must be at least 750 feet. Scarcely 200 yards southerly from Rutta Otoor on the road to Shah-ka-Noorpoor is exposed a gray slightly reddish sand rock that dips about 45° northwesterly, seeming to pass under the lime rock just mentioned, and 20 yards further south a similar sand rock contains a six-inch layer of reddish and gray sandy lime rock. This sand rock begins probably a short distance above the Gunda group of rocks, and would in that case be also of nummulitic age. Indeed, reddish gray and red shales are exposed a mile or two south-east of Noorpoor that look extremely like some of the rocks near Gunda.

4.—OIL AND ASPHALTE.

a. Mode of occurrence.—At the oil spring scarcely any digging at all has been done ; the earth has merely been scooped out of a hole some two feet long and six inches wide, and at most some nine inches deep. This hole is commonly filled with water from a natural spring, and a thin layer of dark green oil rests upon the water, and flows very slowly away. The oil seems to come from the cracks of a bed of the lime rock, perhaps 15 feet thick, at a distance of some 250 feet above the highest sand rock. In the bed and sides of the small water course, about 40 yards below the oil spring, is some asphalte, partly in the wash, and partly in the cracks of the lime rock. It is merely dried oil that once flowed here from the cracks of the rock, as it still does at the spring. The heat of the sun softens it sometimes, and changes it into a black tar.

b. Yield.—The oil of the spring, if gathered every day, would amount perhaps to half a pint a day, perhaps even less. The asphalte extends for some two yards in length, with an average width of perhaps one yard, and thickness of six inches, and amounts therefore to about a third of a cubic yard, and would weigh perhaps half a ton, as it is impure with earth.

c. Out-crop.—The out-crop of the oil-bearing bed of lime rock runs probably north-easterly and south-westerly from the spring and asphalte exposure, in a direction not far from straight, but bending round a little towards the north on account of the rise of the ground, combined with the south-easterly dip of the bed. Some 200 yards north of the spring would perhaps be found the corresponding out-crop of the same bed on the north-eastern side of the saddle, and it would likewise run north-easterly and south-westerly with a corresponding southerly bend on either hand. Some 200 yards south-east of Rutta Otoor there would probably be another out-crop of the oil-bearing bed, with a course nearly parallel to the one of the springs. As these out-crops run along the hill sides for long distances, and would no doubt give rise to oil springs here and there if it continued to contain oil, it is probably quite barren of oil (beyond perhaps a trace of bitumen), except close about the spring.

d. Working.—In making borings, then, it would be advisable to make them at first very near the spring or asphalte. By boring south-easterly from the spring or asphalte the oil-bearing bed would be found at greater and greater depth, the greater the distance from those points. This depth would probably be 100 feet below the level of the spring for a distance from it of say 80 feet ; 200 feet at a distance of 150 feet ; 300 feet at a distance of 200 feet ; 400 feet at a distance of 240 feet ; 500 feet at a distance of 270 feet ; and so on, growing rapidly greater until a depth of 1000 feet is reached at a distance of about 350 feet. Of course, for the depth from the surface of the ground at any of these points, the height of that point above the level of the oil spring must be added

to the depths just given. It would not be best to bore at first where the oil-bearing bed would be more than from 50 to 100 feet deep from the surface ; and the result of the boring would be an additional guide, not merely as to the prospects of a deeper boring, but as to the dip and consequent probable position of the bed at greater depth. The yield of the spring at present would seem, on the whole, small as it is, to justify the Government in making the experiment of a boring not more than 50 or 100 feet deep.

5.—SHIPMENT.

In case oil should ever be found here in quantity, it could be carried on the backs of camels or other animals by a narrow bridle path to Shah-ka-Noorpoor, one mile distant, and thence by a good unmetalled wagon road, four miles to the Rawul Pindee and Murree big road, and then on an excellent metalled road eight miles to Rawul Pindee, making in all thirteen miles.

Report on the so-called Oil Spring in the Cheerpar Mountain, Rawul Pindee District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The so-called oil spring in the Cheerpar Mountain, discovered by Udhul Moosullee, is three quarters of a mile south-west of the village of Musrot, which is a mile and a half south of Runneal, a village on the Tullagung road, six miles and a quarter south-west of Rawul Pindee ; in all therefore eight miles south-west of Rawul Pindee.

SO-CALLED OIL.

a. Mode of occurrence.—The first Cheerpar Mountain (the most north-westerly of three or four) in its upper part is very thin, and consists of yellowish brown sand rock, dipping about 80° south-easterly. At the point where the oil is said to be found, half way up the steep, almost vertical southern side of the mountain, about 70 feet above the little plain below, there is, along a cleavage plane, a horizontal cave, in some places as much as six feet deep from the face of the rock and three or four feet high. It is said that in the hottest season, say in June or July, oil drips down from the roof of this cave, and forms white stalactites, six or eight inches long ; but through the rest of the year, as at the time of this survey, there is nothing of the kind to be seen. In the rock of the roof there are three or four small dark discolored patches which seem to yield the oil. The largest one is of irregular shape, but at most about two yards long north-east and south-west, and two feet wide, and another two yards south-west of that is about two yards long by one foot wide, and has a still narrower spot alongside of its south-western end, and about a foot from it. The white substance of the stalactites described is probably natural paraffine, which melts in the great heat of mid-summer and drips from the rock. The rock probably belongs to the age of the middle of the Gunda group, that is, nummulitic.

d. Working.—The amount to be obtained from so small a deposit as this seems to be would be far too little to justify any expense in the way of further explorations, such as boring or digging. It seems in fact to be confined to the dark-colored patches just described, and the chances of hitting upon other like patches by digging or boring into the rock below are extremely small, and the likelihood of hitting upon a larger deposit of the kind there is still smaller.

Report on the Bussala Oil Lands, on the Seel River, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The oil spring on the Seel River at the mouth of the Bussala, in the Rawul Pindee District of the Punjab, is 10 miles and a half south-west by west of Rawul Pindee, and one mile and three quarters east of Moorut village.

2.—LAY OF THE LAND.

Both banks of the Seel and of the Bussala (here some 1500 feet above the sea) are very steep, and much gullied with many precipices. Back from these the land lies nearly flat, rising to a height of 100 or 125 feet from the beds of the rivers; but it is broken up in many directions by the steep-sided gullies of the smaller streams, and to the north-east are two or three small chains (two or three miles long) of low hills rising above the general level.

3.—GEOLOGY.

The older beds of rocks near the spring all dip about 75° south-easterly, with a strike of north 57° east; but the newer rocks rest upon these quite unconformably, and are nearly level or quite so.

These newer rocks are of older alluvial age, and consist at the top of a very much contorted concretionary lime rock or travertine, full of irregular holes and of hollow tubes, probably broken fossil stems of plants, and of fossil leaves, and this rests possibly here, as it clearly does elsewhere within three miles, on a very coarse pebble rock with pebbles of fist size or larger. The travertine is exposed on the eastern bank of the Bussala about 100 yards above the mouth in a cliff some eight feet high. The pebble rock is exposed on the east bank of the Seel about 60 yards above the mouth of the Bussala, and is from nothing up to three feet in thickness according to the erosion that had taken place in the underlying rocks before the deposition of the pebble rock. The cliffs, some 40 feet high along the banks of the two rivers, seem to consist mainly of a soft yellowish brown sand rock that rests immediately upon the coarse pebble rock where this is exposed. At the crossing of the Seel, about two miles north of this place, near the village of Tulbeeun, the concretionary limestone to the thickness of 100 feet or so is seen resting upon the coarse pebble rock, and this, about three feet thick, upon the soft brown sand rock which reached to the water's edge, all of these with no dip or nearly none above steeply dipping rocks in the beds of the river. It is likely therefore that there are at least two layers of pebble rock, one between the travertine and soft sand rock and not seen at the oil spring, the other below the sand rock.

The older rocks at the oil spring are probably of the nummulitic formation, of the same age as the Gunda group; and the following section was noticed there on the east bank of the Seel, about 60 yards north-east of the spring downward :—

Shales	...	...	...	...	...	...	...	about	5 feet
Limy sandy shales	...	...	...	...	...	...	...	"	8 "
Blue sandy, clayey, and (limy ?) shales, with a thin layer of lime rock near the bottom like the next	...	...	...	...	...	...	...	"	15 "
Bluish gray lime rock, broken up into thin cross cleavage layers, nearly at right angles with the bedding	...	...	...	...	...	...	...	"	12 "
In all								"	40 "

The oil would seem to come from the blue shales. About 100 yards up the Bussala from its mouth there is a thin layered, almost slaty, light brown sand rock with a like dip, which must be therefore about 350 feet below the section just given, and on one of its blocks are a few spots of black, as if some body had spilt some tar there. It was pointed out as a deposit of mineral tar, but would seem not to be a natural one, nor to have the least importance in any case.

4.—OIL.

a. Mode of occurrence.—The oil rises up through the extremely shallow water of the river; one drop at a time every minute or two gives rainbow colors to the surface of the river for the space of a few inches, then floats away and disappears. At a distance of about 20 yards north-easterly, apparently on the out-crop of the same bed of shales, is another like show of oil also at one or two other places between these extremes.

b. Yield and working.—The whole yield is plainly very small indeed, at most say a gill a day, too little probably to justify any boring to test the bed, especially as this at its exposure on the bank close by seems to be quite barren of oil. Still it may at some time be thought worth while (more particularly on account of the nearness of Rawul Pindee) to test the same bed at some little depth, and in that case it is clear where borings should be made. As this and other deposits of the kind in this Province seem to be of but very limited extent, perhaps a few yards only, it would not be well to make the first boring very far from the points where the oil and gas are seen to rise. As the bed dips some 75° to the south, 33° east, it will be needful to go in this direction; 28 feet and two-thirds only to bore upon the bed at a depth of 100 feet below the river level, twice that distance for 200, and so on. Of course the height of the boring site above the rivers should be borne in mind as adding to the depth of the boring. In this way the bed can be bored upon at any desired depth, and the bed can be tested at the same depth below water level in a north-easterly or south-westerly direction, bearing in mind that the strike is north 57° east, and going in that direction from the point found out as just described for any given depth.

5.—SHIPMENT.

The place is quite accessible, as it is only two miles and a half from the big road that passes through Tulbeeun south-eastward, and that road connects without any bad stream to cross with the Tullagung road south of Runneal. The only bad place in respect to carriage is up the steep, gullied river bank, close by the oil spring, but this could easily be improved, and is already quite passable to horses and camels. The oil spring is by the road three miles and three quarters from Runneal, and 11 miles from Rawul Pindee.

Report on the Loondeegar Oil Lands, near Moorut, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The asphalte and oil places near the house called Loondeegar, on the land of Goolab Shah, a Lumberdar of Moorut, Rawul Pindee District, Punjab, are two miles and a half south-west by west of the main Moorut village, and 14 miles south-west by west of Rawul Pindee.

2.—LAY OF THE LAND.

The two places are about 1550 feet above the sea near the head waters of some small streams that flow south-easterly into a brook that comes down from the southern side of the Khairree Moorut, and empties into the Seel River, and are about half way between the mountain and the river. The asphalte place is on a gently sloping hill side; and the oil place, a quarter of a mile south-westerly of that, is on the bank of a small watercourse. Between the two is a ridge about 80 feet high, running north-west and south-east, and a couple of 100 yards north of the asphalte is a ridge of about the same height, running for some 300 yards east north-easterly. North of that is a wide plain, and south of it the land is nearly flat, and slopes gently south-easterly. The land to the south-west of the oil place is also nearly flat, except where gullied by the small watercourse and its tributaries.

3.—GEOLOGY.

At the asphalte place the solid rocks are not at all exposed, so that the dip and strike are not to be seen, but at the oil place the strike is seen to be about north 55° east; and as the direction from one place to the other is the same, they are both probably on the out-crop of one bed. The dip at the oil place is about 85° north-westerly; but some 45 yards north of that, the dip, although in the same direction, is only about 60° . Some 10 yards still further north the rocks, with the same dip, are covered by a nearly or quite level bed of concretionary lime-stone or travertine, about two feet thick. This is plainly such travertine as that on the Bussala River near its mouth, and therefore of older alluvial age. The steeply dipping rocks are of the nummulitic formation (probably of the Gunda group), and many nummulites are to be found on the hill side east of the oil place. The rocks exposed at the oil place, and at 40 or 50 yards north of it, are all a coarse greenish gray soft sand-stone, and it is the source apparently of all the oil that has flowed at either place.

