Materials from the Earth—

The Stuff Things Are Made Of

by JAMES BOYD

Man's ability to raise himself above grinding poverty depends on how he uses available material and energy

When the astronauts looked back to the earth from their new perspective, they saw it as small and bounded. But is it really small, or only relatively so from a cosmic seat? Is the view that we are doomed to have perpetual shortages of materials realistic, or can man solve this problem through advanced technology and economic measures? Do we take our cue from the biblical lament, "Woe is me, for I am undone"; or from Gilbert and Sullivan's ironic, "Things are seldom what they seem"?

Although the earth *is* finite, the real limit to the availability of materials is self-imposed. Man's resources include his intelligence and curiosity, and they can provide a climate that will encourage him to conceive a positive solution to the problem of materials shortages, to pursue answers and not anguish.

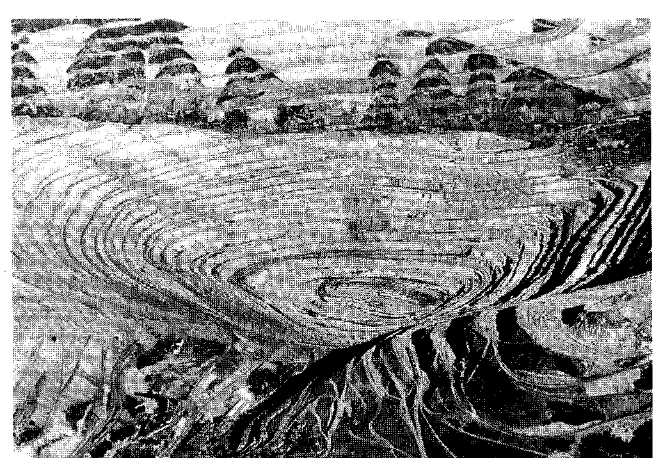
I am not suggesting that resources are infinite. But within and upon the surface of the earth there exists an unimaginably complicated dynamic system, and its capacity to supply men's needs will survive if it is treated with understanding and respect. In fact, the ability of man to raise himself above grinding poverty depends on his utilizing in a wise manner the material and energy sources that are available to him.

There are three basic premises that can relate resources to our daily experience: First, we use materials that have the properties to perform specific functions. For example, we use wood for houses because it is available, easily fabricable, and is a good insulator.

Second, there are few if any functions that cannot be performed by more than one material. Stone, brick, concrete, steel, glass, and aluminum can be used as well as wood for houses.

Third, new scientific discoveries and engineering applications frequently require the discovery of new sources of materials with new properties. The high-speed jet planes of today, for example, could not have been developed before materials scientists discovered how to produce titanium metal, or some other material of the same light weight, high strength, and temperature-resistant qualities. Titanium, and aluminum, iron, and silica are the most abundant elements in the earth's crust. As technology advances, demands for their use and for more exotic materials will continue to increase, but the earth can support those requirements from its vast resources if we use our intelligence in consuming them.

It is, however, one thing to say we have sufficient resources to meet our needs and quite another to make them available to the industrial structure that puts them to use. Engineers and businessmen are inclined to express resources in terms of those that can be produced profitably at the current level of prices and scientific development. They also tend to express reserves in terms of the years of life remaining in those reserves at present rates of consumption. For example, when I graduated from Caltech almost 50 years ago, it was estimated that only ten years of reserves of petroleum



The Bingham Canyon copper mine from 12,000 feet up.

remained in the United States. At that time we were consuming about five million barrels a day. Three or four years ago, our daily consumption was closer to 17 million barrels, and it was still estimated that we had ten years of reserves.

Industry, of course, spends vast sums of money in a search for raw materials that can be produced economically with current technology—but technology is steadily improving. At the turn of the century, the Bingham Canyon copper mine in Utah could mine economically only ore containing 2 percent copper, but by 1970 it was profitable to mine ore containing less than 0.6 percent copper. Through improved economic conditions and technology, we should find new sources of copper equal to those of Bingham Canyon every few months. Geologists have been finding new deposits of petroleum and natural gas at a faster rate than the world was consuming them until the last two to three years. It was only in 1968 that for the first time we discovered less oil in the United States than we used.

Obviously, there are limits to the availability of natural petroleum in the earth's crust underlying the United States and its boundary seas. We have now arrived at the point where it is not possible to find oil as fast as we require it to maintain the present profligate rate of use. But we will never run out of petroleum; it will just become too expensive to use it for the purposes for which we use it today. This does not mean that we will have to give up automobiles and airplanes and trains. We will not have to do without all the electricity which today is generated from petroleum and natural gas. We *will* have to develop industries that can convert other kinds of energy resources to our use.

Some of these other energy resources are extraordinarily large. For example, we have more energy stored in coal in the United States than exists in all of the world's petroleum resources. There are the sun's direct rays on the crust of the earth for the production of solar energy. Immense amounts of energy are stored in uranium and thorium, and in deuterium that will eventually be extracted from the sea. Geothermal energy may seem to be a more limited resource, but recovering the energy from vast masses of cooling rock within the earth's crust is potentially a very large source of energy. Developing it will test the ingenuity of future generations of scientists and engineers. Of course, we don't have to solve all these problems today; we just have to find those deposits or resources that can be put to human use within the present development of technology and economics.

The geologic processes that have been taking place in the crust of the earth for the last four billion years have, almost by accident, concentrated our materials in specific locations. The geologists' task is to find them. Originally, ore deposits were found by the prospector with his trusty burro, but even as the prospectors discovered most of the easily accessible deposits in the earth, the technology for going deeper into the crust was developing.

As it becomes possible to recover material from lower grade ores, the demand upon the geologist to find less concentrated sources increases. This mandates the development of theories of geological events or processes and improved geophysical techniques. It also means that the geologist must explore the far corners of the world, searching for minerals in the deserts and the Arctic and Antarctic. He must take to the air to study the surface of the earth to find the slightest physical anomaly, and then relate it to his understanding of what lies beneath. He must take advantage of geophysical means of actually measuring physical anomalies beneath the surface. Eventually, he must drill into the crust to test his theories; then with the engineers he must determine whether the deposits he finds can be mined economically while preserving and enhancing the environment.

There are those who feel that the extraction of valuable resources for the use of men endangers man's very habitat, but this is not a new idea. It has always been a concern of thoughtful men. It is a rare deposit where the surface could not be temporarily disturbed for mining and then returned to the same, or more productive, use that it originally enjoyed. The preservation of the original contour is in many cases impossible, but the wastes from the mining of materials can be used to resculpture the land. Furthermore, there is misapprehension about the scale of mining. In the total history of mining in the U.S., less than one-third of 1 percent of the surface of the earth has been disturbed, and of that, a third has already been put back to use or returned to the wilderness.

Whether what we need to supply our wants comes from the forest, the farm, the seas, or the earth, great effort is required to put it in usable form. The best sources must be found, developed, and equipped to prepare raw materials for our use. All of this takes vast amounts of capital, and this must come from those who are able and willing to work harder than ever, not only to meet their own requirements but to share some of their affluence with the underprivileged.

But the resources are large enough to meet these needs. We need only use our growing knowledge of science to discover them, and then convert them into the required forms—always being aware of the obligation to use them wisely and conservatively. This is one of the major challenges to us all for the future. □