

Are Our Natural and Human Resources Exhaustible?

By A. RODGER DENISON

Introduction. When this nation was founded our forefathers lived essentially the same way as did men in ancient times. They grew their food by methods and with tools not much different from those which the Romans used. Their clothing was spun and woven by methods differing little from the ancient Greeks. Transportation by sea was with the sail, while on land the wheeled vehicle familiar to the Assyrians was propelled by human or animal power.

The almost unbelievable transformation from then to now has come through the increased uses which we make of natural resources, mineral and fuel. When we consider the part that iron, copper and aluminum, as well as coal, oil and natural gas, together with many lesser minerals, have played in bringing about this change, it is well to pause and consider what the future holds for us in the way of the supply of these minerals. We should also take stock of the human resources which have been responsible for this almost unbelievable transformation, lest we neglect to cherish and work for the perpetuation of that freedom of thought and action which allowed human endeavor to make this improvement.

I desire therefore today to take a brief look at the supply of our mineral resources and then to examine our human resources—both, in terms of their increasing or decreasing supply. In other words, are they exhaustible? I cannot, furthermore, in these troubled times refrain from an examination of the “climate,” economic and political, in which we live, to see if they are favorable to continued progress. Because for a number of years in my youth I wavered between teaching and industry, I may appear at times to **lecture** you. Likewise, because this subject is one about which I have beliefs amounting almost to a religion, I may appear to **preach** to you before I have finished. If I do one or both, I here and now beg your indulgence and assure you that it will not last too long.

Mineral Resources. I belong to that limited group of people whose mission in life is to help find in the earth the materials that man needs for civilized life and prog-

ress. As a practicing geologist, who for thirty years has searched for some of the mineral fuels, you will find, I am sure, that my ideas and concepts will be flavored by basic precepts of earth science, by geology—the “olgy” of the “geo,” or in other words, the science of the earth.

Geology as a modern science is hardly more than 200 years old, even though Leonardo da Vinci in 1508 re-stated basic earth principles which had been incorporated by Pliny in his text, **Natural History**, written in the first century. Pliny in turn borrowed heavily from the teachings of Aristotle, who lived in the fourth century B. C. You will pardon me, I hope, if I ride this “hobby” of mine a little further. I am a prime advocate of geology as a cultural course. I am convinced that it is an excellent thing for every student, man or woman, whether the life work is to sell shoes, rear children, operate an airplane, or become an engineer, to take a course in the broader principles of geology. It will bring an understanding of this world in which we live; it will enable him or her to better appreciate a beautiful landscape, a rocky seacoast or a natural phenomenon like a volcano or a geyser. I am delighted to find from an examination of the catalog of this school that geology is one of the required subjects in ten out of twelve of your cur-

ricula. I very much hope that men pursuing the other two have taken a course or two as electives.

Perhaps because it is necessary in my business to have an optimistic viewpoint, to hope always for success from intelligent search, I belong to that school of mineral economists who believe that our mineral resources are **LARGE AND EXPANDING**—that even though we are using our metals and fuels at an annual rate undreamed of even ten years ago, with very minor exceptions, the supplies are expanding—they are increasing, not declining. This is not to say that I believe they are infinite, that the earth holds the present-day needed minerals and metals for all conceivable future time. It is rather that I firmly believe that we have merely scratched the surface in our search for and proving up of our mineral resources. In the oil business we commonly refer to proven reserves—barrels of oil that we can count. By inference we imply unknown, uncounted, but definitely existing barrels every time we thus qualify the word “reserves.” We say, in other words, that we know it is there—but we are not yet able to make a numerical count. Much the same could be said of nearly every other mineral.

Another approach can be made to this same philosophy of plenty—it is ably expressed by Eugene Holman in the June Bulletin of the American Association of Petroleum Geologists under the title, “Our Inexhaustible Resources”:

“For many years, I believe, people have tended to think of natural resources as so many stacks of raw material piled up in a storehouse. A person with this sort of a picture in his mind logically assumes that the more you use of any natural resource, the sooner you get to the bottom of the pile . . . the idea of a storehouse, at least, a single-room storehouse—does not correspond with reality. Instead, the fact seems to be that the first storehouse in which man found himself was only one of a series. As he used up what was piled in that first room he found he could fashion a key to open a door into a much larger room. . . (and so on to) . . . The room in which we stand in the middle of the twentieth century [which] is so vast that its

IN MEMORIAM

Edgar D. Meacham was one of the leaders in establishing the Oklahoma Quarterly. He helped with the preliminary planning and he named the editor. The Quarterly was but one of the many, many ways in which, as student, teacher, and administrative official, he gave himself to his University, without hesitation and without ever counting the cost. He was a man of strength, integrity, and above all else, of loyalty. He was my friend for forty years.

