BAKU AND ITS OIL INDUSTRY.

NO city on this side of the Atlantic can show a more marvellous growth, within a short period of time, than Baku upon the Caspian; and, even apart from its petroleum industry, its natural advantages are so great, that it seems specially designed for a brilliant future as the emporium of the whole trade between European Russia, her Central Asian provinces, and Persia. So quick has been its expansion that, but an insignificant village of 1400 inhabitants thirty years ago, it can now boast a population considerably over 100,000, which is increasing yearly by leaps and bounds.

This rapid growth is mainly due to two causes: first, its magnificent harbour, well protected from the north by the extended horn of the Apsheron peninsula, and from the east by the Serpent's Island, which forms an efficient and natural breakwater; and in the second place, its immediate proximity to the main area of naphtha supply, which already rivals that of America, and promises in no distant future to become the exclusive market for all Asia, and also for the greater part of Europe. The commencement of the modern oil industry of the Caucasus dates from 1823, when the brothers Doubinin started a small works in the neighbourhood of Mozdak, which, owing to want of capital, they were forced to close in 1850. These pioneers were followed in 1836 by the engineer Voskoboinoff, who established a distillery at the foot of the mud geysers of Bog-Boga; but this effort proved likewise unsuccessful, and no trace of it now exists. Later, in 1859, M. Kokareff founded the Baku Petroleum Company, with the view of extracting the oil from the naphtha-impregnated soil; but experiment having shown in 1871 that the crude oil could be obtained by boring, this first method was abandoned, the artesian boring becoming universal, and a firm foundation was laid for the industry and for those marvellous developments which threaten an economic revolution in the lighting and fuel supply of a considerable portion of the world.

The year 1865 marks an important advance, a M. Witte having in that year established a manufactory of ozokerite on the Sviatoia Gora (Holy Mountain), and it was his engineer, M. Weisser, who, in that same year, established the first refinery in the town of Baku itself. So rapidly did the industry develop, that by 1873 the town was in danger of becoming entirely absorbed by the distilleries that rose on every hand, whilst the black, dense, and acrid smoke from the naphtha-fed furnaces poisoned the atmosphere. Baku, however, being under the influence of a despotic government, M. Staroselsky, the then governor, was enabled to effect a revolution, which, however drastic it may appear to our circumscribed democratic conceptions, was radical and efficacious. This consisted in issuing an edict that the refineries situated in the town were to be removed outside its limits, and for that purpose the corporation ceded certain town properties situated at a distance of about two versts. This land they divided into a series of blocks of from 2000 to 2500 square sargenes each (sargene is seven square feet English), and suddenly, as if by magic, eighty new works sprang into existence, their erection going forward at fever heat day and night until completed.

How intolerable the nuisance had become may be inferred from the fact that the sole firing material in use for boilers and distilling-tuns being the refuse oil, or so called astatki, and no smoke-consuming apparatus at that time being employed, not only the buildings, but the whole surface of the ground became coated with a thick layer of soot, whilst the roads were almost impassable owing to pools and ponds of oil. No wonder, therefore, that it should have received the name of the Black Town, (Tchornoia Gorod) a name which still clings to it, although through the introduction of an apparatus, by means of which steam under pressure and air are proportionately mixed with the naphtha residue, the smoke is now virtually consumed. As a result of this invention, the factories erected under the new conditions beyond the limits of the corporation land, notably Nobel's Villa Petrolia, and Popoff's Gardens, are perfectly clean, and this district in consequence has received the name of the "White Town."

