

*Circular 33*

# A PHILOSOPHY FOR CONSERVATION

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# PREFACE

*The postwar world does not provide the Utopia of peace and prosperity of which man had dreamed. In fact, it seems that the sacrifices and waste of that great struggle are being lost in the morass of stupidity, selfishness, and cupidity which unfortunately are still the most conspicuous traits of the human race. Perhaps it is too soon to expect the blessings which are supposed to appear in a peaceful world, and man's thought is clouded with a pessimism engendered by the conflict itself, in which all activities tend to enhance his pessimistic nature. Must man admit that it is a law of nature for nations to go to war?*

*The war demonstrated that when faced with a common danger, peoples differing in antecedents, language, forms of government, and resources can unite for a time, pool their skills and abilities, and emerge victorious from a contest unparalleled in magnitude, ruthlessness, carnage, waste, and cost. This has been accomplished by great individual and national sacrifices, the submerging of local ambitions to win a victory which will permit free men to develop the form of government and society in which the rights of the individual are respected. Such a society, utilizing the progress made by science, has within its grasp the possibility of forming a structure in which standards of living, security, and intellectual development can rise to unlimited heights. This could be the true Utopia, the ideal environment.*

*However, with victory, the common objective, obtained, man is now witnessing the rapid disintegration of common effort and the emergence of old rivalries and suspicions. It is painfully apparent that man is not capable of the efforts necessary to win the prizes of*

*peace, that he exhibits when faced with the dangers of war. And it must be remembered that the prizes of peace are at least as valuable as those of war. The greatest prize of war is peace itself. There must be a philosophy for conservation now in order to reach the ultimate goal of human improvement.*

*Circular 33 is number 2 of a series of three companion circulars dealing with various phases of higher education in the mineral arts and sciences. The first, Circular 31, entitled ROOTS OF HUMAN PROGRESS, was published on January 1, 1948. The intent of Circular 31 is to invite some timely thinking on humanistic roots, nature, man, land, conservation, and egoisms. The third circular, defining the decentralized, unified program, faculty, physical plant, and objectives of the School of Mineral Industries of The Pennsylvania State College, will be published on or about January 1, 1950.*

Edward Steidle, Dean  
School of Mineral Industries

January 1, 1949.

## INTRODUCTION

The School of Mineral Industries is dedicated to education in mineral conservation and research by which the means may be found to make conservation effective. This includes diligent search for mineral truths and the energetic discovery, maximum recovery, and complete utilization of irreplaceable mineral resources.

Standards of living depend upon two factors: human resources—intelligence, imagination, initiative, know-how, work; and natural resources—plants, animals, and minerals, including water, air, soil, heat and light from the sun, and all other such resources that are useful to man. Human relationships have not kept pace with scientific achievement; as a result man, in desperation, wittingly, premeditatively sacrifices freedom for security. Many natural resources, through overproduction, mismanagement, and greed, have definitely moved over into the exhausted or exhaustible category.

The United States cannot maintain present standards of living on an agricultural economy alone, and serious harm can ensue if there are marked disproportions in numbers and relationships between city and rural populations. The most materialistic New Yorker must see virtue in bucolic loveliness.

The United States is rated wasteful and inconsistent most of the time. It does not make sense to dole out through the keyhole what a wage earner can bring through the open door; to raise wages to lower the cost of living; to encourage thrift by emphasizing social security; to liquidate the national debt by giving away another billion; to recirculate scrap metal by sinking battleships in target practice or for other thin reasons;

to tax a coal miner to subsidize a farmer who depends on local markets; to create a buyers' market by promoting a "new look"; to prevent a depression by importing more mouths to feed; to use a formal education as a criterion of good citizenship; to use productive soil to straighten highways to let automobile killers burn up more petroleum and rubber; to have to purchase a new 35-cent electric switch for the sake of a repair part that costs a tenth of a cent; to unify the command of the armed forces by condoning rivalry between services; or to have to take insults from the Soviets and maintain an air corridor into Berlin. On the other hand, mass production in living; strikes; such canned amusements as movies, radio, and television; easy divorces; too many extra-curricular activities; overemphasis on sports; school holidays to celebrate a team victory—these develop poor perspective, especially during adolescence. Why waste youth? This too shall pass.

Much has been written in regard to conservation but most of it is disjointed. Resources are seldom explained; human resources are usually ignored; and the subject of conservation is usually approached negatively—from the standpoint of waste. Consequently, the curbstone usage of the word conservation has made the term a misnomer. It has become another meaningless catchword, a fad.

The United States must fear ignorance and fifth column influence from within more than foreign conquest from without. Present-day ignorance is essentially the accumulation of 50 years of technical change without an appraisal of its effects and an adaptation to them.

Man must understand what is meant by conservation in a broad sense, think realistically, and not make laws that clash with natural laws until he has all of the facts.

Expediency is an important consideration, but there must be other motives or else civilization will perish as earlier civilizations have perished. True conservation is a problem of education; it must be made a philosophy of everyday living—everybody's job.

## IMPROVIDENCE

Man is still dependent upon energy and matter in certain usable forms, despite the fact that energy is inherent in all matter. Until such progress is made that the energy contained in all matter can be controlled, man must continue to utilize the common fuels.

Advancement of research in atomic energy has cast a gleam of hope for future use of the tremendous energy contained in the atom. Use of atomic power for industrial pursuits would open up limitless resources of power. This energy, of course, is a two-edged sword, since man's progress and his means of destruction have always evolved parallel to each other. Thus it is established that long before man uses atomic energy for his industrial development, he applies it to the destruction of his own kind and jeopardizes his very existence.

Though atomic energy does hold a dubious promise for the future, it still does not relieve man of all consideration of the fundamentals of existence. Preservation of the world's resources governed by an able world authority could yield results. Present efforts by individual nations at best can be only a delaying action. Unfortunately, conservation on a world-wide scale is impossible when world-wide peace cannot be achieved.

The theory of Malthus that the food supply is increasing in an arithmetic ratio while the population

increases in a geometric ratio has acquired a new value in the modern industrial age. For a time his theory seemed disproved by the tremendous advances of chemical and mechanized agriculture, but now statistics show that the yield of the cultivable land of the world will soon be insufficient to sustain the ever-increasing world population. A parallel drawn in the industrial field shows that the per capita consumption of raw mineral materials is increasing while the supplies are decreasing. Malthus' ominous prediction now applies not only to agriculture, but even more to mining.

Whereas the problem in agriculture involves reproducible products—plants and animals—that can conceivably remain adequate, the mineral resources are not endowed with that ability. This leads to the conclusion that since the basic resources are of limited supply and in the main not replaceable, man is faced with an eventual halt to expansion in industry, and a possible inability to replace existing establishments as they depreciate. The unavoidable result will be a radical change in man's machine civilization, for better or for worse. A definite adjustment of man's attitude or character seems to be the only way of adaptation to such a change.

No one can deny the serious import of the situation. No one can contest the implications of the facts that are at man's disposal. Nevertheless, though the need for conservation is undeniable, the majority of people continue to content themselves with paying mere lip service to the ideal. When will man realize that there is very little time left to establish world peace, and that he must take definite and practical steps now to put his heart into conservation?

## OBJECTIVES MANY-FOLD

The conservation movement, initiated during the time of Gifford Pinchot and Theodore Roosevelt, has gradually taken hold of the popular imagination of the American people; and today, although it is little understood, it is an accepted doctrine. But the subject should not degenerate into cheap and misleading publicity.

In the wise development and use of human and material resources lies the answer. (See Chart No. 1.) Conservation does not mean the parsimonious and misguided avarice of the miser, but the prudent and intelligent use of all types of resources, and the opening of a way for the use of those potentialities that lie just beyond the horizon and wait for man's constructive efforts to make them available.

Conservation consists essentially in not emptying the pools of primary wealth before the minds of men, guided by ingenious research, have found ways to replenish them from sources as yet untapped. To advance successfully along this path, man should be guided by science and by a decent understanding of his obligations to his fellow man and particularly to his children and his children's children.

