OZOKERITE IN CENTRAL UTAH.

By Heath M. Robinson.

INTRODUCTION.

The American needs for ozokerite (a substance commonly known as mineral wax) have been largely met in the past by imports from the Galician mines in Austria, but recently interest in the domestic supply of this material has been stimulated. In order to obtain information regarding the supply of ozokerite in Utah, where the principal deposits in this country are situated, the writer spent about a week in September, 1914, in an examination of the best-known localities in the central part of the State. The work was materially aided by the ready assistance of those living in the neighborhood, but more particularly of the officials of the American Ozokerite Co., who kindly furnished maps and other data.

THE OZOKERITE FIELD.

The largest district in the United States in which ozokerite has been mined and prospected is an area in central Utah a little more than 12 miles long and from 1 to 4 miles wide. The index map on Plate I (p. 16) shows the location of this field. It includes parts of T. 10 S., Rs. 7 and 8 E., and T. 11 S., Rs. 8 and 9 E., Salt Lake base and meridian, in Utah and Wasatch counties.

The main line of the Denver & Rio Grande Railroad borders the ozokerite field on the southwest, and as this field is only from 1 to 4 miles wide, all the mines and prospects are within short distances of railroad facilities. Wagon roads have been built from many of the mines and prospects to shipping points on the railroad. As the mines have not been continuously worked many of these roads have been little used and were found to be in poor condition at the time the field was examined.

Colton, the largest town in the ozokerite area, Soldier Summit, and Gilluly are on the main line of the Denver & Rio Grande Railroad. Soldier Summit is on the crest of the Wasatch Plateau. West of the summit the drainage goes into Soldier Fork, whose waters flow into the valley of Utah Lake; east of the divide the waters empty into Price River, the principal stream in the area, which is part of the Colorado River drainage system. Price River heads in the mountains north and east of Soldier Summit and flows in a southeasterly direction past the town of Colton and thence beyond the limits of the field. The altitude of Colton is 7,188 feet, of Soldier Summit 7,440 feet, and portions of the field attain an altitude of 8,000 feet, the maximum relief being therefore more than 800 feet. The ozokerite area is bounded on the northeast by the Roan Cliffs, which extend eastward well into Colorado and have in many localities outside of this field a relief between 2,000 and 3,000 feet. The country north of these cliffs is plateau-like and slopes gently toward the north. The topography southwest of the ozokerite field is largely influenced by the geologic structure, which produces long, gradual dip slopes. Price River in this area flows on soft shale for the most part and consequently has a relatively broad valley.

HISTORY OF DISCOVERY AND DEVELOPMENT.

The first prospecting in this field is said to have been done about 1886 in the vicinity of the old railway station at Media, 3 miles west of Soldier Summit. However, as early as 1879 samples of ozokerite or allied substances which came from Utah were analyzed, and at that time there was much discussion concerning their chemical properties.[1] In 1885 Clayton[2] discussed the Utah ozokerite deposits and also mentioned the associated bituminous shale. Gosling,[3] in a publication dated 1895, treated of the properties of ozokerite and of its occurrences and gave a good bibliography of the subject up to the date of his paper. Eldridge[4] in 1901 mentioned ozokerite as a thin vein crossing the stratification and in small pockets lying with the bedding. The most detailed report that has been published on Utah ozokerite is that of Taff and Smith,[5] which gives a concise description of the field near Soldier Summit and Colton, with descriptions of three samples from different localities and of the development of the field at the time of their examination.

GEOLOGY.

STRATIGRAPHY.

General features.—The rocks of this field have a total thickness of about 4,000 feet and were deposited as nonmarine sediments in early Tertiary (Eocene) time. The lower 1,000 feet of beds exposed, as

[1] Newberry, J. S., Mineral wax: Eng. and Min. Jour., vol. 27, p. 71, 1879. Wurtz, Henry, The Utah mineral wax: Idem, pp. 108, 109. Newberry, S. B., Utah mineral wax: Idem, p. 199.

[2] Clayton, J. E., Ozokerite or mineral wax: Eng. and Min. Jour., vol. 39, pp. 168, 169, 1885.

[3] Gosling, E. B., A treatise on ozokerite: School of Mines Quart., vol. 16, pp. 41–68, 1895.

[4] Eldridge, G. H., The asphalt and bituminous rock deposits of the United States: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 1, p. 361, 1900–1901.

[5] Taff, J. A., and Smith, C. D., Ozokerite deposits in Utah: U. S. Geol. Survey Bull. 285, pp. 369–372, 1905.

outlined on Plate I, are known to contain ozokerite, and the remaining 3,000 feet, exposed to the northeast, contain bituminous or oil shale interbedded with other rocks. On the basis of this distinction two stratigraphic units may be recognized, and on lithologic resemblances to formations in other areas tentative correlations may be made. The lower beds, which do not contain oil shale, are of Wasatch age, and the upper or younger strata, which contain oil shale, are of Green River age.

Three small fossil collections, from points indicated by F1, F2, and F3 on Plate I, have been examined by W. H. Dall, who identified the following species:

Collection No. F1, NW. ¼ sec. 14, T. 11 S., R. 8 E.:
- Physa pleuromatis White.
- Goniobasis nodulifera Meek.
- Planorbis sp. cf. P. parvus Say.
- Unio like U. shoshonensis White.
- Fragments of Anodonta sp.

