The Research Work and Public Activities of the State Geological Survey

By

M. M. Leighton, Chief

REPRINTED FROM THE REPORT OF THE DIRECTOR,
DEPARTMENT OF REGISTRATION AND EDUCATION

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
July, 1940
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Mindful of the paramount and basic importance of the mineral resources of Illinois, the Department of Registration and Education fosters research of a most fruitful kind through its Geological Survey Division.

The work of the Geological Survey is under the control of the scientific Board of Natural Resources and Conservation. Its technical staff comprises geologists, chemists, physicists, and a mineral economist, thoroughly trained in their various fields, both theoretically and practically, and virtually all of them who direct special lines of research bring to their work a valuable background of industrial experience.

The Survey is organized to provide specialists in research on coal, oil and gas, industrial minerals, areal and engineering geology, subsurface geology, etc., as shown in the accompanying chart. Its co-operative working relationships with both State and Federal departments are many, also with the University of Illinois and other universities, colleges and normal schools of the State and geological, engineering, and industrial organizations.

Laboratory Research Expanded

In 1931 the Geological Survey, in order to meet the needs of this technological age, expanded its functions from those of primarily field study to include microscopy, X-ray, chemistry, physics, and mineral economics. It not only continued fundamental investigations into the geology of the State and exploratory studies for special mineral substances, but initiated laboratory research on the constitution and nature of the State's mineral and rock substances with a view to discovering new information that would result in new and improved uses for minerals, beneficiation of mineral products, and promotion of the State's mineral industries with increased employment in the various phases of production, transportation, and distribution of products. During the last part of this decade the fruits of this work have been many and valuable.

Important Coal Discoveries

The competitive struggle which the Illinois coal industry is waging against other energy sources now available in this market area is severe. In recent years the competition has been further intensified by activities in certain cities, particularly in Chicago and St. Louis,
directed toward smoke elimination. Eastern coal has come to dominate the domestic market in Chicago, and during this year the city of St. Louis has passed an ordinance which in effect forbids the use of Illinois coal over 2 inches in size in ordinary hand-fired devices. The situation calls for intensified research embracing coal preparation, coal processing, and combustion devices which will result in better fuels for stokers, relatively cheap smokeless fuels for use in hand-fired furnaces and stoves, and simple devices that will burn raw coal smokelessly.

Better Stoker Fuels Needed

The development of better stoker fuels has required a better understanding of the nature of coal and its variations in the various beds and in different mining districts. The gaining of new knowledge has been necessary.
Valuable fundamental information has resulted from an investigation of what the original plant material was from which Illinois coal has been transformed. Discriminating observations by Survey geologists have brought to light petrifications of the original coal plants in the form of coal balls which now constitute the most reliable source of such information. The discovery of these is a relatively recent achievement which in scientific quarters has brought renown to the Illinois Geological Survey.

Furthermore, microscopic studies have demonstrated the presence in our coals of each of the four banded ingredients named vitrain, clarain, durain and fusain. Study of the properties of these varieties of coal material has demonstrated that they differ in important respects. These differences are such as to make possible the segregation of the individual ingredients by the processes commonly used in preparing and washing coal. Such concentration of the individual ingredient produces a fuel that has a distinctive behavior in combustion.

The combustion behavior of these ingredients has been given careful attention. Concentrated samples of bright vitrain have been found to swell excessively, produce coke-trees in the fire-box and blow holes in the fuel bed, causing non-uniform combustion. Concentrated samples of the duller ingredients, clarain and particularly durain, provide a fuel that permits more uniform combustion.

**Colored Motion Picture Films Used**

A test or criterion has been developed for quickly evaluating the combustion characteristics of a coal for stoker use, and for use in properly blending the separate ingredients to produce superior stoker fuels. This has been done in co-operation with the Department of Mechanical Engineering of the University of Illinois in actual tests made with a domestic underfeed stoker. The combustion behavior of each kind of coal was recorded on colored moving picture films and these showed clearly the tendency of certain coals to form coke-trees and blow-holes, and of other coals to be free-burning. Illinois coals, by virtue of their banded ingredients, lend themselves to the process of blending that will produce superior stoker fuels.

The film made during these demonstration tests has been shown repeatedly at technological sessions and before coal company officials with important consequences.

