Asphaltum

Scientific Department

Bulletin No. 2

The
Philadelphia
Museums

Philadelphia commercial museum.

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1900

The Philadelphia Commercial Museum.

The Philadelphia Commercial Museum is a public institution devoted to the general extension of international commerce. It is maintained by the City of Philadelphia and by private subscriptions from business firms. It is not local in its objects, but works for all sections of the country, and has received the sanction and financial assistance of the State of Pennsylvania and the United States Government. Its high standing and reputation are due to the fact that it does not enter into actual trade of any kind and is in no way affiliated with any political organization. Its advice is always absolutely impartial and without private interest. It has no sources of revenue upon which profits may accrue, as all service rendered to individuals is recompensed on the basis of actual cost. To its large and busy offices and exhibition halls, over its threads of business communication stretching out to every commercial center in the world, come constant reports of trade conditions and opportunities, changes in the condition of business firms, new developments offering profit to idle capital, and new natural products of probable utility in manufacturing industries. It is a center of commercial information, in equally close connection with business houses all over the world, to which reports and confidential advices are regularly and systematically issued; a confidential adviser in opening up new markets for all useful natural or manufactured products; a special mercantile bureau with connections in all foreign countries, reporting not only the general standing of firms, but their disposition and fitness to handle particular agencies; a business institution run by business men, yet carrying on no private transactions. A manufacturer or merchant in the United States, a producer or exporter abroad, an importer, retailer or selling agent in some far off-land—all these apply with equal confidence for the advice of the Institution; and the advice is always given with the same impartiality and care, though to do so investigations be required at the ends of the earth. No similar institution or association in the world wields an influence equal to that of the Philadelphia Commercial Museum.

The first aim and object of the Museum is to foster and promote, by practical and systematic efforts, and by new, original and effective methods, the foreign trade of America. In this work it has the support of an Advisory Board, comprising representatives of the leading Chambers of Commerce and similar organizations in the United States as well as in foreign countries. It also has the benefit of similar advice from an honorary Diplomatic Board, comprising the Ministers of many of the foreign countries resident in Washington. It is in constant communication with over 20,000 foreign correspondents, through whom it keeps in touch with every possible phase of international commerce. This extensive correspondence is carried on in more than a dozen different languages.

A merchant or manufacturer who wishes to trade in a foreign market must first know, specifically, the nature and value of that market. Granted that its trade will repay the effort of securing it, he must know exactly what the market requires, what it can offer in return, what business houses to deal with, and what are the conditions on which business is customarily done.

The activity of the Museum is specifically directed to meet these various requirements by exhaustive commercial reports, which are further illustrated by collections of trade samples, both natural and manufactured. To the general business community the resources are made available by the Bureau of Information. This Bureau is actively reporting trade conditions existing in other countries to leading manufacturers and merchants in every part of the United States. Complete and detailed reports as to the demand of every market in the world, the style of goods required, method of purchase and shipment, customs, of receipt and sale, are all fully described to intending shippers, and every possible assistance is given them, not only in the proper preparation and forwarding of their goods, but in the most advantageous way of approaching possible buyers with a view to securing orders. Through an extensive and well-equipped Bureau attached to the Museum, accurate and reliable reports are on file and readily attainable, regarding the standing and reputation of possible buyers in every country in the world, thereby rendering trade with other nations no more hazardous than trade in the home market.

The Museum is promptly informed, through its agents and representatives, of all important enterprises in other countries—government contracts, tenders for public works, which are referred to probable American bidders through a special News Bureau.

The trade literature of the world is gathered into a special library. Here will be found hundreds of trade and technical journals, in fully twenty languages, together with shipping and market reports, statistical publications of all countries, export and import manifests, etc.

This information is indicated by a card-catalogue system, and every fact that has practical business value finds its way at once into the hands of a body of experts, who include it at once in the individual reports.

An elaborate system of reporting on the specific requirements of business houses in other countries has been established, whereby the complete statements of responsible houses are issued on index cards and distributed to manufacturers and exporters in all parts of the country, who hold confidential cabinets of such cards placed in their hands by the Museum. In this way there is furnished a reliable directory of foreign buyers specially prepared for each individual manufacturer.

The collections of trade samples belonging to the Museum, which are used to illustrate and extend the work instituted by the commercial reporting, are classified under the following heads:

Manufactured Articles—
- (*a*) Arranged in lines of manufacture.

Raw Products—
- (*a*) Geographic arrangement of collections.
- (*b*) Monographic arrangement of collections.

The Museum shows the consuming capacity of any given country by collections of the goods that are most saleable there. These are actual samples of what is in the market, selected with great care by experts of the Museum. Textiles, hardware, clothing, household goods, cutlery, provisions—everything that is imported—are represented in these sample collections. With each sample is found full information as to place of manufacture, price, terms of sale, distribution, etc. These collections are constantly renewed and extended.

Having shown the consuming capacity, the Museum then shows the producing capacity by collections of natural products.

These show at a glance what is produced by any given country, and what it has to offer in the way of a return trade. These collections are made practically useful by scientific and technical laboratories in which complete tests are made, with special reference to the industrial value of any given product. The usefulness of this work is well established in many countries, and merchants are constantly sending samples of exportable products, in order that the Museum may report on their usefulness for the American market.

ASPHALTUM.

Asphaltum is a bituminous mineral substance of somewhat the same nature and appearance as pitch. It is black to brownish-black in color and often occurs mixed with clay, sand or vegetable matter, or impregnating beds of sandstone, limestone or shale. The solid varieties, or true asphaltums, soften under a moderate heat and melt at about 90° to 100° C. (194° to 212° F.). Most kinds burn readily with a sooty flame and a strong bituminous odor.

In addition to solid asphaltums, there are more or less liquid varieties of a viscous nature, which approach the heavy petroleums in character, composition and properties, and seem to have been derived from them.