Owing to the number of valuable bye-products obtainable, the refining process is complicated in its character, although the appliances used are very simple in their construction. The crude oil, fed through lines of pipes from the main sources of supply at Balachani, is stored in large iron reservoirs, from which it is drawn off to be treated in gasometer-shaped retorts. These being heated by steam coils to about 140° C., the products, having a low boiling point, such as gasoline and benzine, are separated, and passing into separate chambers are condensed. A further heating to about 150° C. in like manner separates the low-grade petroleums, which have been largely used in adulteration, and are so dangerous to the consumer. The third distillation becomes the petroleum of commerce, after having been washed and cleaned under treatment with sulphuric acid and caustic soda. The residues of heavy oils are generally treated in a separate establishment, and from them are extracted various grades of dyes, vaseline, lubricating oils, &c.; the demand for the latter constantly increasing, owing to their excellent quality and cheapness. The ultimate refuse astatki is likewise sure to become a keen competitor with coal as a fuel, a ton of this liquid being the equivalent of from two and a half to three tons of coal. To what uses it can be applied is well exemplified in the town itself: until very recently it was used for watering the streets, and not only is its employment universal in every kind of manufacture, but also for all heating and other domestic purposes. Its use is also rapidly extending on the railways in South Russia. All the steamers on the Caspian and Volga, and the locomotives on the Transcaucasian and Transcaspian lines, burn no other fuel; and when we regard its portability and cleanliness, it would seem to be but a matter of time for its advantages to be generally recognised. Owing to the abundance of the supply, at times millions of gallons have been allowed to run into the sea, or have been deliberately set on fire, and it is no exaggeration to assert that a full half of these vast supplies from nature's storehouse have been lost and dissipated unproductively.

Baku is pre-eminently a centre of commerce, and for residential purposes most undesirable, it being subject to heavy dust-storms, rainlessness, intense heat, and almost entire absence of vegetation and fresh water. The only garden is the so-called Alexander II., maintained at great expense, the shrubs and trees being planted in soil brought from Persia. A few fresh-water wells give a very limited supply, the usual sources being brackish; but the railway company supplement it by cisterns filled from the river Koura, and almost every steamer imports some from the Volga. A peculiarity in the distribution of the local supply is, that the few fresh-water wells are in close proximity to those impregnated with salt.

Varied as are the subjects of study presented by the town itself, the chief centre of interest is undoubtedly the plateau of Balachani-Sabountchi, situated about eight miles to the north-east of Baku, and connected with it by a branch line of the Transcaucasian Railway. When viewed from a distance the tall truncated towers erected over the wells seem in such close proximity to each other, that they present the appearance of a pine forest; and it is only on a closer approach, that they prove to be the derricks containing the machinery necessary for boring or the pumping of the oil. These pyramids consist of a wooden-boarded framework, and are easily removable when the bore becomes exhausted. How thickly they are grouped, may be inferred from the fact that, within the limited area of three square miles, over 400 of them are crowded. (Fig. 1.)

Not the least puzzling of the many enigmas presented by these wells, is the nature of the source from whence the oil is drawn. Enclosed in its subterranean prison it needs, in many instances, but an insignificant outlet to rise as a roaring fountain of sand and oil to a height sometimes exceeding 200 feet, continuing in action for days and even weeks, spouting forth during the time many thousands of gallons per day; yet this in no way interfering with the supply from closely adjacent wells, which continue to yield their normal quantity.

It is therefore evident that the sources are independent of each other, and that although the reservoirs may have been originally arranged in regular series, yet, through the strata having become dislocated and faulted, they now form separate and distinct chambers of varying capacity and without direct connection between them.

Small though the evidence, geology throws some light upon the probable structure of the basin, whereas chemistry reveals but little as to the origin of the oil.

Geologically the town of Baku is situated on beds of Quaternary age, which have received the name of Aralo-Caspian beds; whereas the main portion of the Apsheron peninsula, on the south side of which Baku is situated, consists almost exclusively of Pliocene and Miocene strata, subdivided locally into the Baku, Apsheron, and Balachani formations. Wherever the

rocks, which consist mainly of limestones and sandstones, are exposed, it is evident from their highly inclined dips, varying rapidly from point to point, that the whole region has been subjected to great earth-movements, the presence of overthrust faulting having been specially noted by Dr. Sjögren, of Upsala. As a result of these movements, the strata have been thrown into a series of anticlinal and synclinal folds, upon whose upturned and denuded edges throughout the Balachani district beds of Aralo-Caspian age have been unconformably laid down, a most notable feature connected with them being the extreme thinness and the abundance of the layers composing them.

