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LORRAINE: Metallurgical Center of France

E. WILLARD MILLER*

Lorraine in eastern France is the major metallurgical center of the nation. In recent years, this region has produced about 96 per cent of French iron ore, 79 per cent of the pig iron, 69 per cent of the steel, and 63 per cent of finished iron and steel products. Besides this dominant role in France's iron and steel industry, Lorraine also plays a significant part in the larger metallurgical complex of Western Europe. The competition between Lorraine and the Ruhr has often been of major importance in shaping the political policies of France and Germany. Lorraine's border position has frequently made it a pawn of war, and for 52 of the years since 1870 all or part of Lorraine has been German territory.

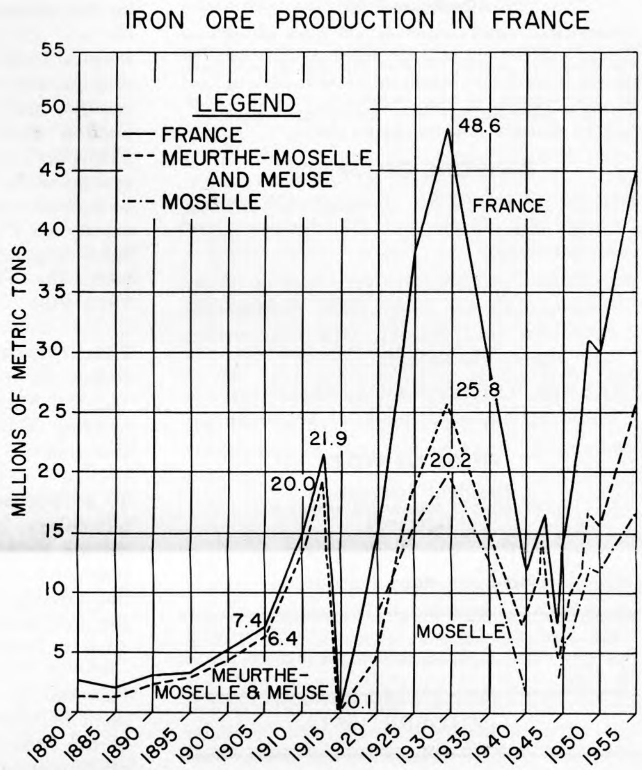

Figure 1

Physical Basis of the Metallurgical Industries

The metallurgical industry of Lorraine rests on the physical foundation of enormous deposits of local iron ore and the availability of some coal (Figures 2 and 3). The Lorraine Minette ore deposit is one of the largest in the world. It outcrops in the escarpment facing the Moselle valley and extends from Nancy in the south to Longwy in the north — a distance of more than 60 miles. The ore deposit, however, is not continuous. Consequently, four distinct iron ore mining basins are recognized — Longwy; Landres, Ottange, and Tucquegnieux; Orne; and Nancy. The iron ore beds dip to the west, and the overburden rapidly reaches 300 feet protecting the ore from surface alteration. Iron ore mining in the vicinity of Conflans is now at a depth of more than 1,000 feet. The thickness of the iron ore bed with 12 workable seams may exceed 150 feet. The beds are remarkably regular with a solid roof facilitating the use of mechanical equipment.

The Lorraine Minette ores are composed of oxides and hydroxides of iron and often exhibit a oolitic structure. From the industrial viewpoint, the low iron content of the ore is now its greatest handicap. The content varies somewhat from district to district, averaging 32 per cent in the Landres district, 36 per cent in the Basin of Nancy, and 31 to 38 per cent in the Basin of Longwy. The ore is characterized by the presence of phosphorous, with the proportions ranging from 2 to 7 per cent. The waste material within the ore varies from basin to basin. In the eastern portion of the seam (Nancy, Ottange, Orne, and Longwy) siliceous gangue predominates, and limestone must be added in the blast furnace as a fluxing material. In the western portion (Landres and Tucquegnieux) there is a predominance of limestone waste, and the ore is self-fluxing.

The reserve of iron ore in Lorraine is enormous. Estimates in 1950 indicated known deposits of 3,595,000,000 tons of calcarious ore and 2,445,000,000 tons of siliceous ore, a total of 6,040,000,000 tons. The ore beds are still not completely defined. Westward the thickness of the beds diminishes, but there are possibilities of extension of the field both west and south.

Coal is found in the Moselle Department of Lorraine as a prolongation of the Saar Basin into French territory (Figure 3). The major mining centers are located in the three districts of Saar-et-Moselle, Petite-Roselle, and Falquemont-Folschviller. The coal is bituminous in nature but until recently was considered noncoking in quality. The deposits dip to the west, with most mines in Lorraine varying in depth from 900 to 1,800 feet. Mining has been difficult because of thin seams, high underground temperatures, presence of water under pressure, great depths, and abundance of faults. Reserves are estimated at five billion tons to a depth of 4,500 feet. This represents half the total French coal reserves.

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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.

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

FIELDS OF WORK

Resident Instruction
Research
Extension Instruction
Correspondence Instruction

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OCTOBER 1958

Ridge is Symposium Speaker

J. D. RIDGE, assistant Dean of the College and head of the Department of Mineral Economics, was banquet speaker on October 3 for the Eighth Annual Drilling and Blasting Symposium held in Minneapolis at the University of Minnesota. His subject was "The Possibilities and Problems of Federal Mineral Subsidies." Howard L. Hartman, head of the Department of Mining, and Boris J. Kochanowsky, associate professor of mining engineering, served as members of the program planning committee.

The Pennsylvania State University is sponsoring the Symposium this year along with the University of Minnesota and the Colorado School of Mines.

The next symposium pertaining to exploration drilling will be held on the Penn State campus on October 8-10, 1959.

THE JOY MANUFACTURING COMPANY of Pittsburgh has given the Department of Mining a powerful, variable-pitch mine fan valued at several thousand dollars for the ventilation laboratory. The new fan enables the department to conduct mine ventilation experiments and research for which no other university in the country is equipped.

College of Mineral Industries Activities

W. A. WEYL, professor of glass technology and chairman of the Division of Mineral Technology, participated in the Conference on Noncrystalline Solids, sponsored by the National Research Council and held in September at Alfred University, Alfred, New York.

JOHN C. GRIFFITHS, head of the Department of Mineralogy, lectured on "Relationships between Reservoir Petrography and Reservoir Behavior in Some Appalachian Oil Sands" at the Petroleum Engineering Conference on Secondary Recovery sponsored by the Illinois State Geological Survey, in Urbana, Illinois on September 25-27.

JOSEPH V. SMITH, associate professor of mineralogy, read a paper on "The Effect of Composition and Structural State on the Rhombic Section and Pericline Twins of Plagioclase Feldspars" at the June meeting of the Mineralogical Society of London and contributed to a conference on feldspars held at the University of Cambridge, England. He has also been appointed editor of the American Society for Testing Materials X-ray Powder Data File.

