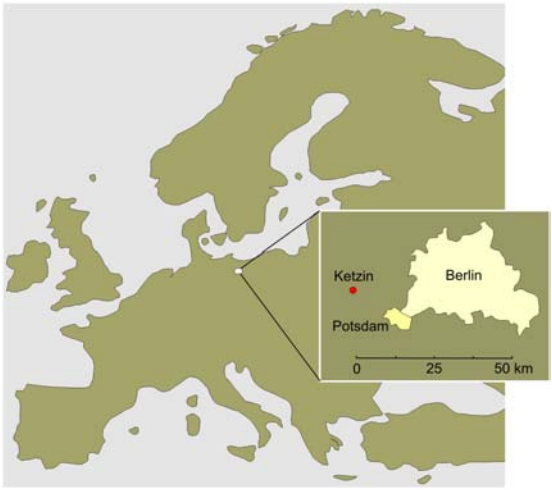
CO_2SINK – The First Year

(by the CO2SINK project team)

It is over a year since April 2004 when this EU Framework 6 research project CO_2SINK was commenced. Significant progress has been made by the consortium, which now consists of 15 members, in investigating the selected site at Ketzin near Berlin (Fig.) and in preparing plans for CO_2 injection and monitoring



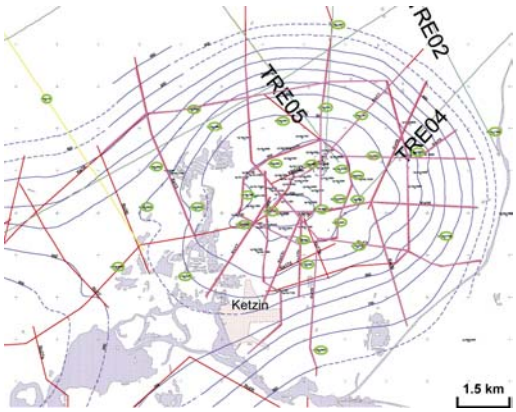
Major objectives of the project are:

- To advance understanding of the science and practical processes involved in underground storage of CO_2 in an onshore saline aquifer to reduce emissions of greenhouse gases to atmosphere.
- To build confidence towards future European carbon dioxide geological storage.
- To provide real case experience for use in development of future regulatory frameworks for CO_2 geological storage.

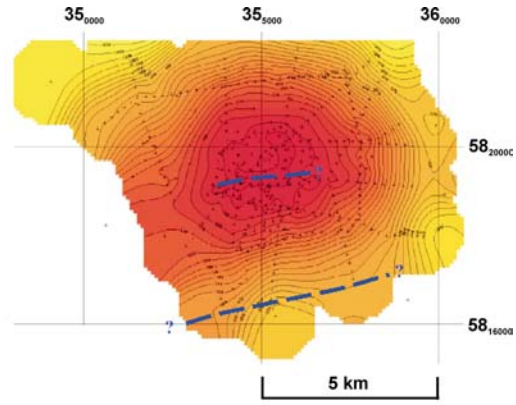
In the first year, much of the research effort has been directed to the first of these objectives. The project calls for extensive investigation of the site prior to any injection of CO_2 to fully understand the geological setting, the risks and how to effectively monitor and control the injection activities.

Site Characterisation

An extensive database of previous exploration at the Roskow-Ketzin double anticline has been set up and is now available online. This data includes seismic profiles and stratigraphic and lithological information from many boreholes drilled in the area in the past.



Seismic lines (pink) and boreholes (green) digitized for a first assessment of depth of the CO_2SINK target formation, the Stuttgart Formation (Fig. below). The K_2 Rx horizon (blue) above the Stuttgart Formation reflects anticlinal closure.

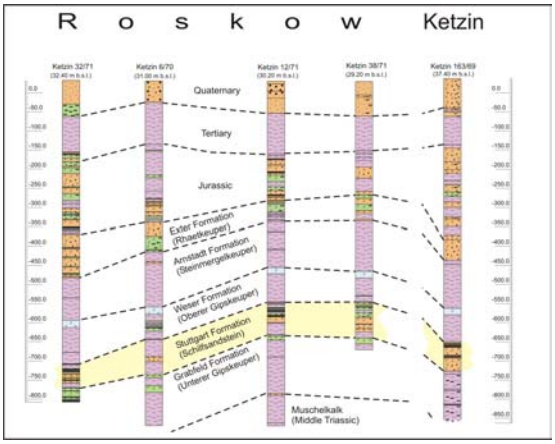


Preliminary structure map of top of the Stuttgart Formation and possible faults (blue).

The database has been used to develop a first structural and lithological model of the Ketzin anticline to be verified by a 3-D seismic survey.

Stratigraphic analysis was done for baseline reservoir/aquifer and cap rock/ aquitard characterization. The analysis was targeted on predicting determinis-

tically and statistically the spatial occurrences, geometries, continuity, and frequencies of rock properties between and beyond well control.