Two pathways branch from this general road. One is the restraining of those spendthrifts who would throw away our national heritage for the sake of a cheap and irresponsible enjoyment of the present. Conservation in the generally understood sense usually has meant such a restraining, and it has taken, more often than not, a legal aspect, colored slightly by technological principles. However, there is always danger in any restraining, even when accomplished for the very best of motives. One danger is the development of a moralizing psychology, of conservation for conservation's

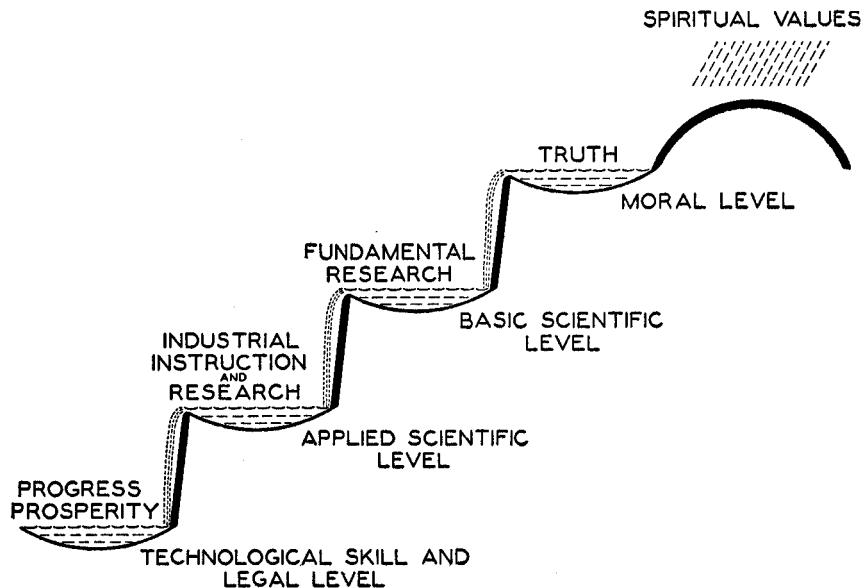


CHART 1  
A PHILOSOPHY FOR CONSERVATION  
POTENTIAL RESOURCES

sake. After all, the conservation of natural resources should help man, not impede his progress. Another danger is miserly fear of having nothing left after known resources are gone. This static approach, typical of European countries, is quite un-American. The American way is to consider material resources as expendable commodities, to be used wisely for the development of a high standard of living while searching vigorously for new ways of maintaining this high standard from other sources.

Even the simple, restricted improvement of industrial practices, either voluntary or enforced by law, leads usually to better utilization of raw materials and eventually to the discovery of still better practices which, in turn, make it possible to utilize waste materials which before were contemptuously thrown away. Hence, even such conservation in the restricted sense leads generally to the opening of new frontiers in the shape of utilization of low-grade resources that, previously, had been ignored completely.

There is another and better way toward this goal. Indeed the intelligently thought out, rather than the casual, approach to this problem may produce much quicker results. This is the function of organized research, or research with a purpose. Industrial and semi-fundamental research is the second great step of conservation which inevitably follows the legal enforcement of improved industrial practices. It opens entirely new vistas for industry and makes it possible to increase rapidly our reservoir of available resources by adding to them newer and newer areas of supplies which, until then, were quite inaccessible. This is indeed an opening of new frontiers and is being more clearly understood as still another aspect of conservation, possibly

even more powerful than conservation in a conventional sense.

But the expansion of industrial research is based upon a limited supply of resources of its own; namely, the amount, quality, and depth of the fundamental scientific knowledge upon which it depends. Industrial research stagnates, gets in a rut, and loses its magic touch when its basic principles become exhausted. Hence, the third and usually not readily realized level of conservation is the expansion of basic fundamental research. The atomic bomb would have been quite impossible without the theoretical and apparently useless researches of Einstein, Curie, and many others. To replenish temporarily the pool of basic principles is the function of theoretical research. It is in this field that the role of the School of Mineral Industries should be paramount. The School must help to guide industry while preserving at the same time its own independence and judgment. It should blaze the trail that will open new frontiers in the mineral arts and sciences without being fettered too heavily by "practical" ideas that may be worth while today but outdated and dead tomorrow.

The third level of conservation is thus the fountain-head from which the other two levels spring. Unless it is kept going vigorously by enthusiastic research workers whose object is the Truth, the waters of the great streams of industry and prosperity which are essentially fed by it are finally going to become murky and cease to flow.

But what good is it for a man to conquer the world and lose his own soul? Action without a worth-while purpose is just as senseless as the running of a squirrel on a treadmill. Beyond the fields of science, so beautifully cultivated by research men in colleges and re-

search institutions, lie those great spiritual values which in the long run are at the bottom of every human activity. The human spirit works best when it is unfettered and when it has for its highest objective—Truth. In the attainment of this goal man can discern what constitutes the Good; he can create those moral values which are necessary for the well-being and happiness not only of the individual but of society as a whole.

When education produces the type of man capable of achieving these ideals of Truth and Goodness, then indeed we will have reached the highest level of conservation, the conservation of those spiritual resources which determine the final end of man and make possible the good society.

Obviously, there must be a conservation cycle. (See Chart No. 2.) When enjoying prosperity man should not be engrossed by crass materialism but should remember that moral and basic scientific values are not automatically self-perpetuating. To replenish these higher fountainheads of progress man must give time, energy, and devotion. This means that he must pump back into these higher levels some of the resources made available by applied scientific technological skill.

Just as the ocean, in order to be replenished by rivers, must give some of its substance, in the form of vapor, into the atmosphere to produce creative rain, so must human prosperity and industry contribute their tithe of time, money, and faith to the support of education and research toward the development of spiritual values and good citizenship.

## HUMAN RESOURCES

Thus far virtually the sole theme of the conservationist has been the preservation of natural resources.



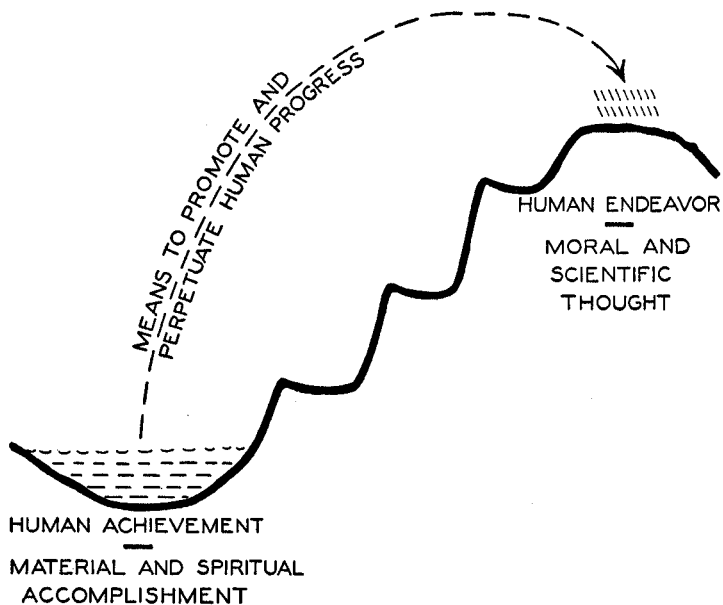


CHART 2  
A CONSERVATION CYCLE  
INTELLIGENCE

Little thought has been devoted to the conservation of America's most significant asset—her people. True, considerable effort has been devoted to conserving man's physical strength by the invention and application of labor-saving machinery. Notable progress has been made also in the conservation of man's health through important discoveries in medicine. However, little if any positive success has been achieved in the conservation of the most valuable attributes of man—intellect, skills, manpower.

Human resources are interrelated and interdependent. There is no monopoly on knowledge or skills or human energy. No one must sell them short. All the knowledge and all the skills and all the energy possessed by all men are required to render all the services needed by all men.

One of the major sources of wasted manpower is found in the nation's schools, with an educational system based on the outmoded theory of uniform education for all. Actually, if democracy means free initiative for the individual, and unlimited progress at the maximum rate of speed of which the individual is capable, then our public schools are not democratic institutions. In fact, the prevalent practice of uniform education borders on the communistic, since it is based on equal rewards (advancement in grade) for equivalent amounts of time devoted to a job (the school year), regardless of quality of work and ability to produce (learn). Results of such a system of education are to lower the intellectual curiosity of young people to a level well below the average capacity, for teaching must be pitched at such a level that only a bare minimum of the total student body fails to advance in numerical grade from year to year. The resulting waste of manpower among mentally superior students during

their formative years is appalling. While the outstanding student should be progressing rapidly, he is forced instead to reduce his pace to that of the average or sub-average level of his class and pitch his rate of mental growth at the level of the near-moron.