LESLEY DENT GLASSER, visiting research associate in mineralogy, read a paper on the "Crystal Structure of Chabazite" at the June meeting of the American Crystallographic Association.

T. S. POLANSKY, assistant professor of fuel technology, presented a paper "Effect of Hydrogen Sulfide on the Sulfur Content of Bituminous Coke at 800° to 1000° C," before the Division of Gas and Fuel Chemistry at the fall meeting of the American Chemical Society, September 7-12, 1958.

HOWARD L. HARTMAN, head of the Department of Mining, has been selected a member of the Mine Ventilation Advisory Committee of Bituminous Coal Research, Inc.

BORIS J. KOCHANOWSKY, associate professor of mining engineering, took a 10,000-mile tour of American mining operations and manufacturing plants this past summer. He was the guest of the Harneschfeger Corp. of Milwaukee during a large part of the trip, which included visits to mines in Missouri, New York, Colorado, Utah, Arizona, and California.

HANS NEUBERGER, head of the Department of Meteorology, has been appointed to membership of the Executive Committee of the Division of Earth Sciences of the National Academy of Sciences — National Research Council. His appointment is for the year ending June 30, 1959.

THE PENNSYLVANIA CHAPTER OF KERAMOS, honorary and professional ceramic engineering fraternity, has established the "Frazier-Keramos Student Library" of reference books in the Department of Ceramic Technology.

Mr. J. Earl Frazier, president and secretary of Frazier-Simplex, Inc., Washington (1953 Honorary Member), provided the funds necessary to start the project, and the national office of Keramos has added $100 to the fund for the purchase of the books.

B. F. HOWELL, JR., head of the Department of Geophysics and Geochemistry, was chairman of the Editorial Committee for the book *Contributions in Geophysics Vol. I in Honor of Beno Gutenberg*, issued by Pergamon Press.

E. WILLARD MILLER, head of the Department of Geography, has been appointed chairman of the Program Committee for the 1959 annual meeting of the Association of American Geographers to be held March 30 to April 2 at Pittsburgh, Pennsylvania. He was elected chairman of the Credentials Committee of the Association at its annual meeting which was held in August at Los Angeles, California. Papers were presented at this meeting by Dr. Miller and other members of his staff, Professors Deasy, Griess, Rodgers, and Wernstedt.

J. W. HUNT, associate professor in charge of mineral engineering extension, presided over the general session of the sixth annual general meeting of The Mining Electro-Mechanical Maintenance Association held September 27 near Uniontown, Pennsylvania. Mr. Hunt was also chairman of the technical sessions for the meeting. F. W. Myers, assistant professor of mineral engineering extension, served on the executive committee of the ME-MMA.

CHARLES L. HOSLER, associate professor of meteorology, participated in two institutes for science teachers held this summer under the sponsorship of the National Science Foundation. He delivered lectures on meteorology at the Randolph-Macon Woman's College in Lynchburg, Virginia, and at the Iowa State Teachers College in Cedar Falls, Iowa.

A. K. BLACKADAR, associate professor of meteorology, presented a paper on wind characteristics below 1500 feet at the 2nd National Conference on Applied Meteorology sponsored jointly by the American Meterology Society and the American Society of Civil Engineers at Ann Arbor, Michigan, on September 9, 1958.

J. J. COMER, associate professor of mineral sciences, presented a paper, "Microstructure in ammonium dihydrogen phosphate crystals induced by clays during growth," before the International Conference on Electron Microscopy held in West Berlin September 10-17. Mr. Comer, who traveled on a National Science Foundation grant, also visited electron microscope laboratories in France and England.

VISITORS to the Department of Ceramics September 5-8, 1958 were Professor R. W. Douglas, professor of glass technology, University of Sheffield, England; Dr. J. M. Stevals, Philips Research Laboratories, Eindhoven, the Netherlands and Dr. H. Cole, Pilkington Brothers, Ltd., St. Helens, England. All three participated in a seminar and Professor Douglas presented a colloquium.

H. B. PALMER, associate professor of fuel technology, attended the Seventh International Symposium on Combustion, August 28-September 3. The symposium meetings were held in London and Oxford, England.

Lorraine: Metallurgical Center of France

(*Continued from page 1*)

Origin of the Iron Industry

The availability of widespread local iron ore deposits and of wood for the making of charcoal was the primary incentive to the early growth of the iron industry in Lorraine. By the end of the eighteenth century more than 50 small furnaces were found in Lorraine, with the major concentration in the eastern portion of the area. In the nineteenth century with the depletion of local bog iron deposits and the growing demand for greater production, the iron industry gradually concentrated in the Moselle valley where the Minette iron ore outcrops. Metz and Thionville developed as major iron centers.

The production of Lorraine iron ore increased from about 110,000 tons in 1850 to 1,697,000 tons in 1869. By the 1860's about one third of the iron furnaces of France were located in the Minette iron ore region. Until 1856 charcoal was used exclusively to smelt the iron ore. Gradually coke began to replace charcoal in the blast furnaces, and by 1869 it was the major fuel. On the eve of the Franco-Prussian War of 1870, Lorraine was producing one third of France's iron output. Since the Lorraine iron could not be used in the making of steel because of its high phosphorous content, the steel industry was still in its infancy with Lorraine output being less than 10 per cent of the French total. Nevertheless, a modern industrial complex was emerging in Lorraine by 1870.

With the conclusion of the Treaty of Frankfurt in 1871, Lorraine was divided between France and Germany. The western portion remaining in France became the Department of Meurthe-et-Moselle, and the eastern portion which was annexed by Germany became the Department of Moselle. There is strong evidence that the Lorraine iron ore deposits were of little or no consideration in the demarcation of the political boundary.[1] The Germans were aware of the existence of Lorraine ore because German iron works in the Saar were receiving iron ore from Lorraine at this time. Official French statistics of Lorraine iron ore production were also readily available to the Germans. The Franco-German border was drawn so that France kept the entire iron ore Basin of Nancy and a large portion of the intensively developed northern ore Basin of Longwy.[2] A minor westward shift of the boundary would have given the entire ore deposits of Lorraine, as well as the developed iron industry, to Germany. During this period, however, the German iron industry was being rapidly converted to a steel industry, and the high phosphorous ores of Lorraine were of little interest to the German industrialists.

Period of Partition 1878-1918

The development in 1878 of the Thomas-Gilchrist basic process of making steel gave the first important impetus to the utilization of Lorraine ore. By using this process it was possible to produce steel from the high phosphorous iron ores. As a consequence, a rapid and significant expansion of the iron and steel industry occurred in both the French and German portions of Lorraine. The first plants in Lorraine equipped with Thomas converters were built in 1880.

