THE PRESIDENT'S ADDRESS

Investigations of Mineral Resources and Industries of the United States

BY F. W. WOLF, DIRECTOR STATE GEOLOGICAL SURVEY

The importance of the United States as a producer and reserve supply of mineral for the World is not commonly realized. According to the latest available figures of the U. S. Geological survey, the country ranks first for eight minerals, and produces percentages of the world's output, (Figures 1 and 2) in each mineral, listed as follows:

Petroleum	64 percent
Smelted Copper	56 percent
Phosphate and Gypsum	50 percent
Iron	40 percent
Coal	38 percent
Lead	33 percent
Zinc	29 percent
Tungsten	28 percent

The history of mineral investigations and a review of their character will, I hope, be interesting to those Academy mem-

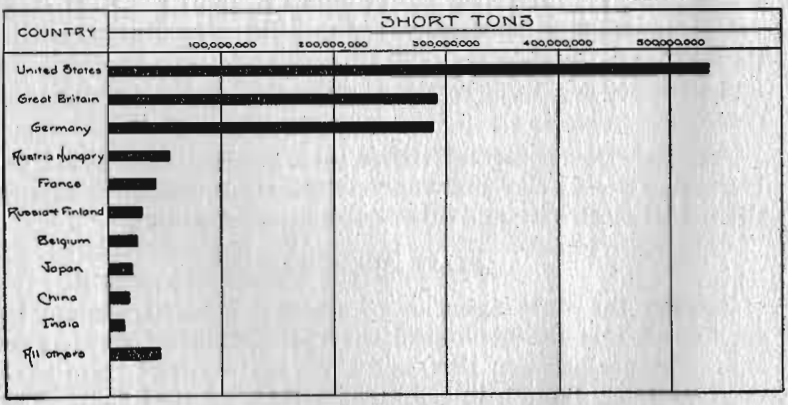


Figure 1. Production of Coal in Various Countries.

bers who are not themselves geologists or mining engineers. It is my plan to mention the important agencies engaged in investigation, and then to review the kind and scope of the various lines of work.

Among the important investigators may be mentioned those of the federal government, those of states, and those of private agencies.

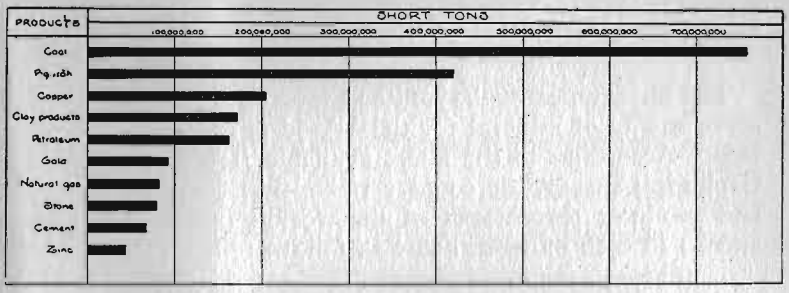


Figure 2. Relative value of United States Mineral Products.

FEDERAL BUREAUS

The U. S. Geological Survey was created in 1879 and has a record of service covering 34 years. During 1913 the work included geologic mapping in 45 states; topographic mapping in 26; stream gaging in 42; underground water studies in 19. Nearly 400 field men of the regular staff, besides numerous temporary assistants, were employed. The appropriations for the fiscal year exceed one and one-half million dollars.

As an off-shoot from the Geological Survey, the U. S. Bureau of Mines was created in 1910 to conduct investigations into safety and efficiency of the mineral industry. More than 150 technical men were employed in 1913. The Bureau maintained offices or laboratories in three cities outside Washington and operated six mine-safety stations and seven mine-rescue cars.

Another governmental office, the Bureau of Standards, conducts tests of clay and concrete materials, and investigates the use of electricity and other substances in mining.

STATE AGENCIES

Among the state agencies of mineral research should be mentioned first the geological surveys. Many of them came into existence between 1830 and 1840, and most of them have enjoyed long, though intermittent periods of usefulness. The present surveys range in age from 6 to 50 years and average

18 years. Three have existed more than 40 years, two others more than 30, and five others more than 20 years. The thirty-five state surveys were especially active during 1913, collecting and disseminating information intended to promote the orderly development of mineral resources. Several surveys also had responsibility in connection with highways, soils, forests, and reclamation of wet lands. Besides having these utilitarian functions, the surveys contributed notably to pure science. Altogether the state surveys expended approximately $475,000, and received the benefits of $140,000 additional expenditure by co-operating federal bureaus. About 100 scientists gave full-time service for the states, and about 50 others, besides topographers and soil experts, were furnished in co-operation.