Natural bituminous substances may be conveniently classified as follows:

1. Liquid (petroleum).
2. Viscous (liquid asphalt or maltha).
3. Solid (asphaltum or mineral pitch).

So many substances are found intermediate between these types that the boundary lines between them are very indefinite.

NOMENCLATURE.

Liquid asphalts are variously called maltha, mineral tar, brea, and pittasphalt.

Solid asphalts are called asphaltum, natural bitumen, native bitumen, mineral pitch, brea (Spanish), asphalte or bitume (French), bergpech or erdpech (German). "Manjak," glance pitch and gum asphaltum are names applied to very pure varieties. "Chapapote" is a variety from Cuba.

The names of some very pure hydrocarbons which are nearly related to and are often classed as asphalts are ozocerite (or ozokerite), uintahite, gilsonite, wurtzilite, grahamite, albertite, lithocarbon, and elaterite.

Asphaltum from Trinidad is called Trinidad asphalt, Trinidad pitch, lake pitch, and land pitch.

Rocks containing asphaltum are called rock asphalt, asphalt rock, bituminous or asphaltic sandstone, bituminous limestone, bituminous shale, etc. In Europe there has been an effort to restrict the use of the term asphalt to what in this country are called rock asphalts

CHEMISTRY.

Chemically no dividing line can be drawn between the liquid, viscous and solid bitumens on account of the many substances intermediate between them, and hence, in the study of asphaltums, we must necessarily consider petroleum to some extent. Petroleum consists chiefly of members of the paraffin or marsh-gas series of hydrocarbons (of the general formula C_nH_{2n+2}), and contains a considerable percentage of oils vaporizable at 100° C. (212° F.) or below; olefines and benzenes are usually present, and sometimes the solid paraffins.

Asphaltum, according to Dana (System of Mineralogy, 1895), contains the following classes of ingredients:

(a) Oils vaporizable at 100° C. or below; sparingly present, if at all.

(b) Heavy oils, probably of the pittolium or petrolene groups; vaporizable between 100° and 250° C.; constituting sometimes 85 per cent. of the mass.

(c) Resins soluble in alcohol.

(d) Solid asphalt-like substance or substances soluble in ether and not in alcohol; black, pitch-like, lustrous in fracture; 15 to 85 per cent.

(e) Black or brownish-black substance or substances not soluble either in alcohol or ether; 1 to 75 per cent.

(f) Nitrogenous substances, often as much as corresponds to 1 or 2 per cent. of nitrogen.

All varieties of asphaltum are wholly or partly soluble in one or more of the following solvents, viz.: carbon bisulphide, alcohol, ether, chloroform, turpentine, petroleum, naptha, and benzene.

The ingredients which compose asphaltums are present in varying proportions in different kinds of asphaltum, and are classified by different authors in many ways.

A convenient mode, and one in frequent use, is a division into petrolene and asphaltene as proposed by Boussingault. Petrolene he described as an oil ($C_{10}H_{16}$), separable from asphalt by heating in an oil-bath to 300° C. (572° F.), asphaltene being the residue. There can be no doubt that these are mixtures of various substances, and not simple compounds as described, still the classification is found very useful. Petrolene embraces the more volatile and liquid ingredients and is the part which gives to asphaltum its cementing power. Asphaltene consists of the solid ingredients and imparts firmness and stiffness. The relative proportion of these two ingredients determines largely the nature of any asphaltum. Too much petrolene renders it soft, while too much asphaltene makes it lack plasticity and cementing power, causing brittleness.

Just enough petrolene should be present to hold all the asphaltene in complete solution. The liquid asphaltums contain a large percentage of petrolene.

DISTRIBUTION.

Asphaltums are found in many places—all over the globe. The greatest deposit is the so-called "Pitch Lake," in the southwestern part of the island of Trinidad, and consists of bitumen mixed with earthy and organic matter.

The Pitch Lake is about 114 acres in extent, 138 feet above sea-level, and a mile and a quarter from the seashore. It occupies a saucerlike depression more than 2300 feet across the center. A boring 135 feet deep did not reach the bottom of the deposit. Numerous borings nearer to the edge have shown that the rock under the asphalt is a sandstone more or less impregnated with bitumen. It is usually stated that this depression in which the asphaltum is found is the crater of an extinct volcano, but there seems to be no indication of this, except the shape of the deposit, and the fact that the asphalt is in a state of continual agitation due to the ebullition of gases. The generation of these gases is more likely caused by chemical reactions in the asphalt as it changes from soft to harder form, than by volcanic action, and at present there is no better reason to suppose that this pitch lake occupies the crater of an ancient volcano than to suppose that many lakes which receive constant supplies of water from springs in the bottom, occupy volcanic craters. The surface of the lake is fairly level, but uneven, the asphalt occurring in spherical or mushroomlike masses of irregular shape, varying from 30 to 200 feet across. The spaces between the masses of asphalt are filled with water, and there is said to be a constant slow suction of this water from below and of the asphalt near the water, with a corresponding upward and lateral motion of the asphalt in the middle of the mass. Most of the lake is so solid that horses and carts are driven over it with perfect safety, but in some places the asphalt is soft and viscous. Carbon dioxide and sulphuretted hydrogen gases are constantly evolved in the soft asphalt, and the pitch as it is dug always contains cavities which have been filled with these or other gases. A small railroad is built on the lake for the removal of the asphalt, which is taken from within a foot or two of the surface by negroes or imported East Indian coolies working with picks and shovels. In the course of a few months, fresh material, slowly rising, fills up any excavations, and the inflow, which has been estimated at 20,000 tons per year, is so rapid that it is very difficult to dig pits over ten or twelve feet in depth. The thickness of the deposit has been variously estimated at from 18 feet to 133 feet. The asphaltum from this lake is known in commerce as Trinidad lake pitch, and is of very uniform quality. Land pitch is a poorer grade, mixed with considerable earth; it is found near-by, and has evidently been derived from an overflow of the lake at some time in the past. Fluid bitumen, oozing from the bottom of the sea and floating on the surface, has been observed on both sides of the island of Trinidad.