Collection No. F2, NE. ¼ sec. 21, T. 10 S., R. 7 E.:
- Vivipara cf. V. wyomingensis White.
- Goniobasis nodulifera Meek.
- Unio sp., fragments.

Collection No. F3, SE. ¼ sec. 24, T. 10 S., R. 7 E.:
- Vivipara wyomingensis? White.
- Planorbis sp. near P. tuneus Carpenter.
- Physa pleuromatis? White.
- Goniobasis nodulifera Meek.
- Fragments of Unio sp. and Anodonta sp.

From these data Mr. Dall concludes that the age of the beds is Eocene.

Wasatch formation.—The principal ozokerite mines and prospects have been opened in the Wasatch formation and are scattered irregularly through a stratigraphic distance of 600 to 700 feet. The base of the formation is not exposed in the ozokerite field, but the part that crops out is about 1,000 feet thick. The rocks consist of shale, sandstone, and limestone. The shale is tinted purple, green, and red in different beds, and all gradations exist between sandy shale and sandstone. The sandstone is brown and shows lenticular bedding. The limestone beds are thin and are sparsely distributed through the section.

The major portion of the formation is made up of sandy shale and sandstone, which occur in alternate beds 1 to 10 feet in thickness. Inasmuch as the extent and character of the fissures in sedimentary rocks depend more or less on the kind of rock, the alternation of sandstone with shale beds has caused an irregular distribution of ozokerite, which fills many of the fissures.

Green River formation.—The lowest beds of the Green River formation border the northeast side of the ozokerite field, and the formation is extensively developed in the area north of that outlined on Plate I. This formation consists of shale and sandstone interbedded with a small amount of limestone and has a thickness of about 3,000 feet. Much of the shale is bituminous and yields oil on destructive distillation. The formation as a unit is gray on weathered outcrops, and it is more evenly bedded and persistent than the underlying Wasatch formation.

STRUCTURE.

The rocks in the ozokerite field dip 1°–25° N., forming a portion of the south limb of the great Uinta Basin syncline. The symbols on the map (Pl. I) show the strike and dip of the beds at a number of places in the field. The rocks are broken by a system of joints and small faults, and zones of brecciated or crushed rock are common. Most of the joint planes are vertical or nearly so, and the most common direction for the principal system of fissures is N. 10° W. There is a minor system of fissures at angles of 60°–90° with the major system. Although small faults are common, no fault with a vertical displacement in excess of 10 feet was found in the examination of the surface and underground exposures. The fault planes dip at an angle of 45°, and slickensided surfaces are common. The fracture planes and zones are important, inasmuch as the ozokerite fills the cavities which have resulted from the fracturing.

OZOKERITE.

COMPOSITION AND PROPERTIES.

Ozokerite is the principal mineral resource of this immediate locality. It is a mixture of hydrocarbons [1] in various proportions, the exact nature of which is a subject of dispute. Some authors consider that it is composed of members of the paraffin series; others place its chief constituents in the olefin series. In commenting on certain experiments, Redwood [2] says: "The natural inference is that in addition to crystalline paraffin ozokerite contains certain colloidal substances (amorphous paraffin), the presence of which hinders the crystallization of the paraffin." In color ozokerite varies from black or dark brown to light yellow, but some specimens have a greenish color. It may be as soft as tallow or as hard as gypsum. The light-colored varieties yield the largest amounts of ceresin, the refined product. The melting point of ozokerite ranges, in general, from 58° to about 80° C., but a very few specimens have been reported to have a melting point of 100° C. Although paraffin with a melting point as high

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[1] Redwood, Boverton, and Holloway, G. T., Petroleum, vol. 1, pp. 217 and 218, 1896.

[2] Redwood, Boverton, The Galician petroleum and ozokerite industries: Soc. Chem. Industry Jour., vol. 11, p. 114, 1892.

as that of ozokerite may be extracted from petroleum, it is not a commercial product, and the paraffin that is put on the market has a melting point considerably lower. The specific gravity ranges from about 0.85 to 0.97.[1] Ozokerite is soluble in ether, petroleum, benzine, turpentine, and carbon bisulphide.

TESTS.

The writer is indebted to Dr. David T. Day and others, of the Bureau of Mines, for the following data on tests of six samples of Utah ozokerite from localities Nos. 1, 3, 6, 10, 15, and 16. (See Pl. I, p. 16.)

Specific gravity and melting point of Utah ozokerite.

Sample No.	Specific gravity.	Melting point (°C.).	Sample No.	Specific gravity.	Melting point (°C.).
1	1.300+	60	10	0.899	62
3	.905	63	15	.915	60
6	.905	66	16	.920	79

The melting point of each sample was determined by placing a minute fragment of ozokerite in a capillary tube strapped to a thermometer and heating the apparatus in a water bath until the fragment melted, then noting the temperature. This is a tedious method but the only one that gives accurate results.

Solubility of Utah ozokerite.