4.—ASPHALTE AND OIL.

a. Mode of occurrence and yield.—The asphalte occurs in the form of bituminous earth, or earthy asphalte, plainly the product of a natural spring of oil that has in former times flowed here, and whose oil in drying has become solid, and remained mixed with sand and small pebbles. It has been dug into at one point to the depth of two feet and a half or three feet without coming to the bottom of it, and extends over a surface, roughly a triangle in shape, about 60 yards long, and about 1000 square yards in surface extent. Taking its average thickness at a yard (and it seems to be fully that though not yet properly tested by digging), the amount would be about 1000 cubic yards. No test of its capacity to yield oil or gas seems ever to have been made, although it is said that 10 maunds of it were taken by Government Agents to Rawul Pindee some two years ago. By mere guess it would seem likely to yield to the cubic yard at least as much gas as half a ton of oil, that is to say, some 11,000 cubic feet. The specific gravity of the asphalte has not been tested either; but as it is earthy, a cubic yard would weigh perhaps a ton and a half, certainly not more than two tons, and probably not less than one ton. The whole thousand cubic yards would weigh then about 1500 tons.

The oil occurs at both places in extremely small quantity, but chiefly at the asphalte place, and is found only in the hot weather, evidently the effect of heat upon the asphalte at the one place, and on the bituminous rock at the other place. This bituminous rock seems to be of very small extent, a mere blotch in the

coarse green soft sand rock, some 15 yards long (north-west and south-east), and three yards wide (north-east and south-west), and only exposed to a depth of two feet by a small trial pit. There are four other such oily spots in the rock close by, all small ones, varying from two feet to two yards long.

d. Working.—The proper place to bore, or dig, to test the yielding capacity of the bed at any desired depth from the surface, is to the north-west ("to the dip") from either the asphalte or the oil place. As the bed dips at an angle of about 85° at the oil place, and perhaps at the same angle at the asphalte place, it will be needful to go only eight feet and three quarters to the dip to find the bed at a depth of 100 feet, or to go 17 feet and a half to find it at 200 feet, and so on. The bed at any such depth may be followed north-easterly or south-westerly by going in the direction of the strike, about north 55° east. There is, however, little or no encouragement to boring except close by the asphalte, that seems to have come from a considerable deposit of oil in the rock which may not have been exhausted. It is plain that all such deposits in this region are, like the small ones at the oil place here, quite limited in extent, and it is therefore not best to bore far from a spot where oil is known to occur. A well elsewhere sunk at random on the bed might possibly hit upon a good deposit, but the chances are very greatly against it.

5.—SHIPMENT.

The places are by a road passable to horses and camels, but hilly, two miles and a half from Moorut village, which is three miles by a good bridle path from Runneeal, and thence it is 10 miles and a half by larger roads to Rawul Pindee, or 16 miles in all. But it is only five miles from the asphalte and oil, over a pretty good country for making a road, to the Tullagung road at a point 10 miles and a half from Rawul Pindee.

Report on the Gunda Oil Lands, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Map of a Rough Survey, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Gunda oil wells are on a tract of three acres and a half of land owned by the Government, about 100 yards west of the big road from Futtehjung to Campbellpoor, and two miles and a half north-west of Futtehjung, and are 23 miles slightly south of west of Rawul Pindee. They are one mile south south-east of Ajoowal, and one mile and three furlongs north-west of Soodkal, and have by different writers been called by the name of each of these villages.

2.—LAY OF THE LAND.

The wells, about 1700 feet above the sea, lie in the middle of a plain about 300 yards wide north and south, about 100 yards on the west from the

head of a small stream flowing westward into the Bugwan, and 400 yards on the east from the head of another small stream flowing eastward and north-eastward to the Nundna. This plain is separated on the south by a ridge about 15 feet high from the wide plain that reaches several miles west of Futtehjung. On the north are three ridges, the highest some 40 feet above the wells, within about 300 yards between the little plain and the valley in which lies the village of Ajoowal. Easterly from the wells for half a mile the ground is little broken and slopes gently, but westward it is much broken by hills, rising 30 feet or so above the wells, and narrow valleys some 75 feet below the level of the wells.

3.—GEOLOGY.

a. Structure.—The little plain of the wells lies in a basin of the rocks which seems to extend for several miles both easterly and westerly. The first ridge north of the well is formed by a saddle in the rocks, but seems to lie within the main basin, which is bounded rather by the rock saddle of the double ridge, about 200 yards further north. The low ridge south of the wells seem to be composed of two or three chains of rock saddles, but to be in the main the northern half only of a large saddle, having the general dip of its rocks northerly. Subordinate to this main structure are many small saddles and basins, the larger ones in general parallel to each other and to the main basin, but the smaller ones filling up the spaces between each other and the larger ones with great variety and apparent irregularity in their directions. The general course of the main basin seems to be about north 80° east, but that of the larger of the small basins seems to be north 70° or only 60° east. The dip is often quite steep, often in fact reversed (as far as 70°), and is seldom less than 45° . Owing to this, and the fact that there are so many small basins and saddles with various directions, it is very hard to form a good opinion as to the precise place of any given bed in almost any place where the rocks are unexposed for a few yards. But in the central part of the basin the rocks are somewhat less disturbed and irregular than at the sides.

b. Rock Beds.—The rocks that share the structure just described belong to the nummulitic formation, and are the only ones that are clearly in place within 200 yards of the oil wells. But a little more than a quarter of a mile south-west of them are exposed some rocks, probably of older alluvial age, lying nearly level upon steeply dipping nummulitic rocks, and capping the hills on the northern edge of the great plain. These rocks, of alluvial age, are a brown pebble rock, with pebbles of walnut and filbert size, some 10 feet thick, covered by a coarse concretionary light buff (but weathering dark bluish gray) limestone or travertine, full of irregular holes, perhaps five feet exposed. Many blocks of this same lime-stone are scattered on the hill tops between that and the wells, and in some places are seen also traces of the pebble rock, and some of this seems to be in place. In the little plain of the oil well there is also a thickness of a few feet (perhaps generally from three to a dozen or even more) of wash or soil and recent alluvium that covers the rocks in the hollows. Indeed, well No. 2 of this year has now been dug to a depth of over 111 feet before coming to solid rock, and a great part of this depth is probably in wash.

The following seems to be the section downward of all the rocks of nummulitic age exposed within a quarter of a mile of the oil wells, and perhaps also within a much greater distance, for the many saddles bring the rocks again and again to the surface, perhaps with some changes of texture, or hardness, or thickness, or color, in the same beds:—

Thin layered, reddish brown, fine grained, hard, calcareous sand rocks, with softer, thinner, redder layers	about	12 feet.
Gray, slightly reddish, soft coarse sand rock	"	12 "
Red, coarse, calcareous, thin layered, sand rock, with white cale spar seams	"	8 "
Soft greenish gray, coarse sand rock	"	30 "
Coarse gray, slightly reddish sand rock	"	30 "
Coarse brown pebble rock, thinning out	"	5 "
Bright red shales, mostly soft, but with some hard layers	"	30 "
Brown shaly sand rock, thin layers, with shales between	"	4 "
Greenish gray shales and sand rock	"	2 "
Bright red shales (partly hidden)	"	4 "
Gray, slightly reddish, weathering dark brown, hard, rather coarse, compact, a little cross bedded sand rock	"	10 "
Bright red shale (partly hidden)	"	15 "
Bright red shale, with some layers of greenish gray (partly hidden)	"	8 "
		<hr/>
Chiefly red or reddish gray sand rock and red shales		170
Light yellowish brown, soft, irregularly bedded sand rock, with some thin (six-inch) layers of harder nodules and some brown shales	"	10 feet.
Yellowish brown, hard sand rock, extremely full of nummulites	"	3 "
Brown hard, nodulon sand rock, made up of little and big nodules, very irregularly joined together	"	4 "
Very soft greenish gray and brown sand rock or shales, with some harder, six-inch, layers of brown sand rock, <i>oily or bituminous</i>	"	20 "
Brown, very coarse pebble rock; the pebbles are rounded, and mostly of sand-stone, and some of them six-inch long or more; some of them weather of a brighter yellowish brown than the rest of the rock; a few small ones are of lime stone, from two feet to six feet, say	"	4 "
Very light brown soft sand rock	"	7 "
Pebble rock like that just described	"	1 "
Light brown, very coarse soft sand rock	"	7 "
Fine pudding rock, full of nummulites, hard (calcareous?)... ..	"	1 "
Very light brown soft sand rock or shales, with here and there a harder rib of the same, and perhaps some red near the bottom	"	20 "
Light brown or slightly brownish gray, very coarse, thin layered shaly sand rock	"	3 "
		<hr/>
Chiefly brown sand and pebble rocks		80
Red shales	"	2 feet.
Light brown calcareous sand rock or sandy lime rock, in thin (four-inch) layers, exposed... ..	"	1 "
Red shales or clay, with about one foot of the same sandy lime rock, in thin layers, about $\frac{2}{3}$ of the way down	"	20 "
Dove-colored rather pure-looking thin layered lime rock	"	3 "
Red shales? hidden	"	2 "
Same lime rock as last, but irregularly bedded	"	2 "
Red shales or clay	"	15 "
Same but less pure-looking lime rock	"	3 "
Red clay? mostly hidden	"	2 "
Reddish and greenish hard calcareous shale	"	1 "
Red clay? hidden	"	9 "
Rather pure-looking dove-colored lime rock, such as above, and shales of a like kind, and softer shales, partly hidden and partly exposed, a succession of beds	"	100 "
Bright red clay or fine shales	"	10 "
Same succession of lime rock, hard and soft shales, partly hidden	"	20 "
		<hr/>
Gray lime rock, red and gray shales		190
Bright red shales, perhaps	"	60
		<hr/>
Whole series exposed		500

4.—OIL AND ASPHALTE.

b. Yield.—The oil wells were first dug in 1866 by Mr. Fenner near a natural spring. There are seven or eight holes dug by him lying in a general north-east and south-west direction, and within 70 yards north-east and 50 yards south-west of the main well, and within about 20 yards of each other. Two or three of the holes are shallow, and most of them have fallen in, and seem never to have yielded oil. One, however, 50 yards north-west of the main well, is said to yield a little oil, but much less than the main well, and it is therefore neglected. It is 13 feet deep, and goes something over half of that distance into the solid rock.

Another hole (now filled up), 20 yards south-west of the main well, yielded still less oil, and a few drops were seen upon the water that was there; one or two of the other holes show a trace of oil also at times. The main well was the most promising when all these holes were 15 feet deep according to Mr. Fenner's report, and yielded "25 seers a day," about six gallons. It was therefore deepened by him in 1869 to 35 feet, and yielded then, he reported, "seven to nine gurrahs every morning," which would be about 25 gallons, allowing a gallon or two for waste in the "wasteful manner of gathering" which he speaks of. At the end of March 1870 the same well yielded about five gallons a day (one gurrah and a half to two gurrahs) when the oil was gathered every day; but, when the well had been neglected for a week, the yield would be about 30 gallons for the first day.

On the 8th of April 1870 a boring was begun in the bottom of this well and was carried to a depth of 75 feet from the surface. The largest yield of the well and boring on any one day was 50 gallons on the 28th of May, just after the boring was finished. The whole yield of the well and boring since the 8th of April has been—

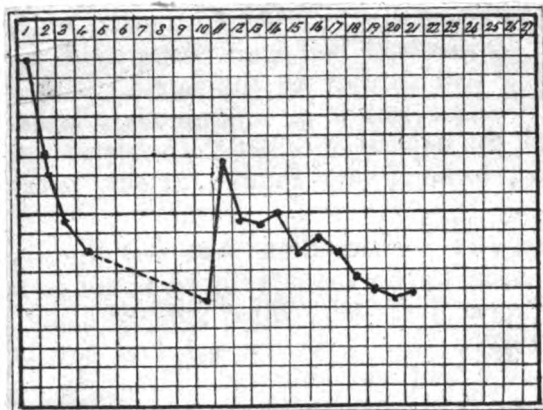
From the 8th of April 1870 to 28th of May 1870 about 1500 gallons.

