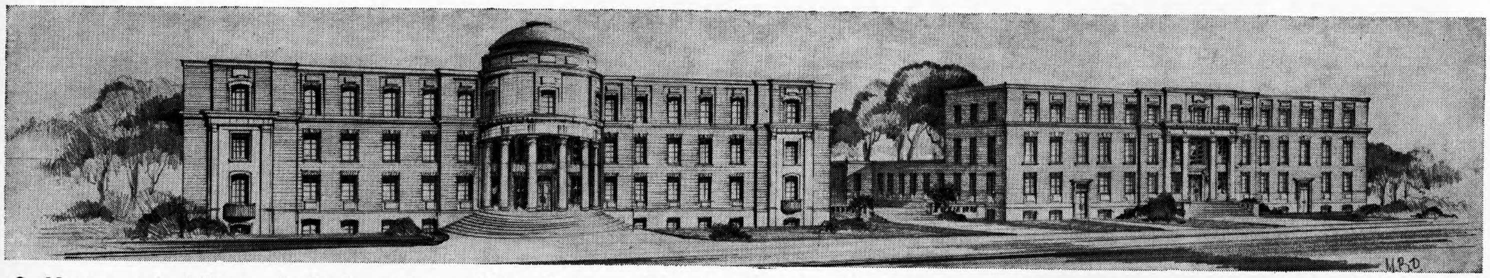
Mineral Industries



College of Mineral Industries, The Pennsylvania State University, University Park, Pennsylvania

VOLUME 30 NOVEMBER 1960 NUMBER 2

Strip Pits and the Sanitary Landfill Process

George F. Deasy and Phyllis R. Griess*

An acceptable method of disposing of waste materials from urban centers is a growing necessity if the public is to be properly served. Interest is centering to an increasing extent upon the sanitary landfill process of waste disposal, because it is low in initial and maintenance costs and at the same time meets all standards of health, safety, and esthetic acceptability. Abandoned bituminous coal strip pits lend themselves admirably to such a process, and urban centers in western and central Pennsylvania should fully utilize the many opportunities afforded by accessible pits as foci for accumulation of waste. Such use offers the additional advantage of providing a cost-free method of removing some of the scars of earlier stripping operations from the Pennsylvania landscape, and may enable some cities and towns to acquire valuable urban, suburban, and industrial land sites that can be employed for community purposes or sold for profit. This study is an initial survey of the opportunities for employment of strip pits as sanitary landfill sites by the scores of urban centers in the western and central parts of the Commonwealth.

Introduction

As urban and suburban areas grow larger and more populous, as their inhabitants become more affluent and can afford to replace old products with new, as the trend toward packaging continues at an accelerated pace, and as standards of sanitation rise, civil authorities in the cities and towns of the United States find themselves faced with a mounting problem of waste disposal. Estimates by public works officials indicate that 60 per cent of the urban centers in the nation now have completely inadequate disposal facilities for garbage and trash, 20 per cent have partially adequate provisions, only 20 per cent are equipped to meet present needs, and almost none have workable plans to provide for future requirements. There is reason to believe that Pennsylvania's cities and towns are no better prepared than those of the nation as a whole to overcome the disposal problem. Indeed, in some respects, it would appear that a number of other states

(*Continued on page 4*)

* Professor and Associate Professor of Geography, respectively.

Top: The authors orienting themselves on a map in an abandoned strip pit in eastern Clearfield County.

Middle: A devegetated strip pit compared with heavily wooded unmined terrain in the background. Photo taken in Clarion County, 1958.

Bottom: Loose rock material bordering the flanks of a strip cut. Photo taken in Clarion County, 1958.

Mineral Industries

Published Monthly
from October to June, inclusive
by
THE PENNSYLVANIA STATE UNIVERSITY
COLLEGE OF MINERAL INDUSTRIES
M. I. CONTINUING EDUCATION
D. C. JONES, *Director*
JEANNE L. SLOBOD, *Editor*

PENNSYLVANIA'S COLLEGE OF MINERAL INDUSTRIES

Dedicated to

Education 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 Education
Research
Continuing Education
Correspondence Education

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

NOVEMBER 1960

L. F. HERZOG, assistant professor of geophysics, gave a paper, "Age Determination of Lepidolite by X-ray Fluorescence," at the Copenhagen meeting of the International Geological Congress, September 22. He attended the Helsinki I.U.G.G. conference and the Copenhagen International Atomic Energy Association conference on isotope applications. Dr. Herzog also visited mass spectometry laboratories throughout Europe during the summer.

HOWARD L. HARTMAN, head of the Department of Mining, and Boris J. Kochanowsky, associate professor of mining engineering, attended the Metal Mining Convention of the American Mining Congress at Las Vegas, Nevada, and the Drilling and Blasting Symposium at Golden, Colorado, in October. The Symposium was jointly sponsored by the Departments of Mining at Penn State, Colorado School of Mines, and University of Minnesota. Dr. Kochanowsky presented a paper, "Inclined Drilling for Open Pits and Quarries," and Dr. Hartman served as a session chairman at the Symposium and as a panel member at the Metal Mining Convention, discussing "Technical Aspects of Mine Dust Control."

Activities in the College of Mineral Industries

GUY E. RINDONE, assistant professor of ceramic technology, was chairman of the annual fall meeting of the Glass Division of the American Ceramic Society held in Bedford Springs, October 12 - 14. Dr. Rindone was elected chairman of the Glass Division for the year ending at the close of the Annual Spring Meeting to be held in Toronto in April, 1961. In addition he was recently made technical program chairman of the VI International Glass Congress to be held in Washington, D. C., in July 1962. This is the first Glass Congress to be held in the United States, the previous ones having been held in Germany, Italy, France, and England. As chairman of this committee, Dr. Rindone will visit laboratories and universities in Europe during the coming year to discuss the Congress program and to solicit contributions to the technical sessions.

THE TWELFTH Biennial Interchapter Meeting of the Pennsylvania Chapters of the American Society for Metals was held at the University on September 9 - 10 under the co-sponsorships of the seven Pennsylvania chapters and the Department of Metallurgy. There were sixty-five registrants who heard papers on the electron theory of metals, semi-conductors, developments in magnetic alloys, nonisothermal diffusion, properties of individual dislocations, and radiation effects on metals and alloys.

G. W. BRINDLEY, head of the Department of Ceramic Technology, presented a paper, "Orientation of Organic Molecules Adsorbed on Clay Mineral Surfaces," before the Ninth Clay Conference, Purdue University. R. W. Hoffman, visiting research associate in ceramic technology, was co-author.

J. C. GRIFFITHS, head of the Department of Mineralogy, gave a lecture on "The Interrelationships between Reservoir and Rock Properties of Some Appalachian Oil Sands," at the Meeting of Western Engineers in Bradford, Pennsylvania, on September 16.

