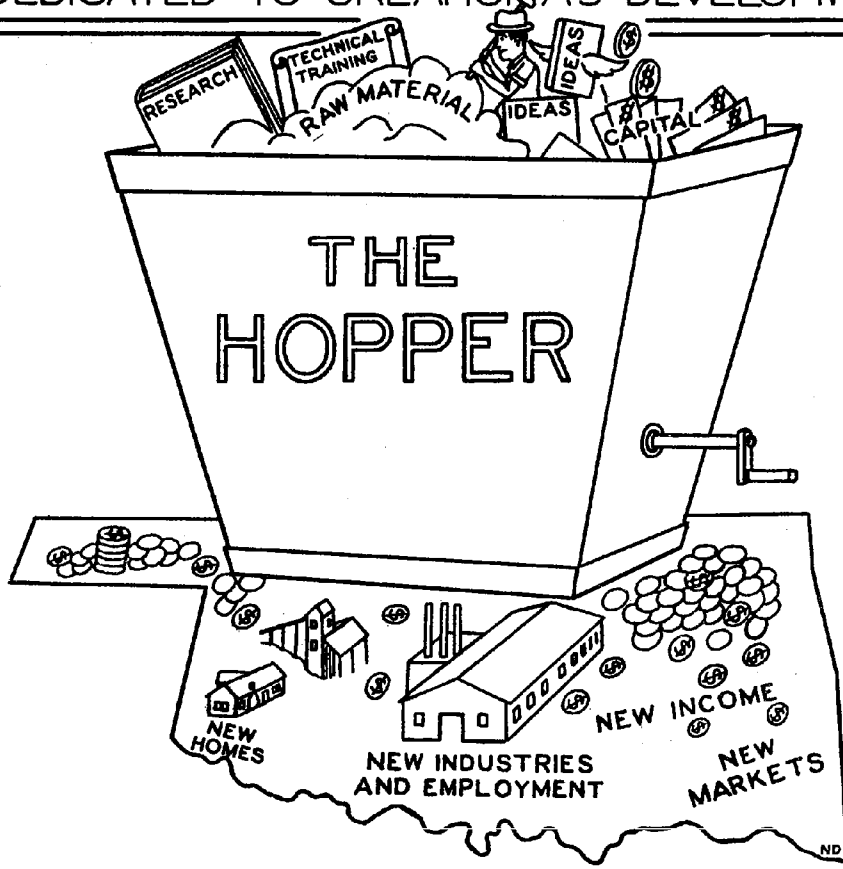
DEDICATED TO OKLAHOMA'S DEVELOPMENT



PUBLISHED IN THE OFFICE OF THE
OKLAHOMA GEOLOGICAL SURVEY
NORMAN, OKLA.

Vol. 13, No. 1 January, 1953

second line of hills is very erratic and beds are not continuous but locally may reach a thickness of 60 ft. There are five ledges in the Southwestern area some of which reach a thickness of 20 ft. It is meaningless to attempt to calculate reserves. According to Snider, "The gypsums of Harper County are well exposed for quarrying and the amount which can be obtained is very great, estimated by Gould at 10,000,000,000 tons". Taking the other counties and the underground material, the figure surely will be tremendous. In addition to gypsum, there are large amounts of gypsite, a weathered mixture of gypsum and clay.

The principal uses of gypsum in Oklahoma are in the manufacture of a great number of specialty products, plaster of paris and gypsum wallboard, and as a retarder in the manufacture of portland cement. Anhydrite finds use in preparation of special cements and as an inert filler. In Great Britain and on the European continent gypsum and anhydrite serve other interesting uses. Consideration of these uses gave us ideas. Two of the ideas are currently in the property of the University of Oklahoma Research Institute and are the subject of patent applications. Briefly, we found:

(1) If an intimate mixture of gypsum and ammonium carbonate is maintained at 80°to 90°C., for about five hours under slight back pressure, the product will be a mixture of ammonium sulfate and calcium carbonate, a desirable compound for fertilizer use.

(2) If a suitable mixture of natural gas and steam be passed over gypsum or anhydrite at temperatures in the range of 900° to 1000°C.,the gaseous product will contain hydrogen sulfide and possibly some elemental sulfur while the residue will be mainly calcium oxide (lime).

Both ideas have the objective of utilization of the sulfur-content of Oklahoma mineral materials.