In the week ending	4th June 1870	...	...	"	180	"
Do.	11th " "	...	...	"	120	"
Do.	18th " "	...	...	"	97	"
Do.	25th " "	...	...	"	80	"
On the 27th and	28th " "	...	...	"	23	"
In the week ending	6th August 1870	...	...	"	55	"
Do.	13th " "	...	...	"	128	"
Do.	20th " "	...	...	"	98	"
Do.	27th " "	...	...	"	94	"
Do.	3rd Sept. "	...	...	"	99	"
Do.	10th " "	"	79	"
Do.	17th " "	"	88	"
Do.	24th " "	"	79	"
Do.	1st October "	"	66	"
Do.	8th " "	"	60	"
Do.	15th " "	"	58	"
Do.	22nd " "	"	59	"

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From the 28th of June to the end of July no oil was gathered owing to a caving in of the well. On the 9th of August a pump was fixed in the well for the first time, and the increased yield from about that time seems to be mainly due to frequent pumping, but partly perhaps also to the re-opening of crevices on the rocks by the water of the rains that soaked through them, and was pumped out by the bore hole. The irregularity of the yield in the last weeks (which is still more striking on the daily record) may perhaps be owing either to irregularity of pumping or else to changes of weather not reported.

A diagram showing the foregoing week by yield of the well gives what is



clearly a broken parabolic curve, and shows that the well will, at the end of this year (1870), yield some 30 or 40 gallons a week, and that the yield will continue worth pumping until 1st July or 1st October 1871, although very small at last. The diagram shows also that the future yield of the well to be about 1000 gallons, making its whole yield about 3000 gallons.

On the surface near the main well, and north-easterly from it towards the next best yielding hole, is a quantity of hardened mineral pitch or asphalt (called by the natives "moomeeai") upon the surface of the ground, clearly the result of the drying of oil that has flowed here naturally in past times. This asphalt covers a space about 30 yards long, and averaging say three yards wide, with perhaps an average thickness of six inches, and making the whole quantity some 15 cubic yards. It is in parts pretty pure, but in other parts much mixed with sand and gravel. It would probably weigh on the average something like a ton and a quarter to the cubic yard, or in all about 19 tons. Of gas it would yield to the cubic yard, probably somewhat more than as much as half a ton of oil, or some 11,000 cubic feet.

c. *Out-crop*.—In the main well (or well No. 1) and in the hole close by it, and on the surface of the ground for a few yards north-east of it, is exposed a soft greenish gray sand rock, and the position of the asphalt shows that the oil issued from it, especially from cracks in it; but the whole rock seems impregnated with bitumen or dried oil, and looks brown on the inside, while weathered gray outside. There is also exposed near to this rock a hard, rather shaly (limy?) sand rock quite filled with nummulites. The soft greenish gray sand rock which contains the oil (perhaps from the decomposition of the soft parts of the bodies of the nummulites, so wonderfully numerous) seems to be the rock about 20 feet thick, noted as bituminous in the general section, about 17 feet below the top of the series of brown sand rocks and shales. The out-crop of this bed of rock runs probably about north 80° east from the wells, but is not exposed there within half a mile at least. Westward it runs nearly in the same direction, with some crooks for about a quarter of a mile, without any good exposure, and then turns northerly and then north-easterly around the middle of the basin. At this turn it is partly exposed, and seems to contain no bitumen, but, from about 50 yards north-east of the turn for about 200 yards in that direction, is seen to be impregnated with bitumen in the same way as at the oil wells, and, although weathered greenish gray outside, looks brown inside, and gives out a bituminous smell. This exposure of bituminous character is a quarter of a mile north-west of the main well, just below a dam across a small watercourse, and along the hill sides on either hand. No asphalt apart from what impregnates the sand rock is seen here. About 450 yards north-east of the turn northward the out-crop is cut short by a fault nearly at right angles with it, and thrown about 160 yards south-easterly to the ridge next north of the wells, and then runs north-east for half a mile or so at least. The oil-bearing bed crops out likewise

along the brow (nearly east and west) of the second hill north of the oil wells, about 360 yards north of them, with a northerly dip, the northern-side of a saddle. Another saddle, with so steep a southern dip as to amount to a fault in some places, brings up the same bed again along the brow of the nearly parallel ridge, some 60 yards still further to the north. But in all these outer-crops, wherever exposed, it seems not to be bituminous, except in the places already mentioned. Indeed, the deposit of oil at the wells seems like those found elsewhere in the district, to be of very limited extent, perhaps a few score yards at most.

d. Working.—It is clear, then, that any digging or boring should be made at first very near to the main well, so as not to fall quite outside of the deposit. As the rock just here dips steeply some 60° or more north-easterly, every 55 feet in that direction will find the bed at 100 feet greater depth if the dip should continue uniform. The rock, however, as seen in the digging close to the oil well, changes its dip here two or three times within four or five yards, with little saddles and basins, so that its place at the distance of 55 feet cannot be counted on with certainty; still its most probable place is as just mentioned. It is possible that if the oil-bearing bed should be bored into at the depth of 100 feet or thereabout, it might yield more oil there than at the present well, but it is not very probable.

The whole cost of the boring and digging of this year has, however, been at least equalled by the value of the oil taken; for that expense up to the end of September was about Rs. 1,200, or a little more, making the 2000 gallons of oil cost about 10 annas a gallon. The cost in America of refining crude oil is about five annas or less a gallon; even if it were double that here, the cost of refined oil from this source would be but 20 annas a gallon, or less than half what it costs in the Rawul Pindee market. If the crude oil yields 80 cubic feet of gas to the gallon as expected, the cost of this oil for gas would be at the rate of one anna for eight feet, or Rs. 7-13 for 1000 feet.

On the 23rd May 1870 another well for a boring ("well No. 2") was begun at 50 feet north-west by west from boring No. 1 (by mistake this point was taken instead of "30 feet north north-west," as directed); and on the 1st of October it had been dug to a depth of over 111 feet without coming to any solid rock on which to begin boring, nothing but red and gray mottled clay. The object of the boring was to test the oil-bearing bed at a depth of 75 or 100 feet quite under cover, but not far from the first boring. The bed at the place taken for the well will, however, be somewhat deeper than that, say 150 feet to the bottom of it. If the dip should have grown steeper than at boring No. 1, or prove greater than 60 degrees, the depth may be still greater.

In August (contrary to the indications of this survey) a second boring was begun alongside of boring No. 1 in the same well; but, at the depth of about eight feet, was stopped by the sticking fast of a chisel that could not be removed. The boring of another hole so near the first was not advised, because the first would probably drain the rock of oil for some distance around it so thoroughly as to make another boring unlikely to pay its expense.

On the 24th September 1870 a third boring was begun at 88 feet east north-easterly from boring No. 1, to be carried on at the same time with the digging of the second well, and to test the oil-bearing bed at a distance of 100 feet or so from the first well along the strike. On the 4th October 1870 a hole was likewise begun about 30 feet north north-west of boring No. 3 to test the bed again at a depth of about 75 or 100 feet. If these holes should give encouragement, a hole might well be bored about 50 yards north-easterly from boring No. 1 near an old hole that has a show of oil in it; after that, if still encouraged by the borings already made, one might be made at 30 feet north north-west of this last, and so on, feeling the way along the strike north-easterly, and at the same time north-westerly to the dip. If these borings near the out-crop are successful, still deeper ones might be made to the dip. The borings

themselves will give, as they go on, better and better information in regard to the course of the bed, both strike and dip, and be a guide to future borings.

5.—SHIPMENT.

As the well is close by the big road from Futtehjung to Campbellpoor, the asphalt can be carried away either on camels or in bullock carts. The distance by the old road to Rawul Pindee is 27 miles and a half, by the new road about 30 miles.

7.—BOOKS AND PAPERS.

The Gunda oil springs are spoken of in the "Report on Petroleum Operations by A. Fenner, Assistant Engineer, Proceedings of the Government of Punjab, Public Works Department, 17th June 1866 ; in a letter on the Gunda Oil by Doctor T. E. B. Brown, Chemical Examiner, Supplement to the Punjab Government Gazette for 7th February 1867 ; in a Manuscript Memorandum, No. 220, by Major C. H. Hall, Deputy Commissioner, 15th February 1868, on file in Public Works Department, Lahore ; in a "Report on Borings for Petroleum," by A. Fenner, Executive Engineer, Proceedings of the Government of Punjab, Public Works Department, July 1869, pages. 2, 3, and 6 ; and in a "Note on the Petroleum Locality of Sudkal," by A. B. Wynne, F. G. S., Geological Survey of India, Records of Geological Survey of India, Vol. III, 1870, No. 3, pages 73 and 74.

Report on the Chhurrut Oil Lands, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Map of a Rough Survey, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Chhurrut oil well is 150 yards south-east of the village of Chhurrut, five miles and a half west by north of Futtehjung, and 28 miles in a straight line west of Rawul Pindee.

2.—LAY OF THE LAND.

The oil well is in the middle of a little valley that stretches with a flat bottom for 200 yards to the east and 125 yards to the west, with a width of 40 yards at the oil well, but of 60 yards further east. This little valley is separated only by a narrow ridge, 60 feet high, from the Bugwan River on the south, which is here about 1500 feet above the sea, and has a general east and west course. The little valley, only 10 feet above the river in level, is drained into the river around the western end of this hill. On the south side of the river is a flat about eight feet above the river in level, and 100 yards wide. South of that is a long double east and west ridge of 80 feet or more in height, followed on the south by a narrow plain and other parallel ridges. North and west of the oil well the land rises to a level of 40 or 50 feet above the river, and reaches back in a plain, 400 yards to the north, to a long east and west ridge, some 40 feet higher, followed closely by other parallel ridges to the north. The village is built on the southern edge of the plain just mentioned.

3.—GEOLOGY.

a. Structure.—The rocks of the first long ridges on the north and south are in the main the same, and dip away from the river, giving the whole valley between the appearance of a rock saddle valley or anticlinal valley, of half a mile wide. But the saddle is not a simple one, and has within it some eight or 10 smaller saddles, and perhaps the southernmost of them should rather be

considered as giving an anticlinal character to the southern mountain, and possibly the corresponding anticlinal on the north, which is half hidden, should cause the valley to be regarded rather as a rock basin with smaller rills within it. At the oil well itself the rocks form, it seems, a very small saddle; 40 yards south is another, and about 140 yards south of that probably another, and 80 yards south of that is another, and 100 yards south of that still another. On the north there seem to be small saddles at 50, 110, and 210 yards north of the oil well, and perhaps still others at 290 and 400 yards north of it.

b. Rock Beds.—The rock beds exposed in this neighbourhood are in the main the same as those seen around the Gunda oil wells, three miles to the east, but with some variations, and are of nummulitic age, except perhaps near the bottom. The following sections are exposed near the Chhurrut place :—

In the double ridge south of the Bugwan, very soft						
greenish gray sand rock	...	...	...	...	about	6 feet.
Rather hard greenish gray sand rock	...	...	...	...	"	16 "
Hidden	...	...	...	...	"	4 "
Greenish gray soft sand rock	...	...	...	...	"	30 "
Hard coarse gray sand and pebble rock	...	...	...	...	"	2½ "
Greenish gray soft sand rock	...	...	...	...	"	5½ "
Red shales	...	...	...	...	"	2 "
Greenish gray soft sand rock	...	...	...	...	"	5½ "
Hard pebble rock (brown pebbles up to two inches)	...	...	...	...	"	4½ "
Greenish gray very soft sand rock (only 2½ feet exposed at top)	...	...	...	...	"	20 "
Greenish gray soft, partly hard, sand rock	...	...	...	...	"	23 "
						<hr/>
Greenish and brownish gray sand rock and shales	...	...	...	...	...	113
Gray nummulitic shale, and two (two-inch) layers of gray lime rock	...	...	...	...	"	4 feet.
Very light gray lime rock, crystalline, and nummulitic	...	...	...	...	"	0½ "
Gray shales, full of nummulites	...	...	...	...	"	2 "
Light gray thin layered lime rock	...	...	...	...	"	1 "
Nummulitic shaly lime rock	...	...	...	...	"	2½ "
Mottled, white, brown, red, but dark weathering-lime rock	...	...	...	...	"	1 "
Brown shales	...	...	...	...	"	2½ "
Nummulitic shaly lime rock	...	...	...	...	"	3 "
						<hr/>
Gray lime rock and shales	...	...	...	...	...	17
A gap here, of perhaps	...	...	...	...	"	50 feet.

Then on the north side of the same ridge—

Hard shaly lime rock, with iron ore (brown hematite altered from pyrites) in small crystalline nodules	...	...	...	...	"	3 "
Brown shales	...	...	...	...	"	6 "
Hard gray shaly lime rock	...	...	...	...	"	4 "
						<hr/>
Gray lime rock and shales	...	...	...	...	...	13
Here a gap of perhaps	...	...	...	...	"	30 "

Then in the north-east corner of the little flat in which the oil wells lie—

Light and dark gray lime rock beds, with gray shales between (in these the oil occurs, and at the well at least the lime rock is sandy)	...	...	...	...	about	80 feet.
Red shales (thick)	...	...	...	...	?

