Mineral Industries

VOLUME 27
NUMBER 1

College of Mineral Industries

EXTRACTION · UTILIZATION · EXTENSION · INSTRUCTION · RESEARCH · DISCOVERY · CONSERVATION

The Pennsylvania State University

UNIVERSITY PARK, PA., OCTOBER 1957

– FOSSIL FUELS –
Future Energy Requirements

E. F. Osborn

Just a hundred years ago a revolution began – a change of incredible significance to man and to the world. We are all so busy because of the consequences of this event that we hardly pause to note the centennial.

This was a fuel or an energy revolution with its origin in the Commonwealth of Pennsylvania. The crucial event was the beginning of the petroleum industry.

Commercial refining of petroleum began in Pittsburgh with Samuel Kier's five-barrel still in 1854. The modern petroleum production industry got underway with Drake's well at Titusville, Pa., in 1859. Now in 1957 we are just between the centennials of these two closely spaced and connected events.

Although the span of a hundred years is a comparatively short time even in human measurement and is ordinarily inconsequential in geologic time, this past century plus the next one will put a mark on this earth that will be noticed by all succeeding geologists. Missing will be much of the fossil fuel that took millions of years to store, for it will be in large measure removed from the lithosphere, oxidized, and transferred to the atmosphere.

I would like to look back briefly 100 years to the birth of the oil industry and to the rapid rise of the coal industry in Pennsylvania, then to some of the consequences, and to the problems we face.

(Continued on pages 4 and 5)

SAMUEL M. KIER

Above: Edwin L. Drake (right) and Peter Wilson at the site of the first oil well. (From a picture on loan from the Drake Museum to the Mineral Industries Art Gallery.)

Far left: Kier's original five-barrel still as it looked in 1939 on presentation to the College of Mineral Industries Museum by the Kier family. This "venerable relic of the oil industry" is currently on loan to the Drake Museum, Titusville, Pa. Standing beside the still are J. E. Moorehead (left) at that time executive secretary of the Penn Grade Crude Oil Association and Dean Emeritus Edward Steidle.

An enlargement of this photograph (taken by Edward C. Dana of New York about 1870 – the only photograph known to have been posed for by Mr. Kier) hangs in the offices of the Department of Petroleum and Natural Gas – a gift of Mr. W. K. Cadman (Mining, class of 1913).

Mineral Industries

Published Monthly
from October to June, inclusive
by

THE PENNSYLVANIA STATE UNIVERSITY

COLLEGE OF MINERAL INDUSTRIES

MINERAL INDUSTRIES EXTENSION SERVICES

D. C. Jones, *Director*

Jeanne L. Slobod, *Editor*

PENNSYLVANIA'S COLLEGE OF MINERAL INDUSTRIES

Dedicated to

Instruction and research in all fields of mineral discovery, extraction, and utilization to the end that true conservation – the efficient exploitation of known mineral deposits, the discovery of new deposits, and the development of new techniques for using mineral raw materials not now industrially employed – shall be achieved now and in the future.

DIVISIONS OF SERVICE

EARTH SCIENCES: Geology, Mineralogy, Geography, Geophysics, Geochemistry, and Meteorology.

MINERAL ENGINEERING: Mining Engineering, Mineral Preparation Engineering, Petroleum and Natural Gas Engineering, and Mineral Economics.

MINERAL TECHNOLOGY: Metallurgy, Ceramic Technology, and Fuel Technology.

FIELDS OF WORK

Resident Instruction
Research
Extension Instruction
Correspondence Instruction

Entered as second-class matter at State College, Pa., November 1, 1938, under the Act of August 24, 1912.

OCTOBER 1957

Distribution of Pennsylvania's Underground Bituminous Coal Mines, 1931 versus 1954

George F. Deasy and Phyllis R. Griess*

Significant changes have taken place in the bituminous coal mining industry of Pennsylvania during the past quarter of a century. Total coal production and total number of employees have declined, but stripping production and stripping employees have increased. Mechanization has advanced, and output per miner has gone up. Unionization has spread, wage scales have risen, and the price of coal has advanced. Accidents and fatalities have declined. These and other aspects of the changing bituminous coal industry have been analyzed as to their significance. One facet of the industry, however, has thus far remained unstudied – namely, the changes that have taken place in the geographical patterns of distribution of Pennsylvania's underground bituminous coal mines.

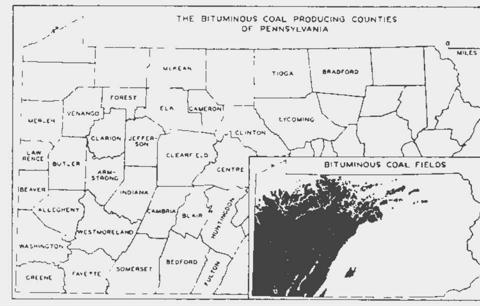
Two maps[1] have been prepared to represent the distribution of all significant[2] active mines at two dates – 1931 and 1954. Each dot indicates the approximate location of an individual mine; no differentiation is made between large, medium, and small mines. A third map, giving the names of the bituminous coal producing counties of the State, is included for identification purposes. No attempt is made to explain the causes for the changes that have occurred in the geographical distribution of mines; such causes are many and complicated, and are beyond the scope of this paper.

Comparison of the two mine maps reveals several basic facts concerning the number and distribution of the underground bituminous coal mines in Pennsylvania. The total number of mines has decreased appreciably between 1931 and 1954, with 1,130 active

* Professor and Associate Professor of Geography.

[1] These maps are based on data obtained from the Bituminous Division of the Pennsylvania Department of Mines and Mineral Industries.

[2] On both maps, mines employing fewer than 5 persons underground are not shown.