An extensive study has been made of the coking characteristics of Illinois coal, and it has been found, among other things, that by giving proper attention to the blending of banded ingredients, good domestic coke can be produced for use in hand-fired furnaces and stoves, especially in the sole-flue type of oven. Much pertinent information is published in a recent bulletin on "Coke from Illinois Coals." Domestic coke is increasing in use, and it is one of the smokeless fuels that will play a more and more important part in meeting the smoke abatement movement.

In our opinion it is important to provide a variety of smokeless fuels from our coals. The spirit of the American people demands a choice of products, and the development of the Illinois coal industry
Microscopic studies of thin sections of the coal yield fundamental information which may lead to new and improved uses for coal.

will be advanced by the development of new, relatively cheap, smokeless fuels.

The Survey has developed a new laboratory method of making smokeless briquets from Illinois coal, without adding an artificial binder. Under certain temperatures and pressures, varied according to the coal ingredients, the coal becomes momentarily plastic and self-binding, producing a briquet which is more dense and uniform than the natural coal, which burns from the outside in, without appreciable swelling or fusing together, and which has a smoke index commonly less than the average for Pocahontas coal. Smokeless briquets may be made from lump coal that has been ground down to pass a 1/4-inch screen and then slightly volatilized; or from deduster dust, which is a mine waste from the blowing out of fine dust from stoker coal, heated but without prevolatilization; or from minus 30-mesh carbon coal from the Belleville district, at room temperature.

Appropriate Funds for Coal Testing

In response to the smoke abatement movement and the suggestion of the city officials of St. Louis, the last General Assembly and the Governor authorized an appropriation of $85,000 for research on smokeless briquets and demonstration of the Geological Survey's new briquetting process for producing briquets from Illinois coals in commercial quantities, also an appropriation of $95,000 for an applied research laboratory for this and other research on a larger scale than
Chemical studies of coal, top, carried on by the State Geological Survey yield valuable information. X-ray photographs of samples of the complete coal bed, bottom, show where impurities occur.
was possible heretofore. A commercial sized unit of the new briquetting machine is now being constructed, the laboratory building is being erected, and it is expected that the demonstration will be scheduled this fall.

In this connection, attention is also being given to the design of a simple economical device for burning smokelessly Illinois small-egg size coal. All of the above mentioned efforts should become important factors in placing the Illinois coal industry on a permanently successful competitive basis with other sources of energy fuels.

Because new fundamental information is imperative at this time in order that applied research can be fruitful for the industry, research is in progress on the chemical nature of coal. Already this research has yielded valuable information as to what some of the changes are
that take place in coal during shipment and storage and that affect combustion and coking.

Existing coal mining operations of large production are after all relatively short lived, and it is important for the effective maintenance of the coal mining industry that the extent, character, and availability of the reserve be thoroughly understood. The geologists of our coal division are more or less continuously engaged in accurately delineating the coal reserves by accumulating and studying drill, mine and surface data, and by making surveys, resulting in carefully prepared maps of the coal beds. Herrin (No. 6) coal bed for the entire area
south of Centralia has been so mapped and tabulations have been made of its thickness and depth, also No. 5 coal bed for the same area so far as these data can be made available. Maps have been prepared, too, showing the position of the workable coal beds in western and northern parts of the coal basin as a guide for the exploration of strip-pable coal in those parts of the State.

Survey Aids Illinois Oil Revival

Within the past three and a half years Illinois has risen from 14th place as an oil-producing state to 3rd place. Many years ago in 1908-10 Illinois held this position, but then its production reached a peak of only 92,300 barrels per day, whereas to regain this place in March of 1940, it was necessary to produce more than 416,375 barrels per day.

Many factors have entered into this unique accomplishment—the advance of technology of exploration and drilling, the high technical ability of the geological and geophysical staffs of the oil companies, favorable geographic situation with respect to refinery markets, and last but not least the technical work of the Geological Survey. Survey geologists immediately recognized the significance of the discovery of oil in the Mt. Pleasant field in the Michigan basin in 1928, and began a review of the immense file of well logs and well cutting samples that the Survey had been assiduously collecting for many years. As a result a map was prepared classifying the areas of the State with respect to oil and gas possibilities. This map, which defined and classified the Illinois basin as having the best possibilities, was exhibited at the Western Society of Engineers in Chicago in September, 1930, and subsequently on many other occasions, resulting in a revival of interest in Illinois on the part of oil geologists and company officials. Many geologists came for conferences, to secure well logs and publications, and to study sample cuttings. Basic information was obtained from the Survey for the interpretation of seismograph results and for the construction of wells, and continuously since the first new discoveries the Survey has been more than taxed assisting in these history-making efforts.