In theory, the progressive education methods in some public schools should have removed the millstone of standardization by permitting students of superior ability unfettered opportunity to develop latent talents. In actual practice, as applied in some schools, progressive education has resulted in a class of students frequently ignorant of discipline and devoid of competence in even the rudimentary skills—arithmetic, writing, geography, reading—the foundation of all advanced training. At least the standardized product of former years could add, subtract, punctuate, spell, and alphabetize. While the opportunities for individual development have improved under the modern non-standardized system of training, with its substitution of “free expression” and “personality development” for the old-fashioned rote memory and drill work, the old stimuli for advancement—the honor of being at the top of the class or, conversely, direct social and physical coercion by parents and teacher—are weakened or lacking. And today’s children, like most adults, will follow the path of least resistance in their academic work unless directed along other channels. Too many lose the persistence and intellectual curiosity of youth.

Even more appalling, however, than the poor use of manpower within the schools are the effects of such early training on students entering fields of higher learning. All too often, by the time the superior student begins his collegiate career, he has never learned how to study and has developed habits of mental laziness that are difficult or impossible to erase. So he runs

along in second gear, content to pass through college with a minimum of mental exertion.

The grass roots of democracy are in the home. Secondary schools, quite justifiably, point to preparation for citizenship rather than for higher education. High school graduates are supposed to be eligible for college; but half of them do not have the necessary mental capacity, nor can they meet requirements for technical curricula. College board or well-conceived comprehensive examinations should be used as exacting yardsticks of mental capacity and preparation for college. The first two years of higher education should consist of basic training; first, some mathematics, physics, chemistry, and English; second, some work in geology, botany, biology, and geography; third, some integrated humanistic—social courses—resulting in discipline in thought and flexibility in deed. Professional schools would impose a superstructure upon this foundation, and students would work at full capacity. The plan would liberalize some curricula, now liberal only in words, eliminate some fraudulent courses, and reduce the number of stillborn degrees, including masters’ and doctors’ degrees.

Higher education has become overspecialized. Some concentrate more and more on less and less. There are too many divisions, too many departments, too many little fields of knowledge, and above all, too much competition between schools, functions, and departments. Conservation of human resources needs more pedagogy and less tinsel trimming.

Higher education is criticized because it fails to produce leaders out of poor raw material. Excellent reports—from Harvard, Princeton—have been published on postwar educational needs. Liberal arts committees have proposed revisions in organization as well as in

subject-matter requirements. But egoisms hold the line and little happens. The report of the President's Commission on Higher Education places little emphasis on the need for maintaining high academic standards in colleges, does not explain the economy that will provide jobs for all college graduates, ignores the training of young men who are needed to fill gaps in industry following high school, fails to mention educating young people into trades and skills—in short, it suggests no ways of conserving manpower. The sum total sounds like glorified high school in terms of the melting pot of the early nineties.

There is greater need now than ever before for higher education under the terms of the organic Land-Grant Act. Land-Grant institutions should study their individual problems and arrive at a solution to these first. It is all right to consult and cooperate, but to attempt to fix a scheme into which all should fit would be fatal. After all, the Act is a heritage, not a convenience.

Let us now examine the manner in which colleges and universities conserve their basic assets—the minds and skills of their faculties. It is not far from correct to state that today, in America, the prestige of the majority of universities in the popular mind (and in the minds of many who should know better) is measured in large degree by the number, size, and splendor of their buildings; the size of their student bodies; the rank of their athletic teams; the size of their endowments; the number of books in their libraries; and other similar criteria. Low on the list of standards for judgment is the mental quality of their academic staffs. Consequently, it is not surprising to see the average university making strenuous efforts to accommodate all would-be students; nor is it remarkable that vast sums

of money are being devoted to construction of new athletic fields, and buildings where the harassed undergraduate can find surcease from the cares and troubles of college life amidst expensive trappings. Simultaneously, and on the same campus, the heart and soul of the university, its staff, is forced to work amidst conditions that, to say the least, are not conducive to the maximum utilization of a free and unfettered mind. Colleges must recruit the best prospects for their staffs, beginning with graduate assistants, and then provide that physical solitude and quiet that is so fundamental for true scholarly, constructive thought, with academic freedom. An excessive teaching load, with the innumerable interruptions associated with too many class hours and too many students per class, together with nonproductive committee meetings and reports, plague the scholar with so many nonintellectual duties that time for mental pioneering and creative effort is drastically reduced or nonexistent. Sometimes inadequate salaries, incommensurate with the status and caliber of work being performed, disturb that financial peace of mind which is so essential to scholarly work.

In view of the above, the question might well be raised: Is true conservation being practiced in the one basic human resource in our colleges and universities? Or are institutions of higher learning, by taking on all comers as students and devoting their dollars to bricks instead of brains, wasting the best minds of the nation? How much farther might the intellectual horizon have been advanced today if more consideration had been given the lowly professor and less thought and effort devoted to outward symbolisms of higher education!

One need seek no further than the days before Columbus to find strikingly demonstrated the inability of man to employ his physical legacies. Coal, iron ore,

petroleum, water power, and a host of other assets that are vital present-day needs were at the disposal of the early Indians in quantities in excess of those available today. But lack of mental advancement among the aboriginal population prevented their utilization, and their value to the natives was no more than that of any other worthless bit of Nature. Today, solely because of man's mental advance, such resources have become invaluable.

A question arises naturally from the above sequence of thoughts. If man has achieved his present goals in the employment of environmental assets under the handicaps of mental retardation spawned in the public schools and colleges (industry, government, and the armed forces are no exceptions), how much more advanced could we have been today if man's unfettered mind had been given full and unretarded rein to develop and grow? Manpower is an expendable resource. Every day of inefficient use of brain and hands is a day that is lost forever; it cannot be recovered at some future time. Furthermore, the results of wasted manpower are cumulative. For when mental achievement is retarded one day, the springboard for progress on the next day is set that much lower. When in doubt, do something intelligent.

## FALLACIES

The greatest single obstacle in the path of constructive action in making conservation a reality is the inherent discord in the hearts of men. A perfect society doubtless is many millenniums removed from the present generation, but it must be admitted that progress toward a conservative use of our natural heritage with the altruistic concept of the greatest good for the great-

est number for the greatest time can be attained only by a society in which discord is reduced to a minimum compatible with the limitations of human nature. Daily industrial discord is witnessed between management and labor which passes the bounds of arbitration and results in stoppages of production, waste of productive capacity, idle capital, idle labor, and the complete loss of the most unrecoverable element of all-time. The conservation of material things cannot progress independently of the conservation of the efforts of the human worker, and the results of these efforts are proportional to life itself as measured in hours and years.

Unfortunately discord passes international boundaries, and the story of war is as old as the story of mankind. All forces of destruction are liberated to prey upon military units and civilians alike. It is now a matter of common knowledge that the destructive potential of war is incredibly greater than even dreamed of in the past generation. And man continues to witness the prostitution of research to make the engines of war even more efficient and horrible. War is accompanied by waste of men, materials, and time; and the final winner often appears to be bankruptcy, famine, poverty, disease, and hopelessness for the future. In an immature state of development man continues to feel that war, carried on for national defense, is the lesser of evils, for it defends the institutions from which it is hoped that a wiser posterity may derive the benefits which are so elusive today. Meantime conservation becomes a mockery and waste reigns supreme.

At the beginning of World War I President Wilson said, "To the miner let me say that he stands where the farmer does; the work of the world waits on him. If he slacks or fails armies and statesmen are helpless. He

also is enlisted in the great service army." Wilson recognized the true significance of the extractive industries.

In spite of this wise counsel, the mining industry suffered from a critical manpower shortage in World War II. Mining personnel was dissipated by competitive bidding for skills carried on by the construction interests in the prewar period. Contracts were on a cost-plus basis which resulted in higher hourly wages plus considerable overtime. On the other hand, the 40-hour week was retained for almost a year after Pearl Harbor. It was not until late 1942 that the bituminous coal mines went on a 6-day week and not until early 1943 that anthracite mines followed suit. The War Manpower Commission did not order a minimum work-week of 48 hours in the metal mines until early 1943. The final blow was the loss of experienced personnel to the armed forces. Selective Service classified 606,438 registrants as miners. A total of 126,384 were inducted and an additional 17,085 had volunteered by July 1945. The labor shortage in the Far West was so severe that in the fall of 1942 the army released 4200 soldiers to work in metal mines, and again in 1943 they released 5306 for the same purpose. In many instances experienced miners were drafted and inexperienced soldiers were released to work in the mines. Secretary Ickes requested the release of 30,000 soldiers to work in coal mines in 1945, but the end of the war eliminated further consideration of the matter.

