Looking for CO2 Buried at Sleipner

The Sleipner project in the North Sea, off the coast of Norway, is the model that SCS Energy says it hopes to emulate with its PurGen project proposed for Linden, N.J., which will bury 500 million tons of CO2 beneath the Atlantic Ocean.

The Sleipner project was developed by BP (the oil company formerly known as British Petroleum) and the Norwegian state-owned oil company, Statoil (now renamed StatoilHydro). Sleipner is a production platform anchored in the North Sea where natural gas is pumped from below the sea floor. At Sleipner, the natural gas comes up mixed with naturally- occurring CO2. Because Norway has a tax on CO2, BP and Statoil made the decision in 1996 to separate the CO2 from the natural gas on the pumping platform and then to pump the CO2 back into the ground below the floor of the North sea. Since 1996 they have pumped about 1 million tons per year into the Utsira formation, which is a 200-meter- thick layer of sandstone and mudstone.

In 1999, 2001 and 2002, Sleipner's buried CO2 was "imaged" using seismic techniques. The goal was to draw a 3-dimensional picture of the buried CO2, to find out how it has moved and where it has gone. In 2007, a group of British scientists examined the data from 1999, 2001 and 2002 and published a lengthy technical paper on their findings.[1]

The scientists reported a discrepancy between their model and actual measurements of the permeability of the Utsira formation. Permeability is a measure of the ability of a porous material (such as sandstone) to transmit fluids. Permeability will determine how rapidly CO2 pumped below the sea floor will spread horizontally. As they said, "A number of factors could cause the apparent discrepancy between estimated and measured permeabilities."[1, pg. 174] They listed 4 possible explanations for the discrepancy:

1. The first possible explanation could be that the CO2 has flowed into a dome-shaped cavity and so has not flowed laterally as rapidly as was expected.

2. The second possibility could be that the actual measurement of permeability was not representative of large-scale permeability in the Utsira formation; in other words, when they took actual physical measurements of permeability in the Utsira formation, they sampled a spot that was not typical of large-area permeability.

3. The third possibility was that "a significant fraction of the injected CO2 is not stored in the layers imaged." In other words, much of the injected CO2 has gone somewhere else.

4. The fourth possibility is that assumptions in the mathematical model are wrong.

The authors of the report commented on possibility #3 as follows:

"The volume of CO2 imaged would need to be reduced to 19% of that injected for the whole-reservoir estimate of permeability to be compatible with the lower bound of measured permeabilities and the seismic data suggest this is unrealistic."

In other words, to make sense of the measured permeabilities and the permeabilities derived from their model, they would have to assume that 81% of the injected CO2 had gone somewhere outside the area that they imaged.

So their modeling affirms that at least 19% of the injected CO2 has stayed put, and the scientists believe that more than 19% has stayed put but the discrepancy between measured permeabilities and calculated permeabilities remains unexplained.

They conclude (pg. 175):

"Reservoir permeabilities estimated from the shape of the accumulations [of CO2 in the Utsira formation] are below the range of measured values and it is not yet clear to what extent this discrepancy is a result of limitations in the modeling, a difference between permeability on the scale of the reservoir and the scale of the measurements, or whether less CO2 is stored in the layer imaged than estimated from the seismic studies."

To put it bluntly, no one is able to say for sure whether CO2 injected at Sleipner has leaked or not.

Summarizing this study in a PowerPoint presentation, Peter M. Haugan, director of the Geophysical Institute, University of Bergen (Norway), Bergen Marine Research Cluster, has made this point explicitly:

"Layers have started filling gradually. Leaks occur through thin mudstones. Model-data consistency requires either CO2 permeabilities order of magnitude lower than measured on core samples or CO2 layer thickness from seismic are overestimated. Possible that CO2 saturation is small and CO2 has escaped."[2]

--Peter Montague, July 27, 2010

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[1] Mike Bickle and others, "Modeling carbon dioxide accumulation at Sleipner: Implications for underground carbon storage." *Earth and Planetary Science Letters*, Vol. 255 (2007), pgs. 164-176. Available here: http://www.goo.gl/Tp6u

[2] http://goo.gl/3DCO slide #12.