Of the 66 new pools that have been found, only two are outside the Survey's No. 1 area, shown in Fig. 2, and these are producing probably less than 225 barrels per day out of a total of 518,224 barrels production for the State during the week ending June 29, 1940.

Salem Pool Second in Nation

Among the highlights of oil and gas developments during the past year was the discovery of Devonian limestone production, following recommendations of the Survey, in the old Sandoval field in December, 1938, and then in the Salem pool, which ranks second in the nation, next to East Texas.

Within the past year, 27 new pools have been discovered in the State. Of this number, 14 new pools are in Wabash and White counties. In these two counties "wildcat" drilling has been particularly active for many months. Two pools were recently discovered in
Jasper County near Boos and West Liberty. Other counties having new pools which were added to the list of producing counties of the State are Edwards and Hamilton. Of the new pools discovered during the past year, development has been most active in the Keensburg pool in Wabash County which now has 146 producing wells and the Storms pool in White County which has 75 producing wells as of July 2, 1940. About half of the wells in the Keensburg pool are in the village of Keensburg which has an area of 160 acres. There were 3480 producing wells in the new pools of the State on July 3, 1939, as compared with 6653 wells in the new pools as of July 2, 1940. Much of this increase is attributed to the development within the Salem, Louden, and Centralia pools.

The monthly production has increased from 6,978,000 to 14,652,000 barrels within the past year. The discovery of Devonian production in the Salem and Centralia pools has added considerably to the State's production. The Trenton limestone, which is productive in the Dupo and Waterloo fields of St. Clair and Monroe counties in
the western part of the State and in the Westfield pool, Clark County, in the old southeastern field, has been tested in the Centralia pool by a well located near the center of the structure. The initial production on July 2, the date of completion, was 120 barrels on pump. As the
Drilling in the Salem pool for deeper productions in the Devonian “sand”, which has given wells with initial productions exceeding 10,000 barrels per day

Trenton limestone was found to be productive in this well, there will doubtless be further drilling to this formation in the Centralia field, and it is reported that a test to the Trenton limestone has been started in the Salem field. It is anticipated that there will be considerable drilling to the Devonian and Trenton formations in the Illinois basin since both formations have been found to be productive in some of the new fields.
Some idea of the gigantic operation involved in brick making is gathered from the working face of a clay pit of a brick and tile company in Vermilion County.

Two new pools were discovered during June, 1940, one in Wabash County, the other in Washington County, and a number of wells have been reported to have saturation in various formations and will undoubtedly open new pools.

The Survey has maintained a monthly publication of oil and gas drilling since the first discoveries in 1937, in co-operation with the Scout Check of the various oil companies. It has also issued many technical papers, development maps, and a State oil and gas map.

Investigation of Clay Resources

The potential possibilities of the clay and shale resources are very great and much attention is being devoted to them. And, just as in coal or petroleum research the work calls for specialists, so it does in clay research. Two fundamental lines of investigation have been followed in the search for new information: (1) field studies of all of the varieties of clays and shales in the State having potential promise of development, and (2) a study of their constitution and properties to determine new and improved uses for both ceramic and non-ceramic purposes. An immense amount of work is to be done along these lines.

In the case of the ceramic products, the Department of Ceramic Engineering of the University of Illinois and the Survey are seeking cheaper and better methods of processing and the means of producing more attractive and better products for the construction industry, and analyzing the economic factors that affect the welfare of the industry. During the past year a report was prepared for publication giving the results of a scientific group of tests on the quality of the face brick produced in the State as compared with that produced in other States which enjoy a remarkable reputation. The results of these tests showed that the face brick produced in this State is at least equal in quality in all respects and is superior in quality in some respects to brick which is being shipped into the State.

The study of the constitution and properties of our native clays and shales is also revealing definite commercial possibilities of treat-
ment which will improve their working properties and the products. This work shows very definitely that in the past too little attention has been paid to beneficiation methods, chiefly because the research technique had not been fully developed and, therefore, too little was known about the kinds of minerals that compose the various clays and shales and what their real and potential properties are.