To enumerate the mining schools or departments, and the experiment stations of the country would almost require a roll-call of States. But among the notable contributors to the profession may be mentioned Columbia, Yale, Michigan, Colorado, Minnesota, Missouri, and our new school at Illinois. These, together with the geological and chemical departments of our universities are producing the graduates who influence the mineral industry. The field and laboratory researches of these schools and colleges include real contributions to practical knowledge.

PRIVATE AGENCIES

Aside from official surveys, bureaus and educational institutions already presented, there are many private agencies of research and publication. An important work is done by professional and practical men who publish the accounts of their work in the dozen or more technical papers of the country. Mention should be made also of the research by great corporations which annually explore and drill mineral land. They either follow-up and utilize the results of official field work, or take the initiative themselves. The spectacular but fundamental work of the Carnegie geophysical laboratory has a practical bearing on problems of mineralization. Finally, a necessary forum of the mining business is provided by the American Institute of Mining Engineers, the American Mining Congress, and related organizations.

CHARACTER OF INVESTIGATIONS

A review of the character of investigations of mineral resources and industries includes, first, the early frontier ex-

plorations, then modern work. In this latter division are included topographic mapping, general geologic surveys, land classification, economic studies of particular minerals or substances, and technologic investigations.

The frontier explorations are described by Merrill,* from whom I quote freely.

The era of state surveys begins with the decade 1830-1839. During this interval scarcely a year passed but witnessed the establishment of a state survey or the organization of an exploring expedition, to which a geologist was attached. Thus were established surveys in Massachuetts in 1830; in Tennessee in 1831, Maryland in 1834, New Jersey, Connecticut and Virginia in 1835, Maine, New York, Ohio and Pennsylvania in 1836, Delaware, Indiana and Michigan in 1837, and in New Hampshire and Rhode Island in 1839. In addition, the United States Government for the first time recognized the practical utility of the geologist by authorizing the surveys by G. W. Featherstonhaugh of the elevated country between the Missouri and Red Rivers in 1834, and of the Coteau des Prairies in 1835; and by D. D. Owen of the mineral lands of Iowa, Wisconsin, and Illinois in 1839.

The fever for the state surveys, so prevalent during the first decade, seems to have quickly subsided, since during the following period, new surveys were established only in Alabama, South Carolina, and Vermont. Governmental surveys were also few, being limited to those by D. D. Owen in the Chippewa land district, and Jackson, Foster and Whitney in the Lake Superior region.

The cause of this sudden cessation is not quite apparent. It is possible, that the period of great financial depression beginning in 1836 may have had something to do with it. An important factor may have been the lack of geologists to agitate the subject and carry on the work, since nearly every man of prominence and experience was engaged in surveys and organizations already under way. The period was one of importance for results rather than for organization and preparation.

The single event of greatest consequence during this second decade was the appearance of the final reports of the New York survey. The volume of literature was naturally greater than at any previous period, since it included many of the reports of organizations of the previous decade, as those of Percival in

*Geo. P. Merrill, Contributions to history of American Geology; Annual report, Smithsonian Inst. 1904.

Connecticut, Booth in Delaware, Jackson in New Hampshire and Rhode Island, and Rogers in New Jersey. The establishment of a geological survey of Canada in 1841 should also be mentioned.

The financial depression, which proved so fatal to the state surveys during the second decade, 1840-1849, ran its course. Several new states had in the meantime been added to the Union, some of which showed commendable promptness in authorizing geological surveys. During the decade 1850-1859 new organizations were thus formed in fourteen states, eight of which had made no previous attempt. These eight, in alphabetical order, are California, Illinois, Iowa, Kentucky, Mississippi, Missouri, Texas, and Wisconsin. Six states for the second time undertook the work—Michigan, New Jersey, North and South Carolina, Tennessee, and Vermont. The National Government was also active, the most importat undertaking being the surveys in connection with the proposed Pacific railways. In addition to these, Capt. R. B. Marcy made a survey of the Red River region of Louisiana; Maj. W. H. Emroy, one of the Mexican boundary, and Colonel Pope one in the region of New Mexico along the thirty-second parallel. To each and all of these expeditions, geologists, or at least naturalists, were attached. The publication of by far the greatest importance of this third decade was, however, the long-delayed report of the Pennsylvania survey, which was truly epoch-making.