Chemically, numerous suggestions have been made as to the origin of the oil. Mendeléef ascribes it to the carbon enclosed in metallic iron, deep seated in the earth's crust. Daubrée and Coquand connect it with combined chemical and eruptive action; Fuchs and De Launay lay special stress upon its relation to disturbed districts, whereas Lesquereux ascribes it without reserve to the decomposition of vegetable remains, and Hofer regards it as being of animal origin. Seeing, therefore, that the geological and physical characteristics lend support to all the theories enunciated, to none of them can as yet be granted any other than a hypothetical value.

Since the introduction of boring in 1871, this system has been exclusively employed. The number of the bores in 1881 reached 375, and in 1886 490, of which, however, only 160 were in actual work, 180 having become exhausted, and 150 being plugged down as reserves. The enormous supply of the crude oil may

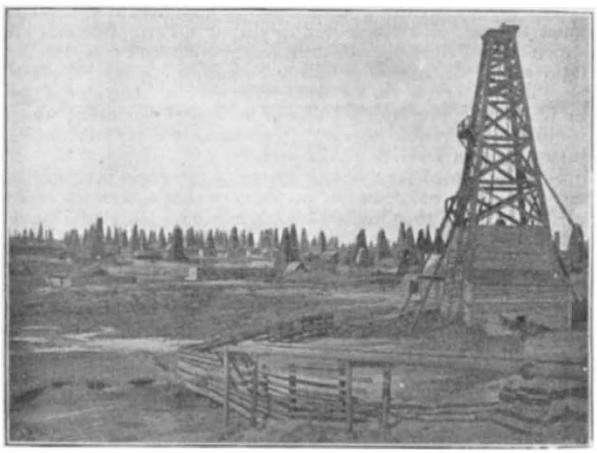

FIG. 1.—General view of the Balachani Oil-field.

be gathered from the following figures. In 1832 the yield was only 150,000 poods (pood = 36 lb.) = 2000 tons; in 1867, 999,999 poods, = 14,500 tons; in 1880, 300,000; and in 1890, 3,100,000 tons. That the supply is not inexhaustible, may be inferred from the fact that the depths of the bores are being progressively increased. We thus find that in 1871 the oil was reached at 70 feet, in 1873 this increased to 120 feet, in 1883 to 450 feet, in 1886 to 700; whilst a later bore, sunk to a depth of 1000 feet, has yielded no oil. It is evident, however, from the cellular character of the oil-bearing strata, and the immense supplies already obtained from a very limited area, that the period of exhaustion is indeterminable, and any conjecture baseless.

The means employed for raising the oil are of the simplest character; pumping, as understood in the ordinary acceptation of the term, is, owing to the depth of the bore, of course impracticable, so that after cessation of the flow consequent on the exhaustion of the gas, copper tubes called "jalonkas" are employed. These cylinders, about 12 feet long, are provided with a valve opening inwards on touching the bottom of the bore, and close on the tube being lifted filled with the oil. On reaching the surface the jalonka is lowered on to a platform, thus pressing in the valve and releasing the naphtha, which flows in a greenish-tinted stream to reservoirs connected by pipe-lines with the refineries in Baku.

It will be readily understood that in a district so saturated with naphtha oils, there must be an ever-present danger from the ignition of the exhalations of hydrocarbon gas, which escape not only from the bores, but through every fissure and cleft in the soil; and although every possible precaution is taken against such a catastrophe, many disastrous fires have occurred. Our illustration (Fig. 2) is from a photograph of one that took place in 1887, which was specially notable for its duration and devastation, all the derricks within a considerable area having been consumed, and all efforts to extinguish it failing until the volume of gas had become weakened and it burnt itself out.

These exhalations are most powerful in the district of Surachani, where the natural gas is made use of for lime-burning, for every domestic purpose, and as fuel for the boilers; in fact, it is only necessary to sink a pipe a few feet into the soil to obtain on ignition a flame of considerable length, and this is practically shown at the works of Messrs. Kokareff, where one such has been burning many years.