A PROJECT concerning the "Texture and Usability of Blast Furnace Slag" has been initiated under the sponsorship of the National Slag Association for the year 1960-61. The project is under the direction of J. C. Griffiths, head of the Department of Mineralogy. John H. Carman, candidate for the Ph.D. degree in Mineralogy is assisting Dr. Griffiths.

T. F. BATES, professor of mineralogy, spoke on "The Geology, Volcanology and Mineralogy of Hawaii" before the Pennsylvania Mineralogical Society, September 24 at the biennial exhibit meeting in Doylestown, Pennsylvania.

PAPERS by members of the Department of Metallurgy were presented before the 42nd National Metal Congress of the American Society for Metals which met in Philadelphia, October 15 - 20. H. M. Davis was co-author of two papers: "Occlusion of H by Annealed Hypoeutectoid Fe-C Alloys" with M. Kotyk of the U. S. Steel Corporation; and "Occlusion of H by Cold Worked Hypoeutectoid Fe-C Alloys" with J. E. Werner of the Bethlehem Steel Company. K. E. Pinnow spoke on "Tensile Properties of Type 410 Stainless Steel Deformed Before and After Martensite Transformation" with Yuzo Hosoi of the National Research Institute of Japan.

TWENTY-TWO papers were presented by staff members of the College of Mineral Industries at the joint annual meetings of The Geological Society of America, The Paleontological Society, The Mineralogical Society of America, Society of Economic Geologists, and Geochemical Society held in Denver, October 31 - November 2.

Papers from the Department of Geology were: A. A. Adler and L. H. Lattman, "Floodplain Sediments of Half Moon Creek, Pennsylvania"; R. Scholten, "Origin of the Bosporus"; W. Spackman and C. P. Dolsen, "Uranium, Sulfur, Iron, and Mineral Concentrations in Organic Sediments from Selected Marine, Brackish, and Fresh-water Environments"; W. Spackman, "Processes and Products of Coalification"; A. Davis, R. R. Dutcher, F. Dachille, and W. Spackman, "High Temperature-pressure Studies of Wood"; R. R. Dutcher and W. Spackman, "Electron Microscope Observation of Vitrinitic Materials" and S. P. Mansfield, W. Spackman, and R. R. Dutcher, "Sulfur Studies of Selected Bituminous Coal Seams in Pennsylvania."

Papers presented from the Department of Geophysics and Geochemistry were: A. M. Taylor and R. Roy, "Structural and Compositional Changes During the Dehydration-rehydration of Phillipsite and Related Synthetic Zeolite Na-P"; M. L. Keith, R. Eichler, and R. H. Parker, "Carbon- and Oxygen-isotope Ratios in Marine and Fresh-water Mollusk Shells"; W. B. White, F. Dachille, and R. Roy, "Sernarmontite-Valentinite and Arsenolite-Claudetite Relations Determined by Displacive Shearing"; P. L. Roeder and E. F. Osborn, "Phase-Relations in the Mg_2SiO_4-$CaAl_2Si_2O_8$-FeO-Fe_2O_3-SiO_2 System and Their Bearing on Crystallization of Basaltic Magma"; C. W. Burnham and O. F. Tuttle, "Composition of the Magmatic Vapor Phase"; and H. L. Barnes, "Sphalerite Solubilities in Sulfide Solutions."

Other papers presented by the Department of Geophysics and Geochemistry were: D. B. Hawkins and Rustum Roy, "Distribution of Trace Elements Between Clays and Zeolites formed by Artificial Weathering of Synthetic Basalts"; Abraham Hoffer, "Structural Petrography of a Specimen of Metaquartzite"; B. F. Howell, Jr., and Robert Woodtli, "Factors Influencing Thickness of the Earth's Crust"; Seymour Merrin, "Synthesis of Epidote and Its Apparent P-T Stability Curve"; George W. Putnam and C. Wayne Burnham, "Distribution of Minor Elements in Some Igneous Rocks of Central and Northwestern Arizona"; and L. Walter, "P-T Stability Curves of Reactions in the System CaO-MgO-SiO_2-CO_2 and Geological Applications."

The Department of Mineralogy presented the following: J. V. Smith, "Complex Disorder of H_2O Molecules and Ca Ions in Wet-Ca Chabazite"; and P. D. Krynine, "Primeval Ocean."

J. D. Ridge of the Department of Mineral Economics presented "Behavior of Sulfur Under Magmatic and Hydrothermal Conditions and Its Effect on S^{32}/S^{34} Ratios."

ROBERT HO, Chairman of the Department of Geography, University of Malaya, addressed the Geography Department and its guests on the subject, "Man and Land in Malaya," in the Assembly Hall of the Hetzel Union Building, Friday, September 30.

Graduates Receive Advanced Degrees

June 11, 1960

Major Field	Name	Degree	Thesis and Dissertations
Ceramic Technology	Jyung Oock Choe	M.S.	The Reaction Series: Gibbsite – Corundum for Fine Grained Gibbsite
Fuel Technology	Bernard Deklau	Ph.D.	Nitrosyl Chloride Decomposition Rates in Shock Waves
Geochemistry	Robert Francis Fudali	Ph.D.	Experimental Studies Bearing on the Origin of Pseudoleucite and Associated Problems of Alkaline Rock Systems
	Peter Ludwig Roeder	Ph.D.	Phase Relations in the Mg_2SiO_4-$CaAl_2Si_2O_8$-Fe_2O_3-SiO_2 Systems and Their Bearing on Crystallization of Basaltic Magma
	Philip E. Rosenberg	Ph.D.	Subsolidus Studies in the System $CaCO_3$-$MgCO_3$-$FeCO_3$-$MnCO_3$
Geography	George Adam Schnell	M.S.	A Geographical Analysis of Factors Affecting Distribution of Unirrigated Cotton Cultivation in the United States
Geology	Edward Alex Stanley	Ph.D.	Upper Cretaceous and Lower Tertiary Sporomorphae from Northwestern South Dakota
	Robert S. Sohon	M.S.	Ostracodes of the Glenerie Limestone at Catskill, New York
	James Aertsen Wells	M.S.	Pleistocene Geology of Union County, Pennsylvania
Metallurgy	Glenn W. Bush	Ph.D.	X-ray Determination of Residual Stresses in Electrodeposited Nickel Coatings
	John Ellis Werner	M.S.	The Mechanisms of Occlusion of Hydrogen by Cold-Worked Hypoeutectoid Iron-Carbon Alloys
Meteorology	David Lloyd Jones	Ph.D.	Evaluation of the Kinematic Method for Measuring Large-Scale Vertical Air Motion in Winter
	John Murray Mitchell, Jr.	Ph.D.	The Measurement of Secular Temperature Change in the Eastern United States
	James Roy Scoggins	M.S.	Ozone Variations at State College, Pennsylvania
Mineral Economics	Walter Gibson Jaworek	Ph.D.	The Use and Interchangeability of Fuels in Pennsylvania
Mineralogy & Petrology	Gordon Conrad Grender	Ph.D.	Petrology of the Vaqueros Formation Near Gaviota, California
	William Peter Shulhof	Ph.D.	Relationships Between Uranium and Some Other Trace Elements in Pyrite, Galena, and Sphalerite from Vein Deposits
	George Vincent Wood	Ph.D.	A Comparison of Three Quartzites
Petroleum & Natural Gas Engineering	Krishna I. S. Kamath	Ph.D.	Transfer and Movement of Materials During the Recovery of Oil and Water from a Porous Medium by an Alcohol
	Joseph Emmett Warren	Ph.D.	Reverse Combustion
	Robert Eugene Beamer	M.S.	The Application of Experimentally Determined High-Pressure Gas Viscosity Data to Flow Behavior in Porous Media
	Ronald Nelson Beamer	M.S.	Study of the Boundary Effects in Five-Spot Water Flooding by Means of a Hele-Shaw Model
	Robert Allan Beamish	M.S.	The Alcohol Slug Process – Study of Solubility Characteristics and Displacement Behavior of Alcohol Mixtures
	Albert Karoly Csaszar	M.S.	Miscible Displacement in Capillaries and Porous Media Effect of Rate and Particle Sizes
	Virgil Lee Powell	M.S.	A Microscopic Study of Immiscible and Miscible Displacements in Porous Media
	John Edward Smithyman	M.S.	The Determination of Oil-Gas Relative Permeability in Synthetic and Natural Unstratified Sandstone Cores by Using Residual Oil Saturations

