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Pennsylvania's Water Resources

C. L. Hosler*

Water is the mineral resource that is most vital to our society. From the point of view of exploration of our future needs as compared to our resources, water has been grossly neglected in favor of other minerals. In discussions of mineral resources it is often not even mentioned. The history of man shows a rapid development of new ways to use water and a consistent refusal to face the reality that the supply is not unlimited. Sections of Pennsylvania are rapidly approaching the point where industrial and domestic water requirements are as great as the annual contribution by rainfall to the existing surface and subsurface storage facilities. Some communities have already experienced serious water shortages during recent periods of below-normal precipitation. These periods were quite wet by comparison with drought periods that occurred during the past 30 years, and which can certainly be expected to recur in the future. For example, 1954 saw some Pennsylvania communities go through water crises because of a dry summer. These same communities had only 25 inches of rain in 1930, whereas they had over 40 inches in 1954.

These facts provide cause for alarm, since as each day passes our water needs grow and our available supply oscillates about a level which shows no sign of increasing. With each day, the probability becomes greater that our water supply will not satisfy our needs during dry periods.

This is graphically illustrated in Figure 1 which shows the variations in annual precipitation that have occurred from 1887 to 1954 in University Park, Pennsylvania. From the standpoint of the possible and probable variability of precipitation at stations in Pennsylvania this graph is representative of any section of Pennsylvania. Some sections would show a slightly greater variability and of course the absolute value of the precipitation will differ from place to place. If we were to consider seasonal or monthly precipitation, the variability would be much greater than indicated in Figure 1. Looking at Figure 1 we see that since 1947 precipitation has been fairly high; yet during the period 1947-1954 many communities have experienced water shortages. This would indicate that under present conditions, in order to supply present water needs, we must have more

rain than occurred in the driest years since 1947. It also indicates that in many areas, the natural supply and the demands of civilization have been very nearly equal since 1947. In the absence of any other information, we can only assume that the climate is fairly conservative and that the past 67 years are an index of what might follow. On this basis we could expect that on five occasions in the next 60 years there may be less precipitation than

in any year since 1947 and serious water shortages will develop in Pennsylvania. If present trends in water usage should continue for another 10 years without taking steps to increase the usable supply, a water crisis will develop in all but the very wet years.

The prospect of expanding industry, growing population, and the accelerated use of water for irrigation by agriculturists in the same areas that have already experienced

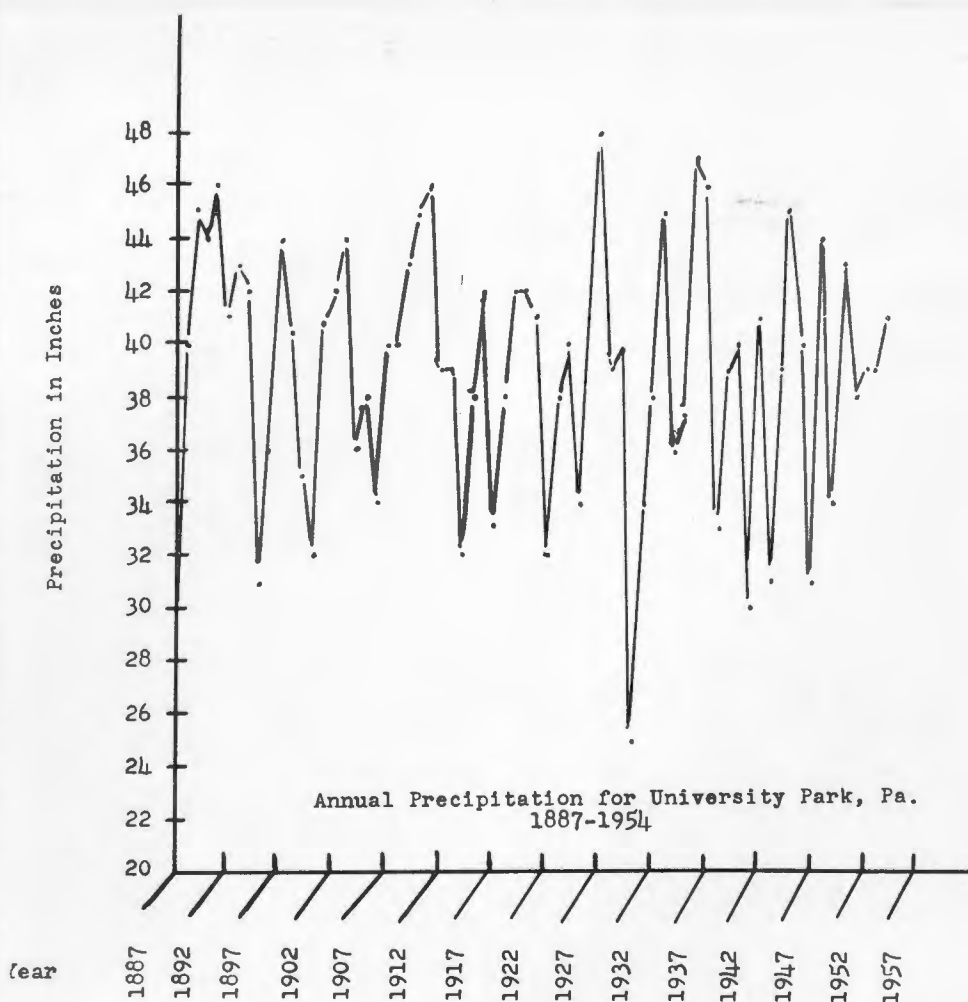


Figure 1

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shortages raises the question, how long will we wait until we institute a comprehensive survey of Pennsylvania's water needs and resources?

Perhaps because water is a problem to so many phases of our technology, what should be everyone's problem has not concerned anyone to the point that serious efforts have been directed toward discovering our over-all position with respect to water supply.