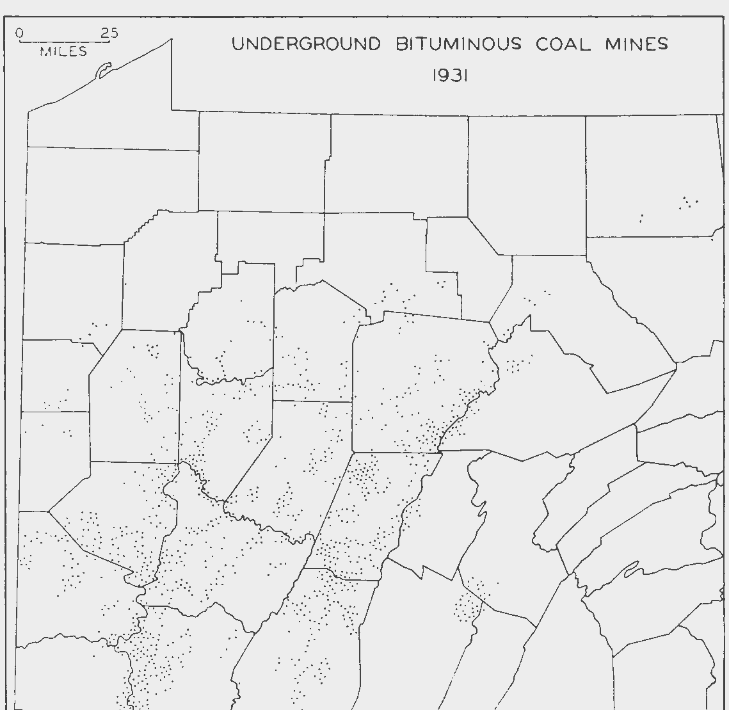


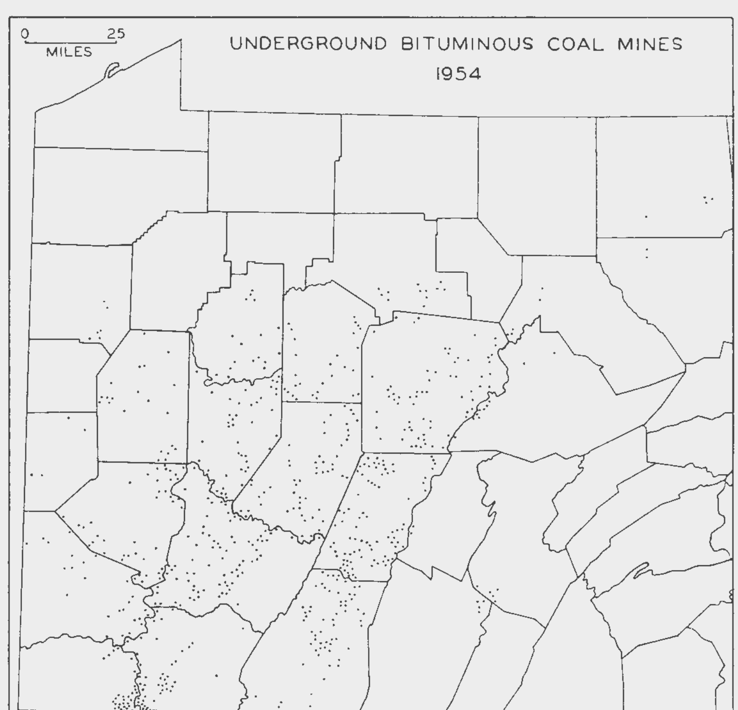
mines in the earlier year and only 653 in the later year. Inspection of the maps further reveals that the broad over-all pattern of mines has remained remarkably stable. With rare exceptions,[3] the same counties that had underground coal mines in 1931 had them in 1954; and the same general northern and eastern limits to mines are found on both maps. Obviously the coal areas being exploited have neither expanded nor contracted appreciably.

However, examination of the internal distributional pattern of coal mines, within the broad regional framework of western Pennsylvania, reveals noteworthy changes. Certain areas with numerous mines in 1931 now have few, whereas some formerly insignificant regions now have a considerable number of mines. A brief analysis of the more important changes on the maps is given below on a county basis.

Allegheny. Underground mines in Allegheny county decreased from 109 in 1931 to 42 in 1954. In the former year mines occupied a continuous belt in the eastern and southern portions of the county, and the belt was sufficiently broad to extend almost to the center of the county at Pittsburgh. Today, remnants of the former belt are found in

[3] Bradford, Fulton, Lawrence, and Venango counties.





two separate groups of mines — one in the northeastern corner of the county and one along its southern margin. Coal mining in Allegheny county thus is becoming more peripheral in location.

Armstrong. Armstrong county had 68 underground mines in 1931, and 41 such mines in 1954. In the earlier year, most mines were located in the western half of the county, with a concentration along the Allegheny River. Today the pattern of mining is reversed, and mines are most numerous in the eastern half of the county.

Beaver. There were 5 underground mines in Beaver county in 1931, and 4 in 1954. Formerly mining was concentrated exclusively in the northern townships; now mines are more widely dispersed.

Bedford. Bedford county's 22 underground mines in 1931 had dwindled to 4 by 1954. No shift in the general location of the mines was possible, for coal is limited to the Broad Top Field in the northeastern corner of the county.

Blair. There were 10 underground mines in Blair county in 1931, and only 2 in 1954. In both years the mines were located along the western border of the county, to which area coal is restricted.

Bradford. Bradford county had one underground mine in 1931, and none in 1954.

Butler. Underground mines in Butler county numbered 40 in 1931, and 21 in 1954. In the former year practically all mining occurred in the eastern half of the county. Now underground mines are dispersed throughout all but the county's southwestern quarter.

Cambria. In both 1931 and 1954, Cambria county had more underground bituminous mines than any other county in Pennsylvania — 145 and 86 respectively. The distributional pattern of Cambria's mines has been remarkably constant throughout the years, only the interior of the county remaining essentially mineless. Three major concentrations of mines are found on both the 1931 and 1954 maps: in the northwestern corner of the county along the headwaters of the West Branch of the Susquehanna River; in the county's southwestern corner along the headwaters of the Conemaugh River; and along the eastern border of the county.

Centre. Centre county's 28 underground mines in 1931 had been reduced to 10 by 1954. In both years mines were confined to the western margin of the county — the only portion possessing coal.

Clarion. There were 21 underground mines in Clarion county in 1931 and 17 in 1954. During the former year most mines were located along two branch rail lines, one in the south-central part of the county and one in the east-central part. In the latter year, mines were dispersed throughout the eastern two thirds of the county.

Clearfield. Clearfield has ranked as one of the more important counties of the state in terms of number of underground bituminous mines, having 102 in 1931 and 66 in 1954. The 1931 mine pattern showed a pronounced concentration in a belt along the eastern border near Moshannon Creek. A lesser number of mines formed a second, parallel, northeast-southwest trending belt through the interior of the county along the West Branch of the Susquehanna and its tributaries. In 1954, the mine pattern remained similar but with a reversal of emphasis between the two belts; the interior belt had now become the more important.

Clinton. There were 7 underground mines in Clinton county in 1931, and 5 in 1954. In both years, mines were confined to the northwestern corner of the county, along tributaries of the West Branch of the Susquehanna River.

Elk. Elk county had 13 mines in 1931 and 12 in 1954. The southern third of the county contained all mines in both years.

Fayette. The declining significance of Fayette county as a coal producer is indicated by the dwindling number of underground mines, from 107 in 1931 to 48 in 1954. In the former year mines were found in much of the western half of the county. Today, mines are limited to a narrow belt along the western border of the county, and to a parallel but less important north-south trending belt in the interior of the county.

Fulton. Fulton county had one underground mine in the Broad Top Field in 1931, and none in 1954.

Greene. Greene is the only county in the State in which there was a marked increase in the number of underground bituminous mines between 1931 (17) and 1954 (31). Mines were confined in both years to a belt near the Monongahela River along the eastern border of the county.

Huntingdon. In 1931 there were 12 mines operating in the Huntingdon portion of the Broad Top Field; by 1954 the number of mines had decreased to 5. The distributional pattern of the mines was the same in both years.