Sample No.	In ether (per cent).	In benzol.	In oil of turpentine.	In petroleum.	In ethyl alcohol.
1	17.1	Complete [a]	Complete	Complete	([b])
3	46.7	Complete [c]	do	do	([b])
6			do	do	([b])
10	38.8	Complete	do	do	([b])
15	27.9	Complete [a]	do	do	([b])
16	2.1	do	do	do	([b])

[a] A little residue of limestone after benzol extraction.
[b] Ceresin soluble in hot alcohol; asphalt insoluble.
[c] A little residue of organic matter after benzol extraction.

The solubility tests given in the above table were made by shaking fine shavings of each sample with each solvent, then heating the mixture. Generally, much time was necessary for the solution of any considerable quantity of ceresin by any of the solvents when cold, but heating greatly increased the capacity of the solvent. As will be seen by the table, ozokerite is completely soluble in three of the five solvents used.

Ceresin is easily soluble in boiling ether, and the associated asphaltic material is only slightly soluble, a fact which renders possible

[1] Gosling, E. B., A treatise on ozokerite: School of Mines Quart., vol. 16, p. 41, 1895.

the partial separation of ceresin from asphalt. A weighed portion of each sample of ozokerite was placed in a Soxhlets extraction apparatus, and ceresin was extracted with boiling ether so long as the ether ran through without any appreciable discoloration. The solution was then evaporated and the residue weighed as ceresin. The ceresin was considerably discolored, it being impossible with ether to prevent the solution of slight amounts of asphalt.

The solubility tests suggested a possible method for the separation of ceresin from asphalt by a boiling solution of alcohol, based on the fact that ceresin is soluble and asphalt is insoluble in alcohol. A 20-gram sample of ozokerite (sample No. 6) was boiled with 300 cubic centimeters of strong ethyl alcohol (between 98 and 100 per cent pure), which dissolved a large percentage of the ceresin in the sample. After the solution was poured from the undissolved asphaltic residue and the liquid allowed to cool, most of the ceresin which it contained crystallized out white and clean, with no trace of asphalt. The alcohol solution was then cooled down to −15° C., when a further amount of ceresin crystallized out, leaving a small amount of the oil originally present in the asphalt. By reboiling the asphaltic residue with the same alcohol and repeating this process several times it was possible to dissolve all the ceresin, making a complete separation of ceresin from asphalt. The treatment yielded 3.6 grams of oil, 8.5 grams of asphalt, and 7.9 grams (39.5 per cent) of ceresin. It is believed that by the use of a cheap though strong denatured alcohol this method of separation can be made commercially practicable. There need be very little distillation of the alcohol, it being necessary simply to boil the rock containing the ozokerite with alcohol, which may then be drawn off and allowed to cool, the ceresin will crystallize out, leaving the same alcohol suitable for repeated extractions. Finally a leaching form of this process would give ceresin in a pure and satisfactory condition.

It was thought that the last ceresin to go into solution would have a higher melting point than the portion going into solution earlier. In order to determine this matter 15 successive extractions were made from the ozokerite, and the melting points were determined for most of these extracts, as shown below:

Melting point of ceresin extracted from Utah ozokerite.

	°C.		°C.
Extracts 1, 2, and 3	50–56	Extract 10	66
Extracts 4 and 5	66	Extracts 11 and 12	68
Extracts 6, 7, and 8	65	Extract 14	70
Extract 9	68		

These figures show in a general way what was expected, namely, that the melting point of ceresin increases as the relative solubility becomes less. The increase is not constant, but the melting point ranges from 50° C. in the most soluble to 70° C. in the least soluble portion of the ceresin. The first extracts, melting at 50° to 56°, were probably contaminated by oil, but there was not sufficient difference in the extracts of any other group to justify assuming the presence of other hydrocarbons. These results indicate that it is possible, by treatment with alcohol, to separate distinctly different grades of ceresin from a single lot of ozokerite.

The separation of asphalt from ceresin by sulphuric acid is a very tedious operation, on account of the persistent emulsions formed by the sulphuric acid and the ozokerite. A sample of crude ozokerite (sample No. 10) in the form of shavings was boiled with especially refined gasoline, varying in boiling point from 65° to 95° C. Gasoline was used in large excess, 300 cubic centimeters to 5 grams of ozokerite. The solution of gasoline containing ozokerite after cooling was treated with strong sulphuric acid (specific gravity 1.84), and after repeated agitations with the acid the gasoline solution was treated with a water wash. After washing several days at a time to break up the emulsion and remove the excess of acid, a final treatment with sulphuric acid reduced the ceresin content of the gasoline solution to 21 per cent, or in other words 21 per cent of the gasoline solution of ozokerite was ceresin.

A second and similar test with sulphuric acid was made of the residuum remaining after the distillation of the crude ozokerite (sample No. 10). The test was carried out in precisely the same manner as the one described above, and the ceresin content of the gasoline solution was reduced to 19 per cent.

It is the practice in Galicia and elsewhere to treat either molten ozokerite or ozokerite in a hot solution of gasoline or benzol with strong sulphuric acid or with fuming sulphuric acid for the purpose of extracting asphaltum, which is attacked by the acid. The ceresin is left in solution and is afterward separated by evaporation of the solvent. It appears from the experiments reported above that the separation of asphalt from ceresin by alcohol gives more satisfactory results.