Many of the technical personnel of the mineral industries were dispersed by the war. Geologists and mineral engineers were subsequently diverted to jobs that had no relationship to their technical qualifications. Several state geological surveys were disrupted by the draft. Metallurgical engineering was the only mineral

industries curriculum included among the science and engineering curricula approved under the Army Student Training Program, with the result that the total number of students enrolled in mining, for example, declined from 1978 in the academic year 1940-41 to only 357 as of July 15, 1943. The consequent disruption of mineral industries faculties is still being felt in the colleges, as well as in loss of technical personnel in industry.

The skill of experienced miners is a resource to be conserved. The armed forces educated the younger men away from mining; no new crops were available to enter the mines during the war period. Management and labor must give co-operative consideration to problems of community housing, schools, recreation, sanitary facilities, and medical care in mining communities. It is not enough for a company to pay high wages and for a union to demand high wages. The miner is already high in the wage scale; still he strikes and advises his sons to leave the industry.

Most of the ideas on how to conserve the mineral resources will undoubtedly come from college-trained men—men who are familiar with the earth sciences and the extractive, processing, and utilization procedures. However, the burden of administering these ideas falls on the shoulders of the mineral industry worker, and the success of the over-all conservation program will depend on the level of the worker's understanding of the problem. Like the adage that "a chain is no stronger than its weakest link," conservation will progress only as fast as the level of worker understanding is raised; and this level for the entire group is affected more by those who care nothing about the problem and shun training than by those who recognize the enormity

of the problem and prepare themselves to do something about it.

Conservation and training of the adult mineral industry worker go hand in hand. A sense of insecurity breeds aggressiveness, but there is no need for an inferiority complex. In order to secure maximum conservation, it is necessary to secure maximum coverage of education among the workers in their particular fields of application. For example, the supervisor should be provided, not only with technical training related to the work he controls but also with training in human relations in order that he may guide his men and secure the results that are most desirable. The workman should be provided with training on his level in the technical aspects of his job, not only that he may know how to do his work better and to avoid material waste, but also that he may gain more satisfaction from his daily task and thereby become a happier human being. Satisfaction in daily accomplishments contributes to happier living, and this in turn reduces the possible friction that might develop between groups of employees or between employer and employees. An aggressive on-the-job, vocational-technical, upgrading extension program is a "must" in any conservation program in the mineral industries.

The United States cannot afford to waste the human resources of its basic source of strength—the mineral industries—with such abandon, even in times of peace. The gap in the training of technical leaders and skilled workers caused by Selective Service must be filled. Veterans from the mines and mills must be educated back into the mineral industries. The ultimate might of the mineral base of national security should be strengthened without delay, lest the future find the United States not only without armed forces in being but also

without the physical means of creating and supporting armed forces.

## MATERIAL RESOURCES

The plant, animal, and mineral arts and sciences are interrelated, interdependent, equally distinctive subject-matter fields. The artificial, erroneous, and popular idea that minerals occur in great storehouses in nature's treasure room to be removed at will at fabulous profits is about as correct as the assumption that the farmer's life is one of ease in which the crops spring miraculously from the ground. However, both of these fundamental industries, mining and agriculture, have much in common. The extraction of minerals from the ground and the extraction of plants from the soil for immediate use, or conversion to meat, are fundamental activities and subject to many common economic laws. In other words, in many important basic concepts there is little difference between surface and subsurface crops. The farmer owner working the surface of the earth and the owner of a fraction of the oil or coal rights in the subsurface, from which a small yearly income is derived, are interested in the best management of the land for the mutual benefit of all concerned. Therefore, it is essential that in any planning or political action intended to create a new scheme of things, it should be remembered that one plan must fit all sources of primary wealth, whether coal or wheat, petroleum or milk, iron ore or beef. And what basic economic difference is there in the processing of a gallon of petroleum and a bushel of corn?

Subsidies and appropriations that are the will of the people should apply to all of the extractive industries, clear across the board. But a strong industrial society

cannot waste its power of production on uneconomic enterprises. Consequently, subsidies must be reserved for extremely few ventures that have high national health and security aspects.

Agricultural economists acknowledge that the old production unit of farm, man or boy, and horse is disappearing and is being replaced by mechanical assistance. In other words, the people cannot be fed or clothed without the machine made of metals and the mineral fuels to power it. This condition, like so many others connected with the production and utilization of minerals, has been in evidence only since 1900.

The same economic principles hold for real estate values, in farming areas or mining towns. If government subsidy is used to mechanize the farm it should also be used to mechanize the mine. Free-for-all subsidy is false economy—not even a stop-gap compromise—only a one-way ticket to complications and trouble. Possible subsidies that may be warranted from now on should be free of all pressure groups and used in the sole interest of all of the people.

The starry-eyed reformer with his visions of a socialized state in which mineral resources are under one command must remember that the workers of the surface soil will be under a similar management, and that such a scheme is impossible in the America which has developed from free enterprise. For when man asks Government to do something man should do for himself, he puts himself in chains.

Mother Earth—land masses, air, water—is composed of 92 natural elements. Almost all of them occur as metals, or as metallic or nonmetallic minerals, rather than as animal or vegetable compounds—inorganic rather than organic matter. But life depends upon minerals. Plants require water, carbon dioxide from the

air, and a variety of other minerals from the soil. Animals require water, oxygen from the air, and a variety of other minerals from plants and other sources.

Minerals are the primary building blocks of the earth. A mineral is a natural inorganic substance with a characteristic chemical composition and a definite internal atomic structure which gives to the mineral certain characteristic physical external properties, such as form, color, hardness, and so on. For all practical purposes coal, oil, and natural gas are considered to be minerals, as they are recovered from the ground by techniques similar to those employed for iron, sulphur, and potash. Therefore, they are called mineral fuels and belong to the mineral kingdom, although of organic derivation.

A rock is an aggregate of certain characteristic minerals which forms an important part of the earth's crust. Mineral resources occur as certain types of rocks that contain an adequate concentration of some valuable minerals.

The definition of soil is not so clear, but it is required for mapping. A definition can be physical, economic, or esoteric. Marbut always contended that a soil should be defined by its internal characteristics, irrespective of use. To hold to this concept is to contend that the only useful definition must be physical. This does not in any way prevent mapping of soil on the bases of productivity, load-carrying capacity, or any other feature.

Wise use of some resources may mean preservation in their pristine condition. Sometimes restoration is a prerequisite to proper use. In conserving and restoring the western range, the kind and intensity of use must be brought into harmony with the capabilities of the land. Water resources can be conserved only by use; and the uses to which water is put depend upon the works and programs by which it is developed. The



national forests are managed not only to produce timber, but also to protect and improve water supplies, reduce erosion, abate flood runoff, provide forage for livestock, and enhance wildlife and recreation. Development of river basins involves flood control, irrigation, power generation, navigation, agriculture, fish and wildlife, recreation, pollution, economic minerals, and, in general, the entire economy of the region—always in the interest of the nation.

The multiple-purpose idea is well established also in engineering planning. It is generally agreed, for example, that a dam should not be designed just to control floods, or for power generation alone, or for any other single purpose. In general, it should be planned with a view to maximizing the sum total of all realizable benefits.

Closely allied to the concept of multiple-purpose planning is the idea of comprehensive, unified programs. Programs for developing and utilizing the water resource of a region must go forward with complementary and co-ordinated programs for the land and the minerals. Again, the wildlife and recreational resources of the area are inextricably interrelated with both water and land programs.

To achieve full and efficient resource development, utilization, and conservation, the various agencies responsible for these functions must integrate and unify their plans and activities. Teamwork, then, is another prerequisite for effective conservation.