Indiana. Ranking among the leading counties of Pennsylvania in number of underground bituminous mines, Indiana had 80 such mines in 1931 and 54 in 1954. The geographical distribution of mines was essentially the same in both years, the latter year being characterized merely by a decrease in number.

Jefferson. Jefferson county had 38 underground mines in 1931 and 28 in 1954. In both years mines were confined mostly to the western, southern, and eastern margins of the county.

Lawrence. There were 8 underground mines in Lawrence county in 1931, all but one of which were located in the south-central part of the county. In 1954, there were no underground mines.

Lycoming. Lycoming had 1 underground mine in 1931, situated in the northeastern part of the county. In 1954 there were two such mines, located in the northwestern part of the county.

Mercer. All 5 of Mercer county's underground mines were located in the southeastern corner in 1931. By 1954 the number of mines had increased to 6, of which 2 had shifted to the east-central part of the county.

Somerset. In 1931, Somerset county's 108 underground mines were distributed in a broad, irregularly shaped, north-south trending belt, extending through the interior of the county along tributaries of the Conemaugh and Youghiogheny rivers. Mines then were numerous in both the northern and southern portions of the county. By 1954 mines had essentially disappeared from the southern (Youghiogheny River) drainage area, leaving a majority of 61 mines in the north.

Tioga. Tioga county had 7 underground mines in 1931, located in two separate nodes in the southern part of the county. In 1954 the number of mines had been reduced to 4, corresponding in location to those of 1931.

Venango. Venango county had 1 underground mine in 1937; none in 1954.

Washington. Washington county has experienced one of the more drastic decreases in number of mines — a 60 per cent decline from 64 mines in 1931 to 25 in 1954. However, the over-all geographical distribution of mines remained almost unchanged, for the number of mines declined proportionally throughout the county.

Westmoreland. In contrast to most other counties, Westmoreland experienced a smaller than normal decline in the number of underground mines between 1931 (110) and 1954 (79). The most significant change in the mine pattern was the virtual disappearance of mines in the eastern one third of the county, and the reduced concentration of mines in the southwestern portion of the county.

MI Promotions Announced

PROMOTIONS within the College of Mineral Industries have been announced by Dean E. F. Osborn.

From associate professor to full professor: Robert B. Hewes, Floyd A. Hummel, Rustum Roy, and Shiou-Chuan Sun.

From assistant to associate professor: Joseph J. Comer, Phyllis R. Griess, Boris J. Kochanowsky, Malcolm McQuarrie, Evelyn C. Marboe, Arnulf Muan, Howard B. Palmer, John J. Schanz, Robert Scholten, Joseph V. Smith, Charles Drew Stahl, and Harold D. Wright.

Satellite Subject of Talk

"THE EARTH SATELLITE" was the subject of a talk before the Penn State Chapter of the American Society for Metals October 8 in the Mineral Industries Auditorium. The speaker, Alexander Simkovich, Aeronautical and Mechanical Engineer working on Project Vanguard for the Naval Research Laboratory in Washington, graduated from Penn State in 1955 and received his MS in Metallurgy here in 1956. Mr. Simkovich spoke on the problems of designing and selecting materials for the satellite which is expected to be launched this fall as part of the International Geophysical Year projects.

TWENTY-SIX students have made the "Dean's List" in the College of Mineral Industries, Dean E. F. Osborn has announced. This honor is reserved for those students who have achieved an average of 3.5 or better out of a possible 4.0 for the past semester.

Freshmen: L. Robin Brody, Laconia, New Hampshire; Robert R. Luckie, III, Hanover; Russell L. McCarron, Wayne; and James F. Traynor, Philadelphia.

Sophomores: Robert L. Caton, Uniontown; George M. Clark, Boalsburg; David D. Houghton, Media; Harrison E. Hunsicker, Pottstown; James F. Mechlin, Pittsburgh; Donald B. Megahan, Meadville; Walter Mitronovas, Erie; William A. Nystrom, Emporium; Charles W. Racer, York; and David G. Towell, Fillmore, New York.

Juniors: John L. Buchanan, Englewood, Florida; and Charles F. Conaway, Warren.

Seniors: Charles H. Bowman, Pittsburgh; Barron H. Cashdollar, Indiana; Walter Cox, Glenside; Thomas Forkin, Morris Plains, New Jersey; Joseph F. Gregory, Ford City; John A. Leese, Dover; James F. Sarver, Jr., Brackenridge; Stanley J. Sharpe, Wycombe; James E. Stuchell, Punxsutawney; and Robert E. Zartman, Lititz.

— FOSSIL FUELS - Future Energy Requirements* —

(*Continued from page 1*)

Birth of the Oil Industry

Oil and gas have been used by man to a small extent in various parts of the world for hundreds and even thousands of years, but a sizable industry did not develop, and consumption of the fuels was not appreciable, until circumstances were just right; then their increase in use was like an explosion.

The particular circumstance 100 years ago that encouraged men to look into the possibility of large-scale use of petroleum was the demand for illuminating oil. The demand was threatening to outstrip the supply of whale oil, lard, tallow, and beeswax. Kerosene, or coal oil, invented about 1846 and made from cannel coal, was a good but expensive illuminant. Could the Rock Oil, or Seneca Oil, skimmed from seeps in northwestern Pennsylvania by Mound Builders 400 years ago and by later white settlers be commercially refined for use as an illuminating oil? The man who demonstrated an affirmative answer to this question and hence started the petroleum refining industry was Samuel M. Kier.

Samuel Kier of Pittsburgh had been in the oil business for several years prior to his now famous distillation experiments. He had collected petroleum ("devil's tar") rising with the brine from salt wells along the Allegheny River near Pittsburgh, bottled, and sold it as "Petroleum, or Rock Oil — a Natural Remedy." With more oil being available than he could peddle as a medicine, and with the pressing need for a cheap illuminating oil, Mr. Kier looked into the matter of obtaining by distillation a fraction that would be suitable as an illuminant. In 1854 his five-barrel commercial still was in operation in Pittsburgh at a site back of the present Penn-Sheraton Hotel.

With the petroleum refining industry now started and a rapidly accelerating demand for the product developing, petroleum production bogged down. The oil that could be skimmed from the springs in northwestern Pennsylvania and shipped down the Allegheny River to Pittsburgh along with that recovered from salt wells became insufficient to meet the demand.

Into this picture stepped "Colonel" Edwin L. Drake. The modern petroleum production industry was born with completion of his well near Titusville, Pa., on August 27, 1859. Drake demonstrated a practical means of obtaining oil in good supply. The great oil rush was on.

The Coal Industry

The coal industry was not born in Pennsylvania, nor was there a great "coal rush," but we can fairly say that coal production flowered in this Commonwealth. The first system of inland navigation in Pennsylvania had its origin in efforts to get to market the "stone coal" of the Schuylkill, Lehigh, Wyoming, and Lackawanna Valleys.

