tives. The diffraction patterns can be magnified by changing to a higher-power ocular.

In most cases the microscope-generated diffraction pattern transmits the useful spatial information in the thin section more completely than the conventionally produced diffraction pattern; the photographic inputs for the conventionally produced diffraction pattern emphasize lower-frequency spatial information. This property, combined with the microscope system's better response to twinning, makes the microscope more sensitive to commonly used microfabric elements.

For the analysis of thin sections, a conventional ODA system is superior to the microscope system in only three cases. First, if one wants to analyze the entire thin section at one time, a conventional system must be used with a photographic input of the thin section. Second, if the thin section is extremely heterogeneous (crystallographically or mineralogically), the microscope-generated diffraction pattern may exhibit gross smearing even with the highest-power objectives available. Finally, the thin section may contain only elements of low spatial frequency that will not generate diffraction dots far enough radially from the central spot to be resolvable.

More study will be needed to establish the precision of spatial frequency measurements from diffraction patterns generated directly by thin sections with the microscope system. Experiments with a variety of film types and sources of illumination will, in all likelihood, lead to a reduction in the exposure times used to record diffraction patterns with the microscope (*9*).

A complete ODA system must have directional and frequency-filtering capabilities. In order to establish these capabilities for the microscope system, components will need to be designed and fabricated and the microscope body may have to be modified.

The possibility of applying the microscope technique in reflected light on a real-time basis should be investigated. This would be a valuable tool in the quantitative analysis of microfracture initiation and propagation and the analysis of overall fabric changes during experimental deformation of rock both in situ and in the laboratory.

The technique presented here can be used with a less expensive microscope, if it has a focusable Bertrand lens. Our experiments with relatively inexpensive microscopes indicated that the only major problem is alignment of the illuminating system (light-filter-condenser).

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10. This research was supported by the University of Wisconsin–Milwaukee and by the Advanced Research Projects Agency of the Department of Defense under contracts H0210003 and H0220016, monitored by the U.S. Bureau of Mines. The views and conclusions contained in this article are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the agencies cited above or of the U.S. government.

NEWS AND COMMENT

Cancer and the Environment (I): A Creaky System Grinds On

The Environmental Protection Agency's recent order declaring aldrin and dieldrin an "imminent hazard" and suspending production* of these pesticides was the culmination of a proceeding in which the dominant issues were characterized as "cancer and corn." And, in fact, the EPA administrator, Russell E. Train, concluded that the risks involved in continued use of these two compounds strongly suspected as human carcinogens would vastly outweigh the benefits they offer in the control of corn pests. Possibly the most potent of all the chlorinated hydrocarbons, aldrin and dieldrin thus join DDT as the tarnished miracles of modern agriculture.

Although this preliminary (but probably permanent) decision to ban aldrin and dieldrin is welcomed by environmentalists familiar with pesticide problems, they are anything but complacent about the present state of regulation of chemicals that may be dangerous environmental contaminants. Indeed, the decision to eliminate aldrin and dieldrin as a health hazard comes nearly 4 years after a ban was first requested. Furthermore, there is strong evidence that heptachlor, a chemical expected to be heavily used next year in corn fields of the Midwest as a substitute for aldrin, is itself a potent carcinogen.

The Environmental Defense Fund (EDF), the environmental law group that has led the fight against persistent pesticides, first petitioned for a ban on aldrin and dieldrin on 3 December 1970, the day after EPA came into existence. Several months later, William Ruckelshaus, then the EPA administrator, concluded that there was a "substantial question as to the safety" of these compounds (dieldrin poses the major problem because aldrin usually converts to dieldrin in soil, water, and living organisms).

But Ruckelshaus also concluded that there was insufficient evidence to suspend their production as an "imminent hazard," and he merely gave notice to the Shell Chemical Company—the sole manufacturer of aldrin and dieldrin—that he was initiating proceedings to cancel the pesticides' registration. Shell of course contested the cancellation, thereby virtually ensuring that it would be able to continue producing and selling the pesticides for another few years, while the proceedings wore on.

