Letters

Pseudoscopic Illusion

That visual perception of surface relief can easily turn Mayan moats into raised mounds, steep-sided Arctic basins into flat-topped mesas, or even the "Grand Canyon of Mars" into an extended dome mountain, may surprise unwary readers of *Science*. We refer specifically to illustrations accompanying an interpretation in the article by R. T. Matheny of ancient hydrographic modifications in Mexico (20 Aug., p. 639, figure 5), a comparison by L. W. Gatto and D. M. Anderson of martian fretted terrains with flat-floored thermokarst valleys in Alaska (Reports, 18 Apr. 1975, p. 255, figures 2 and 3), and a report by L. A. Soderblom on Viking 1 orbiter images of Mars (Reports, 1 Oct., p. 97, especially the cover picture).

It is possible to rectify these distorted impressions by viewing the illustrations upside down (for example, Figs. 1 and 2). Indeed, almost all instances of this type of pseudoscopic illusion (apparent reversal of surface depressions and elevations) in vertical aerial photography can easily be avoided by careful orientation of prints before publication. A useful convention, dictated not by editorial policy but by the way we see shaded relief, is simply to position each photograph so that heavy shadows fall more toward the bottom than toward the top margin.

Because illumination of familiar environmental features comes mostly from directions other than below our horizontal line of sight, we readily interpret unfamiliar views of textured surfaces represented in continuous-tone vertical photographs as if shadows were cast toward the bottom or either side of the displayed imagery. This leads to a frequently perceived reversal when such an illustration is placed so that actual shadows extend upwards ("away from the viewer"). Additional variables affecting this visual ambiguity include: resolution and other technical qualities of the photography, planimetric scale of representation, depth and form of relief, location and source of illumination, and the initial degree of the viewer's unfamiliarity with the subject matter or mode of presentation.

This widely experienced phenomenon has been the subject of experimental and technical discussion in psychology, photogrammetry, and allied fields for some time (*1*), but it apparently remains less universally recognized by users of vertical imagery.

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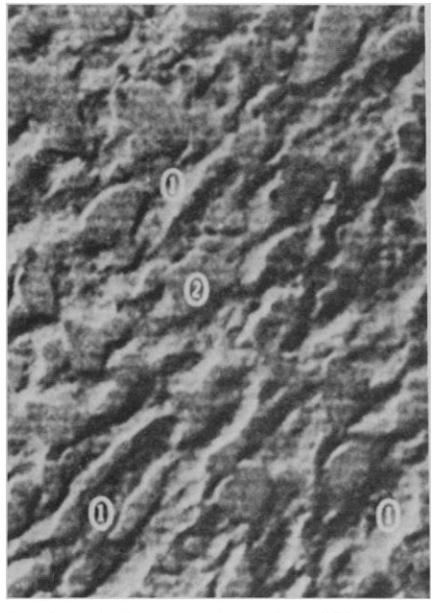

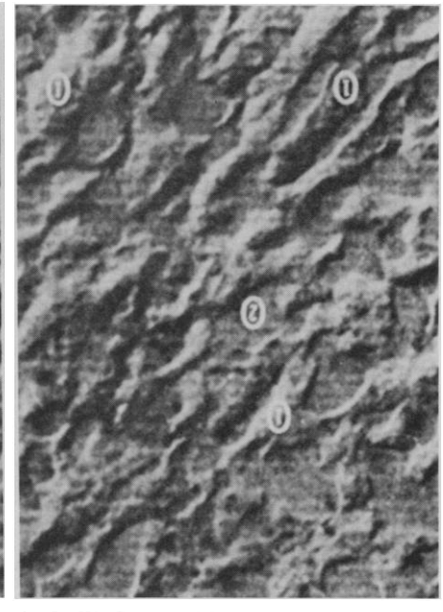

Fig. 1 (left). Portion of figure 3 (p. 256) in report by L. W. Gatto and D. M. Anderson (18 Apr. 1975, p. 255) showing Alaskan thermokarst terrain; *1*, uplands; *2*, basin. Fig. 2 (right). Same photograph viewed upside down.