The role of engineering geology in this work arises from the concept that most civil engineering works—for reclamation or any other purpose—are built on rock and soil foundations and are largely constructed from rock and soil materials. Moreover, the effectiveness, economy, and safety of a completed engineering work de-

pends to a large degree on how well it has been adapted to conform to these natural conditions. The rocks and soil at structure sites or materials deposits, and the faults, folds, lithologic and ground water conditions, and the like, comprise the natural conditions of the site to which the structure must be adapted, and are the geologist's metier and stock-in-trade. If, then, structures are to be most effective, most economical, and safest, the geologist must assume the responsibility for interpreting these conditions to the engineer so that he may design and build his structures in the most appropriate way.

Coal stripping operations were accelerated during World War II in order to meet coal production quotas. Reclamation of stripped areas is complex under the best conditions. Above the coals studied in the Somerset area there is an average of three feet (from a few inches to over 10 feet) of black shale which contains numerous pyrite grains. This shale immediately overlies the coal, is the last to be stripped, and therefore lies on top of the spoil banks. When soil is formed on these banks, iron oxide, sulfuric acid, and sulfates derived from the weathering of the pyrite are present in relatively large amounts, tending to retard the growth of acid-sensitive plants. There is nothing to counteract this acid condition because there is no lime in the rocks found above the coal. Leveling of the spoil banks tends to reduce the penetration of rain water and retards deep weathering due to the formation of soil and plant growth.

Water is life and death, the most important of all minerals, and in its solid, crystallized state it is known as ice. There is wanton waste of water from all sources and in all uses. Ground water, not to be confused with surface water, is used for condensing, refrigerating, air

conditioning, and drinking because it is less likely to be contaminated and has a relatively low and constant temperature. Without an ample supply of ground water industrial operations in many fields would be hampered and perhaps halted.

It is a well-known fact that the subsurface water level over most of the thickly settled and farmed sections of the United States is slowly lowering, causing wells and springs to go dry. This is due mainly to soil erosion causing increase in surface runoff and decrease in the amount of water going underground, also to mining and well drilling and to many industrial plants drawing on the underground water supply, polluting it, and turning it into surface streams.

Pennsylvania has many farms where soil erosion is taking its toll; large areas of forest land have been cut down and burned over. Many mines in the State pump out ground water, many oil and gas wells destroy its usefulness, and a large number of industrial establishments use it up. Nearly every farm and community in the State has an active ground water problem to deal with at present. In the future these problems will become more acute. A general ground water survey of the State has been published, but it does not deal with the problem of conservation. This survey needs to be amplified to secure data as to what is happening to our ground water due to man's legitimate uses as well as abuses and what can be done to protect it for future generations. Search must be extended for new areas of suitable ground water supply to meet the needs of shifts in population, and new and expanding industries.

## GOOD EARTH

Mother Earth has had a long life extending over two billion years, during which time she has changed from a mass of incandescent gases to her present form, exhibiting a density stratification from the extremely tenuous gases of the stratosphere to the heavy central nickel-iron core. Man is now mining all the principal divisions of Mother Earth except the centrosphere. Nitrogen, oxygen, neon, and other rarer gases are being recovered from the air; magnesium, bromine, potash, borates, and other salts from lakes and seas; brines, medicinal mineral waters, and great quantities of water for domestic and industrial uses from surface and subsurface reservoirs; and, from the rocky crust, many minerals and fuels for our present industrial civilization as well as plants and animals for food and shelter.

Productivity of soil is influenced both positively and negatively by man. There is some cause to bewail what may be considered a wasteful influence of men on soil. The general situation is bad in spots but not hopeless. The passing of large areas of fertile land in some areas is merely to be noted and not to be mourned. These lands could not have been used without decrease in their fertility.

The productivity factor is affected by human activities. Many soils in the eastern and southern states are far richer and more productive now than they were at any previous time. Arctic soils are not productive when cleared. It takes something like five years of cultivation and the addition of a lot of materials to establish productivity.

Soil scientists consider soil to be dynamically undergoing constant geological erosion and regeneration. There is a continual turning over of organic matter and a steady flux of the lower forms of life. The soil, even though it is but a thin covering of the land, is probably undergoing more change than are great masses of underlying structures.

On the other hand, great empires have fallen because of the misuse of their natural resources. Greece, between the fourth and seventh centuries B.C., was the power center of the world. This position was attained by a combination of competent people, good crops, good diet, some minerals, the right density of population, good health, and ready intercourse with the most progressive parts of the world. Gradually, her downfall was caused by irresponsible politics, internecine strife, disease, and land erosion. Today, after more than 2200 years, history is all that remains, for mines, forests and productive soil are gone, in their turn. She is a poor struggling country with essentially no mineral wealth, no modern industry, unable to feed her 6,500,000 people except on the very lowest subsistence level. Greece can only be a pawn in the modern game of European power politics.

The state of Israel occupies one of the most niggardly natural environments in the world. The entire region, except along the coast, has less than ten inches of rain a year. The natural vegetation is so sparse and the land so overgrazed and carelessly cultivated that the typical torrential desert rains have led to serious soil erosion which has laid bare many hillsides. The absence of high mountains with permanent streams makes irrigation a limited possibility. There are no known minerals except potash and a little bromine from the Dead Sea. Here is a state which is being built on weak nat-

ural foundations, lacking nearly all of the natural resources requisite to the development of a sound and permanent nation.

Despite the record amounts of food production in recent years, the United States is farming more land than necessary for that yield. Agriculture is inefficient in getting the most from the soil. The output per acre does not approach the peak, even with mechanical, technical, and financial aid.

The root of the inefficiency lies in the neglect of the fundamentals—soil preservation, maintenance, and restoration. The methods of preventing erosion have become, in some cases, familiar to the farmer, but the replacing of life-giving mineral and organic material has been sadly underemphasized. Very few of our present-day farms return to the soil the tremendous quantities of minerals that are removed each year by crops and livestock.

Elimination of soil erosion is a requirement of the first order. Contour planting is essential in preventing the formation of gullies and consequent loss of valuable top soil. Proper planting will result in trapping rainfall in the ground instead of having most of it run off. A by no means unimportant result will be a replenishing of our sinking water table.

The next line of attack is the return of life to the soil. This is fulfilled partially by proper use of lime and commercial fertilizers for their mineral values. Legumes, grasses, and manure must be plowed in to bring bulk, decaying organic material, bacteria, fungi, and molds to retain moisture and aerate the soil. The grain grasses with their intricate root systems supply organic material to the soil instead of destroying it in the fashion of the coarse roots of corn and cotton. If these methods are followed, several inches of top soil can be

restored in a few years rather than in the thousands of years required by nature.

Finally, the return to the soil of minute quantities of critical trace elements may produce almost magical increases in crop yield. Modern surface geochemistry can make a major contribution to agriculture, as well as to prospecting for concentrated mineral deposits. This science extends over many fields and an expanded knowledge of its fundamentals will be profitable to plant production and the production of animals that live upon the plants.

Results of such a program as this are far-reaching. The return of life-giving elements to the soil will increase the abundance of crops enormously. In addition, healthy plants will be able to resist the ravages of disease and insects. Furthermore, the program will answer the recently recognized problem of the lack of vital elements in the soil which retards the growth and development of people and animals in whole areas.

Conservation of the soil, one of the most valuable natural mineral resources, is definitely needed. However, the program must not stop with the prevention of soil erosion. It must take definite steps toward restoring vitality to soil that is growing increasingly sterile. Education of the farmer in practical and understandable terms can do it.

## INDUSTRIAL RAW MATERIALS

The age of specialization has made man increasingly dependent on a larger number of different metals and minerals. Overexploitation during World War II and lavish squandering of irreplaceable mineral wealth in

the past has resulted in the rapidly approaching exhaustion of some of the major domestic ore sources. History clearly points out that the United States cannot continue to be a world power on an "import to survive" *policy*. *A constructive program of development and appraisal of the nation's mineral wealth, including the planned conservation of her resources, must be adopted.*

Strictly speaking, conservation of minerals must mean the orderly exploitation of our resources and the prevention of waste in use, with due regard for the future. Real concern for the future may not extend beyond a few generations. Eventually science and invention should take care of the problems arising from shortages of some minerals, and the national defense aspects of domestic deficiencies can be provided for by stock piling and other measures. Early conservationists had this viewpoint; but with a rapidly developing industry and population, a farsighted policy that would deny full realization of immediate ambitions became unpopular. Consequently, the politically minded conservationist broadened the concept to include "prudent use of resources" and brought under the conservation umbrella a variety of projects—some of questionable economic merit—designed to bring into production latent resources. A classic example of this is manganese. Now any project designed to foster the development of economic resources is regarded as a conservation measure, and immediately it is supposed to assume an aura of righteousness.