OKLAHOMA FUELS AND MINERALS FOR CHEMICAL INDUSTRY

by
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The following discussion was taken from a talk given before the Trisection Meeting of the American Chemical Society held at Tulsa. It is not intended as a full discussion of all the mineral resources and possibilities that exist in Oklahoma, but does emphasize the dependence of industry on fuel and power of which Oklahoma has an abundance. Most of the resources discussed are of interest in the chemical industry. The recent discoveries and ideas pertaining to minerals emphasize the importance of a persistent program of field and laboratory investigations and research as one of the important factors in promoting industrial expansion.

In any consideration of natural resources for industry, mineral fuels are entitled to first place. Machinery and power are key words in talking of the possibilities for further expansion of manufacturing industry. Modern manufacturing industry is characterized by machines and the machines are powerdriven. Oklahoma has bituminous coal, petroleum, natural gas liquids, and natural gas in relative abundance and we process a goodly portion of the petroleum and natural gas liquids into motor fuel, diesel fuel, and fuel oil. We are corralling and harnessing the latent power of our streams. Only in isolated cases, however, has the geographic pattern or the magnitude of industrial life in the United States been determined by falling waters. Rather, the pattern has been delineated by our availability of industrial fuels. Oklahoma is indeed fortunate in having an abundant supply of all of the major sources of industrial energy.

On the accompanying table are shown the estimated reserves of energy resources in Oklahoma as of January 1, 1952, and figures on production and

consumption of the five items within the State based upon information for the year 1949. The figure on petroleum consumption is the refining capacity of the State which, of course, is greater than the actual amount processed. You will observe that Oklahoma processed less than 55 percent of the petroleum, consumed less than 42 percent of the natural gas, and less than 30 percent of the coal produced in the State during that year. The petroleum and natural gas reserves are "proven" reserves and not the "probable" reserves which would be a much larger figure, I am sure. At the present rate of production the coal reserves are sufficient for 9,000 years, which is "quite a spell".

FUEL RESERVES AND PRODUCTS IN OKLAHOMA

	Reserves January 1, 1952	Production 1949	Used in Oklahoma 1949
Bituminous Coal	54.6 Bill. Tons (total) 27.3 Bill. Tons (recoverable)	3 Mill. Tons 68% from Strip Mines	893,000 Tons
Petroleum	1.74 Bill. Bbls. (proven)	187 Million Bbls.	Less than 104 Mill. Bbls.
Natural Gas Liquids	311 Mill. Bbls. (proven)	25.8 Million Bbls. 48% L P G Approx.	?
Natural Gas	11.8 Trill. Cu. Ft. (proven)	727 Bill.Cu. Ft. 39% from Oil Wells	278 Billion Cu.Ft.
Water Power	1.56 Bill.Kw. Hrs. (Developed & Undeveloped)	389 Mill. Kw. Hrs.	?

Mineral raw materials - mineral resources - with which we are concerned at this moment are the foundation upon which rests what we know as modern

civilization. Undoubtedly the most powerful factor influencing, directing, and developing this civilization has been the presence of ores of iron, their production and conversion into metallic iron and steel. Your first personal contact with the metal may have been in the form of a safety pin, later as numerous playthings, then a bicycle, and now an automobile. Modern buildings, modern bridges, modern paving are what they are because of the use of this metal. Factory machines and transportation equipment made of iron and steel are responsible for much of our progress.

Other metallic ores have had their part in this progress too, but in less quantity and with less influence. Lead, zinc, and copper have contributed toward the general welfare. More recently aluminum and magnesium and now titanium are entries for honors. You will recognize as indisputable the fact that each and every one of these metals is a product of fuel equally as much as it is a product of mineral ore. No one has as yet found a way to produce a metal without using fuel or electrical energy. Most of the iron is produced in the blast-furnace and no one has found a satisfactory substitute for hard, porous, strong load-bearing coke. Metallurgical coke cannot be made from just any bituminous coal. Although there are tremendous deposits of bituminous coal the supply of coking coal is limited and the districts in which it occurs are few. Oklahoma possesses coal that yields metallurgical grade coke. Mineral ores and mineral fuels are both indispensable basic raw materials in producing metals.

In the past, small amounts of iron ore have been produced in Oklahoma. Limonite-type ore from the Arbuckle region has been used in the manufacture of special low-heat cement for use in the construction of flood control and hydroelectric power dams. The tonnage in these deposits is not large. Iron ore occurrences in Le Flore County have not

been evaluated. The tonnage of titaniferous magnetite in the Wichita Mountains region may prove to be much greater than thought and currently is the subject of investigation.