August 12, 1960

Major Field	Name	Degree	Thesis and Dissertations
Ceramic Technology	John Franklin Argyle	M.S.	Liquid Immiscibility and Subsolidus Phase Relationships in the System PbO-La_2O_3-SiO_2
Fuel Technology	John Francis Rakszawski	Ph.D.	The Catalytic Effect of Iron on the Carbon-Carbon Dioxide Reaction
	Richard Allen Anderson	M.S.	Changes in Coal Sulfur During Carbonization
	Clement Seymour Finney	M.S.	The Ignitibility of Bituminous Coal: A Laboratory Study
Geochemistry	Louis Simon Walter	Ph.D.	Pressure-Temperature Univariant Equilibria of Some Reactions in the System, CaO-MgO-SiO_2-CO_2
Geography	James Richard Wallace	M.Ed.	No thesis
	Lee Charles Hopple	M.S.	Ecological Crop Geography of the Sugar Beet in the Northern Great Plains
Geology	Russell Richardson Dutcher	Ph.D.	Physical, Chemical, and Thermal Properties of Selected Vitrinitic Substances
Meteorology	Sarah Hibbs Wollaston	M.S.	Breakdown of Nocturnal Inversions
Mineral Preparation Engineering	Sidney Martin Cohen	M.S.	Amine Flotation of Pennsylvania White Residual Clays
Mining Engineering	Young Chang Kim	M.S.	A Laboratory Study in Rock Fragmentation in Bench Blasting

Strip Pits and the Sanitary Landfill Process

(*Continued from page 1*)

are appreciably ahead of the Commonwealth because the employment situation and the fiscal condition of their urban areas are more favorable.

It is with these facts in mind that the authors present a plan which might ease the financial burden of waste disposal in many of the cities and towns of western and central Pennsylvania, maintain or increase standards of sanitation, and at the same time remove from the landscape of that area the legacy of raw-earth blemishes that is bequeathed it by the bituminous coal strip mining industry.

Waste Disposal Methods

A number of methods are available for disposal of urban debris. The oldest, and least acceptable from sanitary and safety standpoints, is the open dump wherein garbage and trash are piled in surface accumulations. The well-known accompaniments of this method — rodents and flies, smoke and fire, odors and unsightliness — are, of course, objectionable to the public and unacceptable by modern standards of health and fire control.

A second method of waste disposal is use of an incinerator, a completely adequate device that passes all tests for health, safety, and esthetic acceptability. Despite its advantages, the incinerator is excessively expensive to build and operate. The cost of the structure for even a modest-sized town exceeds a million dollars. Thus, financially, such a method of waste removal is beyond the means of many urban areas.

The third procedure for handling garbage and trash is composting. This process, whereby useless materials are turned into valuable humus, has two disadvantages: it is, at present, only in the experimental stage of development, and it is thus far applicable only to the organic component of refuse, since it does not work on glass, metal, and similar constituents of trash.

The final method of waste disposal is the sanitary landfill process, wherein debris is concentrated in a low-lying area and each day's accumulation is covered with a layer of dirt by a bulldozer. This is currently the most practical means of ridding a town of its unwanted waste. It is low in cost, since it necessitates only a bulldozer and a hole in the ground; it meets the highest standards of health and combustion safety, because insect-breeding, rodent-nourishing, and burnable materials are exposed for only a brief period of time; and it has the added advantage of eventually converting generally useless land into salable property, for at the completion of the landfill operation the terrain has been elevated and restored to usable condition.

Suitability of Strip Pits for the Sanitary Landfill Process

The sanitary landfill process is particularly appropriate for development in the bituminous coal mining country of western and central Pennsylvania, for the region literally is pitted with thousands of abandoned strip mines. These mines have all the requisite attributes to serve as foci for sanitary landfill operations.

First of all, such mines are widely dispersed. Thirty-three counties have them; and their pattern of distribution is such that in a majority of the counties most places are situated less than five miles airline from one or more pits (Figure 1) — certainly a reasonable distance for trucking waste materials. In fact, an estimated 3,700,000 people, representing one third of the population of Pennsylvania, live within such a distance of past stripping operations (Table 1). Thus, ready-made depressions, available for filling, lie within easy reach of all these people.

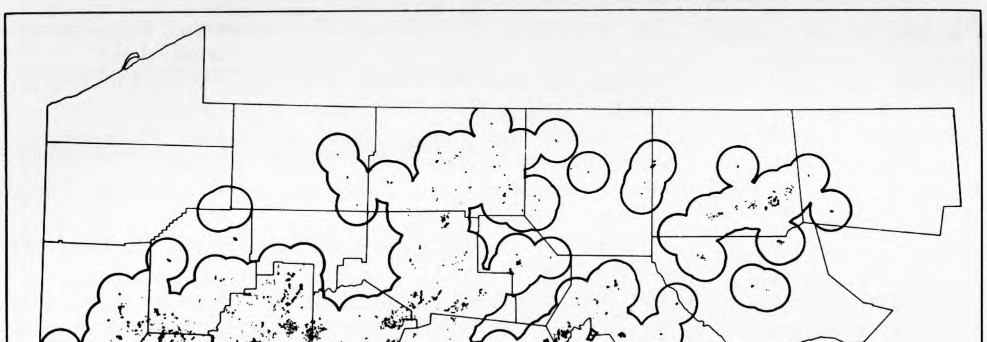


FIGURE 1. Areas within five miles or less of a bituminous coal strip pit in Pennsylvania. Individual strip pits, the irregularly shaped black areas, are plotted from aerial photo mosaics issued by the U. S. Department of Agriculture. Some recent stripping operations are not shown, for the photo mosaics on which the map is based are several years old. Also, a few backfilled and revegetated pits are not recognizable on the photos and therefore are not plotted. In addition, certain clay and gravel pits undoubtedly are confused with coal pits on the photos and thus are mapped erroneously.