By the time the oil industry was started, the coal industry was already here to stay. The anthracite industry was underway by 1820, and the bituminous coal industry in the Pittsburgh area by 1830. The canal boat and breaker boys were common sights of a century and less ago which we see no more.

Production Record for Fossil Fuels

Some idea of the manner in which the production of oil, gas, and coal has skyrocketed since the times indicated by these pictures is given by Figures 2, 3, and 4 taken from a recent paper by Hubbert.[2] Production of crude oil for the first hundred years in the U. S. is shown in Figure 2. The curve has been concave upward in trend, indicating an increasing rate of increase, but this rate cannot continue indefinitely. It must pass through an inflection point and become concave downward inasmuch as we are dealing with an exhaustible resource. Hubbert[2] concludes that in the past few years we have passed through this inflection point. The curve for marketed natural gas (Figure 3) begins at a later date but has a very similar slope, again with an indication of a change of slope in the last few years. The coal production curve (Figure 4) reached its inflection point about 1914 and has been zigging and zagging since to the distress of the coal industry. The last large drop coincided with the dieselization of the railroads, and production is again climbing rapidly.

Curves for world production of fossil fuels naturally are similar to those for the U. S., with about half the world's production and consumption being here.

Future Demand for Energy

What is the future?

Even if we look only briefly at the causes of this increase in energy consumption, we must conclude that these curves will keep right on going up at a steep slope provided the energy can be produced fast enough.

In Figure 1 is plotted world population based on estimates of Carr-Saunders and the United Nations.[3] A smooth curve is obtained. This curve also has an increasing slope, and it does not show any indication of a concave downward trend. World population doubled in the last hundred years, and apparently will double again in less than 100 years, perhaps in 50 years. One prediction estimates that India's population will double in 25 years and reach nearly 800 million.[4] China with 600 million people is increasing by 15 million per year. Egypt is increasing at a rate expected to double its population in 40 years. U. S. population is increasing almost 2% a year. This spiral of population increase must level off sometime, and books are being written on what to expect, but the significant point for our consideration here is that with this explosive increase in people using energy we will need to keep energy production going up similarly.

To make the energy requirements figure even more fantastic, however, is the fact that the energy consumed per person in the world is rising rapidly. Many factors are causing this.

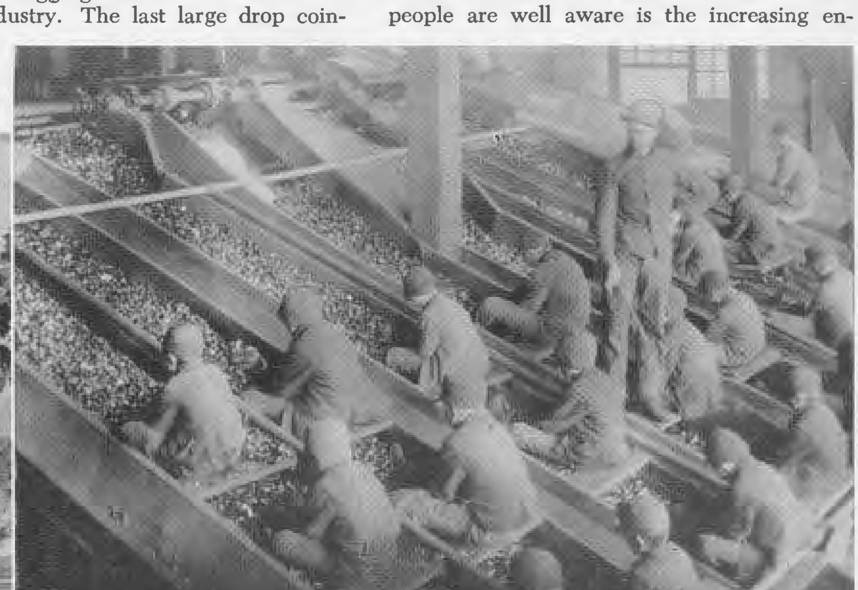
One is the industrialization of the "underdeveloped" countries. Imagine the energy required in a world of 3 to 4 billion people, which we will have shortly, where all have the per capita consumption of energy of people in the U. S. We are moving in this direction rapidly, and estimates for energy consumption are frightening.

Another factor of which mineral industries people are well aware is the increasing en-

* Based on an address by Dean Osborn delivered at Spring Meeting, Central Appalachian Section AIME, May 24, 1957.

Early Days of the Coal Industry

Canal Transportation[1] **Breaker Boys ⇨**



Above: from a photograph on display at the St. Louis Exposition in 1904.

Left: Courtesy Lehigh Navigation Coal Co.

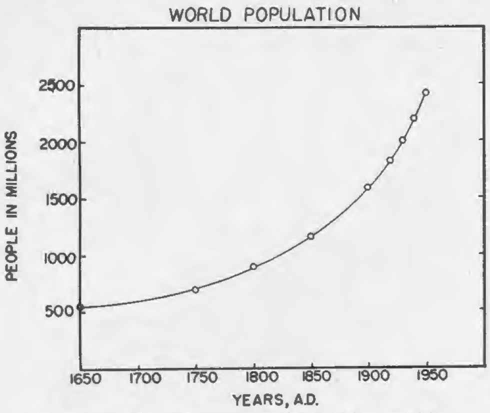


Figure 1: Curve showing change in world population.

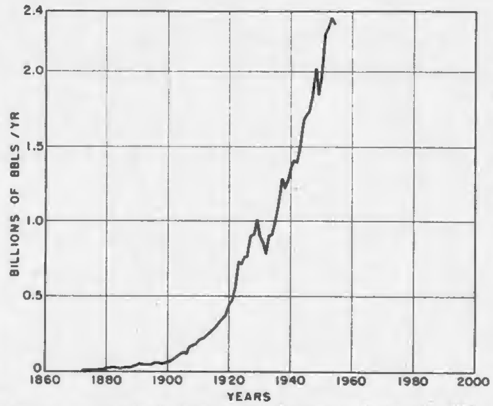


Figure 2: United States Production of Crude Oil (After Hubbert[2]).