Unlike other mineral resources, our water supply is at no time static but is subject to fluctuations primarily influenced by precipitation. It is a manageable resource in the sense that by our land usage and regulation of dams and reservoirs we can greatly influence the fraction of the precipitation that is stored. A complete survey of our water needs and resources would be the first step toward instituting a long-range plan to protect and develop them to meet the needs of our population. Meteorological factors control the ultimate amount of water available, geological and physical factors determine the extent of underground storage, and geophysical and geological methods provide knowledge of underground storage. Geographers and mineral economists can provide information on the distribution of the demand for water. Thus, within the Divi-

sion of Earth Sciences of the College of Mineral Industries there are the human resources necessary to perform the job of exploring the extent of our water needs and resources. Such a survey urgently needs to be carried out. An outline of the primary steps to be taken if a survey were to be started might include the following:

1. Examine population trends and shifts in the last 50 years.
2. Determine per capita water usage over past 50 years.
3. On the basis of trends indicated, make an estimate of geographical distribution of demand for water in the near future, considering any special problems created by new agricultural and industrial water usages.
4. Investigate on a continuing basis the relations of the detailed geology of the State to ground water intake, occurrence, and movement.
5. Gather data on fluctuations in ground water table in last 50 years.
6. Gather data on fluctuations in river flow in last 50 years.
7. Relate 5 and 6 with precipitation over the past 50 years to determine trends and variability of supply as related to rainfall.
8. Make a detailed study of precipitation distribution over the State.
9. Investigate the degree to which natural rainfall might be supplemented by cloud modification techniques.
10. In view of the geological structure of the various sections of Pennsylvania, study the degree to which storage might be increased by charging the water table through directing surface run-off during wet periods.
11. Delineate the areas which drain a common underground supply in order to determine the real extent of effects of heavy water usage at any point. These areas have common water problems, and actions to solve them should be on a regional basis.

These tasks begun, answering the following questions might appear possible:

1. In what areas are there serious divergences between trends of water consumption and supply?
2. In what areas are supply and demand so nearly equal now that, in view of fluctuations in the water table that have occurred in response to rainfall deficiencies in the past, there is danger that the normal variability of precipitation will result in serious shortages in the near future?
3. In what areas are there potential sources of water not being utilized?
4. Which areas should be planning now to supply water needs for the future?
5. On the basis of established relationships between rate of run-off and water storage as a function of forest cover, what are the trends over the State? Are forested areas increasing or decreasing, and to what extent will these changes affect water supply?
6. Where might artificial aid in recharging of the water table contribute significantly to the supply available during the dry periods?
7. Where and during which season might artificial cloud modification contribute to the water supply?

8. Will additional surface storage facilities be necessary in some areas? If so, where, and how might they be planned now to serve also as recreational facilities and in flood control?

Detailed discussion of each of the steps and questions enumerated here would go beyond the scope of this article. Perhaps steps 8 and 9 would be worthy of some explanation, inasmuch as the whole subject of water supply hinges upon the distribution of rainfall.

There are maps of Pennsylvania on which isohyets have been drawn to precipitation data collected prior to 1932. Unfortunately, the number of stations with long records of precipitation was very limited prior to 1932 and the network was by no means capable of reflecting the local influences which are very important in the sections of Pennsylvania where the local relief exceeds 500 feet. Utilization of records for the last 25 years would greatly extend our knowledge of the distribution of rainfall over the state. From a detailed analysis of the distribution of precipitation of a few ridge and valley stations it is fairly certain that one would find significant differences in precipitation from one elevation or slope to another. These differences would vary with the seasons and once understood would reveal the distribution of precipitation on a scale useful in watershed planning. The fact that within regions now delineated as having a mean annual precipitation of 40 inches the mean annual precipitation actually varies from 35 inches to 60 inches illustrates the need for a review of presently available data. The mean annual rainfall for a watershed is of course useless by itself as far as estimating the water it will yield. Among the other factors that are important is the variability of the rainfall. There is nowhere available, data that would indicate in addition to the mean, what deviations might be expected, and their frequency.

It appears very unlikely that artificial cloud modification techniques are at present capable of significantly altering the distribution of precipitation in time or in space. Under some circumstances it is possible to modify the internal structure of clouds. These modifications are in the proper direction for starting precipitation, however, it has become apparent that those conditions when precipitation can be induced artificially are also the conditions when the same modifications will take place naturally. Starting the process prematurely seems to be of no consequence in the events that follow and the amount of precipitation remains unaffected. In fact, the physical evidence would seem to indicate that if there is any effect it would be to decrease the precipitation in some cases.

Nearly a dozen independent research studies have demonstrated that the effects of cloud seeding on rainfall could not be detected in those regions where extensive field experiments have been carried on. This does not eliminate entirely the possibility that, in the future, new discoveries may enable us to produce significant results, but it indicates that weather modification is a field for long range research rather than an applied science. During the winter months, Central and Western Pennsylvania have a very high incidence of supercooled stratocumulus clouds. These clouds can very frequently be modified by cloud seeding. Small scale experiments by the Meteorology Department at Penn State have indicated that very often these clouds are already slowly dissipating when they pass over Central Pennsylvania

(Continued on page 5)

THE FUTURE AVAILABILITY OF GRADUATES IN FUEL TECHNOLOGY*

E. F. Osborn

Introduction

I welcome this opportunity to discuss the availability (another way of saying "shortage") of engineers and technologists, and in particular of fuels engineers and technologists. The shortage of our graduates in these fields is of grave and growing concern to educators and to the industries which employ them.

I should like to discuss the matter briefly and suggest a start toward its solution — a solution in which companies here represented may participate.

The shortage of scientists and engineers has been played up enough lately in the journals and even in the daily press that I need not dwell long on the general problem. There just are not enough young men, who at the same time are good students, going into these technical fields. According to surveys of national organizations, as well as just the actual experience of educators, less than half as many engineers and scientists are being graduated now as can be absorbed and as apparently are badly needed to keep our industrial, educational, and governmental operations functioning on the high level we expect. In numbers of technologists and engineers being graduated, we are now well behind the Russians.

Moreover, the outlook is dismal unless we change the trends. A paragraph from a recent issue of *Science* (Aug. 26, 1955) is pertinent in this regard:

"As a forecast for the future, it is perhaps less important that the number of graduates has fallen steadily since 1950 than it is that year after year since 1947 smaller and smaller fractions of all graduating men have, specialized in engineering. The drop has been from 18 percent of male graduates in 1947 to 12 percent in 1954. Here is a trend to cause worry for the future. While one must be cautious in interpreting some of the figures as evidence of a retreat from science, nevertheless, there is a serious manpower problem in the scientific and technologic areas. There has been a decline since World War II in the percentage of students majoring in engineering. There has been a decline in the percentage of students preparing to teach high-school science and mathematics. There is a growing demand in both of these fields. A declining fraction of high-school students is getting adequate preparation in physics, chemistry, and mathematics. These trends justify grave concern for the future supply of scientists."