Likewise, probably, the lower part of this last section in the north bank of the Bugwan, just south of the oil well—

Gray lime rock	...	...	...	...	about	4 feet
Grayish green shales or clay	...	...	...	...	"	10 "
Red shales or clay	...	...	...	...	"	8 "
Hidden	...	...	...	...	"	5 "
Dark purple shales	...	...	...	...	"	4 "

OIL AND BITUMEN.

a. Mode of occurrence.—The oil seems to flow from the crevices of the sandy gray lime rock marked bituminous in the section, and from the more sandy shales between the layers of lime rock, and to come then from the lower part of the sandy lime rock and shales of the Gunda section. The oil when fresh is dark green in color, but turns brown or black in the air.

b. Yield.—At the oil well a hole was dug by Mr. Fenner in 1869, 20 feet deep, according to his report, and a bore hole sunk, he says, to the depth of 72 feet from the surface. He reports that the hole yielded two seers (or say half a gallon) of oil daily. The digging at the time of this survey (April 1870) was almost quite full of muddy water through which many bubbles of gas rose; but the amount of oil on the surface was extremely small, perhaps hardly a spoonful, and the villagers said that there had never been any more. As the oil does not seem to be gathered at all, the amount of it on the water must be the accumulation of a long time, so that the daily, or even monthly, yield would seem now to be extremely little.

On the surface of the ground and of the gray lime-stone rocks that crop out near the well are irregular deposits of solid mineral pitch or asphalt, some times a little softened in the heat of the sun, in some parts quite pure, but in others much mixed with sand and fine gravel. These deposits reach to 33 yards east of the well, and to 47 yards west of it, with a gap of 20 yards where none is exposed, just west of the well. The whole length then is about 60 yards, its average width is perhaps $1\frac{1}{2}$ yards, and its average thickness $\frac{1}{2}$ yard, making the whole amount 15 cubic yards. This impure asphalt would perhaps weigh a ton and a quarter to the cubic yard, making 19 tons in all, and perhaps yield of gas as much to the cubic yard as half a ton of oil, or say 11,000 cubic feet. In the south bank of the Bugwan River, about 275 yards south-east of the oil well, are exposed within a space of 50 yards, four deposits of solid impure asphalt, plainly thrown down by the river in a former bed. They are 1, 5, 3, and three yards long, and average about one-sixth of a yard in thickness, and reach into the bank perhaps one yard on the average, giving in all two cubic yards or $2\frac{1}{2}$ tons. There would be then in all 17 cubic yards, or $21\frac{1}{2}$ tons.

d. Working.—As the rocks here are in saddle form, with a steep dip of about 70° on either side, it is necessary of course in boring to bore either along the top of the saddle or within a short distance of it on either side. The northern dip of the saddle is the plainest, and the oil-bearing bed would be found at 100 feet greater depth for about every 17 feet of level distance in this direction. The small yield of the present holes, however, does not give encouragement to expect much oil from any deep borings. This oil deposit seems, in common with the others of the Punjab, to be of very limited extent, and it would therefore be necessary in boring to keep at the outset very near to the surface exposure of bitumen.

5.—SHIPMENT.

The bituminous earth of any oil that may hereafter be found could be carried either on camels or mules three miles to the big road at Gunda, and could thence be carried either in the same way or in carts 27 miles and a half to Rawul Pindee, or 30 miles and a half in all by the old road, say 33 by the new.

7.—BOOK AND PAPERS.

This oil place is spoken of in the "Report on Petroleum Operations," by A. Fenner, Assistant Engineer, Proceedings of the Government of Punjab, Public Works Department, July, 1866; and in the "Report on Borings for Petroleum," by A. Fenner, Executive Engineer, Proceedings of Government of Punjab, Public Works Department, July 1869, pages 3, 4, 5, and 6.

Report on the Boraree Oil Lands, near Chhurrut, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Boraree well, Rawul Pindee District, Punjab, is three quarters of a mile south-west of Chhurrut, $6\frac{1}{4}$ miles west of Futtchjung, and $28\frac{1}{2}$ miles in a straight line west of Rawul Pindee.

2.—LAY OF THE LAND.

The oil well is in the bed of a very small brook, at its union with a somewhat larger brook called the Boraree Kussee, both coming from the west, and flowing 230 yards further east into a still larger brook that comes from the south, and flows 300 yards further northerly into the Bugwan River, just at a great bend it makes from running westward to running northward. The river here is about 1500 feet above the sea level, and the oil well some 15 feet higher. North of the oil well there are four or five ridges, rising from 50 to 70 feet above the river level, with narrow valleys between them, all within a distance of 300 yards. North of that the land is gently rolling for about 500 yards, with a general level of about 50 feet above the river, and then to the north are parallel ridges of some 50 feet high. South of the oil well rises steeply an east and west ridge, of 160 feet in height, followed on the south by a parallel ridge, of some 90 feet above the river level, and then by a comparatively flat region with low parallel ridges. West of the oil well the land rises very steeply into two east and west ridges, 130 feet or more in height, or perhaps rather one ridge, with outliers on the south between it and the high ridge just spoken of. To the east of the oil place the land is in parallel east and west ridges, some 60 or 80 feet high, with high rough valleys between.

3.—GEOLOGY.

a. Structure.—The high hill or mountain just south of the oil place seems to be made up of rocks in saddle form in the main, but with two subordinate rolls on the south side, and one or two others on the north side. South of these is perhaps another saddle, still within a quarter of a mile of the oil well; just south of the oil well seems to be another saddle, and some 40 yards north of the well a very sharp up-throw or fault of perhaps 50 yards, and at about 190 and 260 yards north of the oil well other saddles.

b. Rock Beds.—The rock beds exposed are the same as those to be seen near the oil well at Chhurrut, and in the main the same as those about the Gunda oil wells, four miles to the east, but with some variations, and are of nummulitic age. The following sections (downward) are exposed near the Boraree well, south of the mountain and south of the oil places :—

Reddish sand rock, with white calc spar seams, perhaps ...	about 50 feet.	
Reddish gray soft shaly sand rock	" 2½ "	
Slightly reddish gray sand rock	" 5½ "	
Reddish sand rocks and shales	"	58

On the north and south side of the same mountain—

Brown sand rock and shales ? hidden	" 64 ? feet.	
Red-pebbled pebble rock	" 3 "	
Gray (brown weathering) sand rock	" 20 "	
Brown and gray pebble rock, sandy	" 12 "	
Greenish gray, rather soft, sand rock	" 3 "	

Brown sand rock and shales	"	112
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On the south side of the same mountain, and at about two hundred yards east of the oil well—

Light gray lime rock	about 5 feet.	
Gray nummulitic lime pudding rock	" 20 "	
Red shales, perhaps	" 10 "	
Greenish gray sand rock	" 1 "	
Gray (weathering brown) sand lime rock	" 5 "	
(In parts a greenish gray sand rock, in other parts a pebble rock)		
Greenish gray sand rock	" 20 "	
Red shales	" 3 "	
Greenish gray shaly sand rock	" 1 "	
Red and green shaly clays, with salt and bitumen	" 30 "	
Gray lime rock and shales	"	100
		270

4.—OIL AND ASPHALTE.

a. Mode of occurrence.—The asphalté here, then, seems to be near the upper part of the 190 feet of gray lime rock and shales of the Gunda section. For some 15 yards west of the digging the shales are bituminous, and three feet in thickness of them richly so. But the well (some 2½ yards in diameter, and, it is said, about six feet deep), although in line with these bituminous shales, exposes only a surface deposit of earthy asphalté, merely wash or alluvium that has been thrown down by the brook in its former bed. The hole is nearly full of muddy water, so that anything below this is hidden. Gas bubbles rise almost constantly in the water, especially in warm weather, seeming to be set free from the asphalté by the heat of the sun. The same heat likewise, as it seems, causes small streams of oil to flow from the edge of the same deposit of asphalté for a distance of some 18 yards east of the hole, where the asphalté is covered by a bank of red earth on the north side of the bank. The amount of this asphalté seems to be about six cubic yards (9 yards long by 1½ yard average width, and ⅔ yard average depth); more may be hidden under the gravel and clay of the bank, which seem somewhat bituminous. The amount of oil is insignificant, perhaps a spoonful a day from the little streams on the bank; and in the hole there is on the water scarcely a trace of oil. About 175 yards east of the hole is exposed likewise in the north bank of the same stream, about two feet apart, two wash deposits of asphalté or bituminous red clay, oily in the sun's heat. They are each some three feet long by perhaps 18 inches wide and a foot thick, and would yield therefore about one-third of a cubic yard. These deposits of earthy asphalté on the Boraree Kussee would perhaps weigh a ton and a quarter on the average to the cubic yard, and yield perhaps as much gas to the cubic yard as half a ton of oil, or say 11,000 cubic feet.

b. Boring.—It is plain that any borings to be made to test the richness in oil of the main deposit must be made very closely along the line of out-crop, that is, about north 86° north, and south 86° west of the present digging; for the dip here is almost vertical, say 87°. The dip is northerly, so that the borings

should be made rather on that side of the out-crop than on the other ; but with a dip of 87° the bed would sink 100 feet in about five feet of level distance northerly. The deposit, however, seems to be, like the others in the Punjab, one of very limited extent, as the same beds do not seem to be bituminous at any great distance, even 20 yards west of the digging, so that any borings should be made very near to the present hole. The prospect, however, is little encouraging for any such expense, and the better plan would be to dig the bituminous earth alone, and be satisfied with this easily won though at this point rather scanty source of oil and gas.

5.—SHIPMENT.

The bituminous earth could be carried only on the backs of animals by the present roads, either mules or camels, to Gunda, three miles and three quarters, and thence on the big roads either in the same way or by carts, 27 miles and a half to Rawul Pindee, in all say 31 miles, or by the new road 34 miles.

Report on the Jafir Oil Bore of 1869, Rawul Pindee District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

The Jafir boring, made for oil in 1869 by Mr. A. Fenner, is on the east bank of the Ramora brook, one mile and a half north of Jafir, one mile and five-eighths south-west of Chhurrut, six miles and a half west of Futtehjung, and 29 miles west of Rawul Pindee. Mr. A. Fenner reports that he bored here 42 feet deep, chiefly or wholly in red sand-stone, but that he found at most only a slight trace of oil. At present nothing is to be seen here but a hole, about four feet in diameter, nearly full of water, with a small exposure on one side of bluish gray soft shaly sand rock. The rock has a strike of about north 87° east, and a dip of about 60° northerly. There is not the slightest trace of oil nor sign of its existence, and none is known ever to have been found there, except the slight trace mentioned by Mr. Fenner. He does not think any further exploration here advisable, and certainly every thing seems to give strength to his opinion.

7.—BOOKS AND PAPERS.

The work at this place is described by Mr. A. Fenner, Executive Engineer, in his report on "Borings for Petroleum" in the Proceedings of the Government of Punjab, Public Work Department, July 1869, pages 5 and 6.

Report on the Dulla Oil Lands, Rawul Pindee District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Dulla oil lands are 38 miles and a half due west of Rawul Pindee, 16 miles west north-west of Futtehjung, three miles south south-west of Boota, and two miles and a half north north-west of Buttlot.

2.—LAY OF THE LAND.

The Dulla brook is a small stream that winds through the central parts of the Choor Mountains. Near the old Dulla trial pit the course of the brook is

about north, and the pit is in the southern corner of a little flattish piece of ground, about 100 yards wide north and south, 300 yards long east and west. About 100 yards up-stream, south, is another flat of about the same size and parallel to the other, and through it the brook, and for a mile or more to the east, and flows westerly; 200 yards north of the pit the brook turns from its northerly course, and flows again westerly for a mile or more, and then north-westerly; 600 yards west of the Dulla pit the Oodee brook, still smaller than the other, runs a little west of north into the Dulla brook, and at its mouth is another flat somewhat larger than the two already mentioned, and here is the deserted house that was once the Oodee salt chowkee. On the Oodee brook, a third of a mile west south-west of the Dulla pit, is the Oodee pit in a flat about 50 yards long and wide, and above this the brook has a north-easterly course, and is very small. Both pits are about 1750 feet above the sea. The space between the two brooks and the two pits is filled by a steep hill, rising at one point to a height of about 270 feet above the pits, or perhaps 350 feet above the junction of the two streams. East and north of the Dulla pit are other steep hills of less height, and south and west of the Oodee pit are others still.