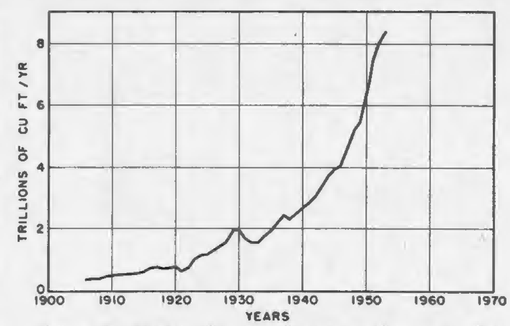


Figure 3: Marketed natural gas produced in the United States (After Hubbert[2])

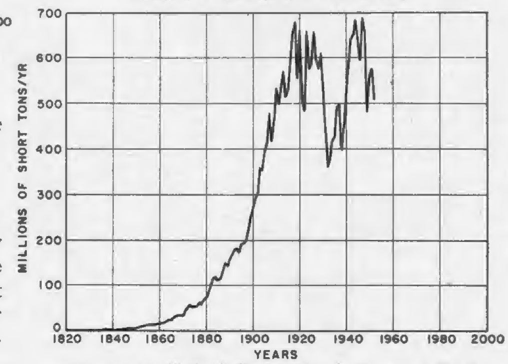


Figure 4: United States Production of Coal United States (After Hubbert[2]).

ergy required to supply the minerals used in increasing quantities, as lower-grade ores are used and more beneficiation is required. For example, iron ore scooped from the soft Mesabi range represented an energy investment of less than 5 kilowatt-hours per ton.[8] The taconite coming in as the soft ores are exhausted is more expensive to mine; it must be finely crushed, the magnetite separated, a fuel in the form of anthracite added, the material agglomerated and then put through a furnace before the finished product is ready to ship. The total energy expended on this blast furnace feed is something like 35 times more than that of the soft Mesabi ores.[8] In addition, steel production, with its vast use of fuel, is expected to increase another 50 million tons in the next 18 years.[5]

Looking at all these factors, the conclusion is inescapable that world energy requirements will double every 10 to 20 years for some time if the energy can be produced.

Can the production of fossil fuels keep up with the demand? In some countries, as for example England, it cannot. This fuel-exporting nation of a few years ago has now gone over the hump. The curves of dropping coal production and increasing energy demand crossed just a few years ago. Britain is importing $700 million worth of oil and coal a year. No wonder the feverish activity there, where an estimated $2.8 billion will have been spent on atomic power generating capacity by 1965.[6]

Reserves of coal, oil, and gas are good in the U. S. and Canada and in some other parts of the world, but can we continue to step up production sufficiently to meet the energy need?

Nuclear Energy

A question mark here is nuclear energy.

There is a mystic touch to the discovery of a means of releasing energy from the atom, just at the stage when humans must have it to avoid a world-wide scramble for fossil fuels and possibly a decay of our civilization.

Nuclear energy potentially available is so large that we really don't have to worry about running out of it. At least at the present there are more pressing problems to worry about. Tennessee and adjoining states alone have about 85 billion tons of shale representing a reserve of 5 to 6 million tons of uranium.[7] If we learn how to get the energy from deuterium, the energy supply is incredibly vast.

The question on nuclear energy is when and how fast we can bring this into the picture, remembering that in order to get nuclear energy we need to consume energy from the fossil fuels. Certain optimists tend to ignore the problems, such as the ashes formed during fission which are a problem in the reactor and a problem to dispose of, radiation danger to humans, and the high cost of this energy. Because of the hazards and because the picture continually changes with progress in research, development work on reactors for industrial power proceeds cautiously and slowly.

Estimates of the rate at which nuclear power generation will develop vary widely; but it is clear that in this country where power generation from coal will be at a low and possibly decreasing cost for decades, nuclear power must be made a lot cheaper before it can compete. Disposal of atomic wastes alone will probably cost a minimum of one mil per kilowatt-hour.

For the next 10 years, at least, nuclear energy cannot even dent the energy requirements of this country. Possibly 20 years from now a fraction of the order of 10 per cent of our requirements will be met by nuclear energy, but in the meantime our energy consumption will have doubled or more than doubled. The effect of nuclear energy on the demand for fossil fuels therefore will be slight – indeed, J. R. Pursglove, Jr., recently predicted that atomic energy installations, which are now one of the biggest users of coal, will use more coal in 1975 than will be supplanted by atomic power.[8]

Unquestionably, for the next 20 to 30 years, which is as far ahead as we can hope to make realistic energy predictions, we must produce in this country fossil fuels at an

(*Continued on page 8*)

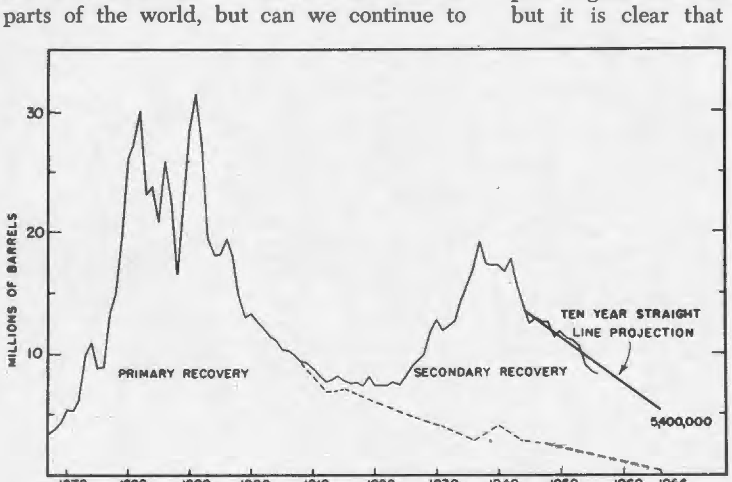


Figure 5: Pennsylvania production of crude oil — showing amounts produced by primary and secondary recovery methods. (Graph prepared by Dr. J. J. Schanz Jr.).

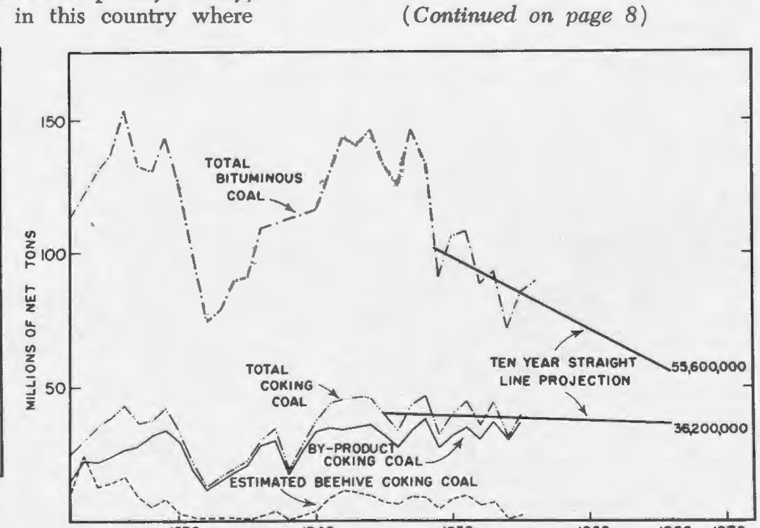


Figure 6: Pennsylvania production of bituminous coal (Graph prepared by Dr. J. J. Schanz, Jr.).

The Zinc Problem — Causes and Possible Solution

John D. Ridge*

Zinc in the Postwar Period

United States mines have produced ore containing at least a half million tons of zinc every year from 1945 to 1956, except 1954, while the total domestic consumption since 1950 has averaged almost a million (961,000 tons) of zinc metal a year. To the casual observer, this might well seem to be the foundation for a sound and prosperous zinc mining industry in this country. Yet today the price of zinc metal is 10 cents a pound or less, and many zinc companies are shutting down their higher cost mines and/or curtailing production from those which they are still operating. This situation exists although the Federal Government is buying zinc for its stockpile at a rate of nearly 150,000 tons a year and collects a tariff of $0.006 per pound on the zinc content of concentrates and $0.007 on zinc metal.