Problem in the Mineral Fields

This is the general picture. More specifically, what is happening in the mineral technology fields of specific interest to us in the College of Mineral Industries and, no doubt, to this audience? In our Division of Mineral Tech-

nology are the three departments: metallurgy, ceramic technology, and fuel technology. I want to mention these three fields specifically, and especially fuel technology, for in each of these fields, we now have a program designed to do something about the problem.

In metallurgy, the record for the whole country is as follows: The number of bachelor degrees in 1950 was 1080

1951 —	912
1952 —	590
1953 —	463
1954 —	539
1955 —	492

In ceramics, the picture has been much the same with at least one ceramics department closing up, even though the demand for graduates is increasing.

B. S. degrees in the ceramics fields followed this pattern:

1950 —	330
1951 —	260
1952 —	187
1953 —	131
1954 —	137
1955 —	95

In both metallurgy and ceramic technology, a fourth or less of the number needed by industry each year is being graduated, probably more like one-tenth.

At Penn State, fuel technology is a separate department. This is fitting in view of the tremendous role fuels play in the economy of the State. Here a student can get a well-rounded background in fuels. Combustion and fuels technologists and engineers with a real interest and background in coal are turned out. Courses are given, for example, on the gasification and carbonization of coal, as well as on its origin and constitution.

The first degree in fuel technology was awarded in 1934. Since then, the number of degrees earned in this department has been: 108 B. S., 23 M. S., and 25 Ph. D., or a total of 156. The size of undergraduate classes was good until the war.



Dean E. F. Osborn

The largest class was graduated in 1942, when 17 received a B. S. degree in fuel technology. Since the war, classes have been small. The record of fuel tech graduates in the last few years is as follows:

1950 —	9 graduates
1951 —	7
1952 —	3
1953 —	2
1954 —	3
1955 —	3

Our observations lead us to believe that the demand for fuel technologists is increasing, but these days there often is little correlation between demand and supply. At the present time, there are three seniors, one junior, two sophomores, and three freshmen in the curriculum. And probably one or more of the three seniors will have to go into the service for two years immediately on graduation.

On the graduate level, fuel technologists are largely supplemented by chemists, and chemical engineers who have been attracted to the field by its problems and opportunities. The number of graduate students in fuel technology was 25 last year and 23 this year — a very creditable number, and more actually than in metallurgy or ceramic technology. This interest in research on such matters as combustion, gasification, and carbonization is heartening, but the undergraduate situation would appear hopeless if we didn't think we had a solution.

Cause of the Situation

Before passing on to possible solutions, we should look for the cause for this situation. Why is a smaller and smaller percentage of high school students entering the engineering and technology fields? There are, I think, two principle reasons:

(1) The shortage of good high school science teachers undoubtedly is a factor, and although I need not enlarge upon this, it seems evident that this will get worse before it takes a turn for the better.

(2) Students are being attracted to other curricula in increasing numbers simply because they are easier. A graduate in any field can get a good job, so why work hard and risk flunking out to boot when there is an easier way.

A Solution to the Problem

It has seemed a remarkable thing to me how statistics take over when we leave things to chance. In the fall about 4500 freshmen enter Penn State. They have decided upon a curriculum for a wide variety of reasons of which no one is clearly dominant over the others. Out of the 4500, then, why don't we one year have say 50 freshmen in fuel technology and perhaps none the next year? Why is there almost exactly the same number as the year before? Why do the numbers in the College of Mineral Industries remain at 5 percent of the student body? Although we cannot answer these questions with certainty, just 3 or 4 out of 4500 elect to go into fuel technology each year.

(Continued on page 6)

*An address by Dean Osborn before American Coke and Coal Chemicals Institute, White Sulphur Springs, West Virginia, October 17, 1955.

1955 STUDENT PRIZE PAPER

The Mechanism of Reduction of Oxides of Metals

Gerald B. Heydt*

Man is constantly striving to understand the secrets of nature in order to better use the knowledge and resources he now possesses. Scientific "know-how" has made it possible to harness many phenomena which are not too well understood. For example, electricity is widely used throughout the world, yet there is a great deal that is not known about the electrons which constitute electricity. One of these phenomena, which man uses and still understands little about, is the mechanism of reduction of metal oxides. It is the purpose of this paper to expound some of the theories that are presently held regarding the phenomena by which metal oxides are reduced.

Metal oxides can be reduced by use of either a solid or a gas as the reducing agent. An example of each of these reduction processes can be represented by the following reaction:^{1,2}

1. $\text{Cu}_2\text{S}(s) + 2\text{Cu}_2\text{O}(s) = 6\text{Cu}(s) + \text{SO}_2(g)$
2. $\text{FeO}(s) + \text{CO}(g) = \text{Fe}(s) + \text{CO}_2(g)$

These two reactions, and practically all other reduction reactions, are performed at elevated temperatures. In order to examine the actual mechanism of reduction, we may take the above two reactions as examples.

Reaction "1" shows that, as reduction takes place, SO_2 is evolved and copper is produced. In order that reduction may take place, there must be intimate contact between the cuprous sulphide and the cuprous oxide. The necessity for having intimate contact between the metal oxide and the reducing agent is one of the obstacles encountered when a solid reducing agent is used.¹ Any theory regarding the mechanism by which the reduction takes place must explain the following questions which arise from a careful examination of reaction "1":²

1. How does the SO_2 diffuse and escape from within the solid material?
2. Does the formation of the reduced copper at the Cu_2S - Cu_2O interface inhibit or slow down further reduction?
3. What variables control the reaction rate?