Non-Ceramic Clay Industry Expands

In the case of the non-ceramic uses of clays (products which are not fired) rapid expansion is taking place. Much clay is now being used for bonding synthetic molding sand for foundry and other related metallurgical purposes, for bleaching various substances and clarifying oils, in the manufacture of rubber tires, and in rotary drilling in the oil industry, for mortar mix with cement or lime, and for other purposes. In view of the existence of many large foundries in various industrial centers, of the huge rubber tire industry, of the large amount of oil drilling in Illinois and nearby, and of the immensity of the refining industry in the Middle West, the benefits of this research should assume large proportions.

The new petrographic microscope has been of tremendous aid in the last few years in learning new things about the constitution of
clays. In one instance a layer of clay which was thought to be mere overburden and a waste was found to contain a useful mineral which sent it into the foundry market by the carload; in another case the microscope revealed the cause of lamination in the brick which a company was producing and the necessary correction of this undesirable feature was intelligently made; in another case the crystal structure of the clay minerals was found to be such that an improvement in the processing equipment was promptly conceived; in still another case the microscopic and chemical studies showed that the properties of the raw material could be improved through a chemical base exchange, and so it goes—new information brings new and improved changes. Some of this new and fundamental research will have its benefits in stabilizing the sub-base for highways carrying heavy traffic and in a better understanding of the properties of soils.

**Facts Ready for New Industry**

An investigation carried on during the past year showed that certain Illinois clays and shales can be satisfactorily used as so-called “mortar mix” to replace a part of the Portland cement or lime in masonry mortars. A preliminary report of this work about to be issued provides the necessary technical data for the establishment of a mortar mix industry in Illinois. This investigation included a thorough study of the factors that cause certain clays or shales to be satisfactory for this purpose. Because such fundamental data are not available for non-Illinois clays or shales, producers in Illinois will have a material competitive advantage.
The year saw the completion of an investigation of the changes that take place when the two common constituents of clays, illite and montmorillonite, are fired. Information on the effect of heat on these pure materials greatly increases the understanding of the reactions in clays when they are subjected to high temperatures.

The surface clays of the State have little use except for the manufacture of brick. Neither has much been known in detail regarding their character and suitability for other purposes. These matters are being investigated and the results of laboratory experiments indicate that some of these clays when properly processed may yield materials suitable for use as drilling-mud for oil wells, as bonding clay for synthetic molding sand, and probably for other purposes.

Rock Products Research

The weather-resisting properties of rock materials used in costly outdoor construction, such as in the thousands of miles of pavement, large bridge foundations, dams and locks, etc., are obviously of critical importance. Rock may be excellent for certain uses in the chemical and metallurgical industries, and yet be inferior for outdoor construction. In order that quarrying of rock strata can profitably be done and rigid specifications be met, a careful study has been proceeding on the dolomites of the Chicago region under the joint auspices of the Geological Survey, the Engineering Experiment Station of the University, and the State Highway Division of the Department of Public Works and Buildings. A comprehensive report is now in preparation. The report will reveal what portions of the rock formations having commercial thickness are most desirable, their geographic distribution, and what their behavior has been found to be under various kinds of tests. Engineers will also find in this report data bearing on the correlations between the two major laboratory tests in current use for determining the weather resistance of structural materials.

A few years ago the Geological Survey began a systematic study of the chemical composition of the limestones and dolomites exposed in the larger quarries of the State. This has already revealed new commercial uses for certain strata in some of these quarries not heretofore recognized and for which markets have now been found. This work will proceed until the potential possibilities in all of the commercial quarries have been determined.

Recently started is an investigation of the crushing and grinding characteristics of different kinds of Illinois limestones and dolomites. This work is designed to provide the stone industry of the State with information which will enable them to make the most economical use of their raw materials in producing products to meet different size specifications.

Following the work done on wool-rock resources and the chemistry of mineral wool by the Survey a few years ago, for which the Survey has won an enviable reputation, a subsequent study has been made of the influence of fluorspar on rock melts with results that
should be of interest not only to mineral wool producers but cement manufacturers and the steel industry.

**Agricultural Limestone Studied**

Agricultural limestone for rebuilding and renewing the soils of the State is a highly important matter. The Survey is constantly aiding county farm advisers and quarrymen in finding suitable limestone ledges for producing agricultural limestone, in furnishing chemical analyses and in publishing the results of its field surveys and laboratory studies. A report on the agricultural limestone resources of Cumberland, Effingham, Clay, Richland, and Jasper counties has recently been completed. County highway engineers also obtain information and assistance from the Survey regarding sources of road materials for farm-to-market roads.