Basically the problem of the domestic zinc mining industry is that, on the average, zinc ore mined abroad and shipped to this country is cheaper. The zinc mining industry suggests that its difficulties could be solved by a flexible set of tariffs which would rise as the domestic price of zinc dropped and decrease as this price rose. In the spring of 1957, the Department of the Interior proposed such a scheme to Congress (this has not been, nor seems likely to be soon, enacted into law) in which the following progressions were suggested — "A" being preferred by the government:

Price (E&MJ, East St. Louis)	Scheme A Ore	A Metal	Scheme B Ore	B Metal
$0.145 or above	$0.00	$0.00	$0.00	$0.00
$0.135 – $0.145	0.06	0.07	0.06	0.05
$0.125 – $0.135	1.30	1.45	1.20	1.25
under $0.125	2.00	2.20	1.80	2.00

In addition to the failure of Congress to provide tariff relief, the Agriculture Department has resumed its program of bartering agricultural commodities for mineral raw materials, zinc included. Although the program is at present more restricted than in the past (zinc metal smelted in the U.S. will not now be accepted), in 1956, 250,000 tons or somewhat more of zinc were acquired through barter which certainly did not improve the zinc market in this country.

All this means that the poor position of the domestic zinc industry, particularly the mining phase of it, is certain to become worse before it gets better.[1]

This unfortunate situation is considered by many as grounds for bringing all the pressure possible on the Federal Government to provide some relief for the industry before zinc mining in this country becomes economically impossible. It is suggested here that something should be done to provide a subsidy from the general income of the nation to keep zinc mining on its economic feet. This relief, however, must not do more harm to other phases of our economy or to our suppliers abroad than can be balanced by gain to our zinc producers. Before making recommendations as to the form such a subsidy should take, the consequences of those methods which have been tried or seriously suggested to meet the zinc crisis must be considered.

This country cannot produce at home, for any reasonable price, all the zinc it needs. From 1945 through 1956, the U. S. had an average excess of consumption over domestic mine production of about 220,000 tons; from 1953 through 1956 this excess averaged nearly 480,000 tons. This domestic production deficiency has been supplied (and oversupplied) by imports. By 1953 these imports had become so large, and the price at which they could be profitably sold in the U. S. so low, that domestic mine production was driven nearly 150,000 tons of contained zinc below that of 1951 (the U. S. maximum). At the end of 1953, the price of zinc was down to $0.10 a pound. In an effort to alleviate this crisis, in 1954 the Federal Government began buying large tonnages of zinc above those needed for the strategic stockpile. Mainly because of a large rise in European demand in that year (a demand which has since continued at about the same tonnages), imports dropped by 135,000 tons in 1954 but then steadily increased to a new, all-time high in 1956 as additional foreign supplies became available. During the 1954-1956 period U. S. prices rose to $0.135 early in 1956 and maintained that level until May 1957. Despite the price rise, U. S. mine production did not regain 1953 tonnages, and the U. S. zinc which went into the supplemental stockpile was more than made up by the rising flood of imports. In 1956 the excess of domestic production and net imports over U. S. consumption rose higher than in 1953, and the $0.135 price was on its last legs. In May 1957 it dropped to $0.115 and by the end of July was down to $0.10. These conditions forced further U. S. production cutbacks and mine shutdowns, and made general the admission that the supplemental stockpiling program had failed.

As long as there is such a huge pressure of foreign zinc to enter the United States, a further drop in price would reduce the U. S. producers' share of the domestic market by a greater proportion than it would that of suppliers abroad because the average producer outside this country can sell zinc in the U.S. market and still make money at a lower price than the average company here can do. In short, unless the Federal Government is willing to stockpile all or nearly all of the tonnage it considers necessary to keep the U. S. zinc mining industry in an economically and technically sound condition, stockpiling will not bring it out of the present doldrums.

Sliding-Scale Tariffs

The solution proposed by the zinc industry is a sliding tariff to be applied to imports of zinc metal and zinc in concentrates. At present prices, the Government's proposal (see above), if adopted, would mean that foreign zinc metal, to be competitive with the U. S. product, would have to be produced at a cost of about $0.09 a pound. Added to this would be the $0.01 a pound cost of shipping it to this country and the two-cent tariff, making a delivered price of $0.12 per pound at East Coast ports. The present price of $0.10 a pound for foreign zinc metal sold in the U. S. (after paying $0.01 freight cost and $0.007 per pound tariff) shows that foreign production costs are not more than $0.08 — a figure well below the $0.09 a pound which must be met if a $0.02 a pound tariff were in effect. Similar considerations govern the import of zinc in concentrates into the U. S. Therefore, the Government's suggestion of a $0.02 a pound tariff when the domestic price is under $0.125 would not appreciably improve the position of the U. S. zinc industry as long as the present relatively low demand in relation to 1955 continues. Nor would the reduction of tariffs as prices rose be any more efficacious in aiding this position although the situation of foreign suppliers probably would be improved.

U. S. Dependence on Foreign Zinc

The point has been raised that U. S. dependence on foreign suppliers for so large a share of zinc consumption (or of that of any other mineral raw material) is undesirable not only because of its effect on domestic mines but also because an increase in demand in other portions of the world might well result in our foreign suppliers selling their product at a greater profit nearer home rather than continuing to supply our needs. This situation might both ruin our own mining industry and at the same time make us vulnerable to the desire of producers in other countries to make maximum profits from their operations. The first charge cannot be denied, but that changes in foreign demand might seriously reduce the amount of zinc available to this country is more subject to question. Over the last three years (1954 through 1956), European consumption of zinc has averaged about 95 per cent of that used in the United States. Even at this high rate it was still possible for foreign suppliers to send nearly 700,000 tons of zinc (as zinc in concentrates and as zinc metal) to the United States in 1955 and over three quarters of a million in 1956. As the 1956 U. S. excess of production plus net imports over consumption was above 300,000 tons, European demand could increase by a third and still leave a substantial margin of foreign production for sale in this country. Therefore, as long as we can produce a few hundred thousand tons of zinc in concentrates a year from our domestic mines we are quite certain of enough zinc, from here and abroad to meet all our needs.

Predicament of "Straight" Zinc Producers

We are probably now in a position to depend entirely on foreign supplies plus zinc that is recovered as a by-product from the concentration and smelting of complex ores. Should zinc demand rise even to 1955 levels in this country and abroad, we should still be able to get all the zinc we need from U. S. complex ores and from imports.

---

* Professor and Head, Department of Mineral Economics.