In the same region beds of sand derived from the basic igneous rock commonly carry "black sand". A large part of this "black sand" may be ilmenite, an ore of titanium. The demand for titanium dioxide pigments and more recently for metallic titanium have spurred investigations of these deposits. Gerald Chase of the Oklahoma Geological Survey staff has some interesting information just off the press, in Oklahoma Geological Survey Circular 30, entitled "Ilmenite in the Alluvial Sands of the Wichita Mountain System, Oklahoma".

Zinc and lead ore have been the basis for a large industry for many years in northeastern Oklahoma, but the depletion of high-grade reserves is a matter of concern to the area. Technical research on flotation and sink-float methods of beneficiation of lean ore has paid off remarkably well and no doubt is responsible for keeping the industry alive. Occurrences of lead and zinc ore in the Arbuckle and Wichita Mountains regions have been explored. To date nothing warranting commercial development has been found. Associated with the zinc ore are indium, gallium, and germanium bearing minerals. Their recovery is a minor but profitable Oklahoma industry. Beryllium has been found in certain Wichita Mountain lead ore. Zirconium and thorium minerals have been found in the same region. Copper minerals occur in a number of Oklahoma counties and in the past small quantities have been mined; Payne, Pawnee, Garvin, Cotton, Comanche, and Kiowa Counties all have at one time or another been excited over the finding of copper. Small deposits of manganese ore are present near Bromide, and in the eastern Ouachita Mountains.

The same materials that we have classed as

mineral fuels are also raw materials for the processing industry. It is well recognized that petroleum, natural gas, and bituminous coal may be utilized interchangably to produce many secondary raw materials. Coal is being processed to yield a number of organic chemicals other than those resulting from the coking process.

Petrochemicals are those chemical intermediates derived from petroleum and natural gas. Catalytic or thermal cracking of petroleum yields such gases as ethylene, propane, propylene, butane, butylene, and isobutylene which are the starting materials for the major petrochemical activities today. Natural gas containing methane, ethane, propane, and butane also finds use. Tens of thousands of compounds could be synthesized commercially from petroleum and natural gas if suitable application could be found.

It is not my intention to list the chemical intermediates that are being produced commercially. I would rather tell you of some of the consumer products being made from the chemical intermediates. We are all familiar with the alcohols in one way or another. Methanol, ethanol, isopropanol, all used as anti-freeze and as solvents. Other solvents include benzene, toluene, amyl acetate, carbon disulfide, and carbon tetrachloride. Then there are the phenols and cresols, and numerous synthetic resins, plasticizers, and elastomers. Together, the resins, plasticizers, elastomers, and the solvents are the basis for the modern paint, lacquer, and coating industry. Some certain items yield our synthetic "rubbers"; others are processed into the so-called plastics.

Fertilizer ingredients derived from natural gas include such materials as ammonia, ammonium sulfate, ammonium nitrate, calcium nitrate, and urea. These materials have an important bearing on our national economy but in the minds of the ladies

I presume they do not rank with products such as rayon, nylon, orlon, and dynel synthetic fibres all of which are petroleum derivatives. Synthetic detergents, synthetic lubricants, motor-fuel additives, flotation reagents for the mining industry, photographic film and photographic chemicals, organic insecticides, fungicides, herbicides, certain drugs and dyes, plus such items as carbon black and elemental sulfur, are included in the list of materials derived from petrochemicals which in turn were derived from petroleum or natural gas.

The growth rate of industry based upon petrochemicals shows no signs of leveling off. The tonnage produced has doubled in each of the past three five-year periods, and there is every reason to believe that this growth rate will be maintained for some time.

Underneath the oil and gas producing areas of the State, and probably under other large areas, are tremendous quantities of brine containing dissolved solids running as much as 250,000 parts per million. The solids are mainly chlorides, but sulfates are present in small amounts. Evaporation and fractional crystallization of this brine yields a crude salt equal in every respect to salt made from sea water in California and so extensively used by the alkali industry on the west coast.

Throughout the western part of Oklahoma salt beds underlie vast areas, and crystal salt is currently being manufactured at Sayre from such beds, using the conventional two-well system for preparing and recovering the brine. As might be expected there are numerous salt springs in this region and salt obtained from the flow is generally quite pure. In Woods County salt is being recovered from the Big Salt Plain of the Cimarron where large quantities of crystal salt accumulate on the surface during dry periods. In Harmon County, salt is be-

ing produced commercially from springs, using solar evaporation methods. In Jackson County, certain springs flow brine in which sulfates predominate and the percentage of potassium sulfate is relatively high. Salt is truly one of our most important industrial minerals.