Other deposits of the same nature or of pure bitumen, are found at many places in the West Indies and in the northern part of South America.

One very large deposit, said to be inexhaustible, is on the island of Pedernales, at the mouth of the Orinoco River. This asphalt is found as a thick black viscous mass, containing a large percentage of volatile oils and considerable water, but almost no mineral impurities.

Bermudez asphalt, which comes from near Maturin in Venezuela, contains very little mineral matter and a large amount of easily volatile oils. The asphalt, which is from 7 to 9 feet deep, is exuded by springs, and a large part of the deposit is covered with a rank vegetation; it has been used to some extent in this country for paving. Large beds of asphalt are found near Maracaibo, Merida, Coro, and other places in Venezuela, and in Colombia. Extensive deposits, most of them entirely undeveloped, are known to occur in Cuba, in the provinces of Havana, Pinar del Rio, Bahia Honda, and Matanzas. At Cardenas there are "mines" in the bay from which superior asphalt has been obtained by dredging in water twelve feet or more in depth. Asphalt occurs in other West India islands, notably Barbadoes. It has been found in Mexico and in Central America.

Small quantities of a fine grade of asphalt have come from Caxatambo, Peru.

It is found in Alsace and Brunswick, Germany; at Chieta, Italy; Auvergne, France; in Hungary; in Russia; at Salonica, Turkey; near Beyroot, and in the neighborhood of the Dead Sea, in Syria; and near the site of Babylon.

It has been observed in Egypt, in Algeria, and on the lower Congo.

Extensive beds of rock asphalt are found in Europe. Nearly all of these are composed of bituminous limestone. The principal mines are at Seyssel, Department de l'Arn, France; Val de Travers, Neufchâtel, Switzerland; Ragusa, Sicily; and Vorwohle and Limmer, Germany. At Seyssel there are eight strata of bituminous limestone, separated by layers of ordinary white limestone.

One of these strata of asphalt rock, about 100 feet above the level of the Rhone, is 23 feet thick, and galleries are dug in it reaching more than seven miles in length. This is the largest known bed of asphaltic limestone.

Other deposits of rock asphalt are found near Alais, France; Mt. Laviano, Salerno, Italy; Chieti, Abruzzi, Italy; and in Austria. Deposits of bituminous sandstone are found in Auvergne, France; and at Maestu, Spain.

In the United States, asphalt is found in many places. The most extensive known deposits are in California, in the counties of Santa Cruz, San Luis Obispo, Los Angeles, Kern, Monterey, Ventura and Santa Barbara, and are of a very varied character. Most of the material is bituminous sandstone, ranging from very fine sand particles to coarse gravel, in many cases with a large percentage of clay.

Some deposits are almost entirely lacking in sandy matter and consist of clay or shale, and in one case the base is an infusorial earth.

At Las Conchas Mine, Santa Barbara County, California, there is an immense deposit of liquid asphaltum, on the ocean beach, which saturates beds of shale known to be 400 feet thick. By a patent process of extraction the liquid asphalt is obtained from an immense bed of sand which lies on top of the bed of shale. There is a continuous upward flow of the liquid asphalt from the shale, and this has caused its presence in the overlying sand, which is very free from clay or other impurity. Similar beds are situated under the ocean, and the upward flow of the asphalt is shown by an oily film on the water for many miles. At La Patera, on the seashore, twenty-five miles west of the Las Conchas Mine, is a very large deposit of rock asphalt. This material contains about 60 per cent. of bitumen and 40 per cent. of very fine quartz sand. It is hard and brittle, resembling cannel coal. The mining is carried on by drifts, one of which is 125 feet underground. Ledges extend under the sea and to a distance of half a mile inland, and the material is remarkably homogeneous. In spite of its apparent solidity, it is constantly forced up from below, in one instance fifty-two feet having been cut off from the floor of a drift in one year as the asphalt swelled up. A mixture of this solid asphalt with the liquid asphalt previously described forms "Alcatraz" cement, used for paving and other purposes.

In Breckenridge, Logan and Grayson Counties, Kentucky, sandstones are found which seem to consist of sand particles held together by no other cementing material than the bitumen. The sandstone is taken out by ordinary methods of quarrying and used for paving. The bituminous matter in these sandstones has apparently been derived from underlying beds of subcarboniferous limestone. Heavy petroleum and mineral tar are obtained in small quantities from many springs in this part of Kentucky. Other deposits of bituminous sandstone occur in Oklahoma and the Indian Territory.

Bituminous limestones are found in Utah, Indian Territory, and Texas.

Very pure hydrocarbons called gilsonite, uintahite, wurtzilite and ozokerite, all of them of them often referred to as gum asphaltum, are found in a deposit extending through parts of Uintah and Wasatch Counties, in Utah, and Rio Blanco County, Colorado. These substances vary somewhat in composition and properties, but all are of a pure nature, brittle, jet black in color, and with a brilliant, pitchy lustre.

Ozocerite (ozokerite, mineral wax, or native paraffine) is generally a brownish or reddish, greasy solid of the consistency of wax; it is found in Galicia and Utah.

Albertite from Nova Scotia and grahamite from West Virginia are related to gilsonite.

Elaterite is an elastic bitumen from Derbyshire, England.

EXPLANATION OF THE MAP.

LOCALITIES.

ON COASTS OF CARIBBEAN SEA AND GULF OF MEXICO.

TRINIDAD ISLAND, the source of a very large part of the world's supply of asphaltum.

VENEZUELA.—The ISLAND OF PEDERNALES and MATURIN are important sources of commercial asphaltum.

At other places in VENEZUELA, GUIANA, COLOMBIA, CENTRAL AMERICA and MEXICO are deposits of asphaltum not at present of commercial importance.

CUBA.—Large deposits, undeveloped. Other WEST INDIA ISLANDS, notably BARBADOES.

NORTH AMERICA.