Adjoining this refinery, and placed by the Russian Government under that firm's special protection, is the ancient and celebrated temple of Zoroaster, which for over 2500 years was the sacred resort for pilgrimage of the Guebers, or fire-worshippers of Asia. (Fig. 3.) Formerly a flourishing monastery,

FIG. 2.—An Oil-well at Balachani on fire.

to-day it is but a decaying and deserted monument of the old religion of the Parsees. It consists of a large square courtyard enclosed by the cells of the monks, all opening inwards. A double-storied erection in the front was the dwelling-place of the chief priest, beneath which, and closely adjacent, was the chapel cell, on whose rude stone altars burned the Eternal Fires. In the centre of the courtyard is a square building, flanked with four towers, from which the flames ascended, and the arched recess in the basement was used as a crematorium wherein, by means of the sacred fires, the bodies of the faithful devotees were consumed. It is not only on land, however, that natural gas is abundant; a favourite excursion of the inhabitants and visitors being to take steamer on a calm dark night to the neighbourhood of the Baibat Point, where the gas rises through the waters of the Caspian sea in bubbling eddies, which, on being ignited with burning tow, covers the water with flames over a considerable area.

Although owing to its prominent position and natural advantages the attention of Europe has been mainly concentrated on the district and town of Baku, it must not be forgotten that this is but one out of many important petroleum fields awaiting

development in South-eastern Russia. Not only are there rich deposits known to exist in immediate proximity to the sea in the Transcaspian province, but an immense area of petroleum-producing strata extends from the Crimea to the Taman peninsula, and thence across the northern boundary of the Caucasian range to Petrovsk upon the Caspian, and many centres of production in these districts are now being opened up, which must shortly come into keen competition with the Baku industry. Already during many years oil has been extracted from borings in the Kouban district, whence by means of pipe-lines it is transported to a refinery at Novorossisk; but these will

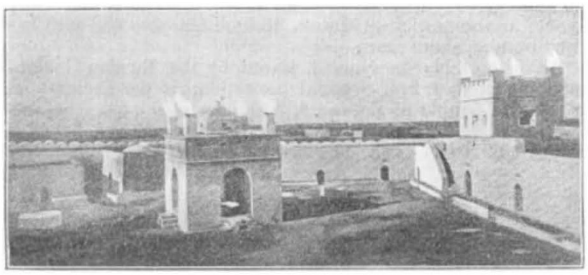

FIG. 3.—The Temple of Zoroaster.

be insignificant when (should all the reports be confirmed) the wells at Groznaia and its neighbourhood are tapped, it being considered that they will rival, if they do not surpass, Baku in productiveness. It would appear that the beds are almost identical in age to those of the Balachani-Sabountchi areas, and it would be an interesting subject for future study to ascertain if the line of petroleum productiveness to the north of the Caucasus follows that of the depression which in a former period connected the waters of the Caspian with those of the Azoff, the Black Sea, and the Mediterranean.

The accompanying illustrations are reproduced from an excellent series in *Globus*. W. F. HUME.

A SEISMIC SURVEY OF THE WORLD.

THE principal object of a seismic survey of the world is to measure the velocity with which earthquake motion is propagated through its crust, and possibly through its interior, and from the resulting figures to give to astronomers and physicists additional data respecting its effective rigidity.

It is the converse of the answer to a problem which in 1889 was incidentally worked out by Lord Kelvin, who, assuming a certain rigidity for our earth, determined the rate at which vibrations were likely to be transmitted through the same, the object of the calculation being to compare the result with that obtained from observations on an earthquake which in that year, originating in Japan, had been noted at many stations n Europe. The feasibility of the proposed undertaking and the probability of its yielding satisfactory results are based upon the existence of observations of the following nature.