A theory by Carl Wagner attempts to answer these questions.¹ Wagner proposes that SO_2 , Cu^+ ions, and electrons are produced at the interface of the Cu_2S and the Cu_2O .^{1,3} These ions and electrons immediately begin to diffuse through the surrounding Cu_2O and Cu_2S ; however, the Cu^+ ions diffuse faster through the Cu_2S than through the Cu_2O . Eventually the Cu^+ ions and electrons reach the outer surface of the Cu_2S , a position which is favorable for the formation of metal nuclei. Metal nuclei will actually form when there exists a solid solution of metal which is supersaturated with respect to metal. As the diffusion process continues, there is a transfer of metal ions and electrons from the copper sulphide to the metal nuclei. Growth of the metal nuclei then takes place and eventually produces a film, or

case, of copper metal around the outer surface of the copper sulphide. The SO_2 formed at the Cu_2S - Cu_2O interface diffuses through the surrounding material until it reaches the outer surface, where it passes off into the atmosphere. The following equations represent the reduction reactions:

- a. $\text{Cu}_2\text{S} + 2\text{Cu}_2\text{O} = 6\text{Cu}^+ + \text{S}^{--} + 2\text{O}^{--}$
- b. $\text{S}^{--} + 2\text{O}^{--} = \text{SO}_2 + 6e$
- c. $6\text{Cu}^+ + 6e + 6\text{Cu}^+ = 6\text{Cu}$

A simplified drawing of the whole reduction process is shown in Figure 1.¹

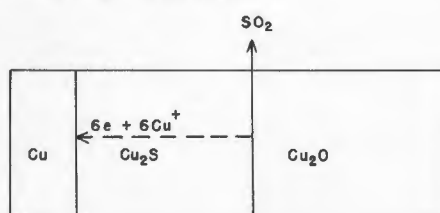


Figure 1: A simplified drawing showing the reduction process of the reaction



The overall reaction rate for the reduction of Cu_2O , or any other metal oxide, depends upon several variables:¹ (1) area of initial surface of oxide, (2) composition of gas phase, (3) diffusion coefficient of metal ions, (4) area of interface between the oxide and the reducing agent, and (5) temperature and pressure at which the reduction is carried out.

The mechanism by which gaseous reducing agents reduce metal oxides is similar to the reduction process which employs a solid reducing agent. Reduction of wustite with CO (reaction 2) will be used to illustrate this type of reduction mechanism.



Gerald B. Heydt

It has been proposed that a film reaction takes place at the FeO - CO interface which can be represented by the following reactions:^{1,2,3}

3. $\text{FeO} = \text{Fe}^{++} + \text{O}^{--}$
4. $\text{O}^{--} + \text{CO} + \text{CO}_2 + 2e$
5. $\text{Fe}^{++} + 2e = \text{Fe}^0$

As these reactions continue, there will be a metallic iron film produced around the outer surface of the FeO . This film of iron separates the CO from the remaining, unreduced FeO ; therefore, in order for reduction to continue, it is necessary for the ions and electrons to diffuse through the iron film. Because the electron and O^{--} ion are smaller than the Fe^{++} ion, it is reasonable to surmise that the diffusion rates of the electrons and O^{--} ions are greater than that of Fe^{++} ion. As a result, some of the O^{--} ions eventually diffuse to the outer surface of the iron film, where they come in contact with the CO , and reaction "4" takes place. The electrons formed by this reaction are then free to diffuse through the iron film. Eventually, some of the electrons come in contact with the Fe^{++} ion, and reaction "5" takes place. This diffusion, of O^{--} ions toward the surface and electrons toward the center of the particle, continues until all the FeO is reduced, or until the system reaches equilibrium. Figure II is a simplified drawing showing the direction of migration of the O^{--} ions and of the electrons.³

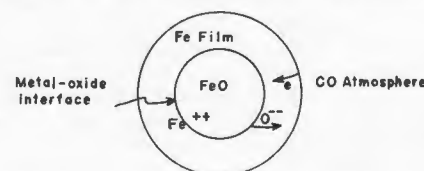


Figure 2: Simplified drawing showing directions of migration of ions and electrons in a partially reduced FeO particle.

The net rate of the reaction



is primarily dependent upon the iron-to-oxygen ratio.¹ If the actual iron-to-oxygen ratio is equal to the equilibrium iron-to-oxygen ratio, the reaction rate will equal zero; but, if the actual ratio is greater than the equilibrium ratio, the sample will take up oxygen. Conversely, if the actual ratio is less than the equilibrium ratio, the sample will give up some of the oxygen, and reduction will take place. These relationships between the iron and oxygen concentrations become evident upon examination of the following equilibrium constant:²

$$K = \frac{(\text{Fe}) (\text{O})}{\text{FeO}}$$

Because a constant supply of electrons is necessary to reduce the iron oxide to elemental iron, it should be possible to increase the rate of reduction by the introduction of an electric field. The use of an electric field would make it possible to saturate the iron oxide with electrons and, as a result, to increase the rate of reduction. It might be possible, for example, to increase the production of pig iron in the blast furnace if electrons were supplied to the reduction zone by the proper use of an electric field.

The mechanism of reduction of metal oxides can be summarized by the following stages of reduction:^{1,2,3} (1) Formation, at the oxide surface, of a solid solution of metal which is supersaturated with respect to metal; (2) form-

*Mr. Heydt was graduated from Penn State in June, 1955, with a B.S. in Metallurgy and is presently employed by the Carpenter Steel Company of Reading. He is working in the company's Research Laboratory in the High Temperature Development Section and, in his spare time, is teaching the first year metallurgy course given in Reading by the M. I. Extension Services.

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Dr. Paul D. Krynine Retires as Head of Department of Mineralogy

Dr. Paul D. Krynine retired on November 1 as head of the department of mineralogy but will remain on the faculty of the College as professor of petrology and sedimentation. Although Dr. Krynine has recovered from his severe illness of 1953, he wishes to devote his time to teaching and research and has given up his administrative duties. He will be succeeded by Dr. John C. Griffiths, professor of petrography, whose career is the subject of a separate notice in this issue.

Dr. Krynine, after much travel during his youth, received his B. A. degree in geology at the University of California in 1927. After working for three years as a field geologist in Mexico and Central America for the Standard Oil Company of California, he did graduate work at Yale University where he took his Ph. D. in geology and petrography in 1936.

In 1937, Dr. Krynine joined the faculty of the College of Mineral Industries as an instructor. He was promoted through the usual academic ranks, becoming a full professor in 1947. He was made head of the department of mineralogy in 1944.

Mineralogy has always been a strong field at Penn State since the days of the late Professor A. P. Honess, that now almost legendary figure, who taught mineralogy here from 1918 to 1942. Dr. Krynine continued the Honess tradition of sound teaching and fundamental research and broadened and increased the scope of the work being done on the undergraduate level and was the leader in developing the graduate program to its present high place in mineralogical education.

