Materials research: A call for new directions to avert future crises

The petroleum crisis is only the tip of a materials shortage iceberg. The United States imports only about a fifth of its petroleum, but must rely entirely on other countries for several vital minerals. So unevenly are some raw materials distributed throughout the earth's crust that almost all the world's tin, for example, comes from three small, developing countries. With such concentration, the potential for materials-based economic blackmail, similar to the recent oil boycott, looms as a frightening possibility. Countering such an eventuality will require not only delicate international negotiations but also a greatly expanded materials research effort, aimed at using limited supplies to their fullest.

In a new report, the Committee on Science and Public Policy (COSPUP) of the National Academy of Sciences has attempted to translate projected materials requirements into a set of national research and development priorities. Special emphasis is placed on the need for materials research as a means of solving the energy and environmental dilemmas facing the country.

The problem in arriving at these priorities, of course, is the very diversity of what constitutes "materials research." As a separate discipline, the field has existed for only about two decades, and only now has the Academy suggested that the term "hylology" (the study of matter) be applied to this amorphous realm. The interdisciplinary nature of hylology has been a particular stumbling block for university researchers, who generally work in department laboratories of traditionally defined fields. As a result the report concludes, even universities with special materials research centers have failed to achieve much innovation.

This failure is made all the more serious by the traditional reliance of industry on the academic community for much of its basic research, and by the increasing need for industry and university scientists to cooperate in solving nagging practical problems. The development and understanding of new materials are necessary to building any of the widely discussed new sources of energy, for example. New ceramics must be developed before electricity-generating turbines can be made less wasteful of their energy. Chemical reactions of materials at extremely high temperatures must be better understood before MHD can make burning coal a clean and efficient procedure. Economically feasible solar energy can [illegible] .e only with development of more efficient light-sensitive materials.

The key to success, according to the report, is a closer wedding of knowledge and application. The development of the transistor, for example, illustrates the alternate leapfrogging of technology and basic research that is typical of materials development. When the search for alternatives to electron tubes narrowed to the semiconductors, each step of "pure" research on these materials had to await a comparable technological step such as the growing of pure crystals, zone refining or miniaturization. Symbolizing the success of this procedure, one of the hottest gift items last Christmas was the family of pocket-sized computers, each built around a quarter-inch-square chip of semiconductor material containing 6,000 transistors.

The NAS committee polled experts in the materials field to see which areas of research should be given highest priority in the future. Among their responses:

- Corrosion. As conservation of natural resources gains in importance, increasing attention will be paid to the problem of corrosion, which now causes untold amounts of structural materials to crumble into waste. Such research will be particularly important if man is to build complex structures in the ocean.
- Biomaterials. Further development of synthetic membranes holds the promise of creating a totally implantable artificial kidney. Other artificial implants may be developed from the techniques of freeze-drying fabrication, and a new "replamineform process" can help replicate living structures in some suitable material.

Among specific recommendations aimed at encouraging new commitment to these priority areas, COSPUP suggests establishment of interdisciplinary laboratories for materials research, drawing on the resources of government, industry and universities. Greater university emphasis, particularly, is recommended, beginning with introduction of hylology into the undergraduate curriculum.

'Downwelling' anchors vs. rising hotspots

Eleven years ago, a revolution, or at least a major uprising, came to geology, with the publication of a paper by J. Tuzo Wilson called "A Possible Origin of the Hawaiian Islands." It was, in essence, the "hotspot theory."

It's become one aspect of the new structural view of the earth, with countless island chains, volcanoes and other features fitting into a picture of molten plumes rising up from the bowels of the earth, freeing the great plates of the crust to slide around the globe. The hotspot theory explains certain linear volcanic ridges as surface tracings of the plates' wanderings over a hot plume rising from below.

In recent months, however, there have been signs that the hotspot theory may not always be valid, although the broader theory of moving plates need not be altered. Cores from the Glomar Challenger, for example, recently revealed (SN: 1/12/74, p. 22) that the Line Island chain in the Pacific was formed in a relatively short span of geologic time, rather than over 10 million years or more, as presumably would be the case if it had slowly been drawn on the surface of the moving Pacific plate.

Now there is a counter theory, developed by the drilling expedition's co-chief scientist, Everett D. Jackson of the U.S. Geological Survey in Menlo Park, Calif., and Herbert R. Shaw at the U.S.G.S. Washington office.

Their idea is presented, in the JOURNAL OF GEOPHYSICAL RESEARCH, not so much as the alternative to the hotspot notion, but as a spur to some rethinking by the geological community. It was born, in fact, almost a year ago, many months before the Challenger findings, as the authors listened to seemingly endless additions to the hotspot theory at the annual meeting of the American Geophysical Union.

"You know damn well," says Shaw, "you can't have a plume under every volcano." Instead, in fact, he and Jackson propose almost the reverse: a localized "downwelling" of heat produced by friction between the plates and the asthenosphere underneath. The heat triggers melting, during which the heavier materials such as iron sink to the bottom of the region and form "gravitational anchors" that attract surrounding material and act as "pinning points" which keep the viscous influx from wandering off with the plate.

A key question still to be answered is that of what makes the localized frictional heating occur where it does. Ratios between heavy and light elements in samples from the Hawaiian Islands, as well variations in seismic velocity measurements through the mantle, support the downwelling theory, but there's work still for all. □