For many years past astronomers, and those in charge of self-recording magnetographs, have observed disturbances in their instruments at varying intervals after the occurrence of an earthquake in some remote locality. In 1867, about seven minutes after an earthquake in Malta, M. Wagner observed at Pulkova an oscillation of 3″ in a level. One hour and fourteen minutes after the great earthquake of Iquique on May 10, 1877 (effects due to which were observed by the writer in Japan), at the same observatory M. Nyren noted oscillations in the bulb of a level of 2″ which had periods of 20 seconds. The late Dr. E. von Rebeur-Paschwitz repeatedly observed and obtained records of earthquakes which had their origin at distances equal to or more than one quarter of the earth's circumference from his observing stations. Vicentini, Agamennone, and others provided with instruments sensible to slight movements of the earth's crust, have made similar records; whilst the writer has not only shared in contributing to this class of observations, but on one occasion at least has obtained satisfactory photograms of a disturbance originating at his antipodes.

The conclusion which may be taken as well established by these observations is that suitable apparatus placed in any part of the globe will record the movements due to severe earthquakes originating in any other portion of our globe, and therefore there is nothing unreasonable in saying that every observatory throughout the world, if it were equipped with proper instruments, would be in a position to contribute to the knowledge of changes which are continually taking place, not only beneath the land, but also beneath the ocean.

For a person or a community to imagine that they reside in a locality free from earthquakes, is one of the greatest of modern fallacies. Although movements may not be felt, all places are disturbed in a manner capable of being recorded very many times per year. In addition to earthquakes the focus of which may have been some thousands of miles distant, to the recording of which the present note is intended to draw special attention, unfelt disturbances of a local origin may be recorded. Even at places where shocks are unknown, excepting as rare events recorded in ancient history, these may sometimes average two a day. Other movements taking place beneath our feet are slow diurnal tiltings, annual variations in the vertical, tremors of probably two distinct characters, earth pulsations and elastic vibrations.

To designate all these movements, which vary in their periods between the fraction of a second and twelve months, as "earth tremors," and an instrument to record them, a seismograph or a tromometer, are evidently misnomers. Although a single instrument may be obtained which will give information about each of these movements, experience has shown that it is better to have a particular instrument for a particular purpose. To record rapidly recurring vibrations the most sensitive arrangement that is self-recording is, perhaps, a Perry tromometer, which will detect the disturbance produced by a moving train at the distance of a mile. To record slight changes of level in a district, such, for instance, as may accompany changes in barometric pressure, a bifilar or horizontal pendulum, which is nearly as insensible to elastic tremors as a Perry tromometer is to change of level, would be best.

What is wanted for a seismic survey of the world is an instrument that is sensible to the preliminary elastic tremors of an earthquake, and then to the slowly recurring quasi-elastic gravitational waves by which these are followed. For this purpose it appears that our choice rests between some form of ordinary pendulum apparatus, like that of Agamennone or Vicentini, or some form of horizontal pendulum. Whatever form is selected, each instrument must be similar and similarly adjusted. If this is not the case, then at each station different instruments may commence to move with different phases of motion, and the records for purposes of comparison are without value. For example, an earthquake may originate at a known locality, at a known time, and be recorded at twenty different observatories in Europe, at each of which good time is kept, but at each of which the recording instruments are different in character.

The result of the calculations based on these observations have shown, in one instance at least, that the velocities of propagation of motion from the origin to each of these stations have varied between 2 and 20 km. per second.

The cause of this apparent discrepancy lies in the fact, that at different stations, during a disturbance having a duration of perhaps several hours, the different instruments have commenced to move with different phases of motion. This is a source of error which has been thoroughly recognised by observers in Japan for the last twenty years, and by timing the rate at which a particular vibration has travelled between given stations, the apparently conflicting results to which we are otherwise led have been greatly reduced.

When an earthquake is observed at stations far distant from each other, it is no longer possible to identify a particular vibration at these stations; but what can be done, is to note the time at which the preliminary vibrations commence and the interval which follows before the undulatory motions appear. So far as observations have gone, the velocity of propagation of the latter movements varies between 2 and 3 km. per second, which is about the rate we should anticipate to be found for motion passing through the materials constituting the earth's crust. The velocity for the former, however, appears to vary between wide limits, 10 or 12 km. per second being about the average. Because this rate of transmission is greater than that at which motion could pass through glass or steel, the inference is that it may possibly pass *through* our earth, and because it is variable the idea suggested is, that the rate of transmission varies with