Coal Research: Progress and Problems

The article by Allen Hammond "Coal research (I): Is the program moving ahead?" (Research News, 20 Aug., p. 665) discusses the coal program of the Energy Research and Development Administration (ERDA) and emphasizes the commercial feasibility of technology being established in large-scale pilot plants. He correctly points out that a fundamental difficulty is the high cost of clean energy from coal. This is followed by some historical background and reporting of the comments by some that the present status of the U.S. coal program is not very satisfactory.

Issue could be taken with these negative comments, as they do not take into account the funding and political constraints imposed during the past two decades. In the period from 1950 to the early 1970's, there was a minimal and inadequate effort on coal conversion R & D. The combined budget for the Bureau of Mines and the Office of Coal Research in 1970 was only $20 million, and less than this was expended by indus-

try. Although far from perfect, the comprehensive, long-term program of the Department of the Interior has been invaluable and unique in providing for the significant advances made in coal science and process technology that are now being tested on a pilot-plant scale.

The fundamental problem is that coal technology has not changed very much since the 1940's. The point not brought out in Hammond's article (which does not really discuss research) is the need for significant improvements in coal conversion processes requiring innovative, exploratory, applied research. The attitude prevails today even in the technical community that, if a great number of large enough pilot and demonstration plants are built and tested, the nation's coal-energy dilemma can be solved. I believe the construction and operation of present and planned plants are well justified by the benefits derived from knowing the operability and costs of these plants, each of which incorporates improvements, essentially of an engineering nature, over the technology of the 1940's.

But these measures will not be enough. In particular, it is already known that the investment cost of coal conversion technologies is too high. This high cost arises because present processes require too high pressure, too low throughput, too many process steps, and too high a hydrogen requirement.

Examples of promising new technologies are now in the research stage in government, industry, and university laboratories supported by ERDA. They include flash hydropyrolysis of coal, catalytic gasification, conversion of carbon monoxide plus hydrogen to aromatic gasoline, reductive alkylation, new molten salt catalysts for liquefaction, and others. Also, recent advances in understanding coal structure by a combination of analytic techniques, notably carbon-13 nuclear magnetic resonance, are providing new concepts leading to innovative research.

Such research projects are thought to be important because they provide the basis for significantly improved "third generation" synthetic fuel processes. But also of great importance is the need to understand and recognize the status of coal research so that a balanced coal program can be planned. An important segment of this program is an adequate and sustained research effort.

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In reference to Hammond's Research News articles of 20 and 27 August (p. 750) on coal research and coal gasification, respectively. I wish to make the following points.

1) Blaming the Interior Department's Office of Coal Research (OCR) for lack of progress in the current coal research program of the Energy Research and Development Administration (ERDA) is completely unjustified and contrary to fact. OCR was a most efficient and dynamic agency. Working on a very small budget, it rekindled coal research in the United States that had lain dormant since the end of World War II. OCR was much less encumbered by the bureaucracy and red tape that is unavoidable in such gigantic undertakings as ERDA. It is unfair to make repeated statements that the OCR program was not technically sound. Indeed, in all the major areas of coal research now administered by ERDA, the concepts were developed by OCR.

2) Hammond concludes that ERDA's aura of failure was underscored by the fact that none of the four gasification processes for which pilot plants had been built were among the two chosen for design of the demonstration plant, implying some basic technical inadequacy in the four ERDA processes.

The facts were, however, that at the time of ERDA's Request for Proposals for the high-Btu gas demonstration plant, the Bi-Gas and Synthane pilot plants had not begun operation. The Carbon Dioxide Acceptor process was not adaptable to caking bituminous coal, as required in the Request for Proposals. The Ken-Tex Corporation bid, which involved the HYGAS process, was not selected because of unacceptable cost-sharing arrangements. The HYGAS process itself, however, was given a high technical rating, second only to that of the Conoco process, by the ERDA Source Evaluation Board.