In response to an EDF petition, the U.S. Court of Appeals for the District

* The order does not suspend production for three permitted applications: restricted use for termites, the dipping of roots and tops of non-food plants, and use in a totally effluent-free mothproofing system.

of Columbia later directed EPA to reconsider whether to suspend production of aldrin and dieldrin—and it clearly indicated that the term "imminent hazard" was broad enough to apply to carcinogens whose effect would not be felt until many years hence. Subsequently, Ruckelshaus announced that Shell had voluntarily agreed to drop the registration of aldrin and dieldrin for several controversial uses (such as all crop dusting by aircraft), but other uses were to continue, most notably that against soil pests in corn fields.

The cancellation hearing on risks and benefits of the pesticides began in August 1973 before Herbert L. Perlman, EPA's chief administrative law judge. It turned out to be something of an extravaganza even by the outsized standards of pesticide proceedings. Literally hundreds of witnesses were scheduled to testify, and, within the first year, a partial transcript of their testimony ran to 24,000 pages.

The hearing still had at least 4 or 5 months to go when, on 2 August, Train, successor to Ruckelshaus, announced that the manufacture of aldrin and dieldrin was to be suspended as an imminent hazard on the basis of new test data. The suspension would prevent Shell from having its Denver plant begin production in September of some 10 million pounds or more of active technical aldrin, which would be used in more than 50 million pounds of formulated final products to be sold in 1975. (Shell manufactures dieldrin at its plant at Pernis, The Netherlands; 3.6 million pounds were used in the United States in 1956, but the amount used is now down to about 600,000 pounds a year.)

The administrator's order became final on 1 October, after a special hearing in which Shell tried unsuccessfully to convince Judge Perlman and Train that aldrin and dieldrin were not human carcinogens and that they were indispensable for control of corn pests. Shell immediately appealed to the U.S. Court of Appeals for the Fifth Circuit in New Orleans—a perhaps vain gesture because, to overturn Train's ruling, Shell must show that it was arbitrary or flawed by procedural error. In an effort to keep the issue in the possibly more sympathetic Court of Appeals for the District of Columbia, EDF also appealed, contending that the suspension order should also have included the sale and use of aldrin and dieldrin products that had already been formulated.

The animal test results that finally convinced EPA that aldrin and dieldrin are carcinogenic were produced in a remarkably ironic way. "If Shell hadn't run these tests [primarily on mice], we wouldn't have had a case," says William A. Butler, Washington counsel for EDF. Testing done at Shell's Tunstall Laboratory in England has shown unequivocally that dieldrin causes liver tumors in several strains of mice. (The evidence that dieldrin is a carcinogen in the rat is less conclusive.) Although the incidence of tumors increases with dose, the incidence is statistically significant at dosages as low as 0.1 part per million—the lowest dosage ever tested in an animal species. This is considered alarming inasmuch as virtually all Americans have dieldrin in their adipose tissues.

Conceding all along that dieldrin causes cancer in mice, Shell has based its aldrin-dieldrin defense largely on the contention that the mouse data cannot be used to predict carcinogenicity in man. The mouse liver, Shell says, is so "labile" that even a change in the oxygen content of the air the mouse breathes or an increase in the protein in its diet will cause a higher than normal incidence of tumors. "If the mouse liver were truly decisive for humans, Judge Perlman will have extended the category of imminently hazardous human carcinogens by several orders of magnitude," says Shell.

