

during the time when fireball conditions were favorable to its formation is not enough to account for the present helium abundance. On this basis it is assumed that much of the present helium was formed later by nuclear processes inside stars.

If that hypothesis is true, then young stars should contain a higher proportion of helium than old stars because the young stars are made of material that has already been processed through stars one or more times while the old stars are made of more primeval matter. What Gross has found is that the old stars in the globular clusters have more helium than they ought to.

His work began with making computer models of stellar compositions. Different assumptions of composition led to different values of surface gravity and surface temperature. These predictions can be compared with observation since the values concerned can be deduced from observation of a star's light. Gross found that his models were particularly sensitive to the amount of helium in the star, and very insensitive to the many other parameters involved. "This is where the whole thing paid off," he says. "It just so happened."

Comparing his models with observations by K. A. James, R. D. McClure, E. B. Newell and W. H. Osborn, all of Yale, Gross found that the helium content of the older stars is 30 to 45 percent in contrast to 22 to 25 percent for the younger stars in the galactic disk.

What Gross thinks is the best explanation is that the fireball started out clumpy. The rate of helium production is very sensitive to the temperature; that is why in the smooth-fireball theory there is a certain period of optimum temperature when helium production is high. If the fireball had variations of density, the laws of thermodynamics demand variations of temperature. The result is that in the denser areas more helium is produced. These denser areas are also likely to be the precursors of galaxies. Also, if there are turbulent motions in the fireball, areas of low angular momentum will produce more helium than areas of high angular momentum. The low-angular-momentum areas condense into galactic halos; the high-angular-momentum areas condense to galactic disks.

There is one mechanism by which the extra helium could be non-primeval. Large supermassive objects (masses 100,000 times the sun) might have condensed before stars and processed large amounts of hydrogen into helium. Gross intends to look into this possibility in future work, but his intuition is that even if the superdense objects existed, they could not have done enough: Most of the extra helium should still be of primeval origin. □

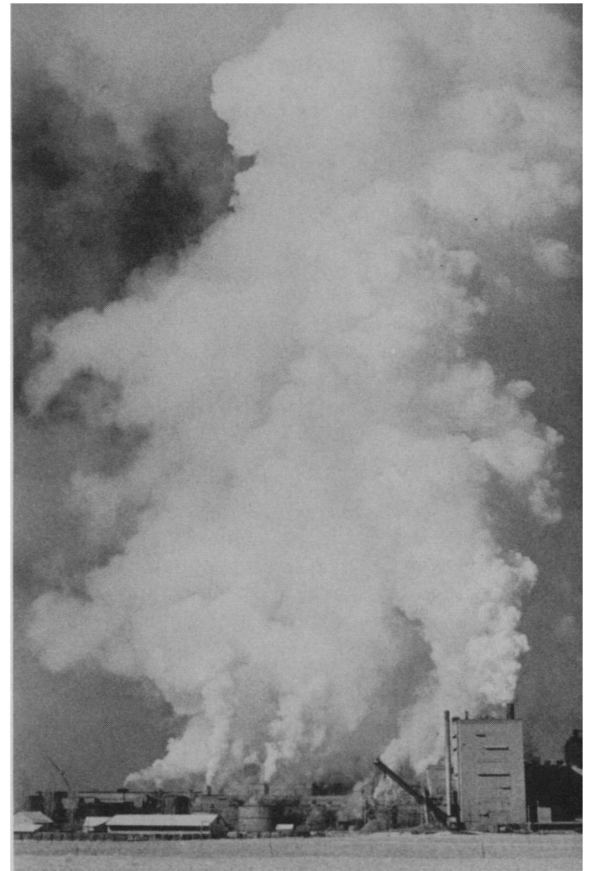
Environmental success: Pulp industry's cleanup

From the environmentalist point-of-view, the pulp and paper industry was the most damned of industries two years ago. Pulp mills belched foul-smelling gases from their boilers and disgorged oxygen-demanding organic wastes into waterways. A single pulp mill could blight life in an entire city, as was the case in Missoula, Mont., where a combination of emissions from the Hoerner Waldorf mill west of town and frequent inversion layers often turned the mountain-surrounded town into a great stinkpot. In 1970, the Council on Economic Priorities (CEP), a respected nonprofit firm that studies social aspects of business activities, termed the industry one of the nation's worst polluters. At the same time, the Missoula situation gained national publicity as local environmental groups brought a landmark suit against Hoerner Waldorf.

Today Missoula citizens are breathing easier. So are residents near pulp mills all over the country. A new CEP report, issued last week, says the pulp and paper industry has made a remarkable effort to control pollution during the past two years and that the mills by 1975 will probably approach 100 percent of "adequate pollution control."

The reasons for the striking turnaround are many. Vigorous enforcement of new antipollution laws backed up by a public outraged by the highly visible—and highly smellable—pollution is one reason. (Lawsuits, such as the one brought by the Environmental Defense Fund in cooperation with the local groups in Missoula, created widespread anti-company publicity, although the Missoula suit was never wholly resolved in court.) Another reason is that there was no need to develop exotic technologies for control. A final, and often important, reason was the unique pollution-control financing devised by Hoerner Waldorf and Missoula County and since applied elsewhere.

"Many of the recent pollution control projects in the paper and other industries are being financed through some form of municipal bond," says the new CEP report. In Missoula, the county floated \$14 million in tax-exempt bonds and gave the money to Hoerner Waldorf, which is now using it for pollution controls and necessary related plant modifications. Hoerner Waldorf will pay off the bonds—at the lower interest rate made possible because bondholders are not taxed on their interest—and nearly everyone benefits. ("Only the Internal Revenue Service loses," says CEP, a slight distortion, since when IRS loses, the na-



Harley Hettick

Missoula mill in 1970: Much better now, but still not a rose garden.

tion's taxpayers make up the difference.)

CEP admits the cleanup job lags in some areas, and Missoula residents report that the town does not yet smell like a rose. Hoerner Waldorf has cleaned up only one of its three pulp boilers, but the other two are scheduled for cleanup within a year. University of Montana scientists will then monitor air quality for another year to determine the effectiveness of the measures. "But there is no doubt that progress is being made," a Missoula environmentalist told SCIENCE NEWS. Hoerner Waldorf, besides abating the odiferous sulfur compounds from its pulping boilers, has also installed particulate abatement devices, as well as secondary treatment facilities for effluents that go into the Clark Fork River.

CEP says the situation varies from mill to mill, but that the Missoula gains are generally reflected throughout the country. Weyerhaeuser, once an industry leader in pollution abatement, still has severe pollution problems at its Longview, Wash., mill, however, and other companies, although they have cleaned up their highly noxious emissions into the air, still lag in water cleanup. Several other companies that to date have done little have now made firm commitments to clean up. Despite a sometimes spotty picture, the pulp and paper industry, says CEP, is "years ahead of other industries, such as utilities and steel." □