Dr. Krynine's research interests lie with the sedimentary rocks which he considers the backbone of the geosciences. His major scientific contributions are in this field and fall into five general classes: (1) A basic study of the composition of sedimentary rocks and the formulation for the first time of a tenable classification of sediments. The "Krynine Classification," proposed first in 1941, has been generally adopted, and the pamphlet describing it has been a best seller of the M. I. Experiment Station, having been reprinted several times in many thousands of copies. His work since the publi-

cation of his classification has been concerned with the relationship between the origin of sediments and geotectonism and he is presently devoting time to work on sedimentary environments. (2) A total re-evaluation of the basic ideas of petroleum geology and formulation of the "specific reservoir concept" (between 1944 and 1946) of the origin of petroleum reservoirs. (3) Considerable work on mineral petrogenesis, particularly of quartz and tourmaline, with the formulation of operational and genetic criteria for microscopic work. (4) Examination and restatement of the philosophy of science and the scientific method as it applies to geosciences. (5) Major contributions to such problems as the origin of red colored rocks, the study of sediments in the Appalachian region, and the study of organic limestones.

In 1943, Dr. Krynine was a Distinguished Lecturer for the American Association of Petroleum Geologists and gave 23 lectures during a three months' tour of the United States.

Dr. Krynine is a fellow of the Geological Society of America and the Mineralogical Society of America, a member of the American Association of Petroleum Geologists, the Society of Economic Mineralogists and Paleontologists, and the Association of University Professors. He is also a member of Sigma Xi, Sigma Gamma Epsilon, and Gamma Alpha.

Water Resources—

(Continued from page 2)

and hence seeding results in quick dissipation. It is possible that if seeding experiments were conducted on the plateau of west central Pennsylvania in winter some light snow might result. Only through controlled experimentation could it be demonstrated whether the precipitation thus produced would be in large enough quantities to be of economic importance.

In a few instances, steps are being taken to provide answers to some of the questions dealing with water supply that are posed here. However, much of this action is on a purely local basis, and the over-all picture will remain hazy until a large scale effort is made to provide answers on a State-wide basis. The answers will not come quickly, and a long-range program will be necessary to place us in a position to estimate what our available water resources are.

Student Prize Paper—

(Continued from page 4)

ation of metallic nuclei, usually at the surface; (3) diffusion of metal ions and electrons from the oxide surface to the metallic nuclei; and (4) the actual transfer of metal ions and electrons from the oxide to the metal. Although Carl Wagner's theory on the reduction of metal oxides has been substantiated by experimental work, there is still a great deal of work to be done regarding the kinetics of reduction processes.²

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Dr. John C. Griffiths Appointed Head of Department of Mineralogy

Dr. John C. Griffiths, professor of petrography, has been appointed head of the department of mineralogy succeeding P. D. Krynine, effective November 1, 1955. Dr. Griffiths joined the faculty of the College of Mineral Industries in 1947 as assistant professor of Petrography. He was promoted to assistant professor in 1950 and full professor in 1953.

Dr. Griffiths received his basic education in the University College of Swansea, University of Wales, graduating B.Sc. (Hons. Geol.) in 1933 and subsequently obtained his M.Sc. (1934) and Ph.D. (1937) degrees. He attended the Royal College of Science, Imperial College of Science and Technology (London) from 1938-40, receiving a Ph.D. from the University of London and a Diploma of the Imperial College (1940).

He specialized in sedimentary petrology doing his graduate work, investigating sandstones from the Coal Measures and glacial deposits of South Wales; for the latter work he received a grant in aid from the Royal Society.

From 1940 to 1947 he worked as Petrographer for Trinidad Leaseholds Ltd., Trinidad, B. W. I., working on the petrographic aspects of exploration and production of petroleum. During this period he investigated the petrography of various kinds of rocks from the West Indies, British Guiana, and Venezuela.

Dr. Griffiths' researches have been directed towards quantifying the techniques of petrographic analysis particularly through the application of statistical methods, and he has continued to apply these research tools to the location and production of petroleum and more recently, on behalf of the U.S. Atomic Energy Commission, to the exploration for uranium and vanadium ores on the Colorado plateau. This work has resulted in some 20 articles published in scientific and technical journals.

Dr. Griffiths is a fellow of the Geological Societies of America and London and the Mineralogical Society of America; he is a member of the American Association of Petroleum Geologists, the Institute of Petroleum (London), the Society of Economic Paleontologists and Mineralogists, the Geologists Association (London), Sigma Xi, and Biometrics.



Paul D. Krynine



John C. Griffiths

Future Availability of Graduates—

(Continued from Page 3)

Now it is time we stopped leaving all this to chance and just waiting for statistics to operate. We must do something that will bring in a bias factor and start influencing this distribution of freshmen.

We do not need to take freshmen away from other curriculums. Plenty of good young men are available who have not been inspired by their teachers or parents to go on to college, or who feel they cannot afford it. According to the data provided by the current annual conference of the American Council of Education, half of the top-ranking quarter of high school graduates — of the order of 200,000 students annually — are not going on to college. Probably half of these would go if they had financial help. (N. Y. Times, Oct. 9, 1955).

The solution to our problem is simple. We need freshman scholarships. Instead of spending \$4000 per graduate in recruiting costs, let's in the long run save some money by putting part of this into attracting good high school graduates into the field. It is not upper-class scholarships which are needed, but freshman scholarships, and this companies are prone to overlook.

Earlier, I mentioned what the dismal picture has been in metallurgy and ceramic technology. Now I wish to relate what has happened in the Mineral Industries College because of freshman scholarship programs we have in operation in these departments.

In the fall of 1953, the ceramic technology department was down to 6 freshmen, two of whom did not last out the first semester. We were able to obtain three freshman scholarships in ceramic technology from ceramic companies for the fall of 1954. These we publicized in the high schools of Pennsylvania by sending a poster to each high school having a certified guidance counselor. There are now 800 such high schools out of the approximately 1500 secondary schools of all kinds in the State. Applications came in, and three good students, in need of this financial assistance, were awarded the scholarships. Unquestionably, because of the publicity attending these scholarships, we had 12 freshmen in ceramic technology in 1954, a 100 percent increase due to our influencing the statistical distribution. The three scholars did well their freshman year, and so the companies continued the scholarships for these boys for a second year. Through the very fine cooperation of the ceramic industry, we then obtained 7 new freshman scholarships for the fall of 1955, and again put publicity out on these. This fall, as a result, we had an excellent freshman group of 18 ceramic technologists — three times as many as in the fall of 1953. Not only is this a good number, but the average student is better than formerly, the companies donating the scholarships have received some good and deserved publicity, and the ceramic technology field has been publicized. In addition, the companies donating the scholarships have a young man in whom they can take an interest and may give a job during the summer and possibly eventually hire, although no strings are attached to the scholarships.