TABLE 1
Estimated Population Living Within Five Miles or Less of a Bituminous Coal Strip Pit, by Counties, 1960

County	Population	County	Population
Allegheny	1,621,000	Fulton	*
Armstrong	79,000	Greene	20,000
Beaver	186,000	Huntingdon	4,000
Bedford	8,000	Indiana	74,000
Blair	122,000	Jefferson	46,000
Bradford	3,000	Lawrence	112,000
Butler	113,000	Lycoming	11,000
Cambria	192,000	McKean	22,000
Cameron	7,000	Mercer	25,000
Centre	16,000	Potter	2,000
Clarion	37,000	Somerset	77,000
Clearfield	80,000	Tioga	20,000
Clinton	30,000	Venango	58,000
Crawford	10,000	Warren	30,000
Elk	35,000	Washington	203,000
Fayette	165,000	Westmoreland	351,000
Forest	*	Total	3,759,000

* Negligible.

A second advantage of strip pits for disposal purposes is the fact that waste materials are deposited on essentially useless lands that will have little economic value for decades, even if they are successfully planted in trees. Possible alternative disposal sites are valley floors in the prevailingly hilly terrain of the region. However, such valleys usually constitute the most valuable farm lands of the region, invariably contain the precious and all too easily contaminated watercourses, and typically are employed as natural corridors by transportation facilities of the area. Their use for dumping purposes, even sanitary landfill dumping, is not in the best interests of the region for obvious reasons.

The third aspect of strip pits that renders them especially appropriate for waste disposal is their typically devegetated surfaces. It is true that most strip pits cut since 1945 have been replanted to trees; but even cursory examination of a representative sampling of such pits discloses that in many the seedlings have completely disappeared, in others there is only partial survival, and in those where plantings are successful the seedling trees remain small [5]. Pre-1945 pits typically are barren of vegetation. In view of these facts, it is evident that expenses for clearing the land prior to dumping operations are held to a minimum if strip pits are employed, in contrast to the greater cost of clearing forested lands adjacent to the pits. (See middle photograph on page 1.)

A fourth advantage of strip pits for sanitary landfill operations is the presence within them, or on their flanks, of large tonnages of earth and loose rock. (See bottom photograph on page 1.) Hence, covering of the daily accumulation of waste materials does not necessitate blasting of local bedrock, or transportation of suitable cover material from other sites. In contrast, most other potential disposal sites, including natural valleys and man-made excavations such as rock quarries, are characterized by a dearth of essential loose material.

The fifth characteristic of strip pits that renders them suitable for waste disposal is their general accessibility to motor transport. Many of them are situated relatively close to paved highways and are connected to those highways by graded dirt roads which were once used to truck out the mined coal. These same graded dirt roadways are now available for refilling the pits with debris, though probably requiring minor repairs.

A final feature of strip pits that is advantageous insofar as sanitary landfill operations are concerned is their location usually out of sight of arterial highways. Hence, landfill operations associated with strip pits are not likely to be esthetically offensive to the motoring public and will not adversely affect the Commonwealth's important tourist industry. The map in Figure 2, for example, shows all pits and all main roads (i.e., federal and state highways, but not legislative routes and dirt tracks) in one of the more intensively stripped areas of central Pennsylvania. Most of these pits are invisible to tourists travelling through the area, since visibility from highways is generally limited to a fraction of a mile by omnipresent hilly terrain, extensive forest cover, and roadside tree and brush rows.

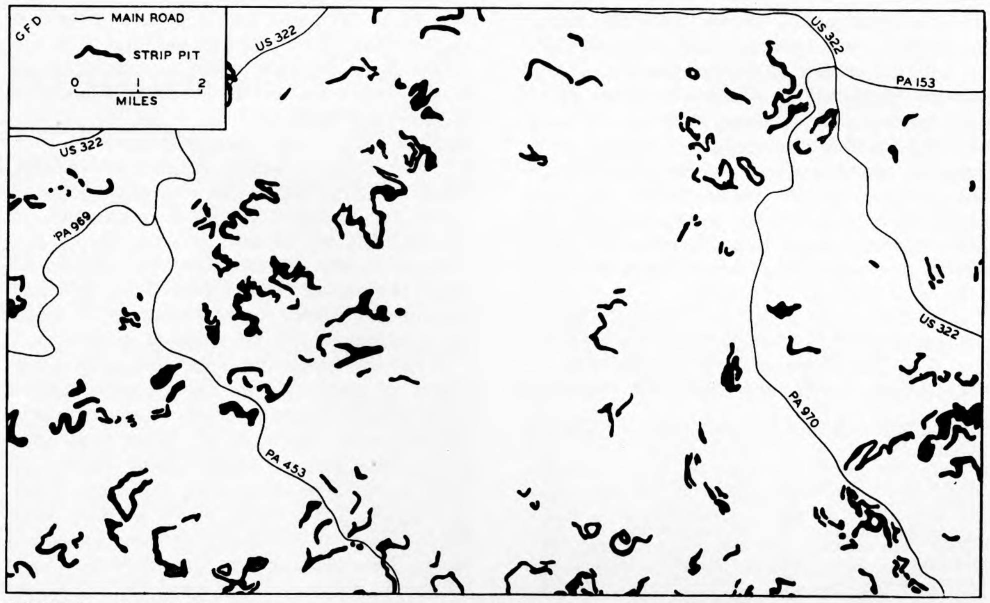


FIGURE 2. Arterial highways and strip pits in southeastern Clearfield County. Data are from U. S. Department of Agriculture aerial photographs and field reconnaissance. All federal and state highways in the area are shown, but not legislative routes and dirt tracks. Note that most strip pits are sufficiently removed from the main roads that they are invisible to tourists travelling such routes.

Urban Centers Accessible to Strip Pits

In view of the advantages associated with the use of strip pits for sanitary landfill purposes, it was decided to investigate the matter of specific cities and towns that conceivably could utilize such pits for waste disposal. A map, Figure 3, was constructed showing every city and town of over 2,500 population in Pennsylvania that is situated within five miles or less airline of one or more bituminous coal strip pits.