Fractional distillation of Utah ozokerite.

Sample No.[a]	Began to boil (° C.).	Ceresin distilled over (cubic centimeters).				Residuum (grams).
		75°-150° C.	150°-300° C.	300°-350° C.	Total.	
3	80	2	10	33	45	14.9
10	75	1	9	30	40	9.5
15	83	.5	7	22	29.5	24.7

[a] Each sample weighed 50 grams.

The same methods were used in the distillation of ozokerite as those in vogue for the distillation of crude petroleum. The results of these tests indicate that the greater part of the ceresin distills over without any appreciable decomposition at moderate temperatures, but decomposition of the portion distilled at temperatures above 350° is evident. The ceresin crystallizes out, taking the form common to the paraffin of commerce, but has a higher melting point.

FORM AND CONTENT OF DEPOSITS.

The ozokerite of central Utah is found in fissures and brecciated zones caused by the fracturing of the rocks. This fracturing has produced joints and small faults, most of which are nearly vertical. The principal fissures trend about N. 10° W. and contain the largest deposits of ozokerite in the field. Brecciated zones are also common, and in these the ozokerite incloses angular fragments of country rock. The included rock fragments show little or no impregnation by the ozokerite and apparently have suffered very little movement. The ozokerite and the walls of the fissures commonly show slickensided surfaces. In the writer's examination of the deposits he observed veins of ozokerite from mere films to 6 or 8 inches in thickness, and according to Taff and Smith[1] veins nearly 3 feet thick have been found in the mines. The deposits are irregular in size, as stated by Taff and Smith:[2] "The extent, either in thickness or length, of the occurrence of ozokerite * * * can not be relied on far beyond the limit of prospected ground. Both the width of the fissure or fractured zone and the occurrence of ozokerite are found to be variable."

The fissures were undoubtedly produced by movement in the rocks prior to the deposition of the ozokerite, but the slickensided condition of some of the ozokerite indicates that movement has taken place since the fissures were filled.

The lenticular nature of the bedding and the alternation of beds of sandstone and shale have influenced the amount of open space resulting from the fracture of the rocks and have caused an irregular distribution of the ozokerite. The fissuring of the sandstone has produced more available open spaces than the fissuring of the clay and shale, and consequently the largest deposits of ozokerite are found in fissures in sandstone.

In addition to filling fissures, ozokerite occurs in the vicinity of zones of fracture as thin films along joint planes. These films imply that at the time of impregnation the ozokerite was fluid enough to penetrate very minute cracks, but the lack of impregnation of the country rock implies a viscosity too great to permit the penetration into rocks even as porous as sandstone.

The material removed from the mines and prospects is reported to contain from 1 to 7 per cent of ozokerite, but the quantity in a single prospect varies greatly within short distances.

[1] Taff, J. A., and Smith, C. D., Ozokerite deposits in Utah: U. S. Geol. Survey Bull. 285, p. 371, 1905.
[2] Idem, p. 369.

ORIGIN.

In this report, which is primarily economic, an exhaustive discussion of the probable origin of the ozokerite is hardly appropriate, but some of the considerations in regard to origin have an economic application.

There appears to be a close relationship between ozokerite and certain kinds of petroleum. In a paper by Gosling [1] an analysis of ozokerite is compared with one of American petroleum, and the comparison shows that the two substances contain the same compounds or fractions, though in different proportions. As would naturally be expected, the paraffin content of the ozokerite is higher than that of the petroleum. In the Galician mines all gradations between oil high in paraffin and ozokerite containing some petroleum have been observed.[2] Some of the veins of ozokerite in the Utah field have a width about equal to that of thick paper, a condition which implies a somewhat fluid state of the material at the time of impregnation and suggests that the substance which first filled the fissures was a petroleum rich in paraffin. Thus from laboratory and field observations all mixtures of petroleum and ozokerite are known to exist, and it may be concluded that the ozokerite of the Utah field is derived from a petroleum high in paraffin.

The passage from petroleum to ozokerite is thought by some geologists to have been accomplished by the oxidation and decomposition of the hydrocarbons of petroleum. However, the probability of the lack of oxidizing agents at considerable depths below the groundwater level would argue against this as a general process. On the other hand, it is now generally accepted that solid hydrocarbons, which of course embrace paraffin, exist in many crude oils at low temperatures. Kast and Seidner [3] have found that the mud which separates out on the bottom of storage tanks containing crude petroleum is made up largely of paraffin, and they suggest that "this amorphous paraffin closely resembles and is evidently identical with ozokerite." Petroleum may be regarded as a solvent holding paraffin in solution, and on evaporation of the solvent the ozokerite is left as a residue. Slight changes in temperature, such as are found with increasing depth below the surface, would be a factor in solution and deposition, but this factor probably is not so important as evaporation of the lighter and more volatile oils of the petroleum.

The petroleum from which the ozokerite has been derived may have had two sources. It may have been derived from the overlying oil shale or it may have been forced up from lower beds. The

[1] Gosling, E. B., A treatise on ozokerite: School of Mines Quart., vol. 16, p. 41, 1895.