**Other Industrial Minerals**

Exploratory work is also being done on the separation of certain minerals from glacial sands, minerals which the State does not yet produce. This has yielded results of sufficient promise that a more thoroughgoing investigation of these sands is to be undertaken.

Also receiving attention is the matter of Illinois sources of certain types of molding sands which may logically replace sands imported into Illinois from other states. This work offers considerable promise of success.

Another study which is being pursued is that of the mineral economics of manufacturing more glass products from the silica sand of the Ottawa district, now that natural gas is being piped in large quantities into the State.

**Research in Fluorspar**

The fluorine element in fluor spar is being studied with reference to the chemical manufacture of new organic fluorine compounds having special uses that will have a world-wide interest. This unique study is a timely one because the most important fluor spar deposits in the United States are in Hardin County, Illinois, and the adjacent area of Kentucky, and also because the prosperity of that county can be substantially promoted by finding a more stable market for fluor spar than the steel industry affords. At present the fluor spar mining industry of Hardin County ebbs and flows with the amount of steel production, which when low results in a lack of market for fluor spar.

The most promising undeveloped commercial outlet for fluor spar appears to be in the chemical industry, which consumed 15 per cent of the United States total in 1938 and 1939, compared with a previous 10-year average of less than 12 per cent. The research of the Survey in this difficult chemical problem, about which comparatively little is known, is already yielding encouraging results.

The recent studies of the Geological Survey on the extent of the reserves of fluor spar in Hardin County have resulted in an extension of mining in the Cave-in-Rock area and as a result of this extension there have been found commercial deposits of zinc and lead which are now being developed.
A modern Illinois stone crushing plant

Ground Water Sources

In northern Illinois, including the area around Chicago, and also in western Illinois and certain other parts of the State, ground water in the deeper bedrock formations is a most valuable resource for the development of our cities and villages and our manufacturing industries. In central Illinois and in certain other parts of southern Illinois the ground water in the glacial drift is likewise of importance. This is especially true in the Coal Measures area where the bedrock aquifers quite generally contain saline waters.

The Geological Survey actively co-operates with the Water Survey and the Sanitary Engineering Division of the Department of Public Health in problems of municipal and industrial ground-water supplies, and its part of the work is the gathering and furnishing of information on the depth, extent, thickness and character of the various geologic aquifers and on problems of where to set casings to protect underground supplies. Constant study is given to the well logs and well cutting samples that pour into our files from current drilling, many daily conferences and letters are handled, and a field party employing the electrical resistivity apparatus is continuously engaged in helping villages to find adequate and satisfactory ground water sources. Study is also given to the geological conditions that allow dangerous conditions for pollution from surface sources and for the entrance of saline and highly mineralized waters into fresh-water strata from some wells which are drilled too deep in their search for water, or wells that are drilled in exploring for oil. Within the last year we have been faced with new demands for information concerning the thickness of the glacial drift over limestone formations in the outskirts of Chicago, Joliet, Elgin, Rockford, and other cities, where new subdivisions are being developed. In
many of these subdivisions private or other water supplies are being obtained from wells in the limestone, and where the glacial drift cover is too thin or too porous pollution from various sources offers serious problems.

**Mineral Statistics Aid Industry**

The Geological Survey maintains a section of Mineral Economics which co-operates with the State Department of Mines and Minerals, the U. S. Bureau of Mines, and the Bituminous Coal Division of the U. S. Department of the Interior, in assembling mineral statistics of production and in studying the flow of minerals into and out of the State. With increase in manufacturing and advance in technology and scientific discoveries and inventions, the State of Illinois has become the third most wealthy state in the Union, and one of the several influencing factors is the State's resources in minerals. The Survey publishes an annual report on all mineral production and a statistical review and analysis of the market trends and conditions. This year's report has the following content:

Data on the production and distribution of coal produced in Illinois and adjacent states and the origin of coal from all sources consumed in the Illinois coal market area;

A special analysis of the sources of coal consumed by market districts of the Illinois coal market area as outlined by the Bituminous Coal Division under the Act of 1937;

A special analysis of the consumption of crude petroleum and refined oil products in market areas affected by the Illinois oil industry;

Data on production of industrial minerals, building activity, and agricultural limestone distribution in Illinois.