The results are striking. Thirty-seven urban centers* of over 10,000 population are thus situated. These include such large cities and towns as Pittsburgh, Johnstown, Altoona, and New Castle, and such widely separated centers as Lock Haven in the east, Warren in the northwest, and Washington and Uniontown in the southwest. In addition, there are 84 towns,** each with from 2,500 to 10,000 population, that lie within the same relatively easy reach of one or more pits. Thus, 121 urban centers in western and central Pennsylvania are in a position to consider the feasibility of developing sanitary landfill programs based on the use of strip pits. Hundreds of other smaller centers of population, situated in the same general area, are in a similar fortunate position to solve their disposal problems.

It is apparent from the map in Figure 3 that most of the urban centers of over 2,500 population having access to potential strip pit dumping facilities are located in the southwestern part of the Commonwealth. Thus, Allegheny County has 26 such centers; Westmoreland County has 17; Washington, 10; Beaver, 7; and Fayette, 6. In contrast, the remainder of the bituminous coal area has only one county, Cambria (13), with more than five such urban centers. The number in other counties is as follows: Armstrong, 5; Jefferson, 4; Venango, 4; Butler, 3; Clearfield, 3; Elk, 3; Indiana, 3; Somerset, 3; Clinton, 2; Lawrence, 2; McKean, 2; Blair, 1; Cameron, 1; Centre, 1; Clarion, 1; Crawford, 1; Mercer, 1; Tioga, 1; and Warren 1. The small size of the figures in the last named group of counties generally is not due to the lack of past stripping activity in those counties, as reference to Figure 1 verifies, but rather to the relatively few towns with a population in excess of 2,500.

Comparison of Figures 1 and 3 discloses major differences in the number of strip pits within a five-mile radius of the above 121 urban centers. Rough estimates as to the number of pits within such a distance of each center are given in Table 2. The figures in the table are not exact, since there is no unanimity of opinion as to what constitutes a single pit. Also, the figures will differ depending upon the specific point within each city or town from which a five-mile radius is struck; and source photos on which the map in Figure 1 is based are several years old and therefore do not show all existing pits. Despite these deficiencies, the data in Table 2 do permit an approximately correct evaluation of the number of pits available for servicing each urban center in western and central Pennsylvania.

Inferences as to the relative strip mine facilities for waste disposal available to each urban center cannot be based solely upon the number of accessible pits, for the pits differ considerably in dimensions and hence in capacity. Moreover, many pits are within the five-mile limits of two or more urban centers and conceivably could be called upon

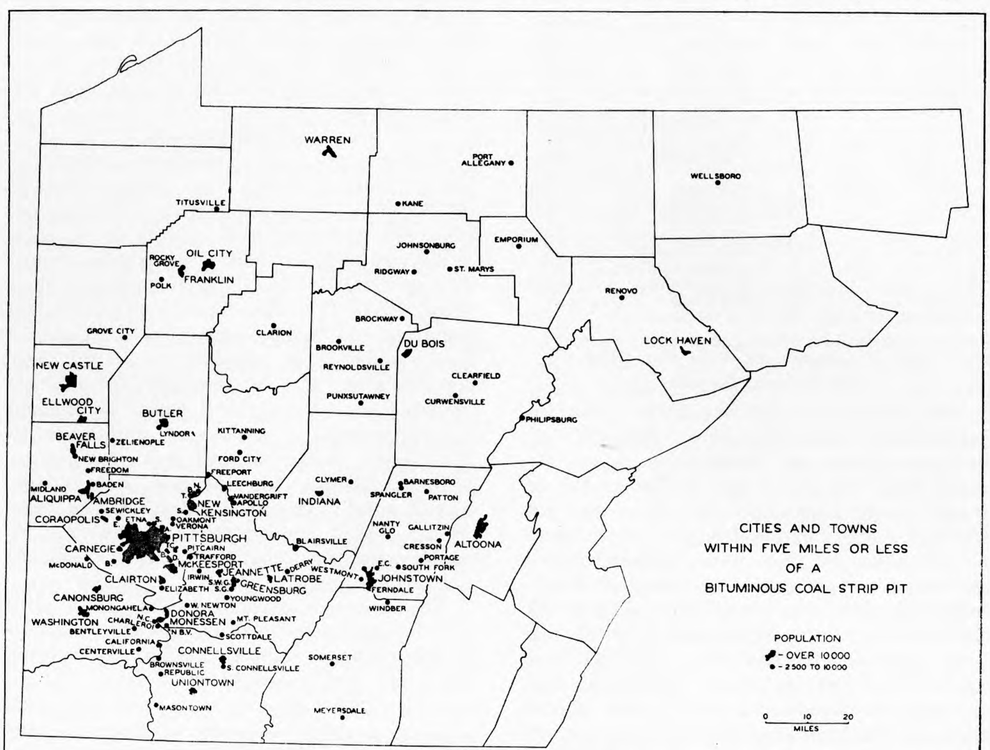


FIGURE 3. Cities and towns within five miles or less of a bituminous coal strip pit in Pennsylvania. Only urban centers with a population of 2,500 or more are plotted. A few of these are not represented separately and named; see footnotes to the left on this page. Hundreds of villages in the area are not shown on the map.

* Five of these are not named and plotted separately on the map because they are physically continuous with other major urban centers. They are Bellevue, Dormont, Homestead, and McKees Rocks, which adjoin Pittsburgh; and Arnold, which adjoins New Kensington.

** One of these, Dale is not named and plotted separately on the map because it is enclosed within the boundaries of Johnstown.

to serve the needs of more than one town. In addition, some strip mines shipped coal by railroad rather than by truck [1] and are not connected by dirt roads to the highway system of the region; these cannot now be used for dumping purposes without construction of relatively expensive access facilities. Hence, some urban centers in close proximity to few pits are relatively well situated, whereas others close to many pits may be less favored than numbers alone indicate.

TABLE 2
Approximate Number of Bituminous Coal Strip Pits Within a Five-Mile Radius of Urban Centers Having More Than 2,500 Population