CALIFORNIA.—The southwestern part of the State is the greatest producing locality outside of Trinidad, and contains deposits of asphaltum, liquid asphalt, bituminous sandstone, and bituminous shale.

UTAH produces uintahite and bituminous limestone.

Deposits of uintahite, gilsonite, etc., occur in COLORADO, WYOMING and MONTANA.

Bituminous limestone is found in INDIAN TERRITORY, OKLAHOMA and TEXAS.

Bituminous sandstone is mined in KENTUCKY and TENNESSEE.

Grahamite occurs in WEST VIRGINIA.

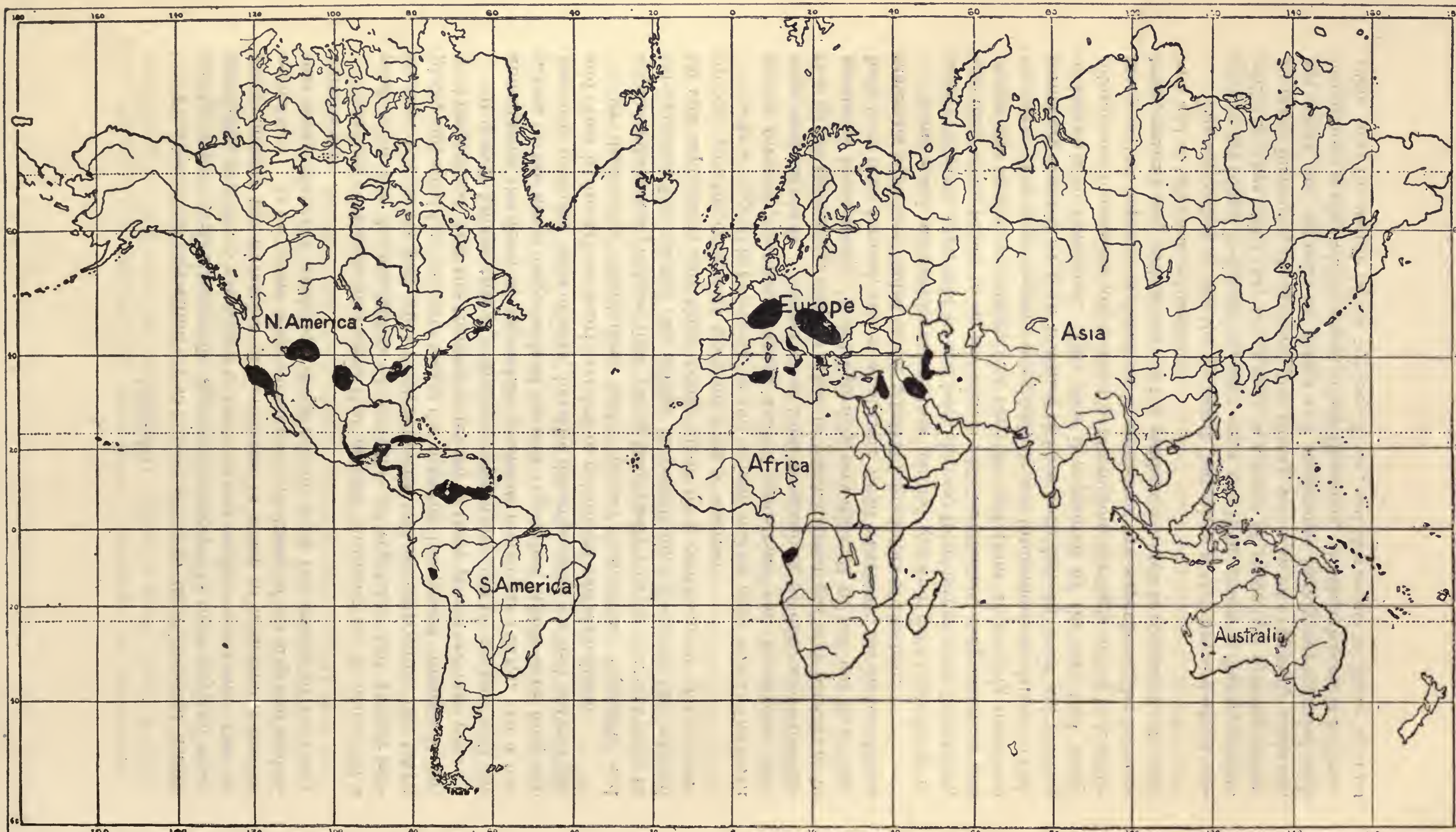
Albertite occurs in NOVA SCOTIA.

EUROPE.

FRANCE AND SWITZERLAND.—Very large deposits of bituminous limestone, mined at Seyssel, France, and Val de Travers, Switzerland, and at other places.

Similar deposits are mined in SICILY, ITALY, and Vorwohle and Limmer, GERMANY. Purer asphaltums are found in TURKEY, RUSSIA, AUSTRIA and HUNGARY, but these localities are not commercially important.

Other unimportant localities are the shores of the CASPIAN SEA, the EUPHRATES VALLEY, the DEAD SEA, ALGERIA, the region of the lower CONGO RIVER, and PERU.


N. America
S. America
Europe
Africa
Asia
Australia

ORIGIN.

Petroleum and asphaltum are so closely allied in their chemical nature and by intermediate compounds, approach so closely in their physical characteristics, and are so connected in their natural mode of occurrence, that we must consider the formation of petroleum in order to understand that of asphaltum. As far as our observation goes, we know of no origin of asphaltum other than the oxidation of petroleum with the escape of its easily volatile oils.

Leading geologists now agree that natural bitumens are in some way a product of the decomposition of vegetable or vegetable and animal substances, but under just what circumstances this decomposition has taken place, and what intermediate stages the material has passed through, is not well understood, and the theories in regard to these points are very varied.

It is well known that at ordinary temperatures, out of contact with the atmosphere, the decay of vegetation produces marsh-gas (CH_4). In a few places in the world large beds of ancient vegetation, which were long ago buried in or under beds of clay, have by decomposition yielded natural gas and other hydrocarbons nearly related to petroleum and asphaltum.