[2] Redwood, Boverton, The Galician petroleum and ozokerite industries: Soc. Chem. Industry Jour., vol. 11, p. 103, 1892.

[3] Kast, H., and Seidner, S., The formation of solid paraffin: Soc. Chem. Industry Jour., vol. 11, p. 598, 1892.

bituminous material in the oil shale is largely made up of vegetal remains, and it is thought by Peckham[1] that oil containing a large percentage of paraffin is indicative of a vegetable origin. On the other hand, Eldridge[2] believes that the veins of solid hydrocarbons in the Uinta Basin, to the northeast, were formed by the forcing into the crevices and later rapid solidification of semifluid hydrocarbons. It would be interesting to know if the ozokerite contains more volatile oils in the lower levels of the mines than in the higher, or if the reverse is true, as such facts may have a bearing on the source of the petroleum from which the ozokerite has been derived. Analyses of the ozokerite compared with analyses of oil from the oil shale might possibly show some significant resemblances.

Results of distillation tests on samples of oil shale collected by the writer in this region will be found in a paper in this volume entitled "Oil shale in northwestern Colorado and adjacent areas," by Dean E. Winchester.

COMPARISON WITH THE BORYSLAW FIELD IN GALICIA.

The ozokerite field of central Utah resembles in a number of places the Boryslaw field of Galicia, Austria, which is the most productive field of ozokerite. The Galician field, as described by Redwood,[3] is less than 1 square mile in area. The ozokerite is found in fissures, usually measuring from 2 to 12 inches in width, which cut shale and sandstone of Miocene age that overlie beds of petroliferous shale. All gradations between solid ozokerite and petroleum rich in paraffin are found in the mines. A sample described by Redwood has a melting point of 60.5° C. and a specific gravity of 0.9236. The mine shafts in this field are very closely spaced and range in depth from 20 to 200 meters (66 to 656 feet). Much of the semifluid material is under high pressure, and it is reported that certain of the mine openings have at times been filled by the squeezing of semifluid ozokerite. The Boryslaw deposits become narrower with increasing depth, and Redwood is inclined to believe that the ozokerite has been forced up from below.

IMPORTS.

The figures given below, showing imports of ozokerite, are taken from the reports on the mineral resources of the United States, published by the Geological Survey. It is believed that the greater part of these imports came from the Galician mines, but the total production of the Galician field is probably considerably more than the amount given as imports to the United States.

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[1] Redwood, Boverton, and Holloway, G. T., Petroleum, vol. 1, p. 233, 1896.

[2] Eldridge, G. H., The uintaite deposits of Utah: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, p. 938, 1896.

[3] Redwood, Boverton, The Galician petroleum and ozokerite industries: Soc. Chem. Industry Jour., vol. 11, pp. 112–118, 1892.

Mineral wax (chiefly ozokerite) imported into the United States.

	Pounds.		Pounds.
1888	1,164,940	1912	6,352,003
1908	3,595,393	1913	7,141,514
1911	4,472,708	1914	8,191,529

The price at the point of exportation was 8.7 cents a pound in 1911, 7.7 cents a pound in 1912 and 1913, and 6.1 cents a pound in 1914.

PRODUCTION.

The first prospecting of this region was done in 1886. Since that time mining and prospecting have been carried on at irregular periods, for litigation has prevented continuous development. Exact figures for the production of the field are not available, and at the time of the writer's examination all the mines were inactive. According to statistics published by the United States Geological Survey in the yearly reports on mineral resources, the Utah field produced over 640,000 pounds of ozokerite previous to 1900, and it is reported by officials of the American Ozokerite Co. that the field has yielded about 120,000 pounds since that date. The total output of the Utah field is only a small fraction of the quantity imported into the United States in a single year, but the production of the past is not a measure of the production that is possible under favorable market and mining conditions.

CONCENTRATION.

The following concise description of the methods of concentration used in the Utah field is given by Taff and Smith:[1]

> The manner of separating ozokerite from the associated rocks is a simple process. The plant * * * consists of a steam boiler and engine, a crusher, and steam-heated vats. The soft rock and ozokerite mixture is crushed and run into long vats with narrow bottoms containing water kept at a boiling temperature. The ozokerite melts at a temperature of 54° to 70° C. (129° to 158° F.) and floats off as a liquid into cooling vats, while the rock is driven out along the narrow bottom of the vats by revolving screws. On cooling the ozokerite is remelted into dry pans to remove the moisture.

USES OF OZOKERITE.

Ozokerite is a nonconductor of electricity and is extensively used for insulating. Candles made from ozokerite have qualities superior to those found in other candles. Much of the ozokerite mined is converted into ceresin, a highly purified product which is used to replace or adulterate beeswax and has a variety of other uses. Ozokerite is also used as a foundation for various waxes and polishes; as a covering to protect metal surfaces from the action of moisture, acids, or alkalies; and for wax figures and dolls.

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[1] Taff, J. A., and Smith, C. D., op. cit., p. 371.

MINES AND PROSPECTS.

In the following description of the mines and prospects, reference will be made to the map (Pl. I), on which the places where ozokerite deposits have been exploited are indicated and numbered. In the report by Taff and Smith[1] many of these localities are described in detail, and in the following description the data collected by them have been used to supplement the data collected by the writer. At the time of the field examination none of the mines or prospects described below were being worked commercially.