3.—GEOLOGY.

The rocks near the two trial pits lie in saddle form; those at the Dulla pit dip some 60° northerly, and those at the Oodee pit about as steeply southerly. Some 10 yards north of the Oodee pit the place of the axis is to be seen, and its dip seen to be some 20° westerly. The course of the axis is probably about north 83° east. The dip on the north side of the saddle seems to be gentler than that on the south, and, within a quarter of a mile of the axis, becomes about 30° only.

The chief rocks exposed are a bluish gray lime rock, in great part flaggy, with perhaps some gray or light brown shales between the layers here and there. The whole thickness of these rocks would seem to be something more than 1100 feet. No fossils have been found in it, but its age is probably the same as that of the Rutta Otoor lime rock, and also of the Punnoba lime rock, both nummulitic, and probably, too, the same as the main nummulitic lime rock of the Salt Range, as, for example, that of the Burra Kutta and Chhotta Kutta oil springs near Jaba, a dozen miles east of the Indus.

Something more than 300 feet above the lowest exposed beds of rocks there is found a small amount of asphalt in the cracks of the lime rock through a thickness of some six feet.

Above the nummulitic lime rock, and unconformable with it, are about five feet of a brown pudding rock and travertine, like those of Gunda and near the mouth of the Bussala River. It lies nearly or quite level, seems never to have been disturbed, and is of very small extent, only seen near the Dulla pit.

4.—OIL AND ASPHALTE.

The asphalt is merely dried oil that was once liquid in this place, and might still be found so at a distance from the surface of the ground. It is exposed in both of the old trial pits, and in the heat of the sun a small portion of it melts, and becomes a black tar. There is also a small quantity of the asphalt in the wash near the Dulla pit, cementing together the rounded pebbles of the old bed of the brook. This deposit is some six feet long and about three feet thick at most, with an average thickness of say two feet, and a width of perhaps a yard, though this is hidden in the bank. Allowing one-half for the larger pebbles, there would be, then, some nine cubic feet of earthy asphalt. At the Oodee pit there is exposed in the cracks of the rock something like a cubic foot and a half of like asphalt. In all, counting some that is exposed in the rock of the Dulla pit, there is perhaps half a cubic yard of earthy asphalt, which would weigh say five-eighths of a ton.

There is no liquid oil exposed at all ; the nearest approach to it is a few spoonfuls of black tar that has melted out of the asphalte in the sun's heat.

The out-crop of the oil-bearing or asphalte-bearing bed probably runs on the north side of the saddle in not far from a straight line from the Dulla pit to the Oodee pit, and near this turns and runs for a quarter of mile at least a little south of east. East of the Dulla pit its course is about east.

As the out-crop of this bed through all this course has not been observed to be oil-bearing, it is highly probable that this character does not extend far from the pits in any direction. In order to test this point, therefore, by boring or deep digging, it would plainly be best to try at first only a very short distance from the pits, and then, if encouraged by success, to go further and further from them by degrees. The first boring ought to be, where the bed would lie, not more than 50 or 100 feet deep below the surface of the ground, that is, not more than about 50 feet northerly from the Dulla pit, or 90 feet south-westerly from the Oodee pit. If the result of such a trial should be encouraging, a deeper boring might be made 120 feet northerly from the Dulla pit, or 150 feet south-westerly from the Oodee pit, so as to strike the oil-bearing bed about 200 feet below the surface. These borings would themselves show more precisely than is known at present the dip of the bed at either place, and would be a guide to further borings.

But the very unpromising amount of asphalte at either pit gives small encouragement for such borings, and the smallest of them would only be advisable on the part of the Government (never of any private individual) after meeting with fine success on other oil lands of the Punjab.

5.—SHIPMENT.

The inaccessibleness of the place is another drawback. It would be possible, however, to transport oil or asphalte down the Dulla brook, then up the Oodee brook, to the Oodee digging, a distance of three quarters of a mile ; or a smoother road, but steeper, might be taken across the ridge between the two pits, rising to a height of 175 feet above them, but going a distance of only a third of a mile. From the Oodee pit the road leads south-westerly to Buttlot, a distance of three miles. Most of the distance from Dulla pit to Buttlot is by an extremely bad road, though a well travelled one ; it runs where possible through the bed of the water-courses, and is very narrow, and much encumbered with large stones. From Buttlot there is a bridle path eastward to Chhurrut, 11 miles and a half, and thence still eastward to Gunda, three miles. Thence south-easterly by big wagon road, two miles and a half to Futtehjung, and thence easterly by a big road, 25 miles to Rawul Pindee, or 17 miles and a half of bridle path from Oodee pit to Gunda, and 27 and a half of big road from Gunda to Rawul Pindee, 45 miles in all. The big road might instead be struck at Jafir, seven miles west of Futtehjung, but the whole distance would still be about the same.

7.—BOOKS AND PAPERS.

The workings at Dulla are described in the report on " Borings for Petroleum," by Mr. A. Fenner, Executive Engineer, in the Proceedings of the Government of Punjab, Public Works Department, July 1869, pages 4, 5, and 6.

Report on the Punnoba Oil Lands, Kohat District, Punjab, accompanied by a Geological and Topographical Sketch Map, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Punnoba oil springs, in the Kohat District, are in a straight line 67 miles due west of Rawul Pindee, 25 miles due east of Kohat, three miles and a half north of Shekh Khan, the same distance west north-west of Choorlukkee Meeshuk, and half a mile south-east of the village of Punnoba, some five miles south-east of the boundary of the land of the Afreedees.

2.—LAY OF THE LAND.

The springs, three in number, within 25 feet of each other, are about 1150 feet above the sea in the eastern edge of the Punnoba brook, or close beside it just where the brook cuts through the first south-eastern high ridge of the mountains that separate British India in this region from Afreedestan. This ridge runs north-easterly and south-westerly, is about 400 feet high, and has a quarter of a mile to the south-east a parallel ridge of about 70 feet high, and south of that a plain many miles wide. North-west of the main ridge, at a distance of a quarter of a mile, is another nearly parallel ridge, about 100 feet high; north-west of that is a narrow valley in which lies the very small village of Punnoba (deserted during the hot season, and without drinking water then), and north-west of that are high mountains in parallel ranges. The brook flows south-easterly from the village to the oil spring, then southerly for a quarter of a mile to the low ridge, then easterly 300 yards, then southerly around the eastern end of the ridge, and then easterly again. The slopes of the ridges are quite steep, especially where the brook breaks through the one by the oil springs.

3.—GEOLOGY.

The rocks at the oil spring dip steeply (70°?) south-easterly; but it seems to be a reversed dip on the north-western side of a rock saddle that composes the high ridge, with a gentler dip on the other side. About 175 yards south-easterly from the oil springs there is another saddle in the rocks, with a dip of about 45° on the northerly side, and of about 80° or more on the southerly. Scarcely 30 yards south-easterly from this saddle the dip changes again to a steep northerly one, at first some 45°, then even 90°, then 70°, and at length, a quarter of a mile south of the oil springs, only 30°. The first ridge north-west of the oil springs is formed by a rock saddle with dips of about 45° on either side, and there seems to be but one basin between this and the oil springs.

The rocks all seem to be of nummulitic age; at the top some 500 feet of gray lime rock, mostly in thin much broken layers with some shales; below that some 500 feet of bright red sand rock and red shales, somewhat limy in the upper part, with white calc spar seams, and below that brown sand rock and brown shales, with some small pebble rock beds. The lime rock contains nummulites and other fossils, particularly a small bivalve shell, like an oyster, three quarters of an inch long, and it is probably the same as the great nummulitic lime rock of the Salt Range. The red sand rock and shales below seem to have no fossils, but closely resemble some of the red sand rocks at the top of Gunda group, to which they probably belong. The brown sand rock at bottom, with its pebble rock beds and shales, likewise resembles closely the brown sand rock, pebble rock, and shales of the Gunda group, and, although less filled with fossils, what seemed an imperfect nummulite was found in it.

4.—OIL.

The oil of the springs seems to come from the cracks in the lime rock through a thickness of some 20 feet of the bed, at a distance of some 175 feet above the red rocks.

The three springs altogether would yield perhaps half a gallon a day if gathered daily ; but it is only taken by the natives at odd times and with the help of wisps of grass, which sop it up, and are afterwards squeezed by the hand. They use it to burn in lamps ; but it is so far inflammable that it can only be used with a lamp that has a tube expressly for the wick. If burned with the wick unprotected by such a tube (as the Gunda oil is burned safely), the oil all blazes up.

The out-crop of the oil-bearing layers of rock runs from the springs north-easterly and south-westerly, probably in nearly a straight line (say north 62° east), with a very steep northerly dip or a quite vertical one, or a reversed southerly one. Some 250 yards north-westerly of this out-crop is probably another nearly parallel out-crop of the same rocks, with a south-easterly dip of say 45° , and consequently with bends to the north where the ground rises into hills. About 350 yards north-westerly of the oil springs is probably still another out-crop of the same layers, with a north-westerly dip of about 45° , with corresponding bends to the south wherever the ground is high. No other oil springs have been discovered along these out-crops, even where they cross the brook ; and it is not likely that the oily character of the rocks extends to any great distance from the three springs. It is clear, therefore, that any borings to test the yield of the oil-bearing bed at some depth below the surface of the ground should be made to begin with as near as may be to the oil springs. As the dip there is some 70° south-easterly, a distance of about 36 feet in that direction would bring the bed to a depth of 100 feet deeper still, and so on. It is probable, however, that the dip of the bed in following it down soon changes to a northerly dip, which grows gentler and gentler to the middle of the basin where the bed is probably only about 500 feet below the level of the oil springs. It would be best, therefore, to make the first boring only 10 yards or so southerly from the oil spring, and it will probably strike the bed within 80 feet below the level of the spring, and follow it to a depth of 200 feet or more from the level of the springs. The bed can also be traced along by borings, say 100 feet apart north-easterly and south-westerly near the out-crop.

Salt.—The brook for a quarter of a mile above the springs and one-eighth of a mile below them, but especially within 75 yards above them, has a great many pools of very salt water, and even the village spring, about a quarter of a mile above the oil springs, is quite brackish at the end of April. The saltiness of the water comes from that character in the rocks and shales from which it seems to have issued ; the brook above and below is quite dry.

5.—SHIPMENT.

A bridle path leads from the oil springs south-easterly to the big road about two miles and a half ; and by this big road, very good for mules and camels, but hardly fit for carts, the distance is nine miles to the big wagon road that leads west 26 miles to Kohat, and east four miles and a half to the Indus at Khooshialguruh, and thence 71 miles to Rawul Pindee, in all 37 miles and a half to Kohat, and 87 to Rawul Pindee.

Report on Aluggud Oil Lands, Bunnoo District, Punjab, accompanied by a Geological and Topographical Map of a Rough Survey, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Aluggud oil lands are on the Aluggud brook, about 10 miles and a half south of Eesa Khêl, Bunnoo District, Punjab, two miles north-west across the mountains from the ancient ruins of Kafir Kot, and 124 miles south-west by west of Rawul Pindee.

2.—LAY OF THE LAND.

The oil lands lie near the foot of a north-west and south-west ridge, about 500 feet high, that has a slope of nearly 25° on the south-western side, and is much steeper on the other. Between this and other parallel ridges on the south-west, from 100 to 200 feet high, the Aluggud brook (here about 750 feet above the sea) winds in a general northerly direction. It comes to the oil lands in a north-easterly course through gaps in these lower ridges, makes an oxbow 200 yards across towards the west, then, instead of cutting through a narrow neck of a ridge of clay, it makes a curious cut in oxbow shape again to the east, about 100 yards across through the lower part of the high ridge just mentioned in very hard rocks; the cut at first scarcely eight yards wide, afterwards 40, and then at the lower end half a dozen yards again, and throughout bordered by cliffs up to 150 feet or so in height. After that the brook flows half a mile or so westerly, and then north-westerly and northerly in a valley perhaps half a mile wide. The high ridge is cut through from east to west by three small valleys. The ridges east of the high one first mentioned are still higher, and rise to 2200 feet above the sea.

3.—GEOLOGY.

The geological structure throughout these oil lands is extremely simple; the rocks all dip south-westerly, with a nearly uniform dip of about 25° , and they seem to form the westerly part of a great rock saddle.