The following period, including the civil war, might naturally be expected to be one of uncertainty and inaction in matters relating to the sciences. With the passing of the war, active work has begun once more in states where it had been but temporarily suspended, and in others, new organizations were authorized, as in Kansas in 1864, Iowa and North Carolina in 1866, and Louisiana, Michigan, and Ohio in 1869.

The decade of the civil war brought to light a number of men for whom the piping times of peace, even when varied by Indian outbreaks in the West, afforded insufficient opportunities. They were men in whom the times had developed a power of organization and command. They were, moreover, men of courage to the point of daring. It was but natural, therefore, particularly when the necessity for military routes in the west and public land questions were taken into consideration, that such should turn their attention toward western exploration. Further, the surveys made in the third decade, in connection with routes for the Pacific railroads, and the

work done by Evans, Hayden and Meek in the Bad Lands of the Missouri, had whetted the desires of numerous investigators. Willing workers were abundant during the fourth decade, 1870-79, and Congress not difficult to persuade into granting the necessary funds. Hence expedition after expedition was organized and sent out, some purely military, some military and geographic, with geology only incidental, and others for the avowed purpose of geological research.

Under such conditions was inaugurated the work which culminated, in 1879, in the organization of the present U. S. Geological Survey, which, for breadth of scope and financial resources, is without counterpart in the world's history of science.

The more important of the expeditions above referred to were Hayden's Geological Surveys of the Territories; King's Geological Survey of the Fortieth Parallel; Powell's Surveys of the Grand Canyon of the Colorado and adjacent regions; and Wheeler's Geographical Surveys West of the One-hundredth Meridian.

It is possible only to mention the organizations of these four decades and it is necessary to omit the results of the work, except to say that the knowledge of the mineral resources of the States and territories was extended rapidly and made a matter of public record by the frontier explorations. Much of the work of the early 50's was wonderfully well done.

LATER INVESTIGATIONS

Topographic mapping is of great value as a basis for study of mineral resources. While at least three states have made such surveys systematically, the U.S. Geological Survey has executed nearly all topographical surveys now available to the public. The total surveyed to date equals 40 per cent of the country. In this work about twenty states co-operate and furnish half of the necessary funds. Practically $600,000 was spent for public topographic surveys in the United States during the fiscal year 1913. More than 22,500 sq. mi. (one half of Illinois) was actually surveyed. The total surveyed to date equals 40 per cent of the country.

General geological surveys of specific areas have been the approved type for public and corporation work, and maps, (Figure 3) and reports based on states, counties, quadrangles, or other units have aimed to portray the kinds and relations of all the exposed formations and to present the facts relating