These industrial scholarships in ceramic technology are \$500 per year. This seems to be a good figure for the State University where fees are relatively low — \$252 for a resident and \$502 for a non resident.

In metallurgy, a scholarship program was put into effect for this fall, again applicable to incoming freshmen, but on a slightly different basis. Funds for the scholarships come from the cooperative metallurgy program at the University in which Pennsylvania companies pool funds for this purpose. As in ceramic technology, the department contacts the candidate and makes the selection and the award. As the program was run in metallurgy, an even more phenomenal success than in ceramic technology was obtained. Freshman enrollment in metallurgy jumped from 32 last year (for the past few years, the freshman metallurgy class here has numbered about 30) to 56. I understand that this is the largest freshman class in metallurgy anywhere in the United States at any time. And the entering students have a fine high school record.

An added dividend will be noted from these scholarships. About twice as many new students seem to come into the field as there are scholarships.

The recommendation I have is probably by now obvious. Let's stop blaming the high schools and stop moaning about the shortage of scientists and engineers. Let's get some freshman scholarships going and we'll have some students. Let's start influencing the statistical distribution. Let's get some boys into the field who are good students and who might not come to college if it were not for this financial assistance.

I am speaking here to you only for our department of fuel technology at Penn State. What we need are freshman scholarships, with the scholarships continuing in subsequent years if the boy makes a good record. We have a routine for publicizing, selecting, and awarding the scholarships.

We want several of these scholarships very soon so that publicity can go out to the high schools with the scholarships becoming effective in the fall of 1956.

We have found that \$500 scholarships are effective. Larger scholarships probably would be more so.

I am happy to state that progress has already been made. The American Coal Sales Association has started the ball rolling. This organization has decided to provide a fuel technology \$1000 freshman scholarship next fall at Penn State. This is to continue for the recipient for four years of undergraduate work if good grades are maintained.

I hope that this Institute may feel inclined to help on this scholarship program in fuel technology, perhaps through a committee to explore this matter just as soon as possible, and try to line up companies or groups of companies behind a freshman scholarship program.

Department of Metallurgy

Dr. A. J. Shaler, head, Department of Metallurgy, was appointed to a committee of the American Society for Metals to help oversee a \$75,000 pilot-plant-scale investigation of a system developed at Western Reserve University to mechanize the searching of scientific literature. He was previously a member of the group which studied the field and recommended that the Society undertake the investigation. Professor Shaler also has been chairman of a committee formed by a grouping of members of the metallurgical profession to look into the impact of governmental sponsorship of research of the nation's schools of metallurgy; the committee has completed its work and will report to the profession in February.

Technical Conference on Petroleum Production Held

The 19th Technical Conference on Petroleum Production was held at Penn State in cooperation with the Pennsylvania Grade Crude Oil Association November 16 through November 18, 1955.

D. T. Oakes, instructor in petroleum and natural gas engineering, and J. DePetro were co-chairmen of the technical session held Wednesday afternoon November 16. At this session the following papers were presented by staff members of the College of Mineral Industries: "Fabric and Permeability of Some Typical Sediments," "Petrography of Some Pocono Sediments of Western Pennsylvania," "Petrographic Investigations of the Weir Sand of the Martha Pool, Kentucky," "A Laboratory Analysis of the Electric Logging Parameters of the Weir Sand," "Comparison of X-ray Diffraction and K-Factor Studies of the Clay Content of Artificial Cores," and "A Gravity Investigation of the Renovo Area of Pennsylvania."

E. J. Burcik, associate professor of petroleum and natural gas engineering, and M. Blanchard were co-chairmen of the morning session on Thursday, November 17. At the technical session held Thursday afternoon, the following papers were presented by staff members: "Report of Miscible-Fluid Displacement in Porous Media," "A Study of Fluid Flow in Synthetic Porous Media," and "Progress Report on the Use of Radioactive Tracers in a Model Five-Spot."

On Friday morning, November 18, L. T. Bissey, assistant professor of petroleum and natural gas engineering, and M. Cook were co-chairmen. Papers entitled "A Study of Head Transfer by Fluid Displacement in Porous Media" and "The Determination of Liquid Saturations in Porous Media by a Method of Matching Refractive Indices" were presented by staff members.

Meeting of the Electron Microscope Society of America

Two hundred and seventy-five scientists attended the 13th annual meeting of the Electron Microscope Society of America held at the University on October 27, 28, and 29. This group included people from all parts of the United States and from at least six other countries.

Dr. E. F. Osborn, dean of the College of Mineral Industries, delivered the address of welcome at the opening meeting on October 27. Joseph J. Comer, assistant professor of mineral sciences, was chairman of local arrangements, assisted by: T. F. Bates, professor of mineralogy, and R. L. Weber, associate professor of physics. H. W. Stetson, research assistant in mineral industries, was in charge of the instrument exhibit.

The organization is unique in that its members are from many fields of science, including such disciplines as chemistry, mineralogy, biology, and metallurgy. The group is held together by a common interest in the electron microscope as a powerful research tool.

Technical papers dealt with instrument design, electron optics, and applications of the instrument. About one-half of the papers were concerned with the study of biological materials. In this group there were reports on studies of viruses, chloroplasts, and cells. Papers for the industrial session included studies of metals, clays, carbons, and polymers.



Mineral Economics

Stockpiling of Domestically Produced Mineral Raw Materials

John D. Ridge*

In the October issue of *Mineral Industries*, the problem of whether the mineral raw materials purchased for our national stockpiles should come as far as possible from domestic or from foreign sources was discussed, and arguments were given for and against both points of view. On the one hand, we do not want to exhaust our own reserves of mineral raw materials and become entirely dependent on suppliers outside the United States nor, on the other, do we wish to cripple or destroy all or part of our domestic mining industry by buying mineral materials which originate abroad in preference to those from our own mines.