The company says that, in the course of a $10 million investigation of tumors in the mouse liver, its researchers have found that the response of the mouse to dieldrin is different from that of other animals, including man. A brief submitted to Train asserted the following:

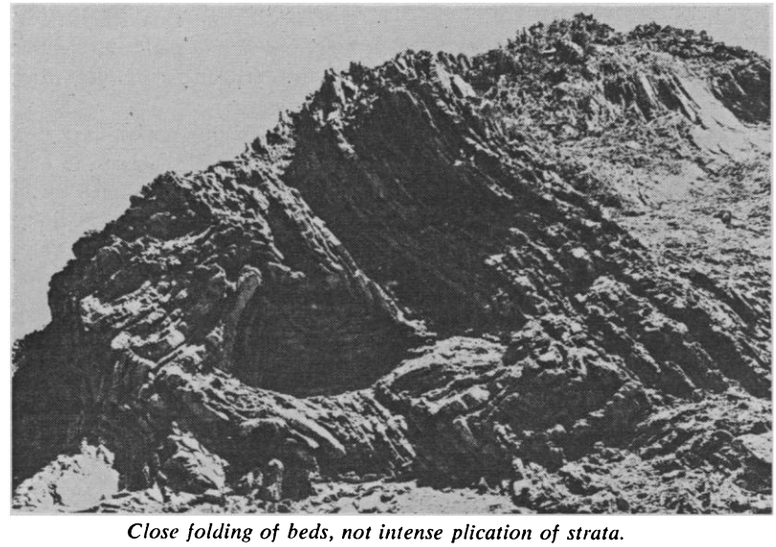
Speak Plainly and

Natural scientists may achieve what passes for immortality in several ways, not all of which require having a good idea. Insinuating one's name (or someone else's) into the name of some newfound animal, mineral, or vegetable will do just fine. And failing that, one can always coin a new technical term.

The drawback to inventing new terms, of course, is that they gradually clutter and impede the language like so many barnacles on a ship. Barnacles and jargon share a certain tenacity, but the U.S. Geological Survey—which sees itself as a communicator with nongeologists as much as a research institution—is not above trying its hand at a little linguistic keel-scraping. Thus the Survey has published an engaging little pamphlet called *Plain Geology*.*

"We may as well admit a certain liking for the sound of words, and

* *Plain Geology*, available from the Government Printing Office, Washington, D.C. 20402; stock number 2401-02529; 30 cents.



Close folding of beds, not intense plication of strata.

Long before liver tumors develop in the mouse, its liver responds to dieldrin in the diet with an alteration in enzyme activity, with subcellular changes consisting of an increase in the endoplasmic reticulum and with an immediate enlargement of the liver through the increase in the number of cells. These changes show that the mouse liver does not handle the detoxification of dieldrin. The liver of other species responds quite differently. At the subcellular level, the changes are visibly different under the electron microscope; liver enlargement occurs largely or wholly by enlargement of individual cells. And Shell has searched [among highly exposed workers at its dieldrin plant at Pernis] in vain for *any* such changes in man, even first-stage enzyme alteration or liver enlargement or biochemical liver responses to dieldrin, at up to 300 times the level of exposure of the general population. This is solid indication that the compound does not act in man as it does in the mouse. *The mouse liver does not predict.* . . . It is overwhelmingly unlikely that aldrin–dieldrin are human carcinogens.

EPA put on witness after witness during the hearings to defend the mouse as a test animal. These witnesses included Walter E. Heston, chief of the Laboratory of Biology of the National Cancer Institute (NCI), and Umberto Saffiotti, associate director for carcinogenesis at NCI's division of cancer cause and prevention. Heston, a geneticist who has done cancer research with laboratory animals for 35 years, observed, "Whether the particular strain or species of test animal chosen has a high, medium, or low incidence of spontaneous tumors is . . . irrelevant so long as animals are assigned without bias to test and control groups." Saffiotti referred to a literature survey which showed in part that, of 58 chemicals reported to have induced tumors in the liver [and sometimes additional organs] of mice, only one was reported not to have induced tumors in either rats or hamsters, and that one was not adequately tested.

EPA's experts found no significance in Shell's failure to find "premonitory" signs of liver cancer, such as enzyme induction, among workers at the Pernis plant. One witness, Emmanuel Farber, director of the Fels Research Institute, Temple University School of Medicine, testified that cancer of the liver could develop without such signs and without loss of normal liver function until late in the course of the disease. The initial exposure of workers at Pernis to dieldrin goes back only two decades, whereas the period of latency for liver cancer may be 30 years or more.