President Truman in his veto message of the extension of the Premium Price bill a year or two ago urged that the United States go easy in adopting measures that stimulate premature exhaustion of our mineral resources. This is a very wise policy.

Coal unquestionably is the No. 1 national asset, since

it guarantees the security of the industrial structure for many centuries. Even though the reserves are very large, it is disturbing to note that in converting coal in place into minable coal reserves, a loss factor of 30 to 50 per cent to account for the waste in mining has to be applied. A prudent nation would not continue such profligate waste of its No. 1 asset, even though the reserves can be reckoned in millennia. Witness the situation in Great Britain at present. British industrial structures basically were made possible by her coal and iron ore resources. The iron ore deposits have long since ceased to be adequate to meet British needs, and England has for decades been a substantial importer of iron ore. This was the first break in her basic strength as an industrial nation and as a political force in world affairs. Now the cream of her coal resources is gone; and this, coupled with the socialization of the industry, probably will result in British industry no longer having the competitive advantage of low-cost, high quality fuel. England has lost permanently a substantial part of her export market for coal which heretofore has been a major factor in balancing British trade. The problem of supporting the indispensable British imports has thus become almost unsolvable.

With England's example before her, it would seem that the United States should take stock of all coal policies and for once become truly conservation-minded. Calculation of reserves must include classification on a basis of quality. Major emphasis is being placed on the utilization of coal measures for the production of synthetic liquid fuels. These can be made from agricultural products. With sufficient emphasis on research the disparity in costs could be substantially reduced.

The United States Bureau of Mines has put to the National Bituminous Coal Council the question of re-

ducing losses in mining, and a subcommittee of that group has been set up to wrestle with the problem. This will be a test of the statesmanship of the coal-producing industry. It is to be hoped that the Council will come forward with some constructive suggestions.

Iron ore ranks second to coal in mineral importance because it is the other essential ingredient for the manufacture of steel, which is required in huge quantities. National security requires that the country does not become dependent on ocean transport for this vital raw material. Consequently, the maintenance of self-sufficiency seem to be fully justified, even though some subsidy, perhaps in the form of tariffs, may be required.

Liquid fuels also are indispensable to modern transportation; and, since they are required in enormous quantities, the United States cannot risk its security in times of emergency on overseas sources of supply. Major emphasis on developing domestic sources is thus justified.

There is a rather easy way to conserve petroleum if there is a will. The average domestic automobile probably runs less than 18 miles to the gallon of gasoline. This consumption is exorbitant in view of the fact that special motor designs and over-drives are available to cut gas consumption at least in half for the same mileage (some European cars make 50 and more miles on a gallon). The public demands more power, more speed; some patents pertaining to gas-saving motor designs are pigeon-holed; and nothing is done to produce cars that run more economically.

Another cliché which has come into wide usage in recent years is "the maintenance of a sound, healthy domestic mining industry." While the present international situation requires drastic measures to maintain war-making ability for the longer view, the maintenance

of domestic production of minerals, other than the big three mentioned, does not appear to be absolutely essential. This well-worn phrase has been concocted by the politically ambitious and the intellectually calloused. They always are embarrassed when they are asked what they mean by "sound" and "healthy." In nine cases out of ten the phrase boils down to a proposition of subsidizing uneconomic industry. The subsidizing of a marginal mineral producer may not be uneconomic when it is considered that production of essential materials is thereby insured which otherwise might be wasted. But the decision must be realistic!

Another misleading argument used by propagandists is the cry, "We must equalize the cost of production." In the days of the protective tariff, emphasis was placed on creating a tariff system that would equalize the difference in basic wage rates in the United States and in other manufacturing countries. Now the mineral propagandist asserts that the United States should also equalize the disparity in costs due to the disparity in the grades of ore found in the country as compared with those elsewhere. It has also been proposed, and is even receiving consideration in some committees of Congress, that the United States embark on a program of developing domestic manganese resources. The only resource that is large is the Chamberlain, South Dakota, deposit, which runs approximately 1 per cent Mn. By no stretch of the imagination can it be conceived as a matter of wise national policy that the United States should endeavor to equalize through subsidy the cost of production of such a low-grade deposit as against the higher grade and direct shipping ores available in other parts of the world. On the other hand, the United States should pursue research vigorously in mining and mineral processing, seeking always to achieve what seems

now to be impossible. Wisdom dictates that the United States refrain from stimulating "premature" exhaustion of our mineral resources and leave something for posterity.

There is need for mineral consumption data. Pennsylvania leads in mineral processing but depends upon raw materials imported from other states and countries. Viewing the nation as a whole, the flow of mineral products is decidedly complex; and full understanding of Pennsylvania's position, for example, requires adequate data on the national picture. The United States Bureau of Mines plans to provide this service on a national basis, but full co-operation with similar fact-finding activities within the mineral industrial states is highly desirable.

## FAITH IN A HERITAGE

It is too late to gloat over the fact that minerals have furnished 67 per cent of the primary wealth of Pennsylvania. It is high time that Pennsylvanians do some constructive thinking in terms of the present and future with regard to the remaining mineral heritage.

The discovery of a deposit of pyrophyllite in the South Mountain region of the Cumberland Valley indeed emphasizes the increased importance of a more exact inventory of the metal and mineral resources of Pennsylvania. Active geological work and research have been in progress for many years, but the surface has been little more than scratched. The results obtained thus far in survey and research have been extremely beneficial to the Commonwealth and a fundamental hub of its industrial development. But these activities are wholly inadequate in the face of rising demands for the future.

The need for an accelerated program to continue a study of Pennsylvania's mineral resources on a more intensive scale was never more acute. In part, this has been caused by the insatiable demands of industry. It has been caused also by wasteful use and ignorance.

The Commonwealth of Pennsylvania imports large quantities of metals and minerals from the leading producing states and from 27 foreign countries. It is quite likely that other undiscovered deposits of some commercially important metals and minerals are located within the State. It will take skill, technology, and dollars to find them.

Further research work on coal, on the marginal and submarginal mineral resources such as the low-grade iron deposits, and on the widely studied subject of petroleum is the best type of insurance for the industrial future. The initial financial expenditure is low when considered in the light of national security and strength and the prize which may be won. The time to inaugurate a more intensive and highly integrated program, better to appraise Pennsylvania's mineral potential, is *now*. The age of abundance of readily available mineral wealth is past, and the problem of the new age with its myriad requirements and specialization must be faced logically through an objective survey of our natural resources, involving both field and laboratory studies. The nuclei to do this now exist within the framework of the State.

Pennsylvania is thought of commonly as a fuel producer, and indeed this is very true. The production of bituminous coal, anthracite, and petroleum attains values varying from \$800,000,000 to \$900,000,000 in a single year, a record unparalleled elsewhere in the world. That this is mineral wealth to the highest degree and that it needs no defense or comment here is

evident. The more obscure role that these matchless raw materials play in the existence of the State's industries is not so commonly recognized. Briefly, it may be stated that without them we could lose most of our industrial power with all its ability to create jobs, markets for farm products, railroad revenue, real estate values, and taxes. Fortunately, coal is available in large reserves, and its geologic occurrence is comparatively so simple that we have accurate information as to the extent and life of the fields. Research is continually finding more efficient ways in which to burn these fuels and thereby prolong the life of the reserves. The use of scarce high-grade coking fuels for steam purposes must be discouraged. Policies must be established to protect the thin upper seams, future coal reserves. There are great opportunities in the process industries where air and water are the principal raw materials in addition to coal.

Fuels are vital, but this is not the place to discuss their problems. They merit treatment by themselves. A word must be said for those materials whose problems are more acute and certainly more neglected, in part because they do not at the present moment play as conspicuous a role in the industrial scene.

Because Pennsylvania produces fuels, the energizers by which all minerals are made useful, a huge consuming center has been established within the State, to which minerals flow from all parts of the world. How many could be produced at home? The simple answer is that they are not produced because they are not here. But this statement is based on the fact that they do not project at the surface so that they can be stumbled over.

Skilled mineral industries labor is a great asset in Pennsylvania. There are many instances where industry has remained in areas where skills are available long

after the original economic factors that influenced industry location have disappeared. Zinc smelting in Belgium and brass in Connecticut are typical examples. This may well be the case in Pennsylvania in the distant future.