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walls are beyond sight, yet it is probably still quite near the beginning of a whole series of storehouses."

This is the philosophy of discovery through use. The world has always witnessed—and still does today—backward and unenlightened people who live in the midst of vast supplies of raw materials. The American Indian made his crude weapons from the native copper of the Upper Michigan Peninsula, but made no use whatever of the nearby iron ores of the Mesabi Range on which the steel economy of the present century in the United States has been built. The Babylonians and Assyrians, even though much more enlightened than our Indians, made only minor use of asphalts from surface seeps—where today the world's greatest oil fields are producing.

There is much talk today of conservation, and there are many regulations which tend to limit the use of certain raw materials. Many still hold to the tenets that the proper way to insure a future supply is to limit the present use of them. This I reject, and say to you that true conservation is the wise use of raw materials, not wasteful, profligate exploitation, but expanded, efficient use.

One example will, I believe, make this point clear. Suppose that in 1900 when kerosene was still the principal petroleum product, a federal government planning board, suitably implemented with the power to do so, had decreed something like this: Petroleum is an exhaustible resource. Our known reserves are limited. We must therefore conserve them and limit their use. We therefore will not allow petroleum products to be used for automotive transportation and haulage, the railroads and horse drawn vehicles are adequate to serve the purpose. We will therefore conserve the supply of petroleum so that the people may always have kerosene to light their lamps. If such a board had so ruled, there would

be today no automotive industry and only an extremely small oil industry.

But, you say, that was long ago; it is in the realm of pure speculation. Let us come a little nearer and consider another "mineral." Since World War II many large pipe lines have been built to transport natural gas from the South and West to the industrial East. All required permission from the Federal Power Commission before construction could start. At every such hearing strong objections were raised by representatives of the coal and railroad industries. One of their chief arguments was that the industrial East was already adequately supplied with energy through the use of coal, that furthermore, gas was a "wasting resource," the supply was limited, and therefore its use should be restricted. It was, they argued, wasteful to burn gas under boilers and for industrial purposes. Gas, they argued, should be "conserved" for domestic use and as a chemical raw material. Had the Federal Power Commission acceded to their contention, it would have eliminated four-fifths of the market for gas in the East. With this market gone, no one could afford to build a pipe line. Without the pipe line no one would spend time and money to look for new supplies or even develop those already known. If the Federal Power Commission had followed this course, it would have denied to the ultimate consumer a choice as to the fuels he could use, causing a serious distortion of the normal progress of competitive enterprise. Thus, freedom would have been curtailed and progress retarded.

Still another approach to the philosophy of increasing reserves of minerals is the "law of accelerating discovery," or "the more you find, the more you will find," as discoursed upon at length by A. I. Levorsen, Max Ball, and others. Their approach is from the viewpoint that each time we

find a deposit we add to our "know how," we improve our ability to search for the next deposit. No one who advocates this viewpoint would want you to believe that the finite quantity of any particular metal or mineral is unlimited. They do contend that the application of science and technology in the past few years to the search for minerals has produced an ever accelerating rate of ability to discover, thus demonstrating that we are as yet a long way from the peak rate of discovery. This of course is abundantly true with respect to petroleum. In the past 15 years more oil has been consumed than in the previous 76 years—back to the discovery of the first oil well—yet today our proven reserves are the greatest in our history and during the past 15 years have nearly doubled—including a 25% increase in 1951.

Somewhat over a year ago my company made a discovery of petroleum in the Williston Basin of North Dakota. This discovery was the principal stimulus for an active wildcat drilling campaign which in the following twelve months led to four additional discoveries. Perhaps an even greater stimulus to oil discovery will be the search for other similar basins throughout the world. This discovery further strengthens the belief that every well-filled sedimentary basin is prospective for oil discovery—until drilling proves otherwise. Thus a discovery has increased the areas of the world in which to search. In doing so, this discovery can be said to increase rather than decrease the chances of finding additional oil.