By destructive distillation, under proper conditions, vegetable and animal substances produce, first, gases, then easily volatile oils, and these in turn produce less volatile oils similar to petroleum, substances like mineral tar and asphaltum, and these being made by a continuation of the same process, pass imperceptibly from one form to another.

Beds of vegetable or vegetable and animal matter exist now in the earth in the form of bituminous clays, shales, sandstones and limestones, peat bogs, and coal beds. Almost all of these formations, by destructive distillation in the laboratory, can be made to yield natural gas and petroleum in greater or less amount. It is frequently very difficult to tell just how these beds have been formed, and at what time, or in what way, the carboniferous materials have been added to the mineral ingredients of the bed.

Some good authorities assert that natural gas and petroleum have in nearly all cases originated in and been derived from bituminous limestones, and that, when found in or associated with sandstones, conglomerates and shales, the bituminous matter has been derived from underlying limestone deposits. The large deposits of asphaltum and bituminous sandstone in Calfornia are asserted by J. D. Whitney to have been derived from the remains of infusoria in limestone. This view is supported by the fact that many bituminous limestones are uniformly bituminous throughout the bed, while many of the deposits of bitumen in sandstone are superficial, the bitumen being present only in that part of the sandstone which is comparatively near to a bed of bituminous limestone.

The supporters of this theory assert that when petroleum and allied substances are found in limestone, they are a result of primary decomposition, while in other rocks they occur only as a result of secondary decomposition. In many instances, the truth of this theory seems to be extremely probable, yet there are deposits of shales and sandstones highly impregnated with bituminous matter which seems to be indigenous. Such a deposit is in Venezuela, near the mouth of the Orinoco River, and this seems to throw light on the formation of asphaltum in Venezuela and Trinidad. This deposit consists of recent beds of shale (belonging to the later Tertiary age) which were formed under the sea, and contain abundant vegetable remains brought down by the river. These beds of shale have been raised to the surface by geological action and are now yielding quantities of petroleum by direct decomposition of the vegetable matter. In the hot climate, exposed to the atmosphere, the petroleum soon changes to asphaltum.

In Tennessee there are many occurrences in sandstone, of oils derived from underlying subcarboniferous sandstone and not traceable to limestone. These oils pass by natural processes of oxidation into viscous tar or maltha, and further into solid asphalt. In Scotland, where beds of coal have been penetrated by volcanic dykes, both petroleum and asphalt occur in seams and fissures in the coal and trap.

In the artificial production of asphaltum from organic substances by distillation, it is necessary to apply considerable heat, sometimes over 400° C. (752° F.). It is not known to what extent heat has influenced the formation of these substances in nature. Some writers think they were formed by the action of intense volcanic heat on beds of organic matter in the earth, protected by beds of rock above.

Other authorities think the distillation took place slowly at a low temperature, some even referring to the possibility of a slow, spontaneous distillation, with no more heat than that caused by the decomposition of the organic material. When petroleum has been derived from limestone, the parent rock seldom seems to have been acted on by intense heat.

Some writers say that asphaltum cannot have been derived from petroleum without the application of a fairly high heat, as many of the oils present in petroleum and lacking from asphalt, are not volatile at low temperatures. In contradiction of this, we see in nature thick viscous tar and fairly solid asphalt formed by the slow oxidation of quite liquid petroleum in the atmosphere at ordinary temperatures.

In view of our knowledge of the facts, we cannot think that it is right to assert that all petroleums and asphalts have been formed by any one method. It seems more probable that all of the theories deriving bitumens from organic substances have in them something of truth, and that primarily some have been derived from original deposits of limestone, some from sandstones, and others from shales or clays or from deposits of fairly pure vegetable or vegetable and animal matter; and further, that the decomposition has sometimes been assisted by volcanic or other heat of considerable intensity, although in most cases the attendant heat has been slight.

The enormous supply of natural gas and petroleum has led to the supposition that they cannot be derivatives from organic life, and theories have been offered to account for their formation in other ways.

A chemical theory proposed by Berthelot in 1866 is worthy of mention. This presupposes the existence of a vast quantity of hot metals in the interior of the earth at a great depth, and the admission to them, through fissures in the earth's crust, of water charged with carbon dioxide—a very abundant occurrence. Under these conditions, it is believed that various hydrocarbons would be formed which would ascend and permeate beds of porous rocks.

This theory would account for a deep-seated and continuous formation of oil and gas. We know that most oils are produced by the decomposition of organic materials, and can only say that, while it may not be impossible, it is highly improbable that any have ever been generated by chemical means from inorganic matter.

HISTORY.

There are references to the use of asphalt in the earliest times of which we have any record. In the Bible (Gen., vi, 14: xi, 3: xiv, 10) the asphalt which is still yielded by springs in the Euphrates Valley is referred to as the material used to "pitch the Ark," and as a mortar in building the Tower of Babel. Nineveh and Babylon used this same mineral pitch or asphalt as cement in construction-work. These springs or "fountains of pitch" were described by Herodotus.

The Dead Sea occupies the place of what was in olden times called the "Vale of Siddim," and it was from this neighborhood that most of the asphalt was obtained by the Greeks and Egyptians. The ancient name of the Dead Sea was Lacus Asphaltites.

In Egypt, asphalt was used as cement in building and for waterproof lining in cisterns. and silos for grain, and in embalming the bodies of the dead. Aristotle and others called it "asphaltos;" Pliny referred to it as "bitumen."

Petroleum was used as a source of light in China, Persia and India at a very early date.

In the United States, crude petroleum was used by the Indians for medicinal purposes before the whites entered the country; but up to 1850, and considerably later, its value as a fuel and illuminant was not recognized.

The asphalt in California was used by the aboriginal inhabitants as a cement and for making their canoes water-tight. More than one hundred years ago, the priests at Spanish missions used it for making floors, walls, roofs, reservoirs, and water conduits. Among the Mexicans it found a limited use for paving, but there was little employed in this way until 1880, and not till 1888 was mining done on a large scale.