Urban Center	Strip Pits	Urban Center	Strip Pits
Aliquippa	1	Lock Haven	1
Altoona	5	Lyndora	14
Ambridge	2	Masontown	56
Apollo	18	McDonald	38
Arnold	43	McKeesport	54
Aspinwall	6	McKees Rocks	25
Baden	1	Meyersdale	32
Barnesboro	52	Midland	2
Beaver Falls	4	Monessen	30
Bellevue	10	Monongahela	29
Bentleyville	9	Mt. Pleasant	24
Blairsville	21	Nanty Glo	15
Brackenridge	26	Natrona	17
Braddock	32	New Brighton	1
Bridgeville	19	New Castle	14
Brockway	49	New Kensington	43
Brookville	27	North Belle	
Brownsville	13	Vernon	36
Butler	21	North Charleroi	30
California	27	Oakmont	15
Canonsburg	15	Oil City	4
Carnegie	40	Patton	23
Centerville	8	Philipsburg	81
Charleroi	33	Pitcairn	48
Clairton	60	Pittsburgh	8
Clarion	65	Polk	2
Clearfield	54	Portage	7
Clymer	50	Port Allegany	9
Connellsville	32	Punxsutawney	60
Coraopolis	40	Renovo	7
Cresson	12	Republic	3
Curwensville	70	Reynoldsville	28
Dale	17	Ridgway	4
Derry	15	Rocky Grove	1
Donora	30	St. Marys	12
Dormont	22	Scottdale	27
DuBois	16	Sewickley	18
Duquesne	40	Sharpsburg	4
East Conemaugh	16	Somerset	14
Elizabeth	70	South Fork	6
Ellwood City	24	South Connellsville	27
Emporium	3	South Greensburg	32
Emsworth	25	Southwest	
Etna	4	Greensburg	30
Ferndale	19	Spangler	49
Ford City	12	Springdale	42
Franklin	1	Tarentum	30
Freedom	2	Titusville	3
Freeport	11	Trafford	37
Gallitzin	17	Turtle Creek	28
Greensburg	29	Uniontown	41
Grove City	22	Vandergrift	16
Homestead	27	Verona	15
Indiana	5	Warren	1
Irwin	40	Washington	4
Jeannette	36	Wellsboro	1
Johnsonburg	4	Westmont	15
Johnstown	17	West Newton	32
Kane	3	Windber	44
Kittanning	20	Youngwood	33
Latrobe	22	Zelienople	11
Leechburg	8		

Life Expectancy of Strip Pits Used for Disposal Purposes

The question might be raised as to the probable life expectancy of one or more strip pits when they are employed as waste disposal sites. Pits, of course, differ greatly in length, width, and depth [2]. Most are narrow, generally ranging from a few hundred to two thousand feet wide, although those in western Allegheny and northwestern Washington counties are much wider (Figure 1). Likewise, most pits are of limited length, seldom exceeding three miles, although here again those in the above mentioned area are exceptional (Figure 1). Depths of pits generally range from a few feet to approximately 100 feet, and, of course the depth of any individual pit varies considerably due to alternations of spoil ridges and intervening troughs upon its floor.

If one assumes that the average pit has an area of 50 acres and a general depth of 25 feet, and if one further assumes that the refuse from a town with a population of 50,000 covers an area of 50 acres to a depth of three feet each year, then the life expectancy of such a pit when employed by such a town is 8 or 9 years. Appropriate adjustments for other sized pits and other rates of debris accumulation permit determination of the probable life of any pit or group of pits adjacent to any city or town. In virtually all cases, the period of usefulness is of sufficient duration to justify development of a single pit or group of pits for disposal purposes.

From the statewide viewpoint, the availability of strip pits for refuse accumulation is equally promising. There are an estimated 90,000 acres of stripped bituminous coal lands in western and central Pennsylvania [3], with a probable approximate average depth of 25 feet. This could provide sanitary landfill facilities for 4,000,000 people (somewhat more than the present population of the stripping region), at the above estimated rate of accumulation per person, for a period of some 187 years. Of course, a large percentage of existing pits is beyond feasible trucking distance from urban centers, and hence is economically unavailable for dumping purposes. Additional pits are dug each year, so that to a degree at least the new supply will offset the unusable fraction of the existing supply. It is worth noting that, whereas stripping activities in western and central Pennsylvania currently are concentrated in the northern and eastern producing counties of the region and will probably continue so in the near future, the more densely populated southwestern counties ultimately may experience a revival of coal stripping [4]. These counties are not without coal outcrops even though those of the Pittsburgh seam are virtually depleted. A reversion of important stripping activities to Allegheny, Fayette, Westmoreland, and Washington counties would be most advantageous from the sanitary landfill standpoint, for those areas have the greatest concentration of urban centers and hence the greatest need for accessible pits.

Summary and Conclusions

Among the several possible methods of urban waste disposal, the sanitary landfill process is most feasible today. Abandoned strip pits are admirably adaptable to such a disposal process, and western and central Pennsylvania has numerous such pits in close proximity to 121 urban centers of over 2,500 population. The life expectancy of strip pits thus employed is adequate to justify their development. Use of strip pits for sanitary landfill purposes, therefore, should be stressed by appropriate governmental authorities in Harrisburg. Such use will convert a former economic liability into an asset, just as storage of surplus imported natural gas in some of the State's drained oil reservoirs provides employment for what was once considered a worthless feature.

The financial advantages of using strip pits for waste disposal are several. First, it is the cheapest sanitary method for ridding our cities and towns of their debris. Moreover, employment of strip pits for such a useful purpose will serve to lessen the cost of a program for complete eradication of terrain deformation due to strip mining. Such a program has been proposed by the authors in an earlier paper [3], and, although no steps have yet been taken toward implementation, its eventual acceptance is inevitable. The original proposal envisioned radical grading of all pits at a cost to the State of approximately five million dollars. However, if a significant percentage of the pits are employed for waste disposal purposes, then the expense of regrading these would not revert to the State and the original estimate of costs would be reduced accordingly.

Another financial benefit also is likely to result from the use of strip pits for sanitary landfill purposes. It is probable that those pits first employed will be situated closest to the boundaries, or perhaps even within the boundaries, of cities and towns. When filled, levelled off, and covered with a layer of top soil, such renovated areas conceivably could become lands for urban, suburban, and industrial development and could be sold at a profit. The experience of a number of cities and towns in other parts of the country substantiates such an assumption, for their refuse has been changed from a liability to an asset. By using the sanitary landfill process, Los Angeles is converting a canyon into a large recreational area, Seattle is changing a swamp into an extension of the University of Washington campus, and New York City each year is transforming useless swamps and marshes into two million dollars worth of valuable land. The cities and towns of western and central Pennsylvania have the golden opportunity to do likewise with nearby strip pits.

As an initial step toward activating a program of extensive sanitary landfill operations employing strip pits as disposal sites, it is essential that detailed studies be prepared on a town by town basis. These studies should evaluate the annual waste disposal volume generated at a town, the total disposal intake capability of pits within economic trucking distance of that town, the road facilities connecting town and pits, the cost of bulldozer and trucking equipment required, the annual maintenance cost involved, and the possible health and monetary benefits that could accrue to the town. Priority for selection of towns to be so analyzed should be based on the adequacy of existing disposal facilities and the willingness of municipal authorities to cooperate in the undertaking. After such studies are completed, the logic of employing the strip pits of western and central Pennsylvania for refuse disposal will be irrefutable.