The development of the iron ore deposits of French Lorraine expanded markedly after 1880 (Figure 1). Production increased from about 1,000,000 tons annually in 1880 to 6,399,000 tons in 1905, and to a pre-World War I peak of 19,629,000 tons in 1913. Until 1900 most of the output came from the Longwy Basin, but after this date production from the deeper Orne, Landres, and Tucquegnieux Basins became increasingly important. Although Lorraine produced about one third of France's iron ore prior to 1878, by World War I French Lorraine was producing between 80 and 83 per cent of the nation's total. The increase in production of iron and steel did not keep pace with the increase in output of iron ore. In 1913 about 40 per cent of French Lorraine's total production was exported, of which about 60 per cent went to Belgium, 25 per cent to Germany, and 15 per cent to Luxembourg. With the outbreak of hostilities in 1914 Germany immediately seized the French Lorraine iron ore deposits and held them until the Armistice in 1918.

During the period from 1878 to 1914 the French Lorraine iron and steel industry developed primarily in the districts of Pont-a-Mousson in the south and Longwy in the north.[3] Output of pig iron rose from 300,000 tons in 1880 to 3,492,000 in 1913. The steel industry also grew rapidly, with production rising from less than 100,000 tons in 1880 to 2,298,000 tons in 1913. Many French iron and steel companies transferred their activities from northern and central France to Lorraine after 1880. By 1913, 72 blast furnaces having a total daily capacity of about 10,800 tons were located in French Lorraine. Since no coal was present in French Lorraine, the area was completely dependent on outside fuel until after World War I. In 1913 approximately 4,074,000 tons of coke were consumed, of which 40 per cent came from northern France and 55 per cent from Germany.

The iron and steel industry of German-occupied Lorraine also grew rapidly after 1878. Iron ore production in Moselle rose from less than 2,000,000 tons in 1880 to 21,100,000 tons in 1913. Of the iron ore mined in German Lorraine in 1913, 11,200,000 tons were smelted locally in 51 blast furnaces. The remainder was sent principally to the Ruhr. German Lorraine in 1913 produced 3,900,000 tons of pig iron and 2,286,000 tons of steel. This was about 22 per cent of the pig iron and 13 per cent of the steel output of Germany. During this period a system of exchange was established between Lorraine and the Ruhr with iron ore and pig iron moving eastward into Germany and coal and coke moving westward into Lorraine. In 1913 German Lorraine produced 3,800,000 tons of coal but consumed 11,000,000 tons. Dependence on coke from outside Lorraine was even greater, with 4,800,000 out of 4,900,000 tons consumed coming from the Ruhr.

In German Lorraine the iron and steel industry was centered in the Thionville district with plants at Audun-le-Tiche, Redange, Knutange, Uckange, and Rombas. Prior to World War I the German and French sections of Lorraine's iron and steel industry developed essentially as distinct units. Only one French company, de Wendel, had plants at Moyeuvre and Hayange in Moselle, and also a major plant at Joeuf in Meurthe-et-Moselle. In the development of Germain Lorraine and the Ruhr, the Germans gave preference to the Ruhr, particularly in the establishment of steel-making facilities. This was mainly due to the availability of coke in the Ruhr, plus the fact that German Lorraine, situated on the border in a contested area, was always considered to have an exposed geographical position.

Lorraine Between World Wars

At the conclusion of World War I, France reacquired the Department of Moselle from Germany. With this annexation the capacity of the iron and steel industry of France was increased between 40 and 50 per cent. However, considerable destruction and deterioration had occurred during the war years. Of the facilities, the iron ore mines had suffered relatively little damage. Apparently the German authorities felt that the future well-being

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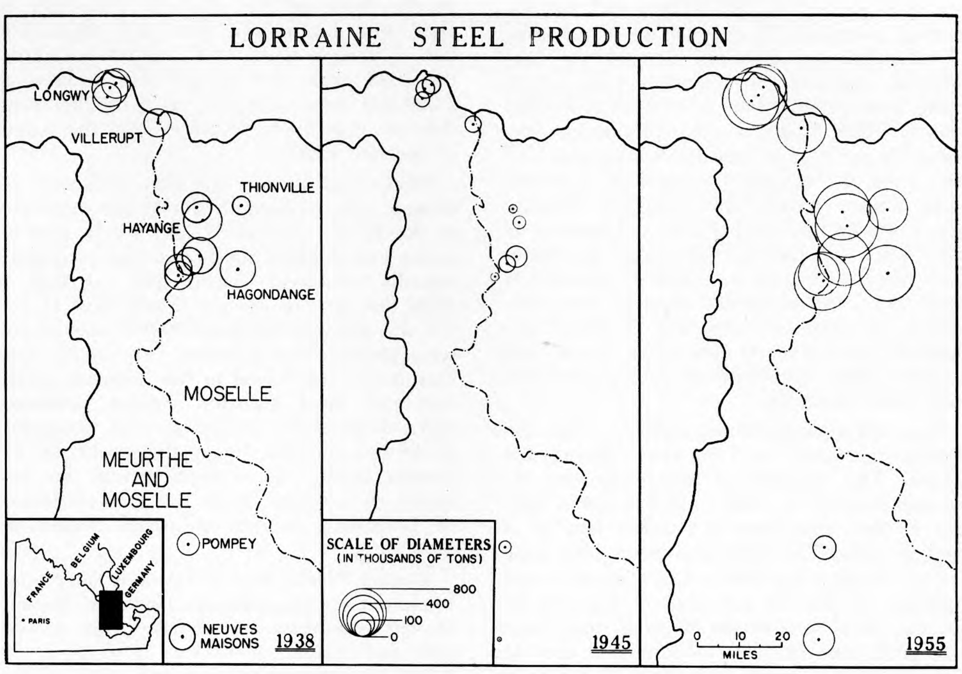


Figure 2

Lorraine: Metallurgical Center of France

(*Continued from page 3*)

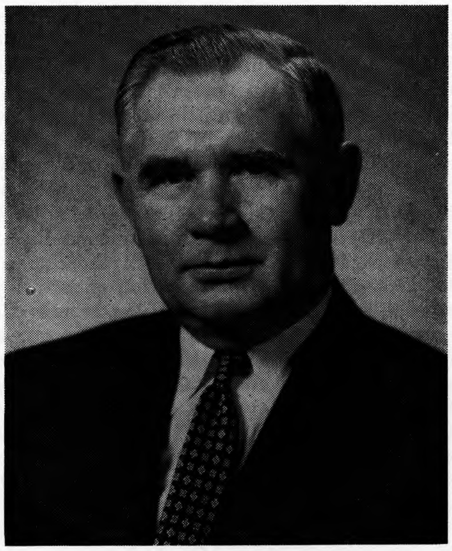
of the German iron and steel industry depended heavily on Lorraine ores.[4] In contrast, there was deliberate destruction of many blast furnaces and steel plants which might have been expected to compete directly with the Ruhr.