In 1832, Count Sassenay called attention to the bituminous limestone in the valley of the Rhone, and in 1838 the first sidewalks of rock asphalt from Seyssel and Val de Travers, were laid in Paris. It was tried in London in 1869 and in New York and Washington about 1872. When the pavements, laid with rock asphalt from the French quarries, proved satisfactory, trials were made of other asphalts for paving. Owing to a lack of experience and want of knowledge of the variable nature of the many similar articles, a large number of the pavements first laid, proved worthless.

As later experience has taught the advantages and disadvantages of different varieties, and the proper methods of preparing the crude asphalt and laying the pavement, the popularity of these roadways has increased, and at the present time asphalt is almost without a rival in popular esteem as a road-making material for cities.

USES.

The purposes for which asphaltums are used are many and varied, and depend on the composition and texture. In brief, they may be classified as follows: (1) For varnish and paint; (2) for insulating; (3) for waterproofing; (4) for cement.

For making black japan and other varnishes and black paints, the pure varieties are used, mixed with turpentine and linseed oil in proper proportions, sometimes with the addition of shellac and other substances.

For insulating, some kinds of asphalt are unsurpassed, gilsonite in particular being remarkable for its resistance to the passage of the electric current.

Asphalts have been used as a substitute for rubber in the manufacture of garden hose, for lubricating purposes, and as a protective covering for metals from the corrosive action of salt water and acids.

As a waterproof covering and a cement, its uses are closely allied. On account of its waterproof property, it is employed as a preservative for wood and metal in places exposed to dampness, preventing wood from rotting and iron from rusting.

As a waterproof cement, it is used in the construction of walls, roofs, cisterns and viaducts, being sometimes put in the joints between stones or bricks, and sometimes spread in a layer over the exposed surface.

Felt saturated with asphalt is extensively used for roofing, being laid on the roof and covered with hot asphalt and gravel.

It is as a paving material that asphalt is most important, 95 per cent. of all produced being utilized in this way. Its value for paving is primarily on account of its cementing power and because the cement which it forms is strong, durable, impervious to moisture, unaffected by frost or by heat (up to 450° F.), and moderately elastic. Pavements of stone or wooden blocks are often laid on a foundation of asphalt concrete, with hot asphalt as a cement run in the joints between the blocks.

Sheet asphalt pavement, when properly laid of good materials, forms a roadway with a perfectly smooth surface, which is hard without being brittle, durable, resilient, less noisy than stone or brick, more easily kept clean and free from dust than macadam or any other paving material, and more hygienic than wooden blocks on account of being waterproof. Larger loads can be drawn over sheet asphalt than over any other roadway with the same power. Repairs can be made to sheet asphalt with less trouble and expense than to almost any other pavement.

Like everything else, it has some defects, but it is conceded that these are more than atoned for by its virtues. On account of its smooth surface (one of its great points of merit) it becomes slippery when wet or when covered with frost, but the newer asphalt pavements are less slippery when wet than those which were laid some years ago, because of improved methods of preparing the composition. The firm, smooth surface does not afford as good a foothold for horses as loose earth, or a rough pavement, or even macadam, but this is made up for, by the greater ease with which loads are drawn over it. The smoothness adds greatly to the pleasure of riding, and lessens the wear and tear on vehicles occasioned by jolting over rough roads.

When the asphalt is not properly prepared and mixed, and not laid with the greatest care, the pavement is liable to the formation of a wavy surface and transverse cracks, to decomposition in the cracks and in gutters, to softening in hot weather and brittleness in cold.

The preparation of asphaltum for paving, or indeed for any purpose, is a process requiring great care and an intimate knowledge of the properties of the asphalt in question, as well as the properties which are requisite in the use to which it is to be applied. Chemical analysis and tests of the consistency and cementing power must be made in order to learn its true nature, and the best results are never attained except after many experiments.

All asphalt pavements are composed of at least 80 per cent., and more often 85 to 90 per cent. or more, of sand or rock held together by asphaltic cement.

Many rock asphalts in their natural state approximate this composition. The European bituminous limestones run from 7 to 20 per cent. bitumen, and average about 14 per cent. These are fine-grained, compact noncrystalline limestones, and experience has shown that they form the best pavement when the rock contains about 9 per cent. of bitumen. The desired percentage is generally reached by mixing limestones containing greater and less percentages, and sometimes by adding Trinidad or other purer asphalt to a low grade bituminous rock. The mere relation of bitumen to rock in any paving material may be misleading, as a great deal depends on the character of the rock, whether gritty, fine or coarse, and even grained, and much depends also on the character of the bitumen as to its cementing power, firmness, and liability to decomposition. No bitumen used for paving ought to contain much oil volatile at 400° F., and the dense, rather coarse-grained limestones are the best. Pavements of rock asphalt are generally laid on a foundation of concrete. The limestone is powdered (if necessary, mixed, to obtain the needed percentage of bitumen) and heated to about 275° F., in order to soften the asphalt, so that when it hardens it will cohere tightly and form a solid mass. The hot rock-asphalt powder is spread in an even layer on a concrete base, and immediately rammed down with heated rammers, then sprinkled with a thin layer of Roman cement, and finally rolled with heavy rollers. The final thickness of the asphalt coating is usually from one and a half to two and a half inches.

The general method of procedure for laying pavements of any rock asphalt is much the same as the preceding, whether the material be limestone or sandstone. The bitumen in some rock asphalts, such as that from La Patera, California, is of a hard nature and does not soften sufficiently under the influence of a gentle heat, usually because of the presence of too little petrolene. These hard asphalts are said to require a "flux" (or, in other words, the addition of some petrolene) to dissolve the asphaltene, lower the melting-point, and increase the cementing power. The flux in most general use, and which is most available, is heavy petroleum oil. This is a residue obtained from crude petroleum by the distillation of the lighter oils. It should be especially prepared for paving purposes, not all of such residues being suitable for this use, many of them being objectionable on account of the imperfect removal of the light oils or the presence of solid paraffins.