The same conclusion can be reached from a study of two publications of the American Association of Petroleum Geologists on "Possible Future Oil Provinces." In 1941 the results of a symposium on this subject, covering the United States and Canada, listed thirty-four provinces. In the symposium held in 1950, a short nine years later, more than thirty additional provinces were enumerated. In the meantime, eleven of the enumerated provinces were proved productive and none had been condemned. This increase came about although 18 billion barrels of liquid petroleum and 61 trillion cubic feet of gas had been produced, and therefore subtracted from the reserves, and 10 billion barrels of oil and 100 trillion cubic feet of gas had been added to the proven resources. Yes, it can truly be said that every new mineral deposit found teaches us something that is valuable in finding another.

By this time, I am sure, you who search for other minerals can say—perhaps that will work with petroleum, but does it apply to the search for copper, for lead, or for another deposit of high-grade iron ore? In my view it does apply, and the same philosophy can be used. Remember that I

About the Author

On June 6, 1952, A. Rodger Denison received the honorary degree of doctor of science from South Dakota School of Mines and Technology. "Are Our Natural and Human Resources Exhaustible?" was his commencement address to his fellow graduates. The degree was awarded in recognition of Dr. Denison's distinguished career as a petroleum geologist which began while he was a student in the School of Geology. He received a B. S. in Geology in 1921 and his M. S. in 1925. Since 1922 he has been with the Amerada Petroleum Company, serving as chief geologist, 1937-50, and as vice president since 1950. He was secretary-treasurer of the American Association of Petroleum Geologists, 1929, and president, 1943-44. He has published a number of research papers. Dr. Denison is an alumnus of the University by descent as well as by graduation. His father was a student at the University the year it opened.



Human and Natural Resources Supply Is Large and Expanding

am a geologist, and I know of vast areas of the world where no search has been made by anyone with more technical training or experience than the old-time prospector. I cannot forget also that there are vast areas of the earth's surface covered with a thin mantle of concealing debris—young rocks—alluvial deposits, which effectively hide from view what is even only a few feet under the surface. With my basic optimism, supported by what I have seen develop in my own working life, I have every confidence that the application of modern techniques, modern tools—not to consider the certain improvements which will come—will enable us to discover—and recover—the minerals and the metals which our modern industry needs. For fifty years growing use has brought growing discovery—I repeat, I do not believe we have passed our peak of discovery.

At this point I should, I feel, pause to correct any impression I may have created that minerals are becoming easier to find or that it is cheaper to prospect for them than in former years. Quite the contrary is true. As deeper wells are drilled in search of petroleum or more inaccessible areas are explored, as wells are drilled on more obscure evidence, the cost of finding is sure to rise—quite the same is true in the search for the solid minerals—the easy places to reach, the obvious areas have been searched, and those that remain, while vast in area, will require far greater exploratory costs. My thesis remains, however, that we learn by doing—we improve our “know how” each year—we are finding this year what a few years ago was unfindable. As witness to this, most of today's petroleum is being found with methods and techniques unknown even 25 years ago. Likewise, the mine dump of yesterday has become the mine of today through improvement in extraction and refining techniques.

Human Resources. The human resources of the world are LARGE AND EXPANDING, just as are the mineral resources. In spite of disease, famine, and wars, the total number of human beings has consistently increased ever since the Middle Ages. At no time have they increased at the rate which they have in this century—a fine tribute to medicine, which has learned to control disease, and agriculture, which has improved food supply. We still have wars, if not as frequently as in past

centuries, at least involving far greater numbers of human beings. Weapons have been fashioned which are far more deadly. But in spite of these factors, wars and their aftermaths, famine and disease, are not as destructive to human life as in former years; at least, they have failed to halt the onward march of numerical growth of the world's population.

With the numerical increase has also come better food and better health, which in turn has led to better education. The average person in the world today is better fed, is more enlightened than he was 50 years ago. He has more material wealth, he owns more things. Some, as those in the western hemisphere, especially North America and notably the United States, have moved ahead faster, further and more effectively than the other peoples of the world. Such has always been the case in this world. The Romans, for example, were far, far ahead of nearly all other contemporary peoples of the world.