The following is a section downwards of the beds of rock exposed here :—

Soft gray sand rock exposed here, say	...	...	...	about 100 feet.
Red and greenish gray clays, with a few layers of brown sand and pebble rock [at 220 feet from the top such a layer (sand and pebble) three feet thick; at 340 feet one (sand) three feet thick; at 370 feet one (sand and pebbles) three feet; at 380 feet one of three feet; at 400 feet one of three feet; at 450 feet one of five feet; and at 475 feet one (sand) of 10 feet ]	...	...	...	700 "
Coarser (up to six inches) pebble rock, with pebbles of crystalline rocks, of metamorphic red sand rock, of magnetite, especially for two feet at the bottom, and of cherty lime-stone, with imperfect encrinurite (?) fossils	...	...	...	40 "
Brown sandy lime rock (with productus and other fossils, weathering gray, in places seeming to become merely a soft gray sand rock, in places richly bituminous)	...	...	...	40 "
Brown and gray shales	...	...	...	180 "
Soft gray sand rock, also bituminous in parts	...	...	...	100 "
Gray sand rock ??				
In all	...	...	...	1,160 "

The gray sand rock at the top of the section, and the 700 feet of red and gray clays below it, seem plainly to be the same as that at Jaba, in the Salt Range, near Kalabagh, and lie at some 1100 feet above the nummulitic lime rock, and have commonly been called Siwalik in age. The coarse pebble rock and the underlying lime and sand rocks seem to hold the place of sand rocks of similar nature that lie at Jaba between those clays and the nummulitic lime rock. The rocks of the sections of the two places correspond in fact very well. But the productus and other fossils in the Aluggud lime rock seem to show these rocks to be of carboniferous age.

4.—ASPHALTE, TAR, AND OIL.

a. Mode of occurrence.—The oil that the oil-bearing rocks contained has partly oozed out of it where exposed in cliffs along the brook, and in drying has turned into a thin coating of black asphalté on the rock. At other places along the brook the oil in like manner formed pools that in drying became masses of asphalté. This asphalté partly melts in the heat of the summer sun, and small pools of black tar are formed, some of the smaller ones, all of tar, but most of them a mere coating of tar from an eighth of an inch to an inch deep upon pools of water which the tar protects from drying up. There is now no flow at all of oil proper.

b. Yield.—The asphalté deposits extend in spots for about a quarter of a mile along the east side of the brook, at most some 25 feet wide and one foot thick, and amount in all to about 350 cubic yards. It is somewhat impure from sand and pebbles mixed with it, and would weigh perhaps in all 550 tons. Of the liquid tar in the pools there was in May 1870 about 100 gallons; and this is likewise somewhat impure from leaves and sticks in it, and perhaps a little sand.

c. Out-crop.—The out-crop of the oil-bearing bed of rocks is to be seen in the cliffs along the brook in the oxbow cut in the lower part of the ridge, mentioned as 500 feet high, and rises to the top of this ridge on either side of the three narrow valleys that cut across it from east to west, that is, the out-crop has a general south-east and north-west course parallel to the strike of the rocks, but with these three long bends to the west where the rocks are cut through by small streams.

d. Working.—As the oil-bearing bed shows no signs of bearing oil, except near the exposures and asphalté deposits already mentioned, it is not likely that it continues bituminous to any great distance. A test by boring should therefore clearly be made as near as may be to these exposures. The most convenient places for the first borings would be in the little flats, just above where the brook enters the gorge in the high hill, and just below where it issues from the hill again. At both the entrance to this gorge and the issue from it the oil-bearing bed is near the water-level of the latter point, and dips south-westerly at such a rate as to be 100 feet lower below that level for about every 200 feet of distance. Owing to the thickness of the oil-bearing rocks, it seems highly probable that borings would meet with success as to the yield of oil. The great hardness, however, of the 40-feet bed of coarse pebble rock would make the boring slow and costly, and perhaps the pebbles by separating now and then from the sides of the bore hole (although they seem in general firmly cemented together) would cause vexatious and serious difficulties in the boring. Should this be found to be the case, it would be desirable to protect this part of the hole by tubing as soon as bored.

5.—SHIPMENT.

The asphalté, tar, or oil could be carried by a good bridle path (that could at small expense be made passable even for carts) two miles and a half

north to the mouth of the Aluggud Valley, thence likewise by bridle path either five miles south to the River Indus at Kafir Kot (whence it could be carried in boats up the river by towing, or down the river by drifting and rowing) or eight miles north to Eesa Khél; thence by wagon road north, 28 miles to Kalabagh, and thence likewise by wagon road (now out of repair near the Indus), 107 miles through Futtehjung to Rawul Pindee, or in all $145\frac{1}{2}$ miles to Rawul Pindee.

7.—BOOKS AND PAPERS.

The oil place is mentioned in the "Report on the Geological Structure of the Salt Range," by Dr. A. Fleming, *Journal of the Asiatic Society of Bengal*, Vol. XXII, 1853, No. 3, pages 264, 265, 268.

Report on the Chhotta Kutta Oil Lands, near Jaba, Bunnoo District, Punjab, accompanied by a Geological and Topographical Map of a Rough Survey, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The oil springs on the Chhotta Kutta brook, near Jaba, Bunnoo District, Punjab, are a mile and a half south by west of Jaba, 10 miles south-east of Kalabagh, and 95 miles south-west by west of Rawul Pindee.

2.—LAY OF THE LAND.

Three or four oil springs lie within a distance of about 50 yards along the banks of the Chhotta Kutta close beside the water's edge, at most some six feet above its level, which is about 1450 feet above sea level. The main spring is about midway between the uppermost and lowermost ones. They are just at the outlet (north-eastern end) of a narrow gorge square across the north-easternmost of the higher ridges of the Salt Range, running here north-westerly, and this ridge rises steeply on either side of the brook to a height of 600 or 700 feet, and within a mile or two to twice that height. The land north-east of the ridge is much broken into low hills, up to some 200 feet in height, growing gradually lower towards the great plain to the north-east. South-west of the main ridge there is a valley half a mile wide, bounded by a still higher ridge on the south-west, and the Chhotta Kutta has its head in this valley up towards the north-west.

3.—GEOLOGY.

a. Structure.—The rocks that form the high ridge by the oil springs lie in the form of a saddle, with a dip of about 60° at the springs, and some 5° more in the gorge 60 yards south-west. The axis of the saddle crosses the brooks about 220 yards above the main oil spring. A dozen yards from the axis the north-easterly dip is 54° , and 25 yards from the axis on the other side the south dip is 73° . On either side, however, the dip soon lessens from the out-crop of the oil-bearing beds to 45° , and a third of a mile north-west of the oil springs even to 30° .

b. Rock Beds.—The following is a very rough section of the rocks exposed within a quarter of a mile of the oil springs downward :—

Greenish gray sand rocks and shales	about 190 feet.
Greenish gray sand and filbert pebble rock	10 "
Greenish gray sand rock (and shales ?)	125 "
Brown pebble rock	4 "
Greenish gray sand rock and shales ?... ..	316 "
Greenish gray sand rock	30 "
Dark red shales	25 "
Greenish gray sand rock (with red shales at bottom)	75 "
Brown fine pebble rock	6 "
Red clay	6 "
Gray soft sand rock	3 "
Greenish gray sand rock and shales ?... ..	10 "
Gray shales	25 "
Greenish gray sand and fine pebble rock	6 "
Red and greenish gray shales alternating	64 "
Blue gray (weathering brown filbert and larger pebble rock) ..	5 "
Greenish gray sand rock and shales, with some fine pebble rock and red shales	900
Blue gray lime rock (and perhaps some gray shales), with nummulites, echinoderms, and other fossils	500
In all ..	1,400

The top of the section is only some 150 feet below red and gray clays that seem to be the same as those of the upper part of the Aluggud group of rocks, and the greenish gray sand rock not only seems to hold the same place as the lower rocks of that group, but to resemble them closely in appearance. But both the sand rock and the clays above have at Chhotta Kutta been commonly called of Siwalik age, while the rocks below the clays at Aluggud have been called carboniferous.

The pebble rock, just above the lime rock, is made up in great part of limy concretions, many of these having water-worn pebbles as a core. In at least one of these water-worn pebbles, of a pinkish lime-stone different from the gray concretions, was found a nummulitic.

The lime rock at the bottom of the section is the so-called nummulitic lime-stone of the Salt Range.

4.—OIL.

a. Mode of occurrence.—The oil comes from the cracks of the gray lime rock through a space of about 100 feet, that is, from 50 to 150 feet below the top of the lime rock, and the main spring comes from about the middle of that thickness. There are three oil springs (the uppermost ones) on the eastern side of the brook near the water's edge (under water in the wet season it is said), and a fourth (the lowest one) on the western edge of the brook near where the brook leaves the upper edge of the lime rock; and perhaps some of the pools of the brook that are covered with a film of oil are supplied with it by other springs. These pools of water come from strong and very sulphury springs; and as the water is uninhabitable for fishes and other animals, the bottom and sides of the pools are covered with a thick white, pink, and red leathery fungus-like vegetable growth. The oil upon the pools of the brook is black, the color that comes from exposure to the air; but in the larger springs the oil can easily be seen to be green when it first rises, although even here there is much black or tarry oil. The oil in the springs rises with water, and floats upon it. At two or three of the larger springs holes have been dug, say a foot and a half across and two feet deep. At the main spring gas is constantly bubbling up.

b. Yield.—Last winter the oil from these springs and from those of the Burra Kutta, half a mile south-east, was gathered by a Chowkeedar every two or

three days for three months, and the whole amount, according to his account, was about 90 gallons, or an average of about a gallon a day. Since that, however, this gathered oil partly dried up or leaked away, so that there was only about two-thirds as much to be seen at the time of the survey, even if it was not over-estimated at first. It would seem, therefore, fair, on the whole, to take the average yield of the Chhotta Kutta springs, if skimmed daily, as about three quarts a day, for they yield decidedly more than the Burra Kutta springs.

c. Out-crop.—The out-crop of the oil-bearing bed runs in general north-west and south-east from the springs along the hill side, but with a bend to the north-east at the springs owing to the depth of the hollow there combined with the north-easterly dip of the rocks.

d. Working.—It would of course be best, as at the other Punjab oil springs, to make the first borings to test the oil-bearing bed as near as may be to the springs, but rather towards the dip. The dip of the bed is such that the middle of it lies at a depth of 100 feet at about 75 feet north-easterly from the main spring, 200 feet deep at about 160 feet from the spring, 300 feet deep at about 250 feet distant, 400 feet deep at about 350 feet distant, 500 feet deep at about 450 feet distant, 1000 feet deep at about 1000 feet north-easterly from the spring. As the oil-bearing beds amount to a thickness of 100 feet, the middle of them would be at 100 feet deep near the lowermost oil spring on the brook where the upper edge of the beds comes to the surface. This would be a good place to make the first boring, as it would be some 200 feet to the bottom of the beds, and this would be a good test of their capacity at no great distance from the springs nor from the surface, yet where the beds are wholly under cover. Afterwards other borings might be made either deeper and deeper to the dip, or along the out-crop south-eastward towards the oil springs of the Burra Kutta brook on the same beds. From the size of the springs, the thickness of the oil-bearing beds, and from the fact that they continue oil-bearing so far as the Burra Kutta, half a mile off, it seems highly desirable and worth while that borings should be made here.

Gypsum and Sulphur.—On the hill sides on either side of the brook at the springs there is a large quantity of porous gypsum, seemingly produced by the action of the sulphur water upon the lime rock. It is said also that a great deal of sulphur was formerly gathered here, but none is now to be seen in the old holes on the hill side west of the springs. It is said to have been visible in small yellow particles in the gypsum, and is probably still to be found so below the surface in a fresh hole. There seem to be some thousands of tons of gypsum (perhaps 20) ; but the amount of native sulphur in it is quite unknown.

5.—SHIPMENT.

The oil gathered here could be carried on camels or mules a mile and a half by a very rough bridle path (that would need improvement for at least 100 yards near the springs) to Jaba, thence by better and better roads, the worst of them very good for camels, and perhaps even passable for carts, 100 miles and a half to Rawul Pindee, in all 102 miles. Calling this eight marches and a half for a camel, and a load of a camel 50 gallons, and his cost Rs. 8 a month, the carriage of oil to Rawul Pindee would cost at least 1 anna and $7\frac{3}{4}$ pies a gallon.

7.—BOOKS AND PAPERS.