The westernmost development in the ozokerite field (No. 1, Pl. I) is in the E. ½ sec. 20, T. 10 S., R. 7 E., and is locally known as the Culmer Bros. mine. A slope about 160 feet long has been opened, trending N. 10° W. at an inclination of 23° to 40° from the horizontal. About 100 feet below the mouth of the slope a main entry has been driven about 215 feet N. 11° 13′ W. A few short side entries have been turned off from the slope as well as from the main entry. Two houses stand near the mine, and some hoisting machinery has been installed at the mouth of the slope. The most prominent fissures containing ozokerite trend N. 10°–30° W. At the time of the examination the mouth of the slope was filled with loose material that had caved from the roof, rendering entrance impracticable. According to Taff and Smith,[2] the fracture zone is 2 feet 6 inches wide. It is reported that some large pieces of ozokerite have been taken from the slope and also that some yellow wax has been found here, but in the examination of the mine only thin films of soft ozokerite associated with gypsum were observed in the entry. A sample from this mine was tested as reported on pages 5–8.

Development No. 2, in the NE. ¼ sec. 21, T. 10 S., R. 7 E., consists of a shaft and a few open-cut prospects and is locally known as the U. S. property. This mine is equipped with electric hoisting machinery and a plant for the separation of the ozokerite from the associated rock fragments. At the time of the field examination the shaft was filled with water, so that entrance was impracticable. Mr. Vorhees, of Soldier Summit, reports that the shaft is 100 feet deep and that entries as long as 40 feet have been driven from the bottom of the shaft. Taff and Smith[2] state that the fractured rocks are 45 feet wide and the fissures have a trend of N. 60° W. In a prospect near the mouth of the shaft the ozokerite, which is well exposed, is irregularly distributed as a filling of the fissures, with a maximum width of 1 inch of solid wax. Along these fissures movement has taken place. The faults, which are normal, dip 45° and strike N. 45° W. The displacement is at least 18 inches, and the fracture zone is between 4 and 5 feet wide. The ozokerite from this prospect has a

[1] Taff, J. A., and Smith, C. D., op. cit., pp. 369–372.

[2] Idem, p. 371.

more or less fibrous structure, is dark brown to black, and has a hardness about equal to that of talc.

Development No. 3, in the NW. ¼ sec. 22, T. 10 S., R. 7 W., consists of a drift about 500 feet long, bearing about N. 10° W. No ozokerite was observed on the mine dump, and only a few films were found filling joints that trend N. 10 W. It is reported that very little ozokerite has been found here. A sample from this place was tested at the Bureau of Mines. (See pp. 5–8.)

Development No. 4, in the E. ½ sec. 24, T. 10 S., R. 7 E., consists of a drift about 30 feet long, opened along the principal joints, which here trend N. 8° W. This prospect is about 700 feet higher than the railroad station at Soldier Summit, as determined by barometric readings. A vein of ozokerite half an inch thick was observed in the face of the drift, but so far as could be observed this was the only vein in the prospect.

Development No. 5, in the SW. ¼ sec. 19, T. 10 S., R. 8 E., consists of a drift about 30 feet long, trending S. 85° E. The exposed system of joints trends N. 43° W. The drift is partly timbered and is equipped with a small car and track. No ozokerite was observed either in the mine or on the dump.

Development No. 6, locally known as the Soldier Summit mine, in the NW. ¼ sec. 30, T. 10 S., R. 8 E., less than half a mile northeast of Soldier Summit, is reported to be one of the largest mines in the field. Tests of a sample from this mine are reported on pages 5–8. The shaft was in so poor a condition at the time of examination that entrance was not feasible. The following description is taken from the report by Taff and Smith:[1]

> A mine has been equipped with hoisting power and in connection with it a concentration plant erected nearly one-third of a mile east of Soldier Summit. The mine was closed at the time visited, on account of reported litigation. Mr. Kroupa, who directed the development here, reports that the shaft is 225 feet in depth and was driven on a band of vertical fissures that contain the mineral wax, and that drifts had been opened 50 feet to the north and south on the strike of the fractures. A north-south shear zone has been prospected one-fourth mile south of the mine. In all cases here the ozokerite is reported to occur in veinlets filling narrow fissures in the strike of the crushed strata and surrounding the brecciated shale and shaly sandstone. Locally the veins swell to a thickness of nearly 3 feet, according to Mr. Kroupa's verbal report.

The mouth of the shaft has an altitude of about 400 feet above the railroad station at Soldier Summit.

Development No. 7, in the SW. ¼ sec. 10, T. 11 S., R. 8 E., consists of a shaft which at the time of visit was filled with water within about 20 feet of the surface. The ozokerite occurs in a brecciated zone that trends about N. 8° W. Evidences of ozokerite were found in the mine dump and in outcrops near the mouth of the shaft.

[1] Op. cit., p. 371.

Development No. 8, in the SE. ¼ sec. 10, T. 11 S., R. 8 E., consists of a small drift opened along the joints that have a trend of N. 9° W. Thin films of ozokerite associated with gypsum were seen. According to Mr. James Miller, of Colton, a number of small prospects similar to No. 8 have been opened northwest of this drift.