Man has a competent idea as to surface conditions, but he knows little enough of what is below. This is the last boundary of mineral exploration remaining in the Commonwealth, and beyond this boundary man must go, in part to keep what he has and in part to expand what he has if it is physically possible. Geologic research has proved that the basic structure of Pennsylvania, like its mineral production, is remarkably complex. There is everything in the nature of rocks. And there is a very reasonable chance that these rocks hold more in mineral wealth than has been disclosed! They will not disclose their secrets unasked.

Specifically, man has certain problems of mineral deficiency which might be solved if he possessed the tools, and the tools are more basic information concerning their properties and the processes by which noncommercial material may be lifted over the boundary to the industrially useful.

In the great nonmetallic field Pennsylvania has been a leader in cement, stone, clay, lime, and mineral pigments. Man does not supply the State's own requirements in many other items consumed in large tonnages by local industry, in spite of the fact that it is a distinct possibility that they are present in useful form, or in a form amenable to modern techniques by which they can be altered to conform with commercial specifications. Salt has become a chemical raw material of prime importance, in addition to all its other known uses. It has been produced in Pennsylvania in small quan-

ties. What are the possibilities that the salt beds of New York project into Pennsylvania at a depth attainable by economic mining? Beds are known at some depth, but that does not preclude the possibility that they are located at much shallower levels in unsuspected places. The knowledge does not exist. Meanwhile, Pennsylvania imports thousands of tons and is without a heavy chemical industry which could be based on salt and coal. Much the same condition surrounds another mineral imported in large quantities from New York, and even by sea from Nova Scotia. This is gypsum, essential to the cement and plaster industries.

Clay is an extraordinary substance with endless variations in composition and behavior. The Commonwealth leads the country in the production of fire clay, and a great and profitable industry has been established. Meanwhile Pennsylvania imports the white kaolins from the southern states for its rubber and paper, as well as for the ceramic industries. The annual freight bill is appalling to the shipper, although desirable for the railroads. It is said that there is no equal clay in Pennsylvania. Is this true or merely the result of man's blindness? The same is true of the high-alumina clays.

There is a large tonnage of such material, but its ultimate possibilities are unknown. There are dolomites, capable of supplying refractories or of use as a source of magnesium metal, limestones of endless variety of composition, shales, ganister, basalt, rhyolite, and other volcanic rocks; something is present in every county. These rocks are not just parts of the Pennsylvania landscape; they are raw materials of potential value and service.

Pennsylvania is not a substantial producer of metals, with the exception of the famous iron mine at Cornwall. But the history of the State shows that in the



past a most remarkable array of metals has been produced on a commercial scale! These include iron ores of four types, chromite, lead, zinc, copper, nickel, and even a little gold and silver. These deposits are supposed to have been exhausted. They were exhausted by the standards of 50 or 75 years ago. Different standards exist now. These minerals must be measured by present standards, or better yet by future standards. There is sound reasoning in the statement that smoke indicates fire. It is equally sound to reason that these indications of mineralization are geologic indications of the greatest value and may indicate mineralization of undreamed extent.

Man sees the surface of the earth as a blank wall. It need not be so blank if the signs are read correctly. Progress in the mineral arts and sciences, like progress in most affairs, depends on that priceless quality, so rarely developed in humanity, imagination. Imagination must be put to work to convert the images to the reality of fact. With the aid of modern science this can be done.

## AROUND THE CORNER

The useful minerals can be subdivided into two large groups. One comprises those which are mined because of their chemical composition. They represent the natural resources of certain materials or of energy (coal). The second group is used not because of their chemical composition but because of certain physical properties or combinations of physical properties. A large number of minerals are mined because of their hardness, their electrical and thermal properties, their color or plasticity.

There has been increasing recognition of the value

of mineral synthesis during the past 30 years. This is illustrated by the development of improved aircraft spark plugs and chemical porcelain about the time of the first World War. During World War II the impact of crystal chemistry upon ceramics became most pronounced. New ceramic bodies were tailor-made, such as those designed with a high dielectric constant and low power loss, for use in high-voltage, high-frequency communication. In the field of refractories special materials were needed for unusual heat-resisting service in jet and rocket engines, and in the processing of fissionable materials.

The synthesis of natural minerals in the laboratory has long been of aid to geologists and mineralogists in their study of the origin of minerals and physico-chemical conditions under which certain minerals were formed. There are now many industrial applications, such as in the pigment industry, where increasing scarcity of the natural products and an ever-growing consumer demand for more uniform materials has led to the production of synthetic pigments. Fluorescent minerals were only a laboratory curiosity not long ago; today many are synthesized for use as fluorescent light sources as on radar and television screens. The rubies, sapphires, and spinels that have been synthesized as large single crystals are important industrially because their hardness and resistance to wear makes them unique materials for bearings in instruments and watches. Well-crystallized quartz is used for oscillator plates in high-frequency communication. Because natural crystals of sufficient purity are rare, artificial crystals are now being developed. Other new developments achieved through a knowledge of the laws of crystal chemistry are the growth of large crystals of several salts for use as

elements in optical systems and the experimental production of micas.

The potter works with clay, which is a mixture of silicates and oxides, all natural minerals. He shapes the clay, dries and fires it, thus making a useful and sometimes decorative object. In the firing process many of the minerals are decomposed or undergo crystallographic inversions to other minerals, or react to form new ones which are often entirely different from those of which the raw clay is composed. Similar changes result when other types of ceramic bodies are fired, and new products with desirable properties can be developed when these high temperature transformations are selectively controlled.

The manufacture of silica brick furnishes an excellent illustration of mineral synthesis. Bricks made of the natural quartz raw material, ganister, would not be satisfactory for service as part of a high temperature furnace; so the ceramic engineer fires the bricks. In doing so, he changes the quartz to tridymite and cristobalite (minerals having the same chemical composition as quartz but much more desirable physical properties) and develops a very useful brick.

Mullite is a stable refractory ceramic mineral that is formed when sillimanite, andalusite, or kyanite is fired to around 1400°C. The three types of raw material are now difficult to obtain for political and economic reasons; therefore, one manufacturer is planning to market mullite fabricated from alumina and silica.

When the ceramist is required to make new bodies with special properties, his approach is now from the standpoint of mineral synthesis. No longer does he have only the complex mineral assemblages taken from the earth; he has also the opportunity of beginning with chemically pure oxides and blending them to produce

new compounds whose physical properties can, in some degree, be predicted from a knowledge of the fine structure of their crystals. Frequently the impure materials that nature provides are not quite suited to the manufacture of the new porcelains and refractories that are needed. The new knowledge of crystal chemistry and mineral structures is beginning to make possible the selection and building of crystals which are known to be favorable with respect to the desired physical properties.

A vast new field of "oxide body" research is rapidly developing in which certain pure oxides or oxide compounds are examined in detail for desired characteristics. A system of investigation is under way in which one-component and binary, ternary, and quaternary oxide systems are being searched in a continuous manner. An adjacent field of carbide systems lies virtually untouched. Although the crystal chemistry of silicon carbide is known, and the substance is used in many industrial ceramic applications, many of the simple metal-carbide systems remain unknown. The analogous systems of binary and ternary carbide compounds and solid solutions similar to those known for the oxide systems present a region of unexplored crystal phases which might give bodies with as yet unobtained special physical properties.

The determination of the crystal chemistry and phase relations of oxides and carbides is but a beginning. Once these relations are known, untold auxiliary problems in fabrication, in the growth and orientation of crystals, in the selection of proper heat treatments, and in the attainment of high temperatures are involved before a desired article becomes a reality. These latter problems are grouped under a new and expanding body of research known as physical ceramics.

Parallel with all this is the exciting and rapid development of silicone chemistry wherein compounds with atomic structures, remarkably similar to those known in the vast field of organic chemistry, are being prepared by inserting the silicon atom in place of the carbon atom. This procedure is possible to a large degree because of the similar valences and sizes of these atoms. The ultimate impact of this upon mineral synthesis and conservation will probably be profound.

Thus it may be said that many of the new products demanded by the electronic, atomic, and aircraft industries probably will come from the laboratories of mineral technologists, who are concerned with the synthesis of artificial compounds of simple composition and in the study of the relation of complex physical properties to the basic atomic or ionic units which comprise the fine structure. It is not likely that the rocket combustion chambers of tomorrow will be made from chance selections of complex natural minerals, but rather that they will be manufactured of calculated crystal units.