References

1. Deasy, G. F. and Griess, P. R., 1959: *Atlas of Pennsylvania Coal and Coal Mining, Part I, Bituminous Coal,* Bulletin 73 of the Mineral Industries Experiment Station, College of Mineral Industries, The Pennsylvania State University, p. 65.
2. Deasy, G. F. and Griess, P. R., 1959, Coal Strip Pits in the Northern Appalachian Landscape: *J. of Geog.*, v. 58, pp. 72-81.
3. Deasy, G. F. and Griess, P. R., 1960, Terrain Damages Resulting from Bituminous Coal Stripping in Pennsylvania: *Proc. Pa. Acad. of Sci.*, v. 34, pp. 124-130.
4. Griess, P. R. and Deasy, G. F., 1958, Past, Present, and Future Foci of Bituminous Coal Strip Mining in Pennsylvania: *Proc. Pa. Acad. of Sci.*, v. 32, pp. 108-114.
5. Hart, G. E. and Byrnes, W. R., 1959: *Performance of Trees Planted on Coal-Stripped Lands in the Bituminous Region of Pennsylvania,* Research Paper No. 28, School of Forestry, The Pennsylvania State University, 2 pp.

Troubled Oil

JOHN J. SCHANZ, JR.*

The Basic Situation

"UNEASY lies the head that wears the crown." Petroleum, king of the energy sources in the United States, may find the wearing of the crown more difficult than the coronation. The downfall of ex-King Coal should serve as a warning of what always has been the eventual fate of any major energy source in the past and should point up the fact that there is an abundance of energy available. The energy producer who offers his product in the most acceptable form at lowest cost gains the advantage.

Many of the economic pitfalls that have trapped the coal industry may prove to be just as dangerous for the petroleum industry. During the prosperity of the last two decades, it was easy to forget that the early history of petroleum was one of boom and bust. The periods of overcapacity and overproduction, which at one time forced petroleum prices down and were then followed by shortages and high prices brought about by lack of development, are similar to problems encountered by the coal industry. In addition, the high fixed costs of the petroleum industry have always made near-capacity operation very attractive. The cost of the "incremental barrel" drops rapidly, and the last barrel produced is markedly cheaper than the first barrel. The "Law of Capture" put further emphasis on rapid withdrawals and movement to market. Fortunately, the state prorationing laws and the integration of oil companies have been able to hold these constant threats to stability in check for almost thirty years.

The Domestic Situation

The domestic petroleum industry, which had appeared to be master of its own fate, has suddenly found itself besieged with difficulties. Crude prices which should go up to meet higher costs tend to go down, product prices are depressed, and, gasoline, a prime money-maker, is in oversupply. Most of these troubles are the inheritance of a chain of events that started 15 years ago.

As World War II ended, two things occurred which brought about a tremendous expansion in both the United States and world petroleum industry. First, people and industry were ready to expand their use of liquid fuels. The individual was anxious to own one or more cars, to drive them more miles, and to shift his home heating to the convenience of automatic heat. Industry was attracted by the greater efficiency of liquid fuels or by the cheapness of the Btu's which were sold as fuel oil by-products of the refining of gasoline. Second, defense officials were anxious to see the petroleum industry develop overcapacity which would be available in event of an emergency. This shift to petroleum coupled with rapid increases in population and prosperity brought about a growth in petroleum in excess of that of the economy as a whole.

It is only natural that an industry riding such a tide of expansion would tend to grow somewhat complacent, inefficient, and overindulgent. Eager investors provided capital, exploration was pushed regardless of cost, large staffs of well-paid personnel were assembled, processing and distributing facilities were expanded and constantly improved, and the industry prospered. Yesterday's party has now become today's "hang-over."

Today the petroleum industry must learn to live with a rate of growth which is consistent with the growth of the national economy. It can no longer expect an "inflated" growth which combines both natural growth and the shifting of customers from other energy sources. Having reached maturity, the industry will find many problems facing it. One of these is market saturation. Although individuals and industry will no doubt continue to increase their use of petroleum products, it is unlikely that per capita consumption will grow as rapidly in the future as in the past. In addition, a seasonal balance between gasoline and fuel oils can no longer be relied upon. With the growth in importance of fuel oils, it will be difficult to gear the output of the industry solely to the demand for gasoline.

If overcapacity is to be maintained for emergency purposes, this will be a constant burden to the industry. Obviously, the last and cheapest incremental barrel can never be produced so long as idle capacity exists. One is reluctant to recommend elimination of such an emergency reserve; yet it is unfair that the industry should have to pay the cost of maintaining one. Since this excess capacity cannot be identified in terms of individual wells or refineries, government support or subsidy would be difficult to apply, and probably would prove to be an unsatisfactory solution.

The high cost of finding and producing petroleum in the United States has become an acute problem. A nation which has depleted its petroleum reserves at twice the rate of the rest of the world will find itself unavoidably producing at higher cost than those other parts of the world where there are relatively new and untapped reserves. Although high costs in the United States create pressure to move prices upward, the downward pressure of foreign oil imports, competition from other domestic fuels, and prorationing allowables is even stronger.

The prorationing system which stabilized the industry for so long is no longer as effective as it was at one time. There is some opinion that not all prorationing authorities are reflecting actual demand in setting their allowables and are permitting an oversupply to be created. Furthermore, secondary recovery and pressure maintenance operations, which may be exempt, are becoming more important. As a result, prorationing actually controls a smaller proportion of total crude production capacity than formerly.

The import quota system, which was designed to put foreign oil under the same type of restriction as domestic oil, has not been entirely successful. Imports have continued to climb. Furthermore, the system, which is based on refinery runs, encourages excess refinery throughput and aggravates the existing overcapacity and overproduction at the refinery level. Although a flexible tariff plan would eliminate this problem, it would leave the domestic industry under prorationing quota control while foreign oil might still flow into the country despite a tariff wall.

Finally, the petroleum industry must face attack by its two competitors, natural gas and coal. Natural gas provides a Btu at the wellhead which is approximately one quarter the cost of the crude oil Btu. How to determine the true cost of natural gas, which is normally discovered and produced by the oil industry itself, has not yet been solved. In any case, the regulated price of natural gas still reflects its original position of being a by-product of the production of petroleum which was to be disposed of at any price it might bring. This has given natural gas a tremendous advantage in its competition with oil and coal. Consequently, it has become our fastest-growing and second most important fossil fuel industry. Coal, in the meantime, has shown a resurgence in competitive strength as the most attractive energy source for conversion to electric power. With a possible transition from coal to oil to natural gas to electric power underway, this would indicate future problems for oil from this direction.

The World Situation

Troubles are not confined to the domestic petroleum industry. While the United States is suffering from the symptoms of maturity, the world petroleum industry is facing a situation not unlike that found in the United States thirty years ago. It seems that the rest of the world is entering the transition phase from coal to oil that the United States has already completed.

With the discovery of a great abundance of cheap oil in the Middle East and other parts of the world, the importance of oil as an energy source will increase. However, the rapidity with which oil can be found and processed exceeds the rate at which markets can be expanded to absorb it. Naturally, the nations with an exportable surplus of petroleum are eager to capitalize on their good fortune and to press for greater and greater volumes of petroleum to be produced and sold. Unfortunately, the total demand for petroleum is inelastic and cannot absorb the excess production. As has been experienced in the United States for many years, a small percentage of overproduction has a more depressing effect on prices than the actual volume would seem to warrant.