Limestones are found in many areas of the State, but only in a few areas is the stone high-calcium chemical grade, such as is demanded for lime burning. The Goodland limestone in Choctaw County, the Bromide limestone in Pontotoc, the St. Clair limestone in Sequoyah, the Waupanucka limestone in Johnston, and the Short Creek oolite in Ottawa County are among the better stones. A quarry near Marble City contains at least 50,000,000 tons of high-calcium limestone in open-pit sites and several times this amount in underground reserves. It is the stone used in the kilns at Sallisaw. It is also crushed, screened and sold for the manufacture of glass, as a flux in iron-ore smelting and in aluminum reduction, for mine dusting, and for agricultural soil conditioning. We hope to see it used before long in manufacturing calcium carbide and in stock feeds. Perhaps we may live to see it used in making soda ash. We have the salt, you know.

Dolomite is an industrial mineral resembling limestone but having a high magnesia content which gives it special properties and hence special uses. Impure stone may be used for crushed stone, agstone, and the manufacture of rock wool, but where exceptionally pure as in south-central Oklahoma and in some other districts of the State, it may find use as chemical-grade raw material. A quarry at Troy in Johnston County is in the central part of a deposit containing at least 150,000,000 tons in an area of 14,000 acres. This dolomite is almost theoretically pure double carbonate of calcium and magnesium. It is currently used in glass making, as flux in reducing iron ore, in mineral stock

feeds, and as agstone. For the manufacture of metallic magnesium and of magnesium salts it should be ideal raw material. Dead-burned dolomite finds large use as a basic refractory, whereas caustic-burned dolomite makes a smooth plastic plaster and is the starting material in preparing basic magnesium carbonate for insulation.

Supplies of high-purity silica are necessary for the production of glass, and of silicates of soda. The 14 glass plants now operating in Oklahoma depend chiefly for their supply on the two operating silica sand plants in the Arbuckle region. They produce, by washing and other beneficiation, a sand containing 99.85 percent SiO_2 and with iron content, calculated as Fe_2O_3, of only 0.025 to 0.040 percent. Other sandstone bodies of high purity occur within the State but not always easily accessible to transportation. Adequate reserves in the Arbuckle region insure long-continued production at the present rate and even with greatly increased demand.

Volcanic ash is scattered in spots over many parts of the State but the granites and basic igneous rocks are found in commercial workable deposits only in the Arbuckle and Wichita Mountain areas where they are the raw material for a large monumental and cut stone industry. Anorthosite, consisting mostly of plagioclase feldspar, occurs in enormous tonnage in the Wichitas. A government-sponsored plant was erected at Laramie, Wyoming, to extract alumina from this mineral. The residue is a good raw material for portland cement manufacture. Oklahoma deposits are much larger than those in Wyoming.

When Nature has brought about alteration in igneous rock through circulating waters and temperature changes, the products are often of economic importance. In Oklahoma, we find bentonitic clays altered from volcanic ash, montmorillonite-beidel-

lite clays from gabbros, and kaolinite clays from anorthosites. These are residual clays, still "in place" where formed.

The sedimentary or transported clays are generally more or less impure in Oklahoma, having gathered extraneous matter in transit. Shales of numerous grades and compositions, - consolidated muds from old sea-bottoms, - may be grouped with the clays. These clays and shales are the raw materials for the present brick, tile, and pottery establishments, and in conjunction with limestone for the portland cement plants of the State. Products from clay and shale often represent fuel consumption equal in value to as much as 16 percent of the gross sales value, whereas the clay or shale may not equal 5 percent. I trust you will pardon my reference to volcanic ash. You may know that I worked with this "cheap as dirt" "no account" material for quite a time. A strong relatively lightweight cellular block or brick was produced by firing in a refractory mold at high temperatures. Also, the individual particles of volcanic ash were popped to form what Will Shearon nicknamed "Pumicite Popcorn", a powdery loose cellular product with very low bulk density.

Gypsum is a mineral resource of great value present in huge quantities. The mineral anhydrite is in some places found associated with the gypsum. As the name implies it is anhydrous calcium sulfate rather than hydrous as are gypsum or selenite. Gypsum deposits of Oklahoma occur in the Permian Redbeds in the western part of the State. The commercial deposits may be divided into three areas: (1) the first line of gypsum hills along the Cimarron River, (2) the second line of hills including part of Dewey, Custer, Washita, Caddo, and Stephens Counties, and (3) the Southwestern Area in the extreme southwestern part of the State. The gypsum in the first line of hills occurs in three beds separated by clay shales. Stratification in the