In order to rebuild war-torn France, demand for iron and steel was high so that immediate steps were undertaken to revitalize the iron and steel industry of Lorraine. This expansion program persisted until 1929. Initial emphasis was placed on increasing iron ore output. As a result, iron ore production rose from less than 10,000,000 tons in 1919 to 46,058,000 tons in 1929 (Figure 1). During the same period the number of iron ore miners increased from about 10,000 to 26,500. At the beginning of the period the Department of Moselle produced nearly twice as much iron ore as Meurthe-et-Moselle. This situation was soon reversed, and in 1929 Meurthe-et-Moselle was producing 25,827,000 tons of iron ore to Moselle's 20,231,000 tons. The French developed most intensively the iron ore mines that were farthest from the German border.

The output of iron ore during most of the 1920's far surpassed the needs of the Lorraine iron and steel industry which consumed only about half of the production. About 10 per cent was sent to other metallurgical centers of France. The remainder was exported to foreign countries, principally to Belgium and Luxembourg, which together took about 60 per cent of the exports. Importation of French ore by Germany rapidly declined so that during the 1920's this nation took only about 6 to 8 per cent of French exports. The Saar, the Netherlands, and the United Kingdom received most of the remainder of the iron ore exports.

Although Lorraine remained deficient in coal and coke production, output in both of these commodities rose during the 1920's. Coal production increased from 2,510,000 tons to a peak for the 1920's of 6,093,000 tons in 1929. Since the coal of Moselle was noncoking, it was primarily used as steam coal for generating electricity and general heating purposes. In order to gain a degree of self-sufficiency, the coke industry was considerably expanded in Lorraine, with output rising from 119,000 tons in 1919 to 2,163,000 tons in 1929. Lorraine coke production was about 23 per cent of total French output. The coal used in the coking ovens of Lorraine came almost entirely from Germany. Despite this, Lorraine remained greatly deficient in its coke needs and had to obtain large quantities from northern France and from Germany.[5] It must, thus, be recognized that by the early 1920's, although Germany was no longer dependent upon French iron ore, France still required large quantities of coking coal and coke from Germany.

Iron and steel producing facilities were also greatly increased in Lorraine during the 1920's. The number of blast furnaces increased from 95 in 1920 to 204 in 1929. Output of iron rose from 2,417,000 tons to a peak of about 7,900,000 tons during the same period. During the 1920's Lorraine produced between 72 and 80 per cent of the iron of France. Steel production likewise rose from 1,383,000 tons in 1920 to 6,550,000 tons in 1929. This was about two thirds of the total French steel output. A considerable quantity



E. Willard Miller

of Lorraine iron was processed into steel in other French regions because of the lack of local coke. By 1926, France's iron production, including German Lorraine, was nearly 5 per cent greater than in 1913, while Germany's production decreased about 13 per cent from 1913 to 1926, and British output fell about 39 per cent.[6] At this time France's output of iron was second only to that of Germany among European nations.

The 1920's witnessed the consolidation of the Lorraine iron and steel industry into a few large companies. As a result of integration, four companies in Meurthe-et-Moselle in 1930 produced about 50 per cent of the iron and steel of the region, each with an annual capacity of more than 400,000 tons. In Moselle, where the Germans began integration prior to World War I, five works produced 78 per cent of the iron and steel.

With the onset of the world economic depression after 1929, the Lorraine iron and steel industry began a long period of decline. At the depth of the economic depression in 1932 iron ore output was only 26,180,000 tons, a decline of about 20,000,000 tons from the 1929 peak. Iron output also declined to 4,360,000 tons and steel to 3,786,000 tons; this was only 50 to 60 per cent of the output of the late 1920's.

Production of iron ore, iron, and steel recovered only moderately during the remainder of the 1930's (Figures 2 and 4). In contrast to the metallurgical industries, coal production actually increased considerably so that in 1939 the peak of the pre-World War II period was attained when 6,700,000 tons of coal were produced in Lorraine (Figure 3). Coal output was not keyed to the demands of the iron and steel industry. France consumed more domestically produced coal, decreasing its foreign imports during this period of low foreign credit. As a consequence the coal mines of Lorraine were the least depressed of Lorraine's mineral industries during the 1930's.

During World War II Lorraine once again became German territory. However, because of war conditions and the shortness of German domination, there was little or no attempt to integrate the iron and steel industry of the Ruhr and Lorraine. The Lorraine iron and steel industry continued to stagnate during the war years, and output declined to insignificance. For example, in 1945 when Lorraine was once again returned to France, iron ore production was only 7,287,000 tons (Figure 1). During this year only 802,000 tons of iron and 681,000 tons of steel were produced (Figures 2 and 4).

The Monnet Plan

At the conclusion of World War II, it was recognized by government and industry that French manufacturing had to be revitalized if that nation were to regain a stable economy. In 1946 France's economic position was desperate in two respects. Not only was there the problem of the destruction and disruption of industry due to World War II, but the plant facilities were so old and so depleted that France could no longer be considered a major industrial power.

In order to revitalize French industry, General De Gaulle organized the *Commissariat General du Plan de Modernisation et d'Equipment.*[7] The Plan, however, was implemented under the direction of Jean Monnet and is commonly known as the Monnet Plan. The first Plan extended from 1947 to 1953, and the second Plan, now in progress, is to extend to 1958. The primary objective of the Plan was to expand industrial investment and to channel the increase, as much as possible, into six key industries which were basic to the entire economy. These were coal, steel, electric power, cement, agricultural machinery, and transportation. Of these industries iron and steel received the greatest attention as the primary industry in modern manufacturing.

The specific objectives of the 1947 Plan for the redevelopment of the metallurgical industries were as follows: to restore and modernize the productive capacity which had remained largely unused since 1931; to adapt the nature of iron and steel production to the demands of the consumer; to reduce the unit consumption of coke in the blast furnaces and to improve the preparation of the iron ore; and to modernize and expand the supplementary installations such as the coke ovens and iron ore mines.

To implement these plans, both public and private investments were sought in ensuing years. Aid from the United States, under such agencies as the Economic Recovery Program, was instrumental for much of the early success of the Monnet Plan. By the end of 1952 the total expenditure in the metallurgical industries was about 350 billion francs (somewhat over one billion dollars). About 65 per cent of this amount was devoted directly to the iron and steel industries, the remainder being given to subsidiary industries such as iron ore and coal. Because of its importance, Lorraine has received about 80 per cent of total metallurgical expenditures under the Monnet Plan. The influence of the state in the development of the basic industries of France was the most systematic and pervasive of all nonsocialist countries since 1945.