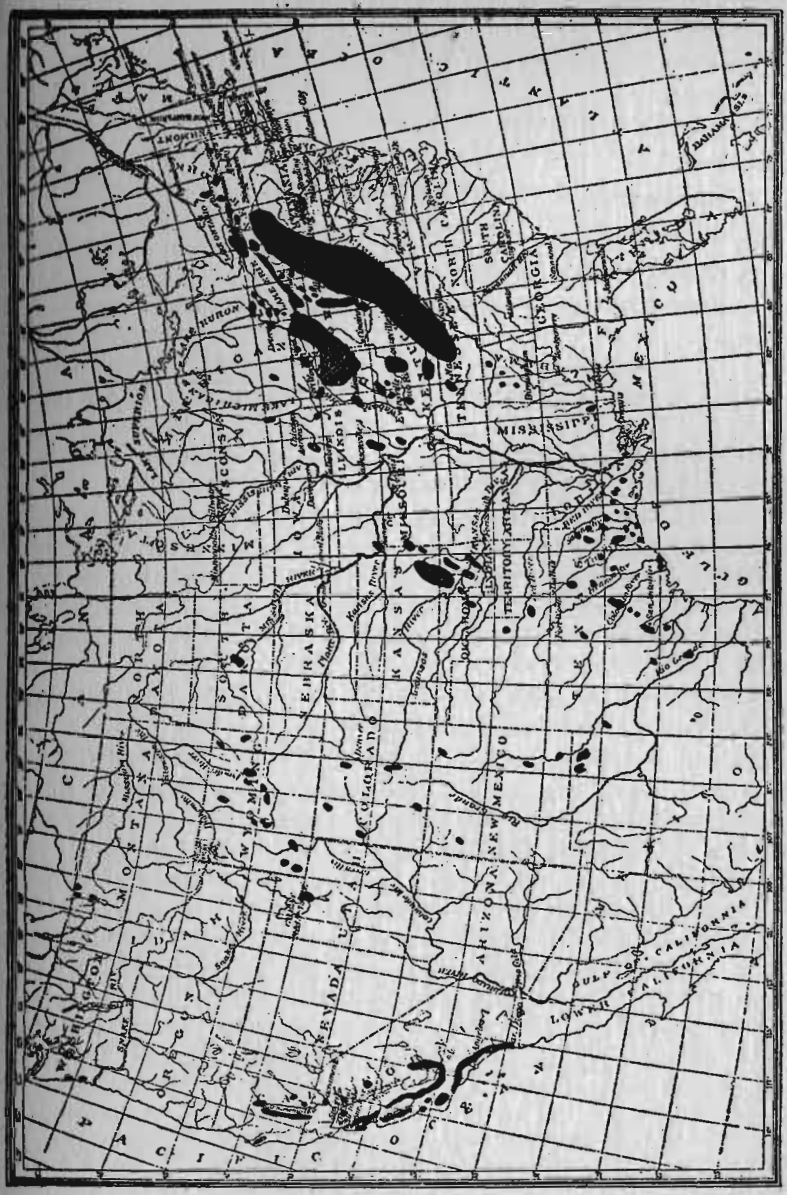


Figure 3. Distribution of Petroleum and Natural Gas Fields in the United States. After Day, U. S. Geological Survey.

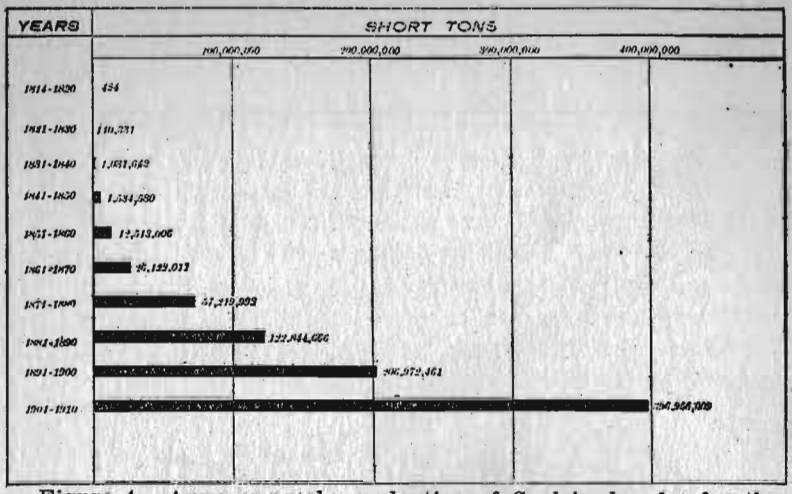


Figure 4. Average yearly production of Coal in decades for the United States.

to all mineral resources, including soils and waters. This is perhaps logical in frontier areas of slight development.

Most of the states have been mapped, at least in reconnaissance by local bureaus, though detailed work after modern standards has been completed only for states of small area, or for small fractions of the larger states. The U. S. Geological Survey work has spread over much of the country as shown by figure 4.

Classification of public land by the U. S. Geological Survey has become an important division of work. The purpose is to determine whether certain lands sought to be acquired from the Government are of the character contemplated by the statute under which they are sought. Large withdrawals from entry of public lands during several years, have been made by the President or by the General Land Office, pending classification of the land as to its mineral character.

The Land Classification Board of the Survey, comprises eleven geologists and engineers, and twenty-three others of minor grade. The work is done by sections devoted to the following subjects: Coal, oil, phosphate, metallic ores, water power and irrigation. The basis of classification and valuation of coal land is logical and depends chiefly on the thickness, depth, and heat value of the coal. Phosphate beds containing less than 30 per cent of tricalcium phosphate are considered to be non-mineral. Beds containing 70 per cent or more, and measuring 6 feet or more in thickness, are reserved to a depth of 5,000 feet. Intermediate grades are reserved to lesser depths.