Development No. 9, in the SE. ¼ sec. 15, T. 11 S., R. 8 E., consists of a small drift and shaft opened along a normal fault in sandstone and clay. The rocks show a vertical displacement of about 8 feet and are brecciated along the fault zone. The ozokerite is confined for the most part to fissures in the brecciated portions of the sandstone and occurs in pockets or irregular masses. The clay carries little ozokerite, for even where it is faulted very little open space remains. A wagon road, which was in poor condition at the time of the examination, has been constructed from the Pleasant Valley mines to this prospect. According to barometric readings the mouth of the drift is about 650 feet higher than the town of Colton.

Development No. 10, in the SW. ¼ sec. 14, T. 11 S., R. 8 E., consists of a drift about 100 feet long driven along the principal joints, which here trend N. 10° W. This drift is about 475 feet above the town of Colton. The associated rocks are sandstone and shale, and masses of ozokerite were observed which measured as much as 6 inches across. The fracture zone in this drift is from 4 to 5 feet wide. The impregnated material exposed in the face of the drift is from 4 to 5 feet wide. The impregnated material exposed in the face of the drift was estimated by Mr. L. V. Shearer, of the American Ozokerite Co., to contain about 7 per cent of ozokerite. Tests of a sample of ozokerite from this mine were made as reported on pages 5–8. Angular fragments of country rock completely surrounded by ozokerite are abundant, and the smaller cross fractures are also filled with ozokerite in many places. The ozokerite from this drift is soft enough to be molded in the fingers. It has a more or less fibrous fracture and on freshly broken surfaces smells like kerosene.

Development No. 11, in the SW. ¼ sec. 14, T. 11 S., R. 8 E., consists of a drift about 200 feet long and some small crosscuts. The drift is opened along the principal system of joints and trends N. 10° W. The general level of this drift is about 400 feet above the town of Colton. Ozokerite is found in films and thin veins along the principal joints and also in the smaller joints that cut the major system. It is probably a part of the same impregnated body that is found in development No. 10. Nos. 9, 10, and 11 are locally known as the Brown Bear group or James Peak group.

Development No. 12, in the SE. ¼ sec. 22, T. 11 S., R. 8 E., in the town of Colton, is locally known as the Town mine. At the time of the examination the mine was partly filled with water. The following description of this development is given by Taff and Smith: [1]

> A shaft is sunk on a vertical shear zone 5 to 6 feet in width to a depth of 110 feet and is equipped with a 10-horsepower hoisting engine. Drifts have been run on the strike of the fractures at a depth of 45 feet and at the base. The mine is now closed, it is claimed, on account of litigation. At the time of inspection it was filled with water below the 45-foot drift. At this level the brecciated zone consists of broken green and purple shale with sandstone fragments. Ozokerite occurs in scales or thin veins or as pockets and veins of variable extent and width, not exceeding a few inches at most.

Development No. 13 is in the NE. ¼ sec. 23, T. 11 S., R. 8 E., on what is locally known as the Midnight claim. A drift has been opened here, principally in sandstone, along the brecciated fault zone, which is between 2 and 3 feet wide, and has a north-south trend. Ozokerite was observed at the surface in solid masses as thick as 1¼ inches and filling smaller fissures and spaces between the faulted and brecciated rocks.

Development No. 14, locally known as the Miller property, is in the SE. ¼ sec. 14, T. 11 S., R. 8 E., and consists of two drifts, one 75 feet long and the other 17 feet long. The shorter drift is about 12 feet above the long one. It is reported that about 5 tons of material has been mined from these drifts and that some of it contained as much as 7 per cent of ozokerite.

Development No. 15, locally known as the Pleasant Valley or P. V. mine, is probably the largest and best-equipped mine in the ozokerite field. Two main drifts have been opened, one in the NW. ¼ sec. 24 and the other in the SW. ¼ sec. 13, T. 11 S., R. 8 E., and are connected by a shaft. The lower drift is about 300 feet above the town of Colton, and the other is about 85 feet higher. Both drifts have been driven on a fracture zone which has a general bearing of N. 10° W., but the trend of the drifts ranges between N. 0° 58′ W. and N. 15° W. The lower drift is about 650 feet long, and the upper about 350 feet, and some lateral entries have been turned off which are over 100 feet long. The two levels are connected in several places, and it is reported that the lateral entries show that the fracture zone containing ozokerite is locally 38 feet wide. Single continuous veins of ozokerite have been traced in these mines for 140 feet, and yellow wax has been found in the upper drift. The main part of the lower drift is opened along a normal fault, which is nearly vertical and has a displacement of over 6 feet. The associated rocks are sandstone, shale, and clay, and these commonly show slickensided surfaces. A plant for the separation of the ozokerite from the associated rock fragments, several houses, and a shop have been erected. It is reported by Mr. L. V. Shearer that shipments of wax were made from this mine to New York City in 1901, 1907, and 1912, which aggregated between 35 and 50 tons. Tests of a sample from the mine were made at the Bureau of Mines, as reported on pages 5–8.