[1] Much that is said here about the zinc industry generally applies to the lead industry although lead is more likely to be mined with other valuable materials and still commands a price some 40 per cent above that paid for zinc.

In 1955 slightly over 150,000 tons of zinc in concentrates (about one third of the total mined in that year) came from districts in which zinc is the only or the major metal produced. In that year some 90,000 tons of zinc went into the Federal stockpile, and there was in addition a further excess of nearly 50,000 over consumption. Thus, if the straight zinc mine and zinc plus minor lead production had been eliminated in the United States even in 1955, the U. S. would still have been able to meet its zinc needs. This is not to advocate that all such zinc mines should be shut down. Many have already shut down, the production in others has been sharply cut and the elimination of many, if not all, such mines is only a matter of time. Certainly only those mines in this category that operate on a large scale with the most modern equipment can expect to remain in business at the current price of zinc, and even these will be in great danger if the price drops still further. In short, if 500,000 tons of zinc in concentrates a year is a reasonable goal for the U. S. mining industry, something drastic will have to be done to insure that the necessary mines remain in operation. Arguments can be presented that this total should be higher or lower, but it should be at least enough to keep the country in a sound position so far as supplying its zinc needs is concerned.

Subsidies as a Solution

Saying that an annual production of 500,000 tons should be achieved and actually making sure that it is provided are two different things. The industry in general is against payments on the order of those provided by the Premium Price Plan during World War II, stockpiling has failed to provide the answer, and tariffs of the amounts suggested by the administration to the Congress have been shown here to be insufficient to stop the foreign flood of zinc into this country. Tariffs much higher than have been proposed would bar large tonnages of zinc from the domestic market, but the countries most hurt by them would be, in the main, countries whose economies we would like to support and whose collapse would be harmful to us. Thus, despite the industry's dislike of most, if not all, forms of subsidy, this seems to be the best solution. To be effective, however, subsidies should be tied to a definite production tonnage, determined by past performance and future value of the deposits involved and not granted to any tonnage produced by any company. This would require a quota system which would determine the payment per ton for the given number of tons to be assigned to each mine in the country producing or wishing to produce zinc. This system would largely limit U. S. production to the tonnages subsidized and would thereby permit large amounts of zinc to be imported into the country to make up the difference between U. S. production and U. S. consumption. Any company would be permitted to produce any tonnage it wished, but it would be paid a subsidy only on its tonnage quota.

If, at any time, imports were to drop off or demand were to rise, the quotas assigned to U. S. mining companies could be raised to the amount necessary to make up the deficiency. As the amount of the subsidy per ton would vary with the market price, price rises resulting from increased demand would automatically lower the subsidy per ton but would raise the number of tons on which it was paid. Obviously, such quota increases could not be produced immediately, but zinc could be drawn from the Federal stockpile to fill the gap until increased domestic production was realized. If, by the time the larger production was forthcoming, imports were on the way up or demand were going down, the excess zinc being mined here could be returned to the stockpile. If it were found necessary at any time to limit imports to maintain a market for domestic quota production, a quota system could be set up for them as well which could be so designed as to make certain that the nations from which we are most desirous of insuring a steady flow of supplies would have their quotas set high enough to protect their mining industries as well as ours.

The amount of the subsidy paid would have to vary carefully with the price of zinc in the open market, and the tonnages mined under the quota would have to be controlled with equal care to insure that mining would not boom in times of high demand and hit bottom as demand fell off. This is, of course, far more control over his enterprise than the average mine operator would like. However, the situation is now at a point where more than the classic controls of supply and demand must be applied to the zinc market if the U. S. is to retain a going zinc mining industry and at the same time is to be certain of the necessary imports to achieve a supply of zinc sufficient for its needs. Should the situation change, as it will eventually, and we need to step up production in this country, the system of subsidies and quotas could be first liberalized and then abandoned altogether. The greatest danger of such a system is that it would not provide the encouragement for exploration that would be necessary to provide for the maximum exploitation of the country's zinc reserves, known and yet to be found. Perhaps the suggestion already made on the Mineral Economics page (*Mineral Industries*, vol. 26, no. 8, p. 7, May 1957; and vol. 25, no. 4, p. 8, Jan. 1956) that tax relief and/or subsidies be paid for not mining proved ore might provide the necessary incentive for future exploration. Both the subsidies for ore mined and for ore not mined would be charges on the general economy of the nation, but this would be money well spent if a balance between sound mining operations for zinc in this country and a maximum recovery of the known and potential zinc ore available within our borders was insured. The program would have even greater merit if it were combined with a sensible and flexible quota system on imports which would insure our receiving each year approximately the difference between our domestic production and consumption from abroad. To iron out fluctuations beyond the power of the proposed system to control, the stockpile could be used, the Federal Government selling when demand was high and buying when it was low.

TABLE I — Zinc 1945-1957 (Short tons)

Year	Domestic Mine Prod (Zn Content)	Apparent Domestic Cons	Excess Prod & Net Imps Over Cons	Imports	Exports	Price (St. Louis) Av.	Price (St. Louis) Year's End
1945	614,358	852,300	226,908	479,197	14,347	8.25	8.25
1946	574,833	801,300	98,676	376,875	51,732	8.73	10.50
1947	637,608	786,400	103,912	370,271	117,567	10.50	10.50
1948	629,977	817,700	96,872	357,476	72,881	13.59	17.50
1949	593,203	711,800	183,359	368,121	66,165	12.14	9.75
1950	623,375	967,100	73,566	435,019	17,728	13.87	17.50
1951	681,189	934,000	95,066	390,946	43,087	18.00	19.50
1952	666,001	852,800	316,730	565,474	61,945	16.22	12.50
1953	547,430	985,900	281,836	749,345	22,597	10.86	10.00
1954	473,471	886,300	170,440	612,308	29.039	10.68	11.50
1955	514,671	1,119,800	46,121	673,811	21,561	12.30	13.00
1956	537,643	988,100	307,108	770,824	13,259	13.49	13.50
1957 April						13.50	13.50*
1957 May						11.92	11.50*
1957 July†						10.01	10.00*

* Month's end
† In July 1957 the Federal Government took about 11,000 tons zinc for stockpile — 25% of domestic mine output.

MI Faculty Attend Meetings; Present Papers

H. B. Palmer, associate professor of fuel technology, and Roman S. Slysh, research assistant of fuel technology, attended the symposium, "Formation and Stabilization of Free Radicals," held in Washington, D. C., September 18-20.

C. R. Kinney, professor of fuel technology, and P. L. Walker, Jr., professor and head of the Department of Fuel Technology, attended the Conference on Industrial Carbon and Graphite held in London, England, on September 24-27, and gave several papers on various phases of carbon and graphite research being done at Penn State. Dr. Kinney also attended the meeting of the American Chemical Society in New York City, September 9-13, as Councilor for the Gas and Fuel Division.

R. L. Slobod, professor and head of the Department of Petroleum and Natural Gas Engineering, attended the AIME Meeting (Society of Petroleum Engineers) held in Dallas October 6-9 where he served as co-chairman of the session on "Modified Gas Drive Processes."