This would also explain the concern over the entrance of the Soviet Union into international petroleum trade, even though the number of barrels involved is not large. Russia is exporting something less than 500,000 barrels daily, but each barrel is placed in such a manner as to have maximum political or economic impact. Russian oil has an advantage in one of two ways. Either it will be bartered at the world market oil price level relieving the customer of some surplus

(Continued on page 8)

* Associate Professor of Mineral Economics.

Dean Tuttle Resigns; Professor David R. Mitchell Is Named Acting Dean

O. Frank Tuttle has resigned as dean of the College of Mineral Industries at the University because of ill health but will continue on the faculty as professor of geochemistry.

David R. Mitchell, associate dean of the College, was named acting dean, effective November 1.

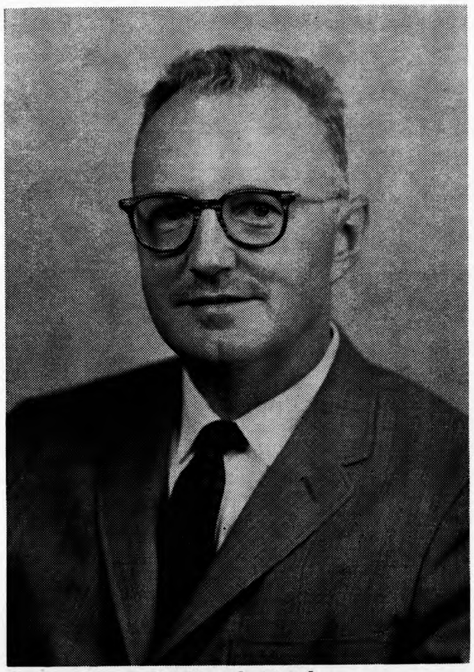
Dr. Tuttle, a native of Olean, N. Y., lived for many years in McKean County, Pa. He first enrolled at Penn State at the Bradford Center, completed work for his bachelor of science degree in 1939, and for his master of science degree in geology in 1940. His doctor of philosophy degree in petrology was conferred in 1948 by Massachusetts Institute of Technology, where he served as a teaching fellow.

From 1942 to 1945 he worked on crystal synthesis problems for the Office of Scientific Research and Development, at first at Massachusetts Institute of Technology, and later at the Geophysical Laboratory of the Carnegie Institution of Washington. He joined the Penn State faculty in 1953 as professor of geochemistry and chairman of the division of earth sciences. He was named dean of the College of Mineral Industries a year ago.

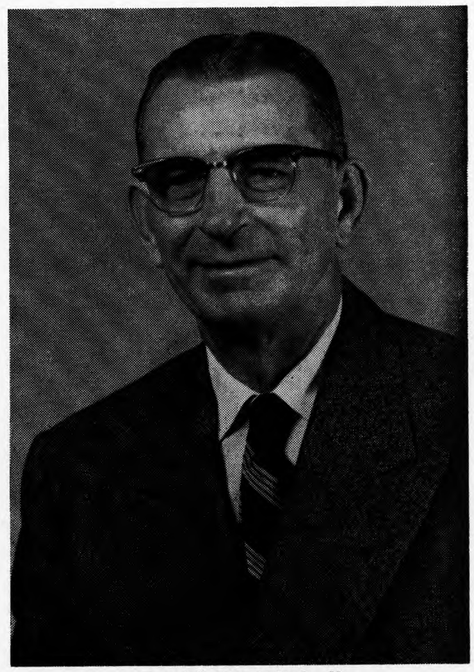
While at the Carnegie Institution, Dr. Tuttle and the late N. L. Bowen made a major break through in experimental petrtology by developing a technique for the systematic study of phase equilibria in aqueous mineral systems at temperatures up to 1,000 degrees C. simultaneously with hydrostatic pressures of many thousands pounds per square inch, duplicating conditions deep in the earth's crust.

In 1952 he was chosen as the first recipient of the Mineralogical Society of America Award.

He is author or co-author of more than 50 scientific papers and one book.



O. Frank Tuttle



David R. Mitchell

Professor Mitchell, who serves also as chairman of the Division of Mineral Engineering and professor of mining engineering, received his bachelor of science degree in mining from Penn State in 1924 and three years later, his master of science degree, also from Penn State. The University of Illinois conferred on him the degree of Engineer of Mines in 1930.

From 1924 to 1926, he served as an engineer with the Bethlehem Mines Corp. and from 1927 to 1938 was on the faculty of the University of Illinois. He joined the Penn State faculty in 1938 and in 1944 was named chairman of the Division of Mineral Engineering. He served in 1958 as acting dean of the College of Mineral Industries and on July 1 was named associate dean of the College.

He is the author of more than 100 technical papers on mining and mineral preparation subjects and is recognized as one of the outstanding mining engineers in the country and particularly in the field of coal mining and preparation he is widely known as a consultant.

MINERAL INDUSTRIES
November 1960

U.Ed. 1-154

Mineral Economics: Troubled Oil

(*Continued from page 7*)

commodity, or it will be sold at a price which may be as much as 20 per cent under the price of competing crude. Although it is apparent that Russia now has sufficient oil to permit foreign trade, growing domestic demand should prevent large quantities from entering world markets. Furthermore, it would seem unlikely that Russia would wish to alienate those countries which are now the major world exporters. However, it can be expected that Russian oil will continue to be an upsetting influence in world oil.

As the United States turned to prorationing to control its excess supplies thirty years ago, the major foreign exporters are considering an international prorationing system. Recently Iran, Venezuela, Saudi Arabia, Iraq, and Kuwait created an exporters' organization and began deliberations on the problem. While agreement was reached on the undesirability of the recent price cuts made by the oil producing companies, there seemed to be no desire for haste on the part of some of the participants to set up a quota system. It is indicated that these nations will consult in the future among themselves and with the oil producing companies about prices. Although they may decide not to press for greater volumes of output, it is probable that they will seek to keep prices up and request a greater government share of income since oil is usually their major source of national revenue.

The Outlook

The United States petroleum industry will have to learn to live in a whole new environment. A slower rate of growth, higher costs of domestic production, and a loss of competitive advantage are not going to be transient conditions. The housecleaning which is now taking place was probably long overdue. However, it would be unfortunate if this would result in overconservative policies with respect to investment, employment, technologic progress, and government protection.

As for the world petroleum industry, the current surplus will probably disappear after three to five years when demand catches up with supply. International control, which has always proved difficult to manage in any mineral commodity, if introduced could very well stifle the prospects for a world shift to petroleum and open the door for entrance of other energy sources at an earlier date than is actually necessary.