But why has the United States moved ahead so rapidly, why has it in one and a half centuries moved from a nation of minor consequence to the world's leader in nearly every achievement of material wealth? The reason, in my view, is the resourcefulness of its people, collectively and individually. Resourcefulness is compounded of a great number of things, but no item is more important than incentive. Incentives basically are hopes of reward—the farmer has as his primary incentive the reward that comes with a good crop; the business man, the reward of a profit from his operations; the scientist, the reward which comes from adding to the world's supply of knowledge; the teacher, the reward which comes from another well-trained student, the reward which comes from the approbation of his colleagues and associates. Incentives then are hopes of rewards, many of which but not all, are for profits. Why should any man try to do a better job, to devise a new machine, to compound a new theory—in short, to be resourceful—if there is no incentive? Thus, without incentive we have no resourcefulness, without which we have no progress.

Our ever expanding use of minerals has come from human resourcefulness, from man's desire to make and use a new machine, to do a job better, to do it easier, to make it possible for one man to do more

and more. There is absolutely no limit to progress which can be made by this method—more incentive, more resourcefulness—more minerals needed, the more that are available—the more incentives to use them—to do more, to live a better life, to progress. This has been the story of America's growth to its present high eminence of prosperity, to its vast per capita use of minerals, metals and fuels, a use which now amounts to more tons, pounds, gallons, cubic feet per capita than any nation has ever known. Yes, our supply of human resources is large and the resourcefulness has been and still is expanding.

The Climate in Which We Live. There has been for the past several years, as we are all aware, a growing paternalism in our government. A philosophy of regulation and subsidized aid, a growing concept that a few shall make decisions for all, shall direct their hours and conditions of labor, that men high in government will substitute their judgment for the tried and proven principles of business.

This all had its start back in a depression, a condition where all of us suffered. In trying to bring back normal opportunity, to restore incentive, to recreate resourcefulness, our government artificially curtailed the normal ebb and flow of business. It substituted bureaucratic planning for individual initiative. In spite of the return of prosperity, interference with normal business has remained, and through the excuse of crises, either real or imagined, has been expanded. Individual freedom and incentives continue to be curtailed, even discouraged.

This trend, if continued, will weaken our whole civilization. Our nation grew and became self-reliant by the work, the struggle, the effort of its people. Resourcefulness does not come from inaction; like a muscle, it grows and develops only with use. No man's judgment is improved by allowing someone else to make all his decisions.

No amount of resourcefulness will of course find a mineral deposit that does not exist, but those that do exist will never be found without it. We must therefore remove those regulations which now stifle incentives. We must restore the full measure of reward for effort. Unless we do so, we will lose resourcefulness—and when this happens, progress will cease.

A Word of Advice. Although in the course of my business duties I have interviewed hundreds of graduating students in the past fifteen years, this is my first opportunity to speak to a large, diverse group, such as are gathered here today. I cannot therefore let this opportunity pass without some comment on the current viewpoint of graduates as I have encountered it. En-

gineering, the profession, is a demanding way of life. The engineer works with tangible things, usually in the open, or with things at least observable by all who care to search. Early in his business career the young engineer must decide whether he will remain basically an engineer or whether he will become a salesman or administrator. Whether, in other words, he will do engineering for the pleasure and satisfaction it brings, or whether making money is uppermost in his plans. No one wishes to remain poor, and I, for one, would never advocate that any man should completely neglect his income. However, may I assure you from my own experience and from years of watching the progress of others, that financial success does not always bring happiness. This is increasingly true as men grow older. Most unfortunate is that man who has achieved financial success but dislikes what he is doing—who gets no satisfaction out of a day's work. Let me urge you to do those things, to direct your energies to those avenues of work in your profession which you like, that you have a peculiar talent for, that you enjoy doing. Do not be led into changing your direction merely for more money—continue to do the things that bring satisfaction, the things in which you can accomplish the greatest good. Normally every man does that which he likes, which he enjoys doing, better than any other job. This means then that when a man follows his "bent" he will do a **good job**—in most cases, an outstanding job. Such a performance always leads to better and bigger opportunity—to promotion and to well-deserved, increased pay. Such a man may never become a millionaire, but he will achieve adequate income and be richer by far than any man who fails to get satisfaction and pleasure from the work he does—from his daily labors. This, some may say, is idealism. With them I agree—but without this kind of idealism there would never have been those who are the giants of the engineering profession, those who have set the precepts, have evolved the great principles, who have in fact made the profession the honored occupation that it is today. We cannot all of course measure up to the precepts of the great, the giants of the profession. We can all, however, use their lives and accomplishments as a pattern for ours, and ever strive, in spite of the hurry of our modern business world, to emulate their achievements.