These springs are mentioned in a "Report on the Salt Range," by Doctor A. Fleming, Journal Asiatic Society of Bengal, Vol. XVII, November 1848, page 517 ; in a "Report on the Structure and Mineral Wealth of the Salt Range," by Doctor A. Fleming, Journal Asiatic Society of Bengal, Vol. XXII, 1853, No. 4, page 347 ; in "Notes on the Geology of the Punjab Salt Range," by W. Theobald, Junior, Journal Asiatic Society of Bengal, Vol. XXIII, 1854,

No. 7, page 669 ; in a "Memorandum on Petroleum in the Rawul Pindee Division," by Colonel R. Maclagan, R. E., Secretary to Government Punjab, Public Works Department, Supplement to the Government Gazette, 5th February 1862, page 23 ; in a "Paper on the Geology of Kashmír, Western Himalaya, and Afghan Mountains," by Doctor A. M. Verchere, Journal Asiatic Society Bengal, Part II, No. 1, 1867, page 13 ; in a "Manuscript Report on the Jaba Petroleum Springs near Kalabagh," by Lieutenant J. A. Armstrong, Executive Engineer, December 1869, on file in the Public Works Department at Lahore, 4 pages ; and in a "Manuscript Report of his last season's Field Work in the Salt Range," by A. B. Wynne, F. G. S., Geological Survey of India, 1870, on file at the office of the Geological Survey of India at Calcutta.

Report on the Burra Kutta Oil Lands, near Jaba, Bunnoo District, Punjab, accompanied by a Geological and Topographical Map of a Rough Survey, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The oil springs on the Burra Kutta brook, near Jaba, Bunnoo District, Punjab, are a mile and three quarters south of Jaba, 10 miles and a half south-east of Kalabagh, and 95 miles south-west by west of Rawul Pindee.

2.—LAY OF THE LAND.

The three or four springs lie within a distance of about 60 yards along the western bank of the Burra Kutta brook close to the water's edge at low water, and about on the same level with it, which is about 1450 feet above sea level. The main spring, a dozen yards south of the northernmost spring, is just at the outlet or northern end of a narrow gorge that cuts in a crooked but generally south-eastern direction across the north easternmost of the higher ridges of the Salt Range, running here north-westerly ; and this ridge rises on either side of the brook at first with high cliffs, and then steeply to a height of 600 or 700 feet, and within a mile or two to twice that height. The land north-east of the ridge is much broken into low hills, up to some 200 feet high, growing rather lower towards the great plain to the north-east. The gap in the main ridge is just at a point where the ridge is double, the north-western part standing a little in advance (north-east) of the south-eastern part, which begins just behind it, and quickly rises to be the main ridge easterly, while the other dies away. The brook comes to the gorge in a south-easterly course after flowing round the western end of this south-western ridge, behind which to the south-east the brook takes its rise in a narrow valley between this ridge and a still higher ridge on the south-west.

3.—GEOLOGY.

a. Structure.—The rocks of the ridge at the oil springs lie in the form of a saddle, with a reversed south-westerly dip of about 80° on the north-eastern side near the main spring, and a like dip in the same direction on the other side of the saddle, just south of the southernmost oil spring. This saddle seems to be the same that is seen at the Chhotta Kutta oil springs, half a mile to the north-west, but is much narrower and sharper here than there, and seems to be dying away very fast to the south-east. The northerly dip here as there grows rapidly gentler to about 45° , which continues for a quarter of a mile, and then grows less and less until perhaps nearly level at a distance of a few miles. This saddle seems to be accompanied here on the south-west by a smaller saddle

(with dips of 80° or more on the north-east, and 50° or 60° on the south-west), which rides upon the side of a larger saddle still further south-west, with dips of about 60° or more on the north-east, and perhaps 45° on the south-west. Both of these last saddles are within a quarter of a mile of the springs, and they seem to rise south-easterly and take the place of the northern saddle which dies away, and is crowded out by them.

b. Rock Beds.—The following is a very rough section of the rocks exposed within a quarter of a mile or a little more of the oil springs downwards :—

Red and greenish gray clays, in all perhaps	...	...	about 700 feet.
Greenish gray sand rock (and gray shales ?), with some red shales, about 100 feet from the top, and with some layers of fine pebble rock	...	...	825 "
Dark red shales	...	...	25 "
Greenish gray sand rock (with red shales at bottom ?)	...	...	75 "
Brown fine pebble rock	...	...	6 "
Red clay	...	...	6 "
Gray soft sand rock...	...	...	3 "
Greenish gray sand rock and shales ?	...	...	10 "
Gray shales ?	...	...	25 "
Greenish gray sand and fine pebble rock	...	...	6 "
Red and greenish gray shales alternating	64 "
Blue gray (weathering brown) filbert and larger pebble rock	5 "
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Greenish gray sand rock and shales, with some fine pebble rock and red shales	1,750 "
Blue gray lime rock (and perhaps some gray shales), with nummulites and other fossils	250 "
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In all	2,000 "
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The red and greenish gray clays at the top of the section are no doubt the same as those near the top of the Aluggud group of rocks ; it has commonly been reckoned as of Siwalik age. The greenish gray sand rock and shales would seem to hold the same place as the similar sand rock of the Aluggud group below the clays ; but this has been called hitherto carboniferous in age owing to the productus and other fossils found near its top at Aluggud. Here, however, although no fossils have been noticed in the rock, its age must be newer than that of the lime-stone below, and this has from its nummulites and other fossils been called the nummulitic lime-stone. If the Aluggud so-called carboniferous rock be really older than this nummulitic lime-stone, then not only that lime-stone, perhaps 1100 feet thick in all, but the 1050 feet of sand rock and shales about it and below the red and greenish gray clays, or more than 2000 feet in all, must have thinned out and disappeared between Burra Kutta and Aluggud, a distance of only 30 miles.

4.—OIL.

a. Mode of occurrence.—The oil comes from the cracks of the gray lime rock through a space of about 100 feet in thickness, and the main spring comes from about 100 feet below the top of the lime rock. The oil is dark green in color at the main spring when quite fresh from the rock, but in the air quickly becomes dark brown or black and tarry, as it is at all the other places near. The main spring is some six feet long and a foot or two wide, and quite shallow, and the other springs are only a foot or two wide. At high water the springs are no doubt quite overflowed. Near the oil springs, as on the Chhotta Kutta, there are sulphur water springs, but not so strong ones as there.

b. Yield.—The yield of the springs here amounts perhaps altogether to three pints a day.

c. *Out-crop*.—The out-crop of the oil-bearing bed comes to these springs in a south-easterly course from the Chhotta Kutta oil spring ; it seems barely to cross the Burra Kutta brook, then to return westerly and north-westerly again towards the Chhotta Kutta. There is perhaps also a small nearly circular out-crop of the bed on the Burra Kutta, about a furlong south-west of the spring.

d. *Working*.—The springs yield so much oil naturally, and the oil-bearing bed is so thick, that it seems quite worth while to test the oil-bearing bed by boring into it at some distance below the out-crop. Of course it would be best to make the first borings as near as may be to the springs, although the Chhotta Kutta oil springs on the same bed seem to show that it is oil-bearing throughout the space between the two sets of springs. Owing to the steepness, and even reversal, of the dip at the Burra Kutta main spring, a boring close by it would go through the oil-bearing bed for perhaps 200 feet. At a distance of only 60 feet north-easterly from the main spring the middle of the bed would be at a depth of about 200 feet ; at a distance of 130 feet about 300 feet deep ; at 240 feet distant about 400 feet deep ; at 340 feet about 500 feet deep ; and so on to 840 feet distant, where it would be about 1000 feet deep. The strike of the bed towards the Chhotta Kutta springs is about north 53° west, and borings in this direction would be likely to yield as well as at the Burra Kutta.

5.—SHIPMENT.

The oil gathered here could be carried on camels or mules about two miles by a very rough bridle path to Jaba, thence by roads, quite good for camels, and growing better and better as you go on, 100 miles and a half to Rawul Pindee, say 102 miles in all. Calling this eight marches and a half for a camel, and his load 50 gallons, and his cost Rs. 8 a month, the carriage of oil to Rawul Pindee would cost at least 1 anna and $7\frac{1}{2}$ pies a gallon.

Report on the Sadeealee Rock Tar Spring, near Nara, Jhelum District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

The Sadeealee rock tar spring, in the Jhelum District, Punjab, is about 90 miles south-west of Rawul Pindee, seven miles south-east of Lawa, four miles south-east of Nara, and two miles east of a Salt Chowkee. It was described by a Chowkeedar of Lawa, one of the very few in that region who had ever seen it, as yielding a very small quantity of a black liquid (tar) that the people there called "Leleera," of whose nature they were quite ignorant. He said that it floated upon the water of a small pool, and covered with a thin film a space of perhaps eight or ten inches in diameter ; that he skimmed off some with a stick, and then held the stick over a fire, but that it would not burn, would only hiss and give out smoke. He and the Chowkeedar of the Salt Chowkee (the latter of whom made little pretence of knowing the way to the spring) tried to show where the spring was, but on getting, as they said, very near to it, were quite unable to point it out. As the dark-colored liquid seemed at the time unlikely to be tar, but rather some vegetable scum upon water, and its quantity was at any rate extremely small, the search was abandoned. After a survey, however, of the Chinnoor, Hungooch, and Dooma rock tar springs, where the tar is called "Leloora," it was clear that the "Leleera" of Sadeealee was also tar ; but as it was also clear that its quantity was quite unworkable, as at those places, it seemed plainly not worth while to try again to find the place. The Chowkeedars, in trying to find the spring, led to a spot where the gray sand rock was exposed below the red and greenish gray clays, and with a gentle dip

northward, all precisely corresponding to what is seen at the other three places. The geological position of the Sadeealee tar and the mode of occurrence, as well as the yield, are beyond a doubt the same as at the other three places. Even if it should be desired to bore here at any future time, the circumstances are so precisely similar to those at the other three places, that the instructions given for them would also apply here, and no doubt could possibly arise as to the mode of proceedings.

Report on the Chinnoor Rock Tar Springs, near Murdowal, Shahpooor District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

The Chinnoor rock tar springs, in the Shahpooor District, Punjab, are 83 miles south-west of Rawul Pindee, two miles and a half north north-west of Murdowal, and one mile and a half west south-west of the Hungooch rock tar.

The springs are near the union of two branches of the Chinnoor brook, one coming from the east, the other from the south, while the main stream flows northerly. Between the two forks of the stream the land rises southerly without any great hollows in it, but north of the easterly fork and west of the southerly fork, and on either side of the main stream, hills rise to a height of 300 or 500 feet, with very steep cliffy sides towards these streams, but with a much gentler slope northerly.

The dip of the rock is gentler northerly, perhaps 25° , and its uniformity is the cause of the uniformity and comparative gentleness of the slopes of the surface of the ground in that direction, while the slopes in other directions are extremely steep and irregular. The slope between the two forks of the stream is formed by almost the very uppermost surface of the great nummulitic (bluish gray) lime rock (that of the Jaba group and of the Salt Range generally). The hills on either side of the main stream are formed by the brownish gray sand rock which reaches up to the red and greenish gray clays, exposed a little further north, and is no doubt the same as the thick sand rock in a similar position in the Jaba group.

The rock tar (called here by the natives "Leloora") issues from the rock in three places; on the easterly fork perhaps 200 yards above the union of the two forks, on a small branch of this fork about 150 yards west of the first place, and on the northerly fork about 50 yards west of the second place. The tar at the first (easternmost) of these places comes from the lime rock, but very close to its upper surface; at the two other places it comes from the brownish gray sand rock quite near to its lower surface.

The amount of tar at the eastern place is scarcely a tea-spoonful, at the middle place perhaps half a pint, and at the western place at the time of the survey none at all, although some white scum was to be found here like that to be seen with the tar at Hungooch.

The out-crop is easily to be traced along the junction of the sand rock and lime rock in a general east and west course; and the uniformity of the dip, as well as its gentleness, makes it easy to dig or bore upon the tar-yielding bed at some depth below the surface by going to a little distance northerly from the out-crop. It would, however, be the height of folly to go to the expense even of boring, for it is very clear that the deposit, or rather the three deposits, are extremely small ones, limited to a few feet or even inches from the places observed.

Report on the Hungooch Rock Tar Springs, near Dhuddow, Shahpoor District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

The Hungooch rock tar springs, in the Shahpoor District, Punjab, are 81 miles south-west by south of Rawul Pindee, and two miles and a half north-west of the village of Dhuddow.