The fact that an evolving technology may support several demonstration plants for different processes at different times is historic in chemical and petroleum processing industries. No aura of failure or deficiency should be ascribed to the ERDA-sponsored processes because they were not selected at this time for the reasons given above. Further development on a pilot-plant scale is necessary for continued process improvements, even after demonstration and commercial plants have been built and operated.

3) Hammond attributes the delay in starting a synthetic fuels industry to the

fact that coal-based fuels are not competitive with imported oil, implying that price competition alone is the correct criterion for choosing between the two options. However, it is the cost of synthetic fuels that sets the price of the imported oil. The declining supply of domestic oil and gas already makes coal-based synthetic fuels competitive with alternative energy supplies. But if we tie the future of synthetic fuels to imported oil, there will not be a synthetic fuels industry for many years, until foreign oil resources are depleted. In the meantime, we will continue to be subject to the uncertain price fluctuations established by the oil exporters and suffer the increasing impact of a negative trade balance. Only by establishing a going synthetic fuels industry in the United States will we be able to establish a stable measure of energy costs and a stable basis for international energy trade. The ability to achieve energy independence by using our indigenous resources is a corollary benefit.

In summary, perhaps a very cold winter *will* panic the nation into realizing the urgency of the energy shortage and the need to develop the synthetic fuels industry. But what we really need is an unwavering mandate from Congress to establish this industry by eliminating unnecessary institutional barriers. We also need the firm resolve of the Administration to implement this mandate.

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Hammond's articles on coal gasification provide a good overview of current gasification work. In light of the high ranking of slagging gasification, some additional comments may be appropriate.

The Grand Forks Energy Research Center (GFERC) of the Energy Research and Development Administration has recently reactivated pilot plant studies in a slagging fixed-bed gasifier. This gasifier was designed and operated from 1958 to 1965 under the Bureau of Mines, and results of that test program have been documented (*1*). The GFERC gasifier operates at coal feed rates approaching 1 ton per hour and is the only pilot plant of its type in the United States. The research emphasis in current studies includes characterization of effluents to develop methods for reducing environmental effects and water usage, comparison of gasification potentials of western and other coals, and studies of hearth refractory and slag removal problems. Shakedown tests are in process, and successful operation has been achieved in several tests completed with lignite fuel.

Slagging gasification offers two important advantages when compared with the more conventional Lurgi process. First, the slagging gasifier consumes only about 20 percent of the steam required by a dry-ash unit. Second, the gas production capacity is about four times as great in the slagging gasifier as in a conventional Lurgi of comparable size.

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Mills' comments on the need for greatly improved coal processes and for research to bring them about are well taken. But these "third generation" processes may be irrelevant if the current round of engineering development does not produce some successes. Neither congressional support nor industrial willingness to put up part of the R & D money is likely to survive major failures in demonstration plants. The Office of Coal Research did keep the subject alive during the 1960's; but it was never intended to and, on the evidence, did not make much progress toward commercial technologies. Unfortunately, the OCR legacy still dominates the ERDA program, although the quality of work going on is much improved and there are signs of a new emphasis on technologies that can be commercially successful.

Congress, however, is obviously not yet convinced of the need to build commercial synthetic fuel plants and subsidize their operation. It recently refused again to pass such legislation, despite rising imports of oil and gas. There are many arguments for building—or committing now to build when the technology is ready—at least a few synthetic fuel plants, perhaps the most important being that these facilities would help to resolve technical, environmental, and institutional uncertainties. But advocates of such a course might do better to admit that snythetic fuels are not yet competitive with imports and will require subsidy in one form or another and instead focus their arguments on the national need, which is to have proven alternative sources of gaseous and liquid fuels well in hand.—A.L.H.