A Shortage of Engineers. All students of this school, the faculty and, I suspect, many of the parents, know that there is a shortage of engineers. A shortage of large and growing proportions—a shortage which the best statistics show will get more acute for the next two or three years. This is a

most unusual phenomenon, when we remember that it was no longer ago than 1950 that there appeared to be an oversupply. I almost said there was an oversupply, that is in fact what the Department of Labor did say, and it was widely reported and repeated. As a consequence, many freshmen in the fall of 1950, who had fully intended to study engineering, enrolled in other sciences or liberal arts. The recall of reservists and the accelerated draft under Selective Service, combined with an enormous expansion of business, particularly those industries needing trained engineers, made an apparent oversupply into a definite shortage in a few short months. This shortage means—and this is especially true for this graduating class—that everyone can find a job; some men will be able to pick and choose from several offers. This year's graduating classes can, then, just sit back and wait for the jobs to come to them. That is fine, and I am delighted that you are finding it that way—but with a proviso or two:

Provided, first, that you remember that it was not always thus—will not always be thus.

Second, that you remember that, although there is competition for your services, you must compete if you expect to get ahead.

Third, that you do not quit looking for work as soon as you get a job.

Fourth, that you do not jump from your first job to a second the first time a few dollars or easier working conditions are offered you.

Fifth, that you remember that you must learn if you are to succeed, and that you cannot learn except by doing.

Why do I mention these provisions? Why do I introduce this disturbing note into what otherwise is a bright, glorious outlook? To answer this I shall elaborate on these five items.

If you decide that jobs come easy, you will not fully appreciate the one you get. If you decide that present conditions are normal, you will never be able to adjust yourself, if and when they change for the worse.

The fact that you do not have to work and struggle to get a job does not mean that you do not need to work and struggle to get ahead. There are still plenty of ambitious men who will rapidly forge ahead of you unless you work to compete with them.

This is of course another way of saying that you must not wait for someone to tell you what to do next—you must be searching all the time for something more to do, a new or better way to do what you are doing. You must, in other words, be con-

stantly searching for work, for things to do.

There is no moral reason why any young man in America should not be free to change jobs as often as he likes. In view of the great premium now existing for experience, there will no doubt come to you after a year or two a flattering offer of another job, more money, more prerogatives. Perhaps you will be fully qualified for this new job, but I fear in many cases you will not. Shortages lead to upgrading of titles, to exceptional pay for very little experience.

The trend in all industry is to work fewer days and fewer hours. This for the man who works with his hands, who only makes things by directing a machine, is fine—I, for one, am willing to say that is progress. I am disturbed, however, to find that a similar philosophy appears to be growing among the graduates of our technical schools. It is shown by questions asked by students seeking employment. Now I do not mean to say that an engineer or a geologist cannot be eventually trained by working seven or eight hours per day five days per week, but it will in my view take an awfully long time. Many men, I fear, will never live long enough to be thoroughly trained. Even when I came into industry it was recognized that five to ten years were needed to further "educate" the technical graduate, to qualify him for independent decisions and effort. Since that time every line of endeavor has become increasingly complex—making more and more to be learned, so that today's training needs to be longer, even in terms of the longer day and week of former years. Are you ambitious, do you want to get ahead, do you want to be outstanding in your profession? Then, gentlemen, I submit that such was never—and will never—be done on a forty-hour week.

So much for a word of warning. I return to the thesis—I am still an optimist, and here is my creed: I **do not** believe that this generation will deliberately forsake the tried and proven principles of work and rewards which are such a large part of our American heritage. I **do not** believe that you graduates are unaware of the dangers to your liberty, your freedom, which are present today. I **believe** that you know that we must have freedom—freedom in choice—and that we must have incentives. And, finally, I **believe** that if we continue to have freedom, incentives will be plentiful, and through these resourcefulness, that greatest of human assets, will find and produce the metals and minerals which our country needs. The answer, then, to the question which is the title of my address is this: The resources of our nation, **natural** and **human**, are not exhaustible—they are indeed inexhaustible.