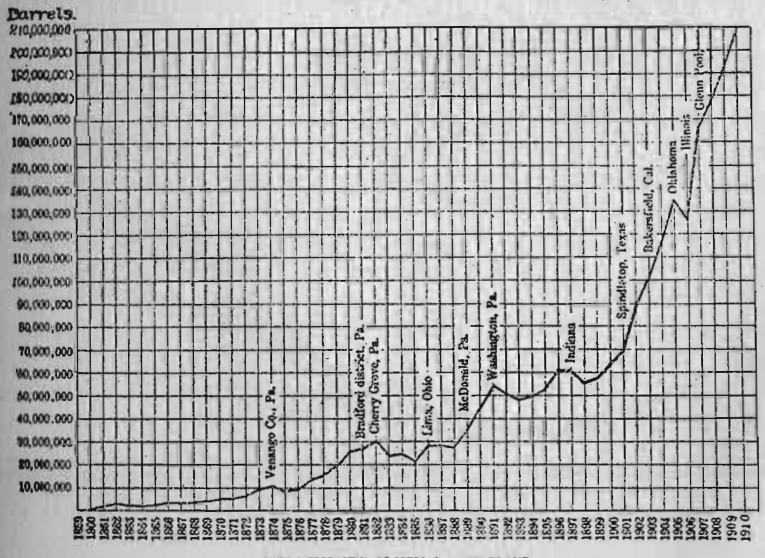
During 1913, more than 2,000,000 acres of coal land were classified, and valued at nearly 33½ million dollars, while nearly 8,000,000 acres were classified as non-coal land. To date the classifications include 19,000,000 acres of coal land, 61,-000,000 non-coal land. There is awaiting classification the following lands, expressed in acres:

Coal—58,000,000; oil 4,600,000; phosphate, 3,000,000; potash, 130,000.

Besides this federal classification work several states, notably Michigan, Minnesota and Wisconsin, delegate similar work to their geological surveys in co-operation with their tax commissions. All mineral lands are to be classified as a basis for taxation. In Wisconsin, during 1913, nine field parties were engaged in making magnetic surveys to determine the iron-bearing lands not yet under development.

Recently investigations of particular minerals or substances are perhaps occupying a more important position than general areal surveys. Reports on coal, oil, iron, clay, phosphate, platinum, etc., of various states or smaller areas, have been issued by public or private investigators and have been of great practical use to the mineral industries. Numerous specialists in particular lines of work have developed and have largely superseded the general geologist and mining engineer of all-around work. This has come about largely because of the increased utilitarian functions of the work, but even in its pure-science aspects a high degree of specialization has evolved. The distribution of important resources is shown by figures 5 and 6.

Figure 5



ANNUAL PRODUCTION OF PETROLEUM, 1859 TO 1910.