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[1] Op. cit., pp. 370–371.

Development No. 16, locally known as the Higgins shaft, is in the NW. ¼ sec. 24, T. 11 S., R. 8 E. The shaft is reported to be about 180 feet deep but at the time of examination was in so poor a condition that entrance was not practicable. It is probable that this shaft is on the same general zone of fractures as the P. V. mine. A sample from the mine was tested, as reported on pages 5–8. About 600 feet south-southeast of the shaft is an old prospect, which shows traces of ozokerite on the dump.

Development No. 17, locally known as the Kyune Canyon property, is in the SE. ¼ sec. 18, T. 11 S., R. 9 E. It consists of a drift over 100 feet long. The general direction of the fractures which carry the ozokerite is N. 5° E., and exposures in the drift show ozokerite in small fissures as much as half an inch thick, scattered through a zone several feet thick.

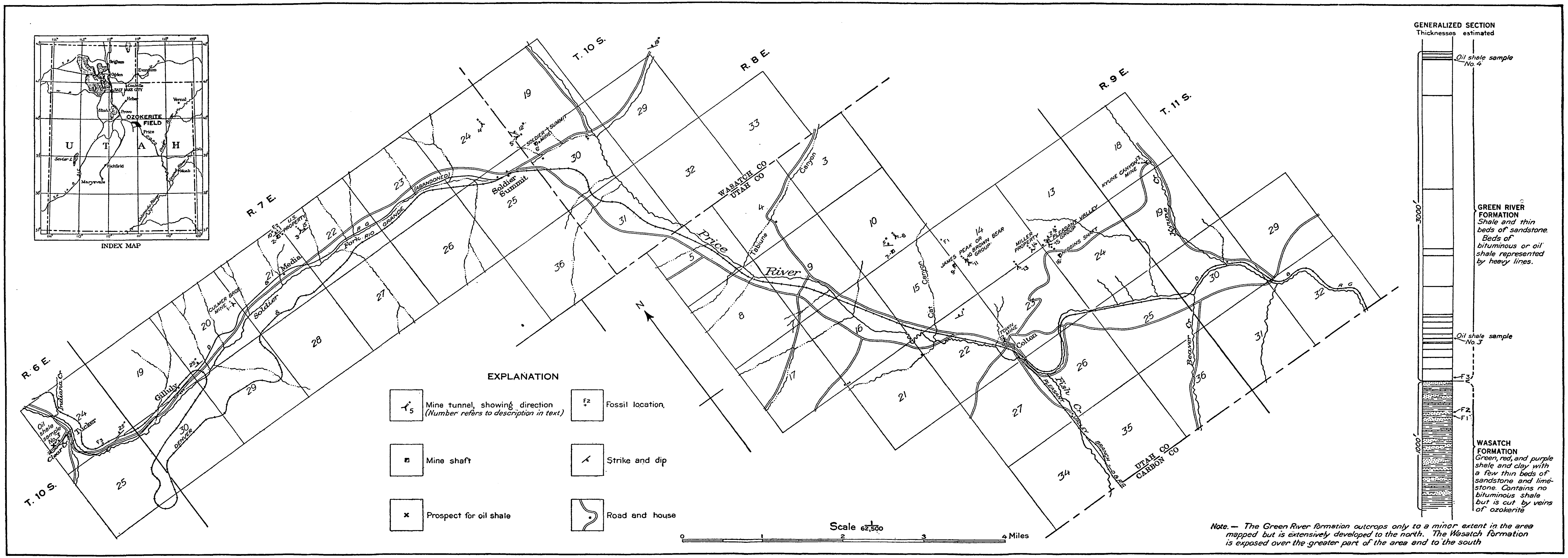
In the descriptions given above only those developments have been considered which show some indication of ozokerite or which have apparently been opened with the intention of commercial development. A number of small prospects were visited, and other occurrences were reported in various parts of the ozokerite field.

FUTURE OF THE FIELD.

The quantity of ozokerite available for future mining in the Utah field can hardly be estimated. The length and thickness of the fissured and fractured zones containing ozokerite are variable, even within short distances, and for areas beyond the limits of prospected ground no quantitative estimate can be made with safety. Many of the prospects and mines, however, showed ozokerite in place, and the fact that it is irregularly distributed should encourage more thorough prospecting.

The melting point of crude Utah ozokerite ranges between 60° and 79° C., which compares favorably with that of the Austrian product. Inasmuch as the melting point is a factor in determining the price, the quality of the Utah product, so far as this point is concerned should encourage future development.

Previous to the outbreak of the war in Europe the Austrian ozokerite sold in New York at so low a price that American producers found difficulty in competing with it. For the year 1914 the imported ozokerite was valued at 6.1 cents a pound at the point of exportation, and in the summer of that year the New York price for crude ozokerite was 27 to 30 cents a pound. About the middle of June, 1915, the price of ozokerite in New York, as shown by the various trade journals, was between 30 and 40 cents a pound. As the imports from the Galician mines have been seriously affected by the war and as the development of these mines in the near future will probably be greatly handicapped, there is an excellent opportunity to market the Utah product.



MAP OF OZOKERITE FIELD IN CENTRAL UTAH.