For many mineral raw materials, there actually is no problem in deciding what proportion of our stockpiles are to come from which source. Copper is an example of such a material; it is presently in such great demand and short supply throughout the world, that there is much pressure on our government to divert copper from the stockpile to private industry. Such a diversion would not reduce either U. S. production or imports into this country — both must be kept at the highest possible levels, stockpile or no stockpile, unless many of our industries are to suffer seriously from a lack of this metal. Supplying copper to industry from the stockpile and other short-supply materials however, would throw the entire stockpile program badly out of balance. There is very little to be gained by stockpiling those mineral raw materials which are in long supply and are easily come by, either here or abroad, if short-supply metals and non-metals which are vital to industry in times of war or emergency short of declared war are not held in sufficient amounts by the federal government.

It is, of course, very easy to say that the government should resist pressures to reduce its stockpile holdings of copper and scarce mineral materials, but it is difficult for any government in a democratic country to refuse to provide from its reserves a raw material for lack of which many men will be thrown out of work. If the copper shortage were a temporary one which would be soon relieved by greatly increased production or by a considerable drop in demand, loans from the national stockpile would be cause for little concern. For copper, however, the chances of production noticeably exceeding demand as long as defense requirements remain near their present level are essentially nil. The only practical answer, therefore, is for the government to demand gradual, but appreciable, return of the borrowed copper and a steady building up of the stockpile to already determined limits. To do this without any disruption of economic activity will re-

quire careful planning, planning which can be upset by failure to maintain domestic production and foreign imports for any cause. In short, for such a material as copper, there is no easy cure-all for the problems that face us; for this reason most of the large copper companies are broadening their fields of activity in the hope of meeting at least part of the demand for that metal with other materials. Such programs, however, cannot be even partly implemented in a short time and will require many years for full realization. In the meantime, plans alone do not reduce the need for actual copper metal, and the government must protect the interest of the entire country even if some temporary harm is done to some fraction of those segments of the economy which depend on copper and copper alloys.

The situation in the lead and zinc stockpiles is far different from that in copper. While the United States cannot produce all it needs of either of these two metals, domestic production (at current prices) plus potential imports offer considerably exceed the demand. This means that the government generally not only can easily meet its stockpile requirements in these metals, particularly in zinc, but also must decide how to divide its purchases between domestic and foreign sources. In times of high demand, the government is relatively free to make this choice on the basis of what it thinks will be the best policy in the long run; mining companies prefer to deal with private customers, all else being equal.

In the summer of 1954, however, all else was not equal. The British government began unloading its stocks of lead and zinc on the London market, and the pressure of cut-price imports drove down the price of these metals in this country and forced many mines to close or considerably curtail production. Not unnaturally these companies turned to the Federal government for relief. As the "Report to the President's Cabinet Committee on Minerals Policy" says under the date of November 30, 1954, such relief was made possible by providing that, "in making purchases, preference should be given to newly mined metals and minerals of domestic origin." This policy had even before this date been put into effect for Federal purchases of lead and zinc and, as the Committee says on the first page of the letter of transmittal of the report just mentioned: "The very announcement of the new stockpile policy gave firmness to lead and zinc markets. When a purchase program was inaugurated under this policy, the market prices of both commodities rose substantially." The immediate result of this policy and its attendant price rise was the reopening of many closed mines and the increase of production rate of many operating mines. At first the additional production encouraged was largely brought by the Federal government; some 8,000 tons of lead and 12,000 tons of zinc were added to the stockpiles in July, 1954. Because of steadily increasing industrial activity in this country and abroad, government purchases of lead and zinc have gradually declined to 2,500 tons of lead and 2,000 tons of zinc in October, 1955 and in-

dustrial demand has increased. Despite these favorable indications, however, the price of lead had advanced only 1.5 cents from July, 1954 through November, 1955 and that of zinc 2.0 cents in the same period. Actually when, on November 30, 1955, the London market price of lead, including transfer costs to the U. S., rose above that of the New York market, U. S. lead prices did not rise and the London price dropped back the same afternoon to U. S. levels. This contrasts sharply with the history of copper prices. In July, 1954, copper was selling for 29.7 cents, but by November, 1955 has reached 43 cents, with foreign copper bringing nearly 44 cents delivered to the U. S. This indicates a definitely lower demand pressure for lead and zinc than for copper and a less stable price structure as well.

The higher prices of lead and zinc certainly have not stimulated the industrial use of these metals; their consumption has risen in spite and not because of the price rise. If the upward price trend continues, many users of lead and zinc will seriously consider whether or not it will pay them to substitute some other metal or material for these metals. In fact, there are presently indications that some brass mills are now taking "high grade" at \$8 a ton less than the "special high" they have been accustomed to use. In addition to such reductions of established uses, higher prices will also retard the use of these metals in new fields, further complicating the problems of the Federal government in maintaining stable prices and optimum production.

This potential weakening of the market for lead and zinc is not, however, the worst effect of the stockpiling so much domestically produced lead and zinc as to raise free market prices. What will happen when the goals determined for the lead and zinc stockpiles are reached? If the government then goes out of the market, even if demand is at present levels, the prices almost certainly will drop. At peak demand, it is possible that this reduction might not be great, but only a small price decrease would put many marginal producers out of business and force others to cut production; the effects of a greater reduction would be even more drastic. Then producers will be in exactly the same situation that they were before stockpiling was limited to domestic sources only and, in addition, the government will be holding a huge supply of both metals, the potential release of which will be a sword of Damocles over the market unless another war insures that they can be channeled back into industry without completely upsetting the market for the two metals.

The effect of the government's lead and zinc stockpile would be even more drastic than that of the government owned agricultural surpluses. This is true because: (1) minerals are not renewable resources in the sense that agricultural products are — a mine once exhausted cannot grow a new mineral crop — and (2) United States lead and zinc requirements cannot be met from domestic production — surpluses such as we have in our basic foods, are not possible in these metals. Sizeable fractions of our domestic consumption of lead and zinc, and of many other metals as well, therefore, must be imported from abroad. If, however, we continue to stockpile these two metals, the stockpile eventually will contain a tonnage equal to several years of U. S. imports. Those interested in keeping the government in the metal market will then suggest that the unmanageable large stockpile be reduced by releasing these metals from it in the amounts needed to

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fill the gap between U. S. production and U. S. needs, at the same time preventing foreign imports by raising the tariff on lead and zinc sufficiently to bar foreign supplies from entering this country. This program would, of course, have two bad effects: (1) our trade with friendly countries would be reduced sufficiently that these nations would be forced to sell these metals to countries behind the iron curtain and (2) our own resources of lead and zinc would be exhausted at an inexcusably rapid rate.