The expansion of production in the metallurgical industries has been obtained in a number of ways. To aid the iron and steel industry, the *Chambre Syndicale de la Siderurgie* has established a Productivity Committee to investigate concrete problems connected with organization, with statistical and accounting methods, and with plant operations on which labor problems have a particularly important bearing. Similarly, with regard to production and production control, the *Association Technique* of the French iron and steel industry offers guidance on engineering problems. There has also been a reorganization of the economic structure of the iron and steel industry. Between 1950 and 1955 mergers reduced the number of French crude steel producers from 24 to 10, thus securing a higher efficiency of operation.

The modernization plans of the iron and steel industry have attempted to raise the efficiency of operations at all levels of production. Before iron and steel production could be increased, there had to be a rise in iron ore output. As a consequence, all operating mines in Lorraine have been modernized. In underground operations, the use of mechanical loaders and electrical transportation has considerably increased the output per worker. To provide greater safety in the mines, a new method of using steel bars for roof support was put into operation. As a result of these and other improvements, iron ore production in Lorraine rose rapidly to 28,250,000 tons in 1950 and to over 44,000,000 tons in 1955 (Figures 1 and 2). The increased production has once again made it possible for France to become a major exporter of iron ore.

Since 1945 there have also been significant attempts to develop the coal resources of Lorraine (Figure 3). Mines have been modernized, and exploitation has extended westward into the deeper seams. Consequently, output of Lorraine coal by 1952 was more than double the pre-World War II peak, and by 1955 annual production was over 19,000,000 tons. Due to increased mechanization the Lorraine coal mines give the highest yield per underground shift in Europe. Because Lorraine coal was noncoking prior to World War II, a research program was inaugurated in 1947 to discover whether this coal could be coked. After seven years of experimentation it was found that by mixing Lorraine coal with others less friable, a good coking coal could be obtained. Although coal from northern France and Germany must still be brought to Lorraine, the metallurgical industries are no longer completely dependent upon outside sources of coke. The coking industry has also been greatly expanded. Within the coal region, Carling, the traditional center, and Marienau, a new center, are major coke producers. Within the metallurgical region six centers produce coke in Meurthe-et-Moselle and three in Moselle.[8] By 1953 the yield of coke from Lorraine coal was about 500,000 tons annually, and additional facilities have been scheduled to raise the total to 4,000,000 tons by 1960. If this goal can be achieved, Lorraine blast furnaces and steel plants will be largely independent of sources of coke from outside the region.

In the iron and steel industry of Lorraine, increased production has been obtained in a number of ways. The most spectacular development occurred at Sollac, near Thionville, where a completely modern integrated steel plant was erected. Less striking but equally important are the attempts to increase efficiency in the older plants. The greater preparation of the ores by crushing and sintering not only has insured a more regular operation of the blast furnaces but has provided a substantial saving of fuel and a reduction in the tonnage of ore consumed per ton of iron produced. There has been a major trend toward fewer but larger blast and steel furnaces, resulting in greater output with proportionately less labor. The gradual replacement of old handmills by mechanized semi-continuous or continuous mills has not only raised output but improved the quality of products with no increase in the labor force. In the same way, mechanization in general, increased thermal efficiency, and the rational organization of transport inside the plant have aided productivity. As a result, iron production rose to 6,460,000 tons by 1950 and to 10,580,000 tons in 1955. Steel output reflected the same trend, rising to 5,950,000 tons in 1950 and to 10,400,000 tons in 1955. By 1952 the previous peak of 1929 had been surpassed in the iron and steel industry (Figure 4).

The expansion of the Lorraine iron and steel industry has provided adequate steel not only for domestic industries but has given France a significant surplus for export. Within recent years French net exports of finished steel have become more than twice as large as those of the United Kingdom or West Germany and much larger than French net imports of engineering products.

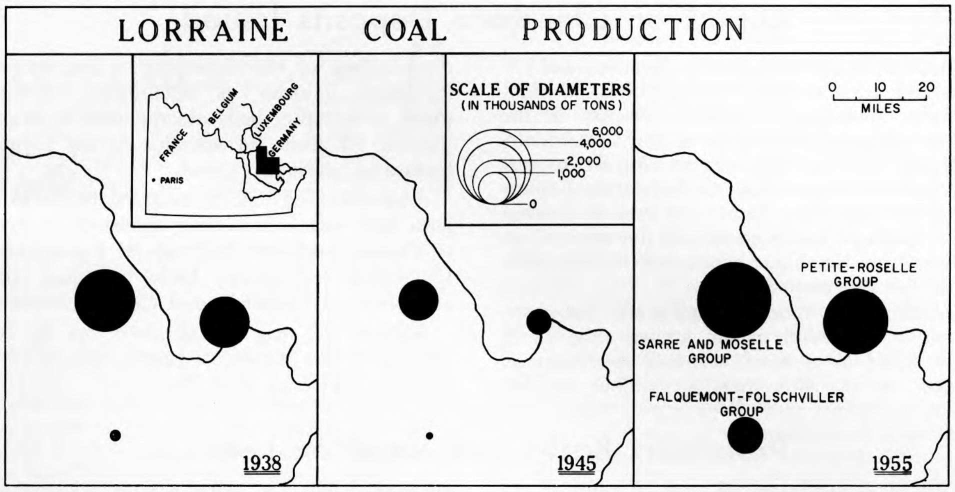


Figure 3

European Coal and Steel Community

The political splintering of the metallurgical region of Western Europe has created many problems. Most present-day European leaders believe that the economic rivalry of Europe is a major cause of conflict. Since World War II, there has been much consideration as to how economic problems of an international nature can be solved. A major proposal to attack these problems was made on May 7, 1950, by Robert Schuman, then French foreign minister, who offered to pool French coal and steel production with that of West Germany and of any other European country prepared to yield national control to an independent supranational authority.[9] The primary purpose of the Plan was the fusion of interests and the creation of economic and political solidarity to eliminate the age-old enmity between France and Germany, making war between the two countries "not only unthinkable, but materially impossible."

After considerable negotiation, six countries — France, West Germany, Belgium, Italy, the Netherlands, and Luxembourg — founded the group now known as the Euro-

