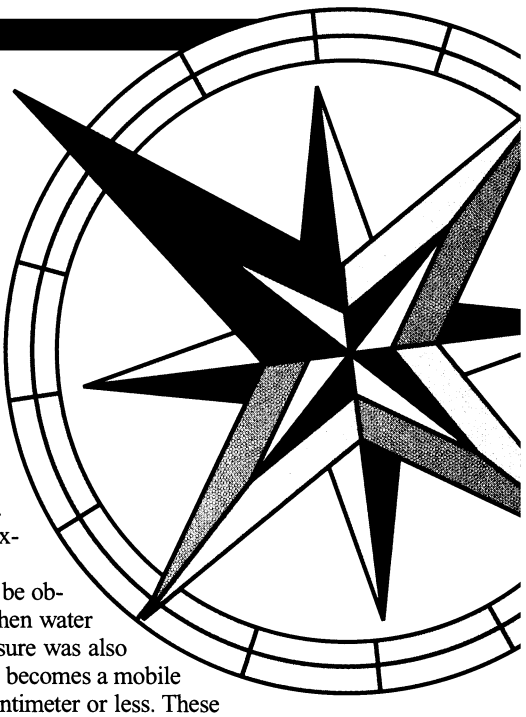

Limiting Atmospheric CO_2

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Worldwide emissions of CO_2 continue to increase, and prudence dictates that technologies be developed to help limit this trend. One of several ways to attenuate the increase of CO_2 in the atmosphere is to sequester it.* The technology for doing so exists. The injection of CO_2 into oil fields is having economically beneficial effects while at the same time sequestering CO_2. In addition, under the surface of the earth in the United States and elsewhere, many structures that once were filled with fossil fuels have been exploited, leaving space that might be used to store CO_2. In the United States, some of the structures from which natural gas has been extracted are being used to safely store high-pressure gas produced elsewhere.

In the exploitation of petroleum fields, about 20 to 40% of the oil can usually be obtained. In the early days, production was often enhanced in neighboring wells when water was forced down into one of them. Later it was discovered that CO_2 under pressure was also effective. In many oil wells, pressures and temperatures are high enough that CO_2 becomes a mobile fluid that is miscible with oils having densities of about 0.90 grams per cubic centimeter or less. These liquids tend to move toward lower pressures in production wells, and with this technique an additional 10 to 15% of the oil in an oil field can often be produced. Much of the CO_2 is recycled, but part of it remains in the oil-bearing formations. The net result can be profitable use of CO_2 and sequestration of some of it. In the United States in 1998, CO_2 had a major role in producing 6% of domestic crude oil.

Later this year, a project using CO_2 will begin at Weymouth Sasketchawan in Canada. A field there that has been producing oil since 1952 will receive 5000 metric tons of CO_2 per day via a 300-kilometer pipeline. The source will be the Dakota Gasification Company, located in Beulah, North Dakota. During the course of a multiyear injection, 20 million metric tons of CO_2 will be sequestered, and an extra 130 million barrels of oil will be produced. An international team will monitor the behavior of the field, and details of their findings will be made widely available. Another benefit could be that more attention will be focused on the Dakota Gasification Company. Among the plant's other outputs are electricity, methane, hydrogen, ammonium sulfate, phenols, and cresols. Its principal inputs are liquid oxygen, steam, and lignite coal.

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Almost all of the efforts to use CO_2 in enhanced oil recovery have occurred in the United States. A notable exception is a large Bati Roman field in southeast Turkey. Its heavy oil has high-molecular-weight components, and primary production was capable of achieving an ultimate recovery of only 1.5% of the original oil. Injection of CO_2 was successful in increasing production. Total miscibility was not achieved, but a large volume of CO_2 dissolved in the oil and its viscosity decreased from 1000 centiposes (cp) to less than 100 cp. This facilitated flow, and a recovery of 6.5% is expected.

The present amount of geological sequestration of CO_2 is small in comparison with emissions. However, the ultimate global potential is substantial. In addition to its use in petroleum fields, a substantial volume of CO_2 could be sequestered in deep unmineable coal and in depleted natural gas fields. A 131-page report commissioned by the International Energy Agency (IEA) and supported in part by the U.S. Department of Energy has included estimates of what might ultimately be achieved.† The IEA report estimates that the ultimate storage capacity of the oil and gas fields equates to over 125 years of total current CO_2 emissions from fossil-fueled power plants.

A major source of CO_2 is the combustion of fossil fuel in power plants. Coal is the major and the cheapest fuel, but CO_2 formed by burning it is polluted. The gas must be cleaned and pressurized before injection. The total cost of these procedures is roughly $53 per metric ton or more. This cost is a barrier to segregating it. A vigorous program aimed at cutting the cost of cleaning CO_2 emitted by power plants should have a high priority and adequate funding. Success in such a program would be an important help in reducing the overall costs of whatever sequestration methods were ultimately employed. Controversy exists about the possible extent of the contribution of CO_2 to present and future global warming. However, if international agreements are implemented to attenuate the buildup of atmospheric CO_2, sequestration of it in unused or abandoned fossil hydrocarbon fields is one good step to take.

*R. A. Parson and D. W. Keith, *Science* **282**, 1053 (1998). †S. H. Stevens *et al.*, *Sequestration of CO_2 in Depleted Oil and Gas Fields* (final report prepared for IEA Greenhouse Gas R&D Programme, Cheltenham, UK, 1999).