Shell is understandably perturbed that, as its product leaves the corn pest control market, a competing product—heptachlor—will probably replace it next year in many situations, with the total amount applied running to perhaps 3 million pounds. Heptachlor and chlordane (which contains heptachlor) are products of the Velsicol Chemical Corporation, which apparently is only now beginning to produce extensive new test data about these chemicals.

Enough is already known about heptachlor to make one uneasy. A mouse test conducted 9 years ago by the Food and Drug Administration indicated that heptachlor and its major metabolite, heptachlor epoxide, were carcinogenic. EPA recently had the slides of tissue specimens from that FDA test examined by its own pathologists. The results were startling: carcinomas were found in about three-fourths of the mice that were fed heptachlor and in more than 90 percent of those fed heptachlor epoxide.

Preliminary findings from animal tests this past summer at NCI's Gulf South Research Institute in Louisiana are also disturbing. "We are very concerned," says Norbert P. Page, who is responsible for NCI's carcinogen bioassay program. "It appears that there has been a carcinogenic response," he told *Science*, referring to tests made with mice (the response in rats was also tested, but Page said that not even preliminary results from the rat tests are yet available). Final results of the NCI tests will be released after the examination of tissue slides has been completed and the results have been analyzed statistically.

In light of its review of the FDA mouse study, EPA is expected to give notice soon of intent to cancel heptachlor's registration—thus giving rise to

Eschew Neologisms

the longer the word the more sound it has," the pamphlet observes. "Especially enjoyable is this mild form of hypnotism if both ideas and words are such as to make us feel that we are moving in the highest circles.

"We too often try to overdress our thoughts . . . our own words fool us, and unconsciously we cover up with long words or tangled rhetoric our lack of plain thinking."

While acknowledging that technical terms have their place in science, the pamphlet suggests that they "best keep their razor edge when used only for hairsplitting scientific distinctions."

The prescription offered for the language of geology—as encrusted as any with terms seemingly belabored in their precision—is a harsh one, perhaps heretical. It is suggested that geologists dispense with some of the terms nearest and dearest to the heart of the science. Leading candidates for retirement and their replacements:

Arenaceous deposits. Sand.

Riparian borders and *littoral margins.* River banks and shores.

Superincumbent material. Overlying beds.

Intense plication of strata. Close folding of beds.

Strata. Beds.

The Survey's plea for plain speaking may well fall on deaf ears, as it did half a century ago. The pamphlet actually is a reprint of a speech written in 1921 by George Otis Marsh, then the Survey's director and one of the nation's more illustrious geologists. Vincent E. McKelvey, the Survey's present director, thought Marsh's plea was just as applicable now as it was then, and ordered it reproduced.

"We in the scientific community must be effective in communicating the results of our work to the public in a way that can be understood and used," McKelvey says in a foreword. "Too often . . . our reports are couched in words and phrases that are understandable only to other scientists, engineers, and technicians."

Or, as George O. Marsh put it, the best science is "that which states facts in plain words."

Simplicity in scientific writing may not be an idea whose time has come, but, in the words of a mercifully anonymous geologist of some years ago: "This holds the promise of large potential possibilities."—R.G.

another tortuous cancellation proceeding. But EPA has cited heptachlor as an alternative—though not a recommended one—that will be available next year to many farmers who have depended on aldrin and dieldrin. Early suspension of the production of this pesticide is therefore unlikely.

Quite aside from the availability of heptachlor, Train concluded that aldrin and dieldrin could be eliminated without major losses on the part of corn growers or other farmers—a finding that has been derided by Shell and its devoted ally, the U.S. Department of Agriculture (USDA). The 9.7 million pounds of aldrin used this past crop season was just half the amount used as recently as 1966, and aldrin is applied now on only about 8 percent of the nation's cotton acreage. A variety of factors have contributed to aldrin's decline—the development of resistance in some pests, changes in cultural practices, the use of post-emergent baits and sprays that kill the mature insect after it leaves the soil, and so forth. The EPA administrator concluded that neither from the standpoint of the farm economy as a whole nor from that of individual farmers was there much to fear from a suspension of aldrin and dieldrin production.