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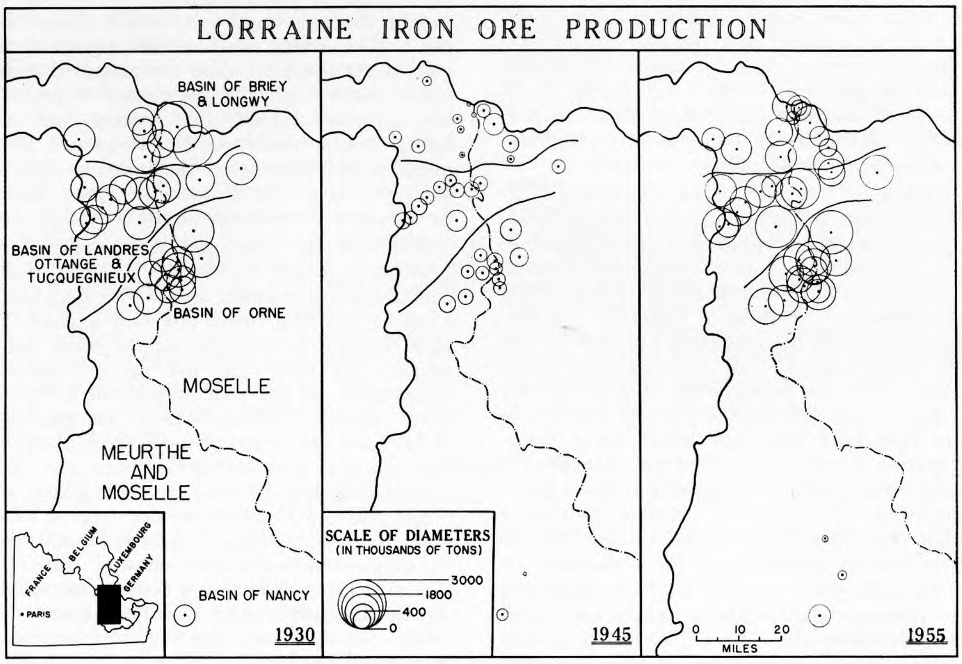

Figure 4

Report on Limestone Deposits Issued

Details of the composition, location, and extent of commercially-valuable beds of high-grade limestone in Franklin County in the area between Chambersburg and Greencastle, Pennsylvania, are given in Bulletin 71, recently issued by the Mineral Industries Experiment Station. The bulletin is one of a series of reports of investigations of the mineral resources of the State conducted by the Mineral Conservation Section.

Millions of tons of high-grade limestone have been added to the known reserves of the State as a result of this investigation. Some of the limestone is suitable for the manufacture of chemical lime or for use in the steel industry as open-hearth fluxing stone, while other beds are reported as being suitable for blast furnace flux or the manufacture of portland cement.

Accompanying reports included in the bulletin deal with iron-bearing sandstone in Perry County and with methods of tracing and identifying sedimentary beds, including coal and clays, in Clearfield and Centre Counties.

Bulletin 71 may be obtained for $1 by writing to the Mineral Industries Experiment Station, University Park, Pa.

Professors Bates and Read on Leave

Two M. I. professors are now on leave of absence.

Thomas F. Bates, professor of mineralogy, is on a year's leave to study the formation of clay minerals in the Hawaiian Islands beginning September 1. He has been named Visiting Colleague in Soil Science at the University of Hawaii in Honolulu. In support of his trip Dr. Bates has received a Senior Post-doctoral Fellowship from the National Science Foundation. During the 16 years he has been at Penn State, Dr. Bates has been engaged in research on clay minerals and their mode of formation.

Harold J. Read, professor of physical metallurgy, is on sabbatical leave from August 1, 1958, to January 31, 1959. Dr. Read will devote his time to research and writing. He is studying the tensile strength and ductility of electroplated protective coatings and the relationship of these variables to the corrosion resistance of the coatings.

Lorraine: Metallurgical Center of France— (*Continued from page 5*)

pean Coal and Steel Community. The High Authority of the ECSC began its functions in August 1952. The fundamental purpose of the Community is the development of a single market through the establishment of conditions which assure the most rational distribution of production at the highest possible level of productivity, while safeguarding employment and avoiding economic disturbances. To initiate the plan, the common market for coal, iron ore, and scrap was established on February 10, 1953, and for steel on May 1, 1953. At this time the custom duties, quantitative restrictions on imports and exports, discrimination in transport rates, and dual pricing practices between the countries of the ECSC disappeared in principle. The ECSC is accomplishing the above objectives in three major ways: by gathering and publishing information and organizing consultations; by placing financial means at the disposal of individual enterprises; and by direct power of control in accordance with the provisions of the treaty but only when circumstances make it absolutely necessary.[10]

Although the ECSC was initiated by France with the ultimate objective of European economic integration, France hoped to gain immediately a more significant position for Lorraine in Western Europe, particularly in relation to the Ruhr of Germany. For decades the Ruhr has surpassed Lorraine in iron and steel output. This superiority is based partly upon the availability of high quality coking coals and partly upon its position in the Rhineland with unexcelled water transportation facilities. In contrast, Lorraine is served essentially by a network of land transportation. Consequently, Lorraine occupies a high cost position in regard to assembly of coal and the marketing of its products.

Lorraine prior to 1952 was also burdened by transport discrimination and excess tariff charges on freight. The ECSC has been successful in abolishing many of these discriminatory charges. For example, between 1952 and May 1957 the cost of shipping a ton of Ruhr coal to Lorraine decreased from 2,300 French francs to 1,600. With the electrification of the Thionville-Coblenz railway the rates will be further decreased.

In order to connect Lorraine with the Rhineland's water routes, the French stipulated on the establishment of the ECSC that one objective of the Plan should be the completion of the Moselle Canal extending from Thionville to Coblenz.[11] Transport experts have calculated that the canal would reduce the cost of sending a ton of Ruhr coal to Lorraine by 50 to 60 per cent and of shipping a ton of rolled steel from Thionville to the world market (through Rotterdam instead of Antwerp) from 2,300 to less than 800 francs. Such a significant reduction in freight charges would substantially lower the price of Lorraine steel in the international market. At the same time the proposed canal would make it possible for France to provide iron ore more cheaply to Germany than any foreign source could. As a consequence, Germany would once again be linked to France by Lorraine ore as France has been bound to Germany in its need for Ruhr coal.

Although the iron and steel industry of Lorraine had long favored the building of the canal, much opposition arose. The steel magnates of the Ruhr were adamant against the plan. Regarding Lorraine as its major competitor, the Ruhr did not favor expanded competition. In the past decade the Germans have pointedly refrained from the purchase of Lorraine ore to complement the high-grade Swedish ores and low-grade local ores. The railways of both France and Germany opposed the canal, which would deprive them of a profitable business. Even the French steel industry outside Lorraine showed little enthusiasm for the canal, for these areas would remain dependent upon high-cost railroad facilities for their raw materials and shipment of finished products.

Nevertheless, the government of France has consistently believed the canal to be fundamentally necessary to the economic welfare of the iron and steel industry of Lorraine. As a consequence, on October 27, 1956, Germany signed a treaty to cooperate with France in the construction and financing of the improved water route in return for political and economic sovereignty in the Saar. The construction of the Moselle Canal of 175 miles, costing $150 to $180,000,000 and lying almost entirely in German territory, began in the summer of 1957.

The ECSC has made considerable progress in establishing a single market for iron and steel in Western Europe. Nevertheless, there is evidence that problems still exist. Lorraine steel makers believe that excessive freight rates are charged for transport of coal from Germany, whereas for iron ore they are artificially low. The French conclude that through the large outlay on the transport of coal Lorraine is, in reality, subsidizing the cheap transport of iron ore on the German railroads. It is also believed that the Ruhr continues to give preferential treatment to other German areas. For example, it has been calculated that for a haul of 200 miles the transport of a ton of Ruhr coke would cost 32 shillings if its destination were Lorraine, but only 23 shillings if its terminus were within Germany.