The specific gravity, flash-point and melting-point of the heavy petroleum are important features in determining the suitability as a flux.

A liquid asphalt from California is, by some, considered superior to the petroleum residuum for use as a flux, on account of the frequent presence in the latter of small amounts of the light oils, which evaporate after the pavement is laid and weaken the cementing power of the asphalt.

When hard asphalts are carefully melted with the right kind of flux, in the correct proportion, they absorb it readily, and form a tough, strong and elastic cement.

In the United States, particularly in the East, Trinidad asphalt is the material most in favor. For a long time it was much easier to obtain this asphalt than any other kind, and so many good pavements have been laid with it that it is considered perfectly reliable, when prepared and laid with care.

As mined, the Trinidad lake pitch is a dark-brown substance, which is solid enough to flake off easily with a pick and is seldom at all sticky. In spite of its apparent solidity, it flows very slowly, and a heap of it, if allowed to do so, will spread out gradually and flow in every direction, at the same time retaining its solid appearance. In its crude state, it contains about 55 per cent. bitumen and 28 per cent. water, the remaining 17 per cent. being very finely divided earthy matter with a little undecomposed organic material. For use it must be refined, a process which consists primarily in removing the water, and the little unaltered organic matter, which it contains. The refining is done by melting the asphalt and driving off the water by heat, the other impurities being skimmed off the top. During the melting, the temperature should never exceed 400° F., as a greater heat is likely to injure the quality of the asphalt. In the best refining processes, large kettles holding twenty-five tons or more of the crude asphalt are heated by coils of steam pipes so arranged as to heat the entire mass evenly. While melted, the asphalt is kept in continual agitation, to prevent the separation of the earthy matter contained in it.

When cool, this refined asphalt is black, hard and brittle, and must be melted with a flux in order to form a cement of sufficient strength. The heavy petroleum before alluded to is employed, being mixed with the melted asphalt in the proportion of from 15 to 21 pounds of residuum oil to 100 pounds of refined asphalt, and the heated mixture is thoroughly agitated for several hours by a current of air in order to obtain a homogeneous material. This is called asphaltic cement, and is carefully tested in an ingenious apparatus in order that it may have the consistency which gives it the desired cementing value.

The foundation for Trinidad sheet asphalt paving is a four to six inch bed of concrete, composed of broken stone, sand and hydraulic cement. In order that the wearing surface may adhere firmly to the concrete base, it has been found advisable to lay on the concrete, a binder layer of small broken stone mixed with asphaltic cement. This binder layer is put down hot and rammed and rolled till it is firm and smooth, and usually is about one and a half inches thick.

The top or wearing surface is practically an artificial sandstone. It is prepared by mixing the previously described asphaltic cement with sharp, clean quartz sand and limestone dust in the proportion of asphaltic cement 13 to 16 parts, sand 79 to 84 parts, and limestone dust 3 to 5 parts.

The ingredients are mixed at a temperature of about 300° F., and it is very important that the mixture of the cement and mineral matter shall be complete and uniform, so that each particle of sand is entirely covered by the cement in order to obtain the perfect cementation and uniform texture that is wanted. It is found desirable to retain in Trinidad asphalt the earthy particles that it contains, on account of their natural perfect union with the bitumen. This mixture for the wearing surface is spread as a hot powder, in an even thickness upon the binder layer, first rammed, and then rolled with heavy steam rollers until it is solid, and, as usually laid, it has a final thickness of from one to two inches. Other foundations than concrete are sometimes employed, usually an old pavement of another kind, the wearing surface being laid with or without binder layer on a pavement of stone blocks, macadam, wooden blocks, asphalt blocks or brick.

Asphaltum in some other forms has found a limited use in paving.

Mastic (asphalte coulé) consists of the powdered bituminous limestone mixed with about 8 per cent. of Trinidad asphalt, and then moulded into blocks. For use, these blocks are broken up and melted with asphaltic cement and mixed with sand and gravel. The mixture is a hot fluid, and is poured on a foundation in an even layer and allowed to harden. Mastic pavements are chiefly employed for sidewalks.

Asphalt paving blocks are composed of a mixture of Trinidad asphalt and crushed stone, moulded and pressed. These blocks are easier to lay than sheet asphalt, and while not nearly so durable, they are well adapted to light traffic.

The proper treatment of other asphaltums depends in each case on the nature of the substance itself. Some are so pure as not to need refining, and each variety requires its own treatment in order to obtain satisfactory results.

In Europe the bituminous limestones have been mostly used for paving, and in the central and western parts of the United States bituminous sandstones have been largely employed. In the eastern part of this country, and, to a greater or less extent in other parts of the world, the Trinidad asphalt has been received with much favor. On account of being mixed with sharp sand, the surface of the Trinidad asphalt pavements is, as a rule, less slippery than those in which rock asphalts are used, the fine-grained limestones being most objectionable in this regard.

Many cities have elaborate specifications in regard to the materials which may be used in asphalt paving, their proportions, and the processes of preparing and laying. These specifications are prepared by persons familiar with the proper treatment of a certain kind of asphalt, and for this reason generally put the paving in the hands of one company, or, at any rate, prevent the use of any asphalt other than the one for the use of which the specifications were constructed, because no two asphaltums have identical composition, texture and properties, and each one, therefore, requires different treatment to obtain the best results.

After short trials, many asphalts have been condemned, some, no doubt justly, because of lack of cementing power or liability to decompose; but it should be remembered that, owing to improper treatment, some very poor pavements have been laid with good materials.

Often, careful study, intelligent experiment, and proper methods of preparing and laying the materials will result in first-class pavements with a material which has at first been deemed unsatisfactory.

ANALYSES.

PURE BITUMENS.