In truth, aldrin and dieldrin never should have been registered without extensive prior testing of animals exposed to low, nontoxic dosages. The only such testing required was that done ex post facto for the setting of tolerances for residues in food—tolerances that have never been set, although the matter has been pending ever since 1957, first before the FDA, then before EPA. According to John C. Kolojeski of the EPA general counsel's office, the test results that were forthcoming from Shell—beginning in the late 1960's—remained virtually unnoticed until the cancellation proceeding in 1971. Some within EPA simply regard the tolerance-setting program as a bad joke.

To make matters worse, EDF, which has spent nearly $300,000 in its fight against DDT and aldrin and dieldrin over the past several years, is operating at a deficit and will face a dilemma should it become necessary to campaign for the suspension of heptachlor and chlordane. Such a commitment might be made only at some sacrifice of the organization's other objectives, such as reform of energy policy and public works programs.

For some time now, there has been a deepening awareness within EPA and among its allies that existing laws for the regulation of pesticides and industrial chemicals must be supplemented by a Toxic Substances Control Act to require chemical companies to do adequate testing of new compounds *before* they are registered for use. Although time is rapidly running out in this Congress, legislation that could establish such a requirement is far enough along to become law this year—given sufficient priority. With or without such a law, the government clearly has an obligation to see that adequate test programs are conducted for all persistent pesticides. NCI will soon organize a new interagency task force that will have this as one of its objectives. In view of the millions of pounds of these chemicals that already have gone into the environment, the NCI knows the hour is late.—LUTHER J. CARTER

Cancer and the Environment (II): Groping for New Remedies

Arduous as the fight over aldrin and dieldrin has been, turning thumbs down on these two pesticides was a relatively easy decision for the Environmental Protection Agency to make compared with others the agency now faces. For the EPA has only begun to grapple with the larger problems of regulating man-made carcinogens, some of which —like vinyl chloride, the raw material of plastic products as diverse as floor tiles and phonograph records—are used so pervasively, in so many ways, as to be an almost inescapable part of American life.

Aldrin and dieldrin, after all, were used in only one way—as pesticides—and on a limited number of crops. Substitutes existed, although their adequacy is in debate. But at least the EPA was able to conclude intuitively, if not by precise calculation, that any risk of cancer these two pesticides might pose thoroughly overwhelmed their limited benefits. Hence the simple remedy of an outright ban.

But for hundreds of other known or suspected carcinogens that crop up in industrial processes and consumer products, an outright ban may not be practical. Accordingly, the EPA is moving tentatively toward setting environmental standards that will limit, but not eliminate, the general public's exposure to some of the more potent and clearly established carcinogens. In a pioneering step last December, the EPA proposed a water effluent standard for benzidine, a chemical widely used by the dye industry and linked unmistakably to bladder cancer among workers more than a decade ago. And by next spring the agency expects to issue an emission standard for vinyl chloride, an industrial gas used by the billions of pounds that was thought to be biologically "benign" until it was linked last January to 21 fatal cases of angiosarcoma, a rare liver cancer, among workers subjected to large repeated exposures.

Last month the EPA estimated that 200 million pounds of vinyl chloride are lost to the environment each year in the process of converting it to polyvinyl chloride plastic (about 5 billion pounds of PVC plastics were produced in the United States last year). Still more vinyl chloride was spread about as a propellant in aerosol cans of hair spray, pesticides, and other consumer products until last spring, when such uses were banned by the EPA and the Food and Drug Administration. The EPA, however, appears to be giving no thought to an absolute ban on vinyl chloride emissions, a move the plastics industry says would cost the nation $90 billion in industrial output and sacrifice 2.2 million jobs.

In trying to set standards for environmental carcinogens, the EPA finds itself in the difficult position of deciding, in effect, what number of human cancer cases constitutes an "acceptable risk" —a potential toll presumably balanced by a carcinogen's economic benefits to society. In the case of benzidine and