The ECSC has not proved to be a panacea for solving immediately all long existing problems. Progress is being made. The European Coal and Steel Community has laid the foundation for further cooperation as exemplified by the establishment of the European Community of Atomic Energy and European Economic Community on March 25, 1957. The leaders of the six cooperating European nations hope that from economic union a united Europe will eventually evolve.

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Natural Gas Liquids — Stepchild of the Oil Industry

W. Gibson Jaworek*

In the past the natural gas liquids industry was the stepchild of the oil industry, since it marketed the uneconomic by-products of the oil and gas reservoir. In a sense its position has been somewhat analogous to the natural gas industry itself, which for many years was a by-product of petroleum. With the growth in the demand for natural gas, the supply of liquids contained therein grew correspondingly. In 1957 these liquid products accounted for 3.3 per cent of the energy consumed in the United States — more than twice the energy content consumed from anthracite, and only slightly less than the thermal equivalent of hydro-electric power. When this amount is added to the natural gas percentage it amounts to 28.9 per cent of our energy consumption, a larger figure than for the entire coal industry, bituminous and anthracite.

Natural Gas Liquids Defined

The natural gas liquids industry is an unfamiliar one to most outside the industry and even to some within other phases of the oil industry. Natural gas liquids, unlike petroleum and natural gas, are not a uniform commodity, and are classified under various names. These include natural gasoline, distillates (not to be confused with refinery distillates), condensates, liquefied petroleum gas (LPG), and liquefied refinery gas (LRG). Each of these is a liquid contained within natural gas. The variations in natural gas liquids result from the differing source materials and methods of separation. Natural gas liquids are manufactured or recovered at the oil or gas well itself, at oil refineries, at natural gasoline plants, at cycling plants, and in recent years at the terminals of long distance natural gas transmission lines.

A commonly accepted definition of natural gas liquids is: "those liquid hydrocarbon mixtures which are gaseous in the reservoir but are recoverable by condensation or absorption." Natural gasoline, condensate, and liquefied petroleum gases fall in this category. Such liquids need not be derived from natural gas; they may be extracted from crude petroleum. Natural gas, from which less than one-half of U. S. production of natural gas liquids is derived, is a mixture of gaseous hydrocarbons consisting predominantly of a series of compounds known as the paraffin series. However, at different temperatures and pressures these compounds may be either in the liquid or gaseous phase. To distinguish natural gas liquids from crude petroleum, pentane ($CH_3(CH_2)_3CH_3$) is commonly considered the heaviest of the natural gas liquids, although natural gasolines may contain hydrocarbons of higher molecular weight. All the hydrocarbons comprising natural gas can, of course, be cooled or compressed to form natural gas liquids, but under the usual conditions of temperature and pressure methane and ethane remain in the gaseous state.

Further divisions of natural gas liquids may be made on the type of geological environment or mode of occurrence. Associated gas or "wet" gas, which is produced in conjunction with petroleum, is sometimes termed casinghead gas. "Wet" gas, however, is somewhat a misnomer, as gas from reservoirs of nonassociated or dry gas reservoirs also contains liquids. In Table I a typical breakdown of a "wet" gas is shown, giving the type of products which are recovered and the compounds which make up these products. It can be seen that there is some overlapping of compounds between the different products. Condensate is roughly equivalent to the composition of natural gasoline, although it is derived from an unassociated or "dry" gas reservoir. The nonhydrocarbon compounds are usually found in very minute amounts and are economic only in isolated instances.

The Future Outlook For Natural Gas Liquids

Today natural gas liquids have become the products of a significant industry competing with petroleum and natural gas. A recent statement by an oil industry official illustrates just how far gas liquids have encroached upon the United States energy market. He stated that crude production was being squeezed from both ends — by the increased foreign imports and by natural gas liquids.

Just how important are gas liquids to oil companies? The sales of gas liquids play a large part in the profitability of their natural gas operations. Federal regulation of natural gas producers has required gas operators to seek other means of recovering the increased costs of exploration. The combined receipts of natural gas and extracted liquids can make such operations profitable.

The two chief problems for further expansion of the industry — transportation and storage — are rapidly being solved. When a steady supply-demand condition can be maintained by putting excess stocks into storage, a better price structure can be maintained. A good example of this condition is a recent price increase in natural gas liquids when it appeared that summer production would not cause excess surpluses for the coming winter. According to an industry spokesman, the stocks of LPG on hand during the coming winter will be the best in the industry's history. Besides storing excess summer production, the industry has pushed the sales of gas liquids in the summer agricultural market for such uses as flame weeding, flame ripening, dehydration, and water pumping.

Another market outlet for excess production has been found in various secondary oil production methods which use liquid hydrocarbon condensates. The newest method being developed is termed "miscible phase displacement." In this method, gases, which are miscible with oil and gas or which will become miscible after entering the reservoir, are utilized to create a "slug" which will displace the residual oil and move it toward the producing well. Laboratory experiments using this process on a small scale indicate almost complete recovery of the residual oil from the reservoir sand. Field tests have been run and show technical promise. However, considerably more experience will have to be gained before the economic potential of "miscible phase displacement" becomes definite.

Natural gasoline is probably in the weakest marketing position of the various natural gas liquids. As long as gasoline specifications become more and more oriented to octane number, natural gasoline must suffer. Currently there are two trends which could reverse the presently stable, or slightly declining, market. First, there is increased emphasis on further processing. This involves larger capital outlays but strengthens the position of natural gasoline plants in the competitive market. Manufacturing facilities at larger plants will be expanded to include catalytic reforming with either isomerization or a combination with alkylation. These processes give closer control on natural gasoline and LPG specifications and give hydrocarbons for which there are special demands. For example, isobutane consumption by refineries and petrochemical plants could be greatly increased, but so far the economics of such operations have not proved attractive enough to bring widespread use of butane isomerization units.

The second trend in natural gasoline processing is to move unprocessed, widely varying specification liquids to refineries where the major processing can be done. This indicates that the installations of refineries may incorporate the fractionation of not only the crude but also the output of gasoline plants. Refineries of this type most likely would be financially linked to the gasoline plants.