The point has been made that ore in the ground is worth nothing — that it must be mined and processed before it has value. In the strict sense of immediate usability, this is true. We shall, however, need lead and zinc for a long time to come, and we never know when political and/or military events will force us to supply all our own needs from our own resources. Thus, through the stockpiling plan, the possibility is good that we would exhaust our lead and zinc resources much more rapidly than if the free operation of the world market alone were allowed to control the amount of these metals imported into the United States. The more rapidly we exhaust our own supplies of these resources, the sooner we will be unable to take care of our own needs from within our own boundaries.

It is, therefore, a matter of simple self-preservation for us to allow other countries to supply us with those portions of our metal needs that cannot be obtained economically from domestic sources. We cannot, however, take so great a proportion of our metal needs from abroad that we no longer have an efficient and expandable domestic mining industry. It is, of course, the maintaining of our mining industry in this condition that the stockpiling of domestic metals is supposed to bring about, but the reasons for its inability to do so have already been pointed out. It remains to offer a reasonable and workable substitute for stockpiling domestic metals that will conserve our resources on the one hand and retain the strength of our mining industry on the other.

This will require action by the federal government in two separate areas of mining company activity. The first of these is exploration. If U. S. resources of lead and zinc, as well as of any other mineral material, are to last as

granted more extensive tax relief than they now can obtain, and, if this incentive does not sufficiently encourage exploration, that direct subsidies be granted to help pay the cost of this work.

Even mining companies do not want to go out of business because they have exhausted their ore supply, and the company which makes no attempt to find more ore is uncommon. At the present time, however, the tax laws do not encourage exploration for metallic ores to the extent that they do for oil. Tax credits or outright subsidies for such exploration within the United States would result in much new ore being found. Not only would exploration be encouraged, but also the incentive to improve current methods of mineral search and to develop new ones would be greatly increased.

Increasing exploration activity alone, however, would only add to the problems of the nation and the mining industry unless steps were taken to make sure that the new ore found did not: (1) flood the market and (2) too rapidly reduce United States' resources. The second form of government action, then, should be to insure that U. S. production, when added to normal imports, would be enough to meet U. S. demands but also should be to make certain that no greater drain would be placed on U. S. resources than would be required to supply the difference between demand and normal imports. Such action on the part of the government would have to be well considered and planned to make certain that it did not result in a weakening of our mining industry. No tonnage limits should be put on any producer; any company should be allowed to produce what it thinks it can sell. So far as producing from newly discovered properties is concerned, however, a company should have, in addition to the right to mine, the privilege of taking tax credits or actual subsidies for not mining ore above that required to satisfy its normal markets. This would make it unnecessary for a company to raise its production markedly solely to recover the cost of discovery and those existence of ore had been proved. Such taxes of holding the property inoperative after the relief and/or subsidies, however, should not be large enough to deter the company from expanding its operations if a real demand made itself apparent through higher prices for the metals involved.

boom-or-bust manner often associated with mining ventures.

This suggestion of compensation for not mining ore will be criticized as similar to the agricultural program by which farmers are paid for not growing crops which would add to domestic surpluses. The problem to be met is not, however, the same in the mineral field. In the first place, minerals kept in the ground are not permanently lost, as are crops not grown, but are available at any time that it is desired to mine them. Secondly, a new crop of minerals cannot be grown, as has already been mentioned, whenever one is wanted. This stockpiling of metals in the ground, as it may be called, would permit the United States to maintain a strong mining industry which would concentrate its efforts on economically valid projects instead of on sub-marginal materials while, at the same time, insuring that as much of U. S. resources would be found and held in readiness for a time when imports might not be available to close the gap between normal domestic production and domestic requirements.

Under such a scheme, labor and capital would not be expended in mining marginal or even submarginal materials, but they would be devoted to finding new ore bodies of mineable grade and to the efficient mining of ores which would command a profit at going metal prices. Domestic production would be flexible, no unmanageable stockpile would pose a threat to price stability, yet a normal program of stockpiling could be carried out which could be stopped at any time the reserve needed for emergencies was accumulated without disrupting the market. As old ore bodies are exhausted, almost all companies would, under this plan, possess such known reserves that they could move on to new deposits already blocked out and partially or fully developed without any disastrous hiatus in production.

Using the stockpiling program to support or increase domestic prices will, as the preceding paragraphs have attempted to show, sooner or later force a situation which can be met only by excessive expenditures of government funds or by prohibiting imports and using the stockpile to provide the metal or metals now being imported to supplement domestic production. Neither result can be anticipated with equanimity. Even if the government accepted the tremendous cost of continuously adding to the stockpile over an indefinite period, this policy would bring about a greater and greater concentration of the available money, men, and equipment in the mining of U.S. submarginal material. This would result in either (1) raising the cost of the metal or metals involved to such heights as to price them wholly or partly out of the industrial market, if any satisfactory substitute is to be had and tariffs are raised sufficiently, or (2) foreign metals being sold in the U.S. at prices below those at which domestic companies could sell and remain in business.

It follows, therefore, that a policy of stockpiling domestically produced metals to raise the prices of the metals involved is one which will sooner or later have disastrous results. The most acceptable alternate plan has two parts, and the accomplishment of both is necessary if the plan is to be carried out successfully. Exploration must be expanded through tax relief and probably actual subsidies from the Federal government. Domestic production and foreign imports must be kept in about the ratio presently obtaining between them through tax relief and subsidy payments as recompense for the charges accruing against known, but unmined, reserves.

long as possible, all mineable deposits must be found. Such exploratory work is much better carried out by the companies who are going to mine the ore than by any governmental agency, but most companies do less exploration than they would like to do because of the high cost and the difficulty of obtaining tax credits for money unsuccessfully expended. It is, therefore, suggested that companies having well-planned and efficient exploration programs be

In addition to receiving tax relief and/or actual subsidy to reimburse it for the charges accruing against unmined ore and for contributing to the national welfare, a company which did not increase its rate of mining despite successful exploration would profit by being able to plan for efficient operation over a long period of years. It would be able to conduct its activities much more as is done by most industrial organizations rather than in the traditional