LOCALITY.	Carbon.	Hydrogen.	Oxygen.	Sulphur.	Nitrogen.	Ash.
Bitumen from Trinidad lake asphalt	82.33	10.69	...	6.16	0.81	...
Bitumen from Trinidad land asphalt	83.68	10.84	...	5.10	0.45	...
Bermudez (soft)	82.88	10.79	...	5.87	0.75	...
Bakersville (California) maltha	84.31	12.41	...	1.40	...	...
Bitumen from Seyssel limestone	85.00	12.00	3.00	...	...	...
Auvergne, France	77.64	7.86	8.35	...	1.02	5.13
Cuba	82.34	9.10	6.25	...	1.91	0.40
Peru	88.66	9.69	1.65	...	...	...
Ozocerite, Galicia	85.50	14.50	...	...	...	...
Ozocerite, Utah	85.44	14.45	...	...	...	...
Uintahite, Utah	80.50	10.00	6.20	...	3.30	...
Gilsonite, Utah	88.30	9.90	...	...	1.96	...
Albertite, Nova Scotia	86.04	8.96	1.97	...	2.93	...
Grahamite, West Virginia	79.00	6.5	14.00	..	...	...
Elaterite, England	83.62	11.19	4.78	0.24	0.17	...
Petrolene	87.39	12.61	...	...	...	...

ASPHALTUMS.

LOCALITY.	Total bitumen soluble in carbon bisulphide.	Bitumen soluble in petroleum-naptha (petrolene).	Per cent. total bitumen soluble in petroleum-naptha.	Organic matter not soluble.	Mineral matter.	Water.	Petrolene.	Asphaltene.	Paraffins.	Asphalt.	Specific gravity.
Trinidad lake pitch, highest	55.02	31.85	58.26	9.93	36.38	. . .	. . .	. . .	. . .	. . .	. . .
Trinidad lake pitch, lowest	54.62	30.52	56.66	9.57	35.40	. . .	. . .	. . .	. . .	. . .	. . .
Trinidad lake pitch, average of seven analyses	54.92	31.72	57.79	9.72	35.46	29.00	. . .	. . .	. . .	. . .	1.45
Trinidad land pitch	53.10	31.09	60.14	9.74	37.16	28.5 to 29.	. . .	. . .	. . .	. . .	. . .
Bermudez, highest	98.52	73.05	76.55	6.45	3.65	10. to 45.	. . .	. . .	. . .	. . .	1.075
Bermudez, lowest	90.65	63.40	67.78	0.62	0.50		. . .	. . .	. . .	. . .	1.005
Trinidad "glance pitch"	88.00	. . .	. . .	4.58	7.4	. . .	. . .	. . .	. . .	. . .	. . .
Barbadoes "Manjak"	97.00	. . .	. . .	0.68	2.32	. . .	. . .	. . .	. . .	. . .	. . .
Liquid asphalt from sand, Las Conchas Mine, Santa Barbara County, California	98.26	92.50	94.13	Trace.	1.74	. . .	92.50	3.52	. . .	. . .	1.050
Ventura County, California	99.77	. . .	. . .	0.23	0.08	0.03	70.30	29.47	. . .	. . .	. . .
Ozocerite, Utah	. . .	. . .	. . .	. . .	2.5	1.5	. . .	. . .	86.5	8.5	. . .
"Alcatraz" paving cement	84.65	61.56	72.48	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

ROCK ASPHALTS.

LOCALITY.	Total bitumen soluble in carbon bisulphide.	Calcium carbonate.	Magnesium carbonate.	Insoluble mineral matter.	Clay.	Sand.	Alumina and oxide of iron.	Water.	Sulphur and sulphide of iron.	Cokey and volatile matter.	Infusorial earth.	Petrolene.	Asphaltene.	Insoluble organic matter.
Val de Travers, Switzerland	10.10	87.95	0.30	0.45			0.25	0.50						
Seyssel, France	8.00	89.55	0.10	0.10			0.15	1.90						
Seyssel, France	9.10	90.35				0.10	0.05							
Forens, France	2.25	97.00	0.70	0.05			0.15	0.20						
Lobsan, France	11.90	69.00	0.30	1.25		3.05		3.40	9.45					
Average of French rock asphalts	14.00													
Sicily	9.72	88.75				0.53	0.23							
Vorwohle, Germany	5.37	90.80				2.55	0.59							
Limmer, Germany	8.26	56.50	27.01		4.98		3.21							
Ventura, California	20.00	3.00			74.65			2.37						
Kern County, California	78.90				9.40			7.17		4.53				
Waldorf Mine, Santa Barbara County, California	76.20							1.80			22.10	64.15	35.85	
La Patera, Santa Barbara County, California	59.15					39.75						42.50	7.35	1.10
Kentucky	8.00 to 9.40					90.6 to 92.								

WORLD'S PRODUCTION OF ASPHALT.

1897.

In metric tons (2204.6 pounds).

ASPHALTUM.

	Tons.
Trinidad	133,310
United States	24,854
Russia	18,000
Venezuela	11,528
Hungary	3,057
	190,749

ASPHALT ROCK.

	Tons.
Germany	61,645
Italy	54,647
United States	51,670
France	30,946
Spain	1,656
Austria	300
	200,864

PRODUCTION OF ASPHALT IN THE UNITED STATES.

1898.

In short tons (2000 pounds).

BITUMINOUS SANDSTONE.

	Tons.	Dollars.
California	46,836	137,575
Kentucky	2,700	8,700
	49,536	146,275

BITUMINOUS LIMESTONE.

	Tons.	Dollars.
Utah	150	750
Indian Territory	13,949	69,745
	14,099	70,495

ASPHALTUM.

	Tons.	Dollars.
California	25,690	482,175

UINTAHITE, ETC.

	Tons.	Dollars.
Utah	2,675	80,250

IMPORTS OF TRINIDAD ASPHALT TO THE UNITED STATES.

In long tons (2240 pounds).

	1897. Tons.	1898. Tons.
Lake asphalt	73,738	47,781
Land asphalt	19,243	18,160

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OF THE

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