Liquefied petroleum gas is the brightest spot in the gas liquids picture. According to recent estimates, consumption of LPG will increase from 6 billion gallons in 1958 to 9-10 billion gallons in 1965 and to 12.5 billion gallons in 1975. The largest part of this increase will be in the petrochemical market. These highly lucrative markets are just beginning to discover the usefulness of gas liquids, and it is impossible to estimate the number of new chemicals which may be dis-

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TABLE I
Typical Breakdown of a "Wet" Natural Gas

Nonhydrocarbons	Dry Gas	Liquefied Petroleum Gas	Natural Gasoline
Helium	Methane	Propane	Isobutane
Nitrogen	Ethane	Isobutane	Butane
Carbon Dioxide	Propane	Butane	Isopentane
Hydrogen Sulfide			Pentane
Sulfur			Hexane
			Heptane

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NSF GRANTS RECEIVED

THE NATIONAL SCIENCE FOUNDATION has made three grants to the College of Mineral Industries.

J. V. Smith, associate professor of mineralogy, has received $15,000 for a two-year period of research on the amphibole group of minerals.

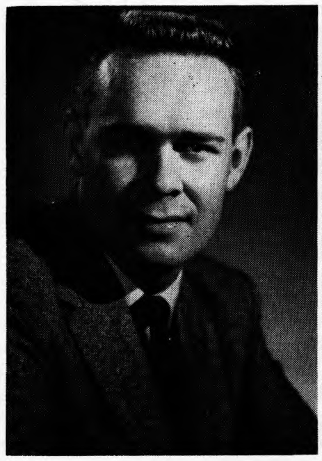
This study has three objectives: first, the development of rapid methods of identification based on chemical and physical methods; second, the delineation of the structural variations; and third, the use of the new information in an investigation of the relationships between the properties of the amphiboles and the rocks which contain them.

G. W. Brindley, professor of solid state technology and head of the department of ceramic technology, will direct a grant of $34,000 for a three-year period of research on thermal reactions in ceramic systems. The research will be concerned with how the atomic structures are reorganized and the rates at which new nuclei form and grow.

The Foundation has renewed for the third year its support of basic research in the division of earth sciences. Under the direction of O. F. Tuttle, chairman, Division of Earth Sciences, a grant of $10,000 for a one-year period has been made to complete studies on silicate systems and to explore the melting temperature in water-carbonate systems.

A COOPERATIVE research program in rock mechanics has been entered into by the Imperial Coal Corporation of Johnstown, Pennsylvania, and the Department of Mining at the University. The company is providing a financial grant and underground facilities for a study of roof and floor conditions in the mine with the objective of minimizing the problems encountered with rock strata overlying and underlying the coal seam being mined.

Mineral Industries Adds Three to Staff



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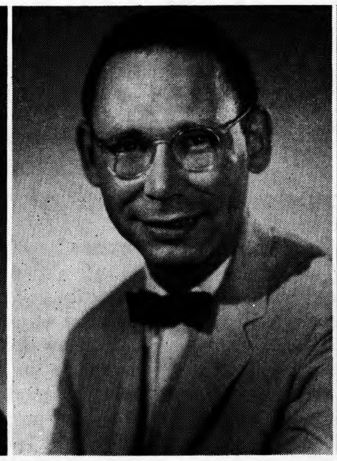
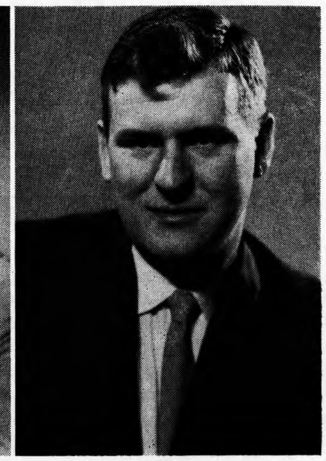


Schmalz



Duquet

NORMAN SUHR, ROBERT F. SCHMALZ, and ROBERT T. DUQUET are new members on the staff of the College of Mineral Industries.

Norman Suhr has been appointed spectroscopist for the Mineral Industries Experiment Station. Mr. Suhr received has A.B. and M.S. from the University of Chicago where he is now a candidate for the Ph.D. degree. He was previously employed by the Heavy Minerals Company in Chattanooga, Tennessee. His field of work is the spectrographic analysis of rare earths. He is a member of Sigma Xi.

Mr. Schmalz, assistant professor, comes to the Department of Geology from Harvard University where he anticipates receiving his Ph.D. degree in February 1959. The subject of his doctoral dissertation is "A Technique for Quantitative Modal Analysis by X-ray Diffraction and Its Application to Modern Sediments of the Peru-Chile Trench." Mr. Schmalz has made geological field investigations in Tunisia, New Mexico, and the Rocky Mountain area and has published several technical articles. In 1955 he served as research chemist with the Directorate of Medical Research in the Army Chemical Center.

Mr. Duquet has joined the Department of Meteorology as assistant professor. A native of Canada, Mr. Duquet received his B.Sc. from Loyola College in Montreal, his M.A. from the University of Toronto, and expects to receive his Ph.D. from New York University in January, 1959. He has worked as Independent Forecaster for the Department of Transport in Canada and was an instructor in meteorology at New York University from 1955 to 1958. He has published two papers on cyclones.

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Ridge Represents University on Cruise; Tours Mines

J. D. RIDGE, assistant Dean of the College of Mineral Industries and head of the Department of Mineral Economics, served as representative of the University on a cruise with the U. S. Second Fleet from Norfolk to Lisbon, Portugal, June 8 to June 25. He observed the operations of the various units of the fleet, the working of the staff of the vice-admiral commanding, and the training of midshipmen, Naval Academy and NROTC.

After his arrival in Europe, Dr. Ridge visited mining districts in Germany and Scandanavia. He obtained typical suites of ore minerals from the various mines to add to the economic geology collections of the College of Mineral Industries which are now among the most complete in the country.

He also visited the Mineralogical and Petrographical Institute at Heidelberg, the Deutsches Museum in Munich, and the Swedish Geological Survey in Stockholm.

Former PNG Head Dies

DR. SAMUEL T. YUSTER, head of the Department of Petroleum and Natural Gas Engineering at Penn State from 1946 to 1949, died on July 3 at the Kaiser Foundation Hospital, Los Angeles, California.

Dr. Yuster came to Penn State in 1934 and resigned in 1949 to head work in petroleum and natural gas at the University of California at Los Angeles. At the time of his death, he was engaged in research on the production of petroleum and on the reduction of smog by altering automobile exhausts.

Natural Gas Liquids—

(*Continued from page 7*)

covered. However, in the case of the synthetic rubber market there will be little growth unless a national emergency occurs which would shut off our supplies of natural rubber from Southeast Asia. Of the other LPG markets, internal combustion engines give the best indication for substantial growth, but, of course, this will depend to a large degree on improvements and innovations in engine technology. The gradual extension of natural gas to those areas not already served will decelerate LPG's growth in the domestic, commercial, industrial, and gas utility markets.

In summary, the future of natural gas liquids looks extremely bright, with many developments depending upon the advance of technology. In any case, it seems assured that natural gas liquids will play an important part in supplying energy and power in the years to come and will no longer be the weak sister of the oil industry.