The tar springs are only 25 feet apart in the bed of a brook which flows thence north-westerly. The land rises south and south-easterly of the springs in a comparatively gentle and uniform slope, but on the east and west it rises steeply, and with high cliffs to some 500 feet. From this height the hills slope down rather gently and uniformly northward.

These gentle and uniform northerly slopes correspond to the uniform dip, about 25° of the rocks in the same direction. The lowest rock exposed is the bluish gray nummulitic lime rock of the Jaba group, and it here also contains nummulites. It is exposed here and there all over the hill side south of the tar. Upon the lime-stone, and forming the high hills on either side of the brook, is brownish gray sand rock, clearly the same as the great sand rock in the same position at Jaba, and there 1000 feet thick or so. Above it, half a mile north of the tar, is seen the red and greenish gray clays found just above the Jaba group and near the top of the Aluggud group.

The tar issues from the brownish gray sand rock within a few feet of its bottom, and the two springs come from layers about six feet apart. The one from the upper layer is, owing to the northerly dip (rather steeper than the slope of the ground), the more northerly of the two, and is the larger, but the whole amount of both together is hardly a pint.

The out-crop of the tar-bearing bed has a general east and west course ; but bends round to the south from the springs on either side owing to the presence of the high hills along whose foot it runs near the upper surface of the lime-stone that forms the gentle hill-side between.

As the sand rock that yields the tar is well exposed at the springs, it is plainly seen that the bituminous matter from which the tar comes must be a very small deposit, not only a very thin layer, but almost certainly of very limited horizontal extent. It would therefore be very unwise to make borings here in hopes of finding a greater yield ; but the uniformity of the dip shows very plainly where borings should be made, if it should ever be wished to test the bed at any depth. The bed plunges beneath the surface of the ground at the springs, and would be found uniformly at a greater and greater depth in a northerly direction.

Report on the Dooma Rock Tar Springs, near Kubbukkee, Shahpoor District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

The Dooma rock tar springs are on the Wudda Dooma and Nikka Dooma brooks, within 40 yards of their union, which form the Dooma brook. They are 77 miles south-west by south of Rawul Pindee, and three miles and a half north north-east of Kubbukkee.

The Nikka Dooma (the smaller of the two) comes to the springs from the south-east, and the Wudda Dooma comes from the south-west ; the Dooma below the springs has, though crooked, a general northerly course for half a mile at least. The land between the two forks and on either side of the main stream is from 200 to 400 feet higher than the brooks, and has high cliffs along their borders, but above slopes gently northward, generally speaking.

The cause of this gentle and uniform northern slope is the uniform gentle dip (about 7°) of all the rocks in that direction. About a quarter of a mile southerly of the springs is seen the same bluish gray lime rock as that of Hungooch and Chinnoor, and the same as the great nummulitic lime rock of the Jaba group of rocks. It then passes below the greenish gray (brown weathering) sand rock, the same as that of Hungooch and Chinnoor, and as that of the Jaba group. The sand rock is much false-bedded, and in places pebbly. About three quarters of a mile north of the tar springs is seen resting upon the sand rock the red and greenish gray clays (perhaps 700 feet thick), which are seen at those other places, and also near the Aluggud oil springs.

The tar issues from the sand rock very near its bottom, perhaps within 30 feet of it, at four places on the Wudda Dooma within 40 yards of the union of the two brooks, and at one place 24 yards above that point on the Nikka Dooma. All the places are within a thickness of perhaps five feet of the rock, or even less. The tar seems to melt in the sun's heat from a small quantity of asphalte imbedded in the rock, but may perhaps issue first as oil, and then turn to black tar on exposure to the air. At two or three of the places the tar has dried to asphalte, rather impure from pebbles and sand mixed with it.

There is perhaps a cubic yard and a half of this asphalte in all. The liquid tar amounts to scarcely a trace at the place on the Nikka Dooma, to perhaps a gill at the lower place on the Wudda Dooma, to two spoonsful at the next place, to a quart at each of the other two, making half a gallon in all. Although the yield here is more than at Hungooch, and is spread over a greater space, it seems clear that the yield to be hoped for from a boring would be far too little to pay for the expense.

The out-crop can, however, easily be followed along the base of the cliffs on either side of the streams until it gradually rises southward to their northern face, always close above the lime rock, and takes in general an east and west course.

To bore from the top of the high lands above the cliffs would be very costly owing to the height above the tar or oil-bearing bed; and the only place where it could be reached from a comparatively short distance (without going far from the springs) is in the channel of the Dooma below the tar. A boring, however, is in any case not at all likely to pay for its cost, and the deposit is to be looked on rather as analogous to the little coal beds, of no value, often seen, formed by a single plant or two turned to coal.

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Lahore, 5th November 1870.

SUPPLEMENT TO THE REPORT ON THE OIL LANDS OF THE PUNJAB.

Report on the Loonekee Kussee Sulphur Pits, Kohat District, Punjab, by
BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of
the Government of India.

1.—SITUATION.

The Loonekee Kussee (or salt brook) sulphur pits, in the Kohat District, Punjab, are near the western bank of the Indus, about a mile south-west of Dundee, on the other bank, and about two miles north-east of Choorlukkee-Meeshuk, and on the road from this village to Dundee. They are about 900 feet above the sea, and perhaps 100 above the Indus.

2.—LAY OF THE LAND.

The pits are on the northern edge of what is in the main a great plain, but here it is very much cut down in steep-sided hollows, through one of which the Loonekee Kussee runs with a south-easterly course to the Indus. From this brook extends eastward for about 175 yards an oval-shaped hollow that is about 50 yards wide, and about 10 feet above the bed of the brook. Around the sides of this little hollow are traces of digging, and the sulphur is said to have been taken in large quantities from the earth here until the region came under British rule. North and south of the hollow the ground rises steeply to a height of 50 feet above the brook. About 150 yards north of the hollow is a low ridge of nodular lime rock; north of that still lower brown sand rock ridges or ledges, and north of them red sand rock and red shales.

3.—GEOLOGY.

The lime rock dips northerly some 60°, and therefore probably passes below the brown and red sand rocks. It seems, then, to hold the place of the lime rock of the Gunda group of rocks below brown and red sand rocks, which are no doubt the same that lie at the Punnoba oil springs in this order below what seems to be the great nummulitic lime rock of the Salt Range. The lime rock of the ridge near the sulphur pits is gray, nodular, and thin-layered, and contains nummulites, and is therefore of nummulitic age.

But south of this ridge and at the sulphur pits the only rocks exposed lie nearly or quite level, and are plainly of the same older alluvial age as the rocks of the same position and appearance at Gunda along the Seel River, and along the Indus near Mukhud. The following section downwards is exposed in the banks of the Loonekee Kussee, just west of the sulphur pits:—

Gray lime rock, full of holes, and with broken nummulitic lime									
rock pebbles, up to four inches long	..	..	..	..	..	..	..	..	about 5 feet.
Pebble rock, in parts hard, in other parts soft	..	..	..	..	..	..	..	..	10 "
Salt shales, in parts very rich in salt, and covered with a white	..	..	..	..	..	..	..	..	10 "
crust	..	..	..	..	..	..	..	..	10 "
In all									25 "

In the bed of the brook is loose gravel containing also salt, and about a cubic yard of earthy asphalte scattered in spots for a distance of some 30 yards.

Sulphur.—The sulphur was got by sublimation from the loose earth (mostly red and mottled clay) of the pits, and probably occurred in the form of small yellow particles. None of it, however, is now to be seen in the surface earth, and it has probably disappeared by exposure to the weather for a little distance (a few inches at least) from the surface. In order, then, to determine

its amount, it would be necessary to dig holes here and there, and to test the amount of sulphur that a given quantity of the earth would yield, and to extend these pits and trials until the limits of the deposit, both horizontally and vertically, had been made out. Such an examination would take more time than would have been compatible with the survey of the Punjab oil lands, to which this visit to the sulphur pits was merely incidental. The extent of the old pits and the traditions of the neighbourhood seem, however, to show that the amount of sulphur here is very large.

Gypsum.—Gypsum is exposed in little crystals in the earth here and there at the sulphur pits ; but its amount has been left quite undetermined for similar reasons to the one just given. It would seem, however, to be quite a large amount ; but the gypsum, so far as observed, was much mixed with clay and other impurities.

Salt.—The salt shales are exposed with their coating of salt for some 40 yards, and the salt seems to be gathered in small quantities by the country-people. There seems to be nothing approaching a bed of rock salt, and it seems highly unlikely that either the richness of the shale bed in salt or its extent will permit of the manufacture of salt here, except on a very small scale, perhaps for the benefit of the immediate neighbourhood.

Asphalte.—The asphalte amounts (so far as exposed) to only about a cubic yard, and is therefore of trifling value. It seems to be a secondary deposit, washed here by the brook, and from what source it came does not appear. It no doubt issued somewhere from the solid rock as oil, then dried to solid asphalte, and then probably was washed by the brook from its original place to the little spots where it is now seen. It may even have formed at one time a small deposit in the older alluvium before this action of the brook, and in this case might be far removed from its original source, as far, say, as from Punnoba.

The amount of the asphalte is in any case so small as to give little encouragement to a search for the oil-bearing rock from which it first issued.

Report on the Punnoba Sulphur Pits, Kohat District, Punjab, by BENJAMIN SMITH LYMAN, Mining Engineer, Public Works Department of the Government of India.

1.—SITUATION.

The Punnoba sulphur pits, Kohat District, Punjab, are about half a mile north-east of the Punnoba oil springs, about three quarters of a mile east of Punnoba village, about four miles north-west of Choorlukkee-Meeshuk, about four miles north of Shekh Khan, and about nine miles north of Khooshialgurh, on the Indus. They are about 1500 feet above the sea, and about 350 feet above the oil springs.

2.—LAY OF THE LAND.

The pits are on the north-western side of the first (south-easternmost) high ridge of the mountains that border British Territory here next to Afree-deestan, the same ridge in which the oil springs occur at the gorge of the Punnoba brook. The general slope near the sulphur pits is north-westerly, but there are many small hollows cut down with steep sides by the small streams ; and the pits are just at the top of a narrow "divide" between two heads of valleys at the point where the main ridge is joined by a small one that runs westerly from it.

3.—GEOLOGY.

This smaller ridge is formed by a saddle in the rocks, with dips of about 45° on either side. The rocks of the main ridge at the one or two points where

they are exposed (about 150 yards south-west of the pits) dip about 45° south-easterly. Above the rocks that show these dips is in places a certain amount of loose earth or rock, with no dip that can be made out.

This loose stuff is partly bright red earth and partly gypsum, and perhaps partly gravel. The rocks that show the dips are gray lime rock, no doubt the same as that of the Punnoba oil springs, of nummulitic age, and probably the same as the great nummulitic lime rock of the Salt Range.

Sulphur.—The sulphur has not been dug here for some 20 years, since the British rule began; but there are still traces of a number of small holes within a space of 15 or 20 yards across. The sulphur is not now to be seen in the earth here at the surface, but has probably disappeared merely from the action of the weather. It probably occurs in the form of small yellow particles scattered through the earth and gypsum, and it was formerly got from them by sublimation. The amount of sulphur that a given quantity of earth would yield is quite unknown, and the extent and depth through which the earth yields it is not known. Until these points are tested by digging at numerous points and trying the richness of the earth at each of them, it will be impossible to estimate the amount of sulphur that exists here. The delay of such an examination would have interfered far too much with the progress of the oil survey, and was therefore not undertaken. Although the holes seem much fewer, and within a narrower space than those of Loonekee Kussee, it may be chiefly owing to the less convenient accessibility of the place, and it is very likely that a large amount of native sulphur is scattered through the gypsum.

Gypsum.—Southerly from the sulphur pits and close to them rises upon the side of the main ridge a little hill that seems to be wholly made up of porous crystalline gypsum, similar to what is seen near the Chhotta Kutta oil springs of Jaba in the Salt Range, about 10 miles east of the Indus. In both cases the origin of the gypsum is probably the same, namely, the effect of the water of a sulphur spring upon the gray nummulitic lime rock. This little hill of gypsum at the Punnoba sulphur pits rises some 75 feet above the pits, and the gypsum reaches to 100 yards or so south of them, and runs some 75 yards or more east and west. There are, then, perhaps 200,000 tons of gypsum here, but more of it may be hidden under loose gravel near by. The inhabitants of the region seem quite ignorant of the great value of the gypsum for its various uses, and it lies quite neglected.

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Calcutta, 25th November 1870.