T. F. Bates, professor of mineralogy, spent several days in August in California collecting lignite samples to be used in research on his AEC Lignite Project. While in the area he attended the 6th National Clay Conference, August 19-23, at Berkeley, California, and presented a paper, co-authored by Joseph J. Comer, associate professor of mineral sciences, entitled "Further Observations on the Morphology of Kaolin-type Minerals."

E. James Moore, assistant professor of geophysics, attended the Seventh Annual Drilling Symposium at the University of Minnesota, October 3-5, 1957. He presented an invited paper on the "Application of Drill Hole Geophysics to Mining Exploration."

(*Continued on page 8*)

Special Issue Planned

In the interest of attracting the high-caliber students who are needed in the field of Mineral Industries at Penn State, a special issue of MINERAL INDUSTRIES for the high school students will be published in November. Readers are urged to send into the editor names of students in the upper third of their class to receive copies of this issue.

Fossil Fuels —

(*Continued from page 5*)

ever-increasing rate. This will be the most critical period to date for the coal and oil industries. Research in all fields of exploration, production, beneficiation, transportation, and utilization must be greatly stepped up.

Research

I would like to return briefly to Pennsylvania for an indication of what can be expected from research.

The curve of petroleum production in Pennsylvania is shown in Figure 5. The second hump, called secondary recovery, was the result of production research. Of the 4 billion barrels in the original reserve, less than one fourth — only 900,000 barrels — was recovered by primary methods. Along with secondary methods we have now gotten about one third of the original oil out of the ground. Our present petroleum production research program is very active, supported by an increased State appropriation in the current biennium. We believe we can put another hump on this curve.

As an example of utilization research, the curve for Pennsylvania production of coking coal is of interest. Although total production of bituminous coal in Pennsylvania has been dropping (Figure 6), that of coking coal remains constant. We intend through research to learn how to upgrade coals so as to maintain this level of production of metallurgical coal as required. Research on coal now going on is making previous noncoking coals useful in coking blends. One of the fastest growing research groups in the College of Mineral Industries is the coal petrology (or anthracological) group[9] which is working on this phase of coal utilization and has industrial and government support amounting this year to $221,000 — a small sum as compared to the cost of the program which must inevitably develop in this field. And this is small indeed, from the standpoint of money, as compared with the research which must and will be done in such fields as combustion, coal transportation, and mining methods.

The two types of research mentioned in the two preceding paragraphs, on production to give more complete extraction and on utilization to upgrade the resource and use it more efficiently, can help to make possible the meeting of the required future demand for fossil fuels.

The federal government, and the state governments and industry too, may wake up to the fact before it is too late that research on coal production, beneficiation, and utilization is a crying and immediate need. Unlike nuclear energy with its military uses and top-secret research, coal is at present in this country a commonplace and abundant material which we know how to produce and burn with reasonable safety. But unless money is poured into research to improve efficiency at all stages, an energy gap can begin to develop which can then be closed only by the familiar, expensive, and wasteful crash program.

The Scientist and Engineer Shortage

But increased production takes increasing numbers of engineers, and the expanded research program that will be required takes increasing numbers of scientists. A very serious and final problem in this picture is the shortage of scientists and engineers. This is threatening to reach disaster proportions and is a general condition throughout the free world. The British government, for example, has recently concluded that it must double its present output of scientists and engineers within the next 10 years[10] and is taking steps to try to bring this about. Considering the vital importance of scientists to our economy and safety in the future, our indifference to their production is one of the wonders of the past two decades. Edward Teller said this spring, "If you extrapolate you will have to say that 10 years from now the best scientists in the world will be found in Russia."[11]

There is a lot we can do to change this dismal picture. Industry is getting behind us in good fashion on our scholarship program and in the support of graduate students through fellowships and assistantships. We now have more than 70 scholarships in the College of Mineral Industries, half of which are for freshmen only, and these, being publicized throughout the State, are attracting more and better students into the mineral science and engineering curriculums. Over 200 graduate students in the Mineral Industries College receive financial support. We look forward to increasing support for all phases of our educational program and in return to expanding service to the mineral industries and government through an energetic research program integrated with the training of tomorrow's leaders in the mineral fields.

References

1. Carl Corlsen, "Buried Black Treasure, The Story of Pennsylvania Anthracite," Fig. 74, p. 51, Owen Publ. Co., Dansville, N. Y., 1954.
2. M. King Hubbert, "Nuclear Energy and the Fossil Fuels," Publication No. 95, Shell Development Co., Exploration and Production Research Division, Houston, Texas, June 1956.
3. "Man's Role in Changing the Face of the Earth," an International Symposium under the Co-chairmanship of Carl O. Sauer, Marston Bates, Lewis Mumford; Edited by William L. Thomas, Jr., The Univ. of Chicago Press, 1956.
4. *U. S. News and World Report*, p. 158, May 17, 1957.
5. *Chemical and Engineering News*, p. 11, May 13, 1957.
6. *Chemical and Engineering News*, p. 48, March 25, 1957.
7. Thomas F. Bates, "Black Shale: Storehouse for Uranium," *Mineral Industries*, V. 26, No. 8, p. 1, May 1957; quoting statement by Jesse C. Johnson.
8. *Chemical and Engineering News*, p. 5247, Dec. 5, 1955.
9. R. R. Dutcher, W. F. Berry, and E. F. Koppe, "Coal Petrology: Aid to Science — Industry," *Mineral Industries*, V. 26, No. 6, p. 1, March 1957.
10. European Scientific Notes, Office of Naval Research, London, p. 96, No. 11-4, April 1, 1957.
11. *Chemical and Engineering News*, ed. page, March 25, 1957.

(*Continued from page 7*)

Benjamin F. Howell, Jr., head of the Department of Geophysics and Geochemistry, attended the meetings of the International Union of Geology and Geophysics at Toronto from September 4-7 as a delegate of the National Academy of Sciences and National Research Council. He presented a paper at the section on Seismology and Constitution of the Earth's Interior on "The Energy Represented by Seismic Waves from Small Explosions."

Harold J. Read, professor of physical metallurgy, presented two papers at the national meeting of the Electrochemical Society held in Buffalo, New York, October 6-10. He presented the introductory paper in a symposium on the mechanism of corrosion in electroplated metals, and with Thomas Whalen discussed recent work on the determination of mechanical properties of electro-deposited metals.

John D. Ridge, Assistant Dean and head, Department of Mineral Economics, represented the College at "A Special Conference on Culm and Stripping Elimination" at Scranton on August 30. The conference was sponsored by the City Planning Commission of Scranton, the Scranton Chamber of Commerce, the Scranton Redevelopment Authority, and the Pennsylvania Department of Commerce. Dr. Ridge discussed briefly the possible lines of research on the problem which could be undertaken by the various departments of the College of Mineral Industries.

Mineral Industries
October 1957