**Special Studies on Varied Industries**

Special reports are issued from time to time as studies are completed, among which have been reports on:

- Potential Markets for Illinois Coal in the Upper Mississippi Valley;
- The Illinois Oil Market in 1937 and 1938;
- Outlets for Illinois Oil in 1940;
- Factors Favoring the Enlargement of a Glass Industry in Illinois;
- Competitive Position of Illinois Coal in the Illinois Coal Market Area;
- Structural Clay Products in New Home Building Activity.

All of these studies in mineral economics are a valuable aid not only to industry but to the Survey itself in shaping and readjusting its program of research to keep it oriented along practical and useful lines.

**Topographic Map of Illinois**

During the period from October 1, 1938, to September 30, 1939, 819.6 square miles of territory were mapped topographically in co-operation with the United States Geological Survey. This brought the topographic mapping of the State up to about 75 per cent complete. All of the primary leveling and horizontal control has been completed.
Silica production is another big Illinois industry which the Survey supervises. In the foreground is a worked out pit at Ottawa

Scientific Information for Schools

The Survey provides six annual field conferences, three in the Spring and three in the Autumn, for high school science teachers, for the purpose of making available to them and the State's future citizens the information accrued by the Survey through many years of investigation regarding the geological resources of the State. Occasionally special field trips are conducted for the Illinois Academy of Science, the Departments of Geology of our Universities, Colleges, and Normal Schools, the Illinois Geological Society and others.

The Survey also distributes sets of rock, mineral and fossil specimens to high schools with a manual descriptive of them. Exhibits are also prepared for mineral conferences of various kinds as occasion merits and as time permits.

Many Requests for Geological Data

The Survey provides for the rendering of much valuable service to the citizens of the State. All calls for information regarding oil and gas possibilities, coal resources and coal utilization, clay and clay products, rock and rock products, ground water supplies and general geological subjects, whether made by letter, telegram, telephone, or in person, are given careful attention. In recent years interest in oil and gas and in smokeless fuels has brought a heavy load of inquiries, and every effort is made to give factual information whenever possible, furnish a logical analysis of the problem, or refer the inquirer to other sources of information.

Co-operation with Other Departments

During the past fifteen years the Geological Survey has co-operated with the State Highway Division mainly and with county highway departments to a lesser degree in furnishing maps and geological information of many kinds. After field conferences reports have been
submitted on the geologic conditions and materials to be encountered or handled in cuts and fills, crossing peat bogs and swamps, avoiding landslides or rock falls along valley slopes, handling of drainage, setting of bridge foundations, and in solving problems of heaving, settling or disruption of pavements due to geologic factors. Incalculable amounts of money have been thus saved by avoiding unnecessarily expensive construction and unnecessary maintenance and reconstruction. The materials in subgrades are also a matter that is being given increasingly critical consideration with respect to the clay minerals present, their texture, and their drainage conditions.

Constant co-operation is given the State Water Survey and the State Sanitary Engineering Division on problems of ground water supply and pollution. The Survey also works hand in hand with the State Department of Mines and Minerals in aiding in the administration of the laws governing permits to drill and the plugging of abandoned wells to protect and make safe the future mining of coal beds and to prevent salt water from entering fresh water sands.

Many other co-operative relationships are supported which can not be described here but are listed in the organization chart appearing herewith.

Technical and Educational Publications

The Survey has published 97 technical and educational bulletins, 60 shorter reports of investigations, 34 issues of Illinois Petroleum, and 4 educational pamphlets, as well as short excerpts, circulars, monthly oil and gas drilling reports, and numerous drainage, topographic, structural and geologic maps.

Among the recent publications of special note are: Rock Wool from Illinois Mineral Resources; The Fluorspar Industry of the United States with Special Reference to the Illinois-Kentucky District; Classification and Selection of Illinois Coals; The Competitive Position of Illinois Coal in the Illinois Coal Market Area; Coke from Illinois Coals; Geology of the Chicago Region (for schools); Briquetting of Illinois Coal without a Binder; Geology and Oil and Gas Possibilities of Parts of Marion and Clay Counties; The Market for Illinois Oil in 1937 and 1938; Geologic Maps and Drilling Reports for the Oil and Gas Industry; etc.

A complete list of publications with a finding index is available and will be furnished upon request.