## IMPERATIVES

In July 1946 President Truman approved the stock piling act providing for the accumulation of stocks of strategic minerals in which this country is deficient. Congress also provided huge sums for the purchase of these materials to initiate the program. In order to meet anticipated stock pile goals it will be necessary for the United States to import very large quantities of 67 strategic materials, by far the largest items being minerals and metals. There are no priorities of relative importance in the list, as the lack of any single item may cause industry to fail in its part in national defense. Stock

piles of material in a form as close as possible to the ultimate fabricated state represent not only the actual material physically on hand but also "canned" labor, transportation, smelting, refining, and all other steps.

Central and South America, together with Canada and Newfoundland, in their normal capacity as sources of supply will be called upon to furnish a sizable proportion of the total requirements. No special measures should be arranged for this purpose; it will be more practical to make purchases in accordance with the availability of materials of desired quality, not by reference to geographic area. Much has been said in the past, and may be repeated in the future, concerning the desirability of hemispheric self-sufficiency—both from a resources and from a military security viewpoint. The mineral industries cannot favor the principle of economic spheres and must support the idea of an interchange of manufactured goods and raw materials between all the nations of the world as the only road to creation of the expanding world economy essential to lasting peace.

A handful of racketeers, ambitious for world-wide control, now force the United States to devote a much larger proportion of the national effort to preparedness and defense. There is bitter competition in the world, and this country can no longer rely on the British Navy to help keep the sea lanes open. Obviously, access to minerals must receive priority attention, including long-range stock piling objectives. It will be impossible to make any major moves in the direction of providing common security unless the American people clearly understand the mission and the magnitude of the task.

President Truman's Council of Economic Advisers asked the Department of the Interior to estimate the

cost of a comprehensive mineral survey on a national basis. The United States Geological Survey and the United States Bureau of Mines jointly recommended an expenditure of about \$1,000,000,000 spread over a period of 20 years. Such a sum is not a wasteful expenditure. One important discovery might replace the entire outlay. The Federal Government cannot and should not do it all. The states have a stake in their own preservation.

The estimate includes many items essential to such a survey, including field and laboratory studies on the concentration and refining of low-grade ores. While the figure seems astronomical it is nothing of the sort. It is less than the value of minerals produced in Pennsylvania alone in 1947. And it must be remembered that this is an investment to insure the future existence of industry and to provide the raw materials without which national security cannot survive. The entire sum is insignificant in comparison with the billions poured into the revival of Europe.

A national mineral policy, supplemented by state policies where warranted, is long overdue. There is no apparent reason why any policy should clash with free enterprise, for a halter does not break the spirit of a good horse. Industry should display leadership in establishing policies and should call on government agencies to administer the policies in the greatest public interest. The needs are many-fold: to insure an adequate supply of minerals, whether peacetime or war economy; to prevent waste all along the line; to aid investment, especially foreign ventures; to clear the way for large enterprises where warranted; to unify the multiplicity of federal and state agencies dealing with minerals; to accelerate mineral resources inventories; to encourage federal and state aid for subsurface exploration; to con-

trol prices and volume; to consolidate mineral consumption data; to clarify tariff and tax problems; to foster research, especially in submarginal resources; to utilize mineral resources on public domains; to aid any subsidized financing; to counteract nationalistic schemes with all of the facts; and to determine how far to use gold reserves in stock piling. These objectives are a few examples, all proconservation, to hold back the evil day when mineral resources will reach exhaustion. Space precludes a discussion of objectives, although each justifies discussion in its own right.

## CONCLUSIONS

The fate of generations yet unborn lies in man's hands. Shall it be prosperity, a high standard of living, and the development of spiritual values; or ruin, misery, and a reversion to jungle law?

World affairs move in high gear, at high tension, in many directions. Each nation fears the other fellow—races, crosses the white line on curves, skids, takes its half in the center; and the devil take the hindmost. For one, the United States is on the horns of dilemma; it must insure a flow of raw materials of industry and world-wide markets in order that the American people may maintain high standards of living, but the commitments of the United States cannot be fulfilled without trimming present standards of comfort and convenience back to the level of perhaps a quarter of a century ago. A way must be found to retreat without anarchy at home as well as abroad.

Everything is relative and all things change, and change is the essence of civilization. It is now clear that man has not kept pace with changes of all kinds, some

of them overnight, during the past 50 years. Conventionality has led to stagnation; man now seeks learning of all kinds at an accelerated pace, but men should not be educated beyond their native intelligence for they must be able to apply their education.

There must be a resolute action now on 10 great challenges in regard to conservation of human and material resources: (1) integrity, ethical human behavior, peace; (2) fundamental education and research; (3) unity of purpose, teamwork; (4) military manpower needs; (5) good stock piles of minerals and metals; (6) inventory of mineral resources; (7) inventory of soils; (8) efficient use of soils; (9) national mineral policy; and (10) subsurface exploration.

Contour strip farming is in the limelight, but the public does not understand the intricacies of productive soil. They must understand in the processes of erosion that the "ganguer" or waste material is deposited on bars and in the estuaries of rivers while the "life" or real values, much of which is dissolved, is carried by water into the sea.

Conservation must be multiple-purpose, comprehensive in scope, planned and carried out by co-ordinated action of all agencies. And there must be proper rehabilitation and restoration of depleted resources where possible in the interest of sociopolitical bulwarks against depression and other threats to man's very existence.

The concept of conservation, therefore, must be introduced into the thinking of every person and every agency whose activities bear upon the development and utilization of human and natural resources. Wise use of the nation's resources requires that all potential uses and values be considered in planning the public program.

The potentialities of multiple-purpose planning are

still comparatively new and undeveloped. Legislative authorities are piecemeal and single-purpose. But the program is heading in the right direction—toward programs in which full consideration and proper weight are given to all purposes and values.

Specially privileged people in education, business, labor, and government must bend to the wind, in order to stem the unrealistic devices and trends obtaining during and immediately after World War II. American industry is rich and envied because it risks, works, and plans. Nothing must be permitted to curb that process. The envious can gain the ends which they covet by earning them—not by stealing from or curbing others.

There is no other country in which capital and labor have had the unbounded opportunities available here. Management must not bite the hand that feeds it, and labor can lead itself to ruin. The "haves" were once the "have nots." Change it now, and for what good, and what sweat is offered to better the American scheme? Other nations were once helped through regular business channels, but look how it is done now! Servants of the government must know about balance sheets, and risks, and industry. And they must understand the real problems confronting friendly nations overseas!

Conservation starts with the truth. False economies do not endure; force and money do not prove anything; the economics of the Marshall Plan and military spending should be made crystal clear; American standards of living are unsurpassed among nations; federal spending cannot exceed income; taxpayers must realize their cut in the national debt; labor must not increase costs faster than technologies, skills and machinery can lower them. Traitors and racketeers must be caught and punished. After all, there is a place for nationalism. And life in these United States must settle for a slower pace,

more production for lower costs, a no-work, no-eat, down-to-earth economy.

Teamwork is the key to industrial progress. Teamwork on the part of geologists, mineralogists, geochemists, geophysicists, meteorologists, geographers, mineral economists, mining engineers, mineral preparation engineers, petroleum and natural gas engineers, fuel technologists, metallurgists, and ceramists is required to solve the technologic problems of the mineral industries. There are in the various divisions of the Commonwealth the organic units by which its mineral interests may be preserved and expanded to unknown limits. Three units are the Department of Internal Affairs with its Topographic and Geologic Survey, the Department of Mines, and the School of Mineral Industries of The Pennsylvania State College, long working under co-operative agreements. These units have the knowledge of technologies and the skills that have been mentioned. The dollars are dependent upon the recognition of the public that their expenditure will pay dividends and be returned manyfold. Teamwork is needed now between State agencies and the public in the interests of all the citizens of Pennsylvania, present and future.

Finally, human beings must be more logical, less emotional—*pro bono publico*. It is imperative that waste of all kinds be made to disappear in order that there can be a new outlook on life, free of ignorance, faithlessness, dishonesty, insobriety, penury, squalor, and the tyranny of mankind over men—for “it doth not yet appear what ye shall be . . .” (John 1:3:2).