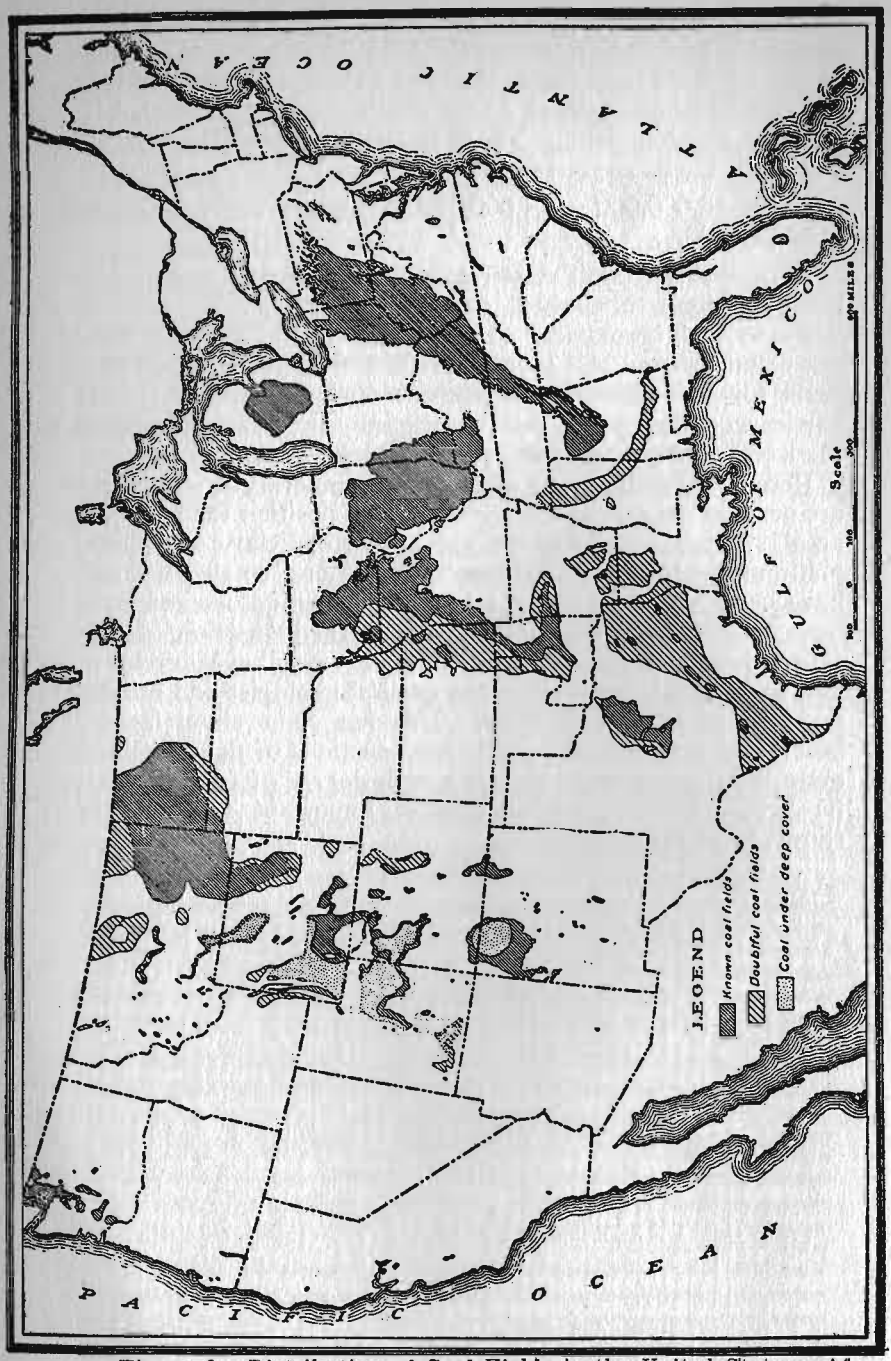


Figure 6. Distribution of Coal Fields in the United States. After Campbell and Parker, United States Geological Survey.

The statistical work of the U. S. Geological Survey is carried on under the direction of twenty or more geologists who have become expert in regard to special mineral industries. Over 62,000 operators report annually the details of their production, but this report is supplemented by personal visits of experts to significant operations in all mineral lines.

Specialization in study of water resources is now common throughout the country. The U. S. Geological Survey maintains twelve district offices in the country and records the stream measurements from over 1100 stations. It also has experts in underground-water studies. A series of reports on this subject for the entire coastal-plain region of the Atlantic and Gulf states has been completed.

Among the subjects covered by the state surveys from year to year may be mentioned those of the 1913 program, as typical. Reports were issued by various states on: Building stone, cement materials, agricultural limestone and marl; stone and gravel for highways, concrete and ballast; clay, shale and fire-clay; asbestos, soapstone, feldspar; salt, gypsum, glass-sand, lithia, rock-phosphate; coal, lignite, peat, petroleum, gas; precious metals, iron, lead, zinc, copper; underground and surface waters.

TECHNOLOGIC STUDIES

Finally a view of investigations of the mineral industries would be incomplete without consideration of *technologic studies*. These are doubtless in progress in innumerable lines by chemists, metallurgists, and engineers employed by corporations and other interests, and the resulting increased efficiency in recovery and utilization of mineral products, and in safety of employes is truly remarkable. Among the lines of public investigation and experiment by the U. S. Bureau of Mines, by various mining schools, and by the state surveys should be mentioned the following:

Increased safety and efficiency in mine timbering, ventilation, hoisting, and in use of explosives and electricity; elimination of explosions due to gas and to coal dust; perfection of processes for by-product coking, briquetting, and for gas-producer operation; recovery of low-grade ores and of colloidal slimes, and other milling wastes; smelting of refractory ores and recovery of waste gases; practical tests of clay materials for extended uses; checking wastes of natural gas and extending the life of oil fields by preventing refrigeration and precipitation in the sands, and by controlling movements of water in the sands.

Truly, the investigation of the mineral resources and industry of the country covers a magnificent field of the highest importance to the nation's life and prosperity. Considering the brief span of years already employed, the knowledge of distribution, character, and utilization of our mineral wealth is surprising. Furthermore, when it is remembered that the most rapid contributions to knowledge and most extensive development in operations have come during the last fifty or even thirty years, the promise for increased efficiency and scientific development and management in the near future is exceedingly bright.