Strat-lith section of the Ketzin area. Aquitards/cap rocks are shown in pink and bright blue, aquifers are shown in yellow and green.

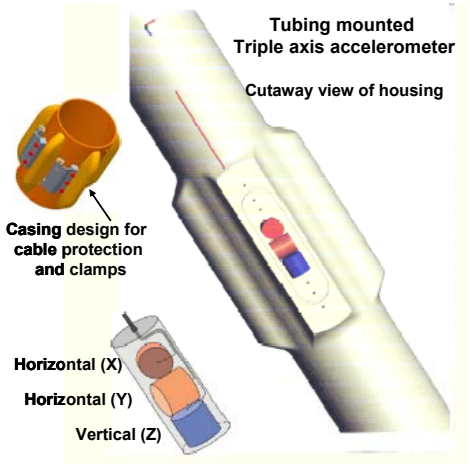
The locations for the injection and observation wells have been selected. The boreholes will be drilled within the site of the existing industrial area of a former natural gas storage facility and will meet the CO_2SINK reservoir formation between 620 m and 720 m depth below ground level.
The area for the baseline 3-D seismic survey, planned for autumn 2005, has been delineated. A field test was carried out to compare various vibration sources that may be used in the larger scale survey. The seismic survey will substantially contribute to better explore the reservoir geometry and to evaluate the risk by faults that may cross the anticline.

Drilling
Three wells will be drilled at the Ketzin site: One for injection, two for observation. All wells will penetrate the Stuttgart Formation and will reach final vertical depth at about 800 m. An arrangement of the well locations in a triangle (with a spacing between the wells in the order of 50 m and 100 m) allows in situ monitoring of the CO2 migration within the reservoir. Key challenges for well engineering are borehole integrity and behind-casing sensor applications. The latter require new systems that are in the process of development and testing. Work is in progress to design the wells and to specify the detailed drilling programme. The work will be performed according to industry-accepted standards and regulations. This specifically applies to health, safety and environmental issues.

Baseline Geochemistry and Geomicrobiology
Work also commenced on characterizing the conditions prior to injection at and below the ground surface of the site. Multi-function sensors have been installed at 35-40 m depth in two boreholes, one of them close to the rim of a channel, where the uppermost aquitard in the anticline has been eroded and upward fluid flow from the deeper levels might occur. Another sensor is installed in a shallow well south of the main structure also to trace possible upward flow of fluids that may be enriched in CO_2. In addition, a grid of 16 soil sampling locations has been set up, and first measurements of soil CO_2 fluxes have been made. Thus an overview was gained on the background level of CO_2, methane and other substances present in the groundwater. Isotopic analysis identified their biogenic origin. This is an indication that the existing natural gas storage reservoir at shallower depth above the cap rock of the Stuttgart Formation has an effective top sealing layer.
Local microflora that could act as biological monitors have been sampled and examined. Studies so far suggest that a sensing organism will be chosen from the population of aerobic bacteria.

Monitoring

A design for innovative in-casing, down-hole triple axis accelerometers (TAA) has been finalized, and prototypes are in process of fabrication and testing.



Down hole triple axis accelerometer

These devices will allow continuous detection of small seismic signals from pressure changes in the reservoir and mass displacements along faults. In combination with vertical seismic profiling, the TAAs allow accurate location of signals. Further monitoring systems (optical pressure gauge for the injection well, optical temperature sensing system, electrical resistivity downhole array) are under development. This multi-method concept, which comprises a number of seismic and non-seismic surface and downhole techniques, will provide an image of the reservoir at different length- and time-scales and facilitates the assessment of petrophysical parameters and processes during and after the injection of CO_2.

Risk Assessment

The consortium is progressing with the risk assessment for the project, which involves identifying all of the potential hazards to persons or environment and ensuring that adequate controls are in place to prevent any undesirable consequences. This is a systematic process that makes use of information about similar activities being conducted worldwide. The major risks for the project have now been identified, and models to evaluate different scenarios are developed. Risk assessment for CO_2 geological storage is an area of intense co-operation in the scientific community at present, and information is freely shared.

Laboratory Experiments

Petrophysical investigations of reservoir and cap rocks have been conducted on core samples from various wells drilled into the Stuttgart Formation. The investigations comprised both standard petrophysical analysis and long-term CO_2 flow and exposure experiments at simulated in situ conditions. Geophysical parameters, such as resistivity and ultrasonic velocity, were monitored during the long-term experiments. First exposure experiments over 2-3 months resulted in chemical alterations, which could be the reason for significant reductions in permeability during the flow experiments.

The laboratory experiments provide fundamental insights into the effect of CO_2 injection on rock properties. They yield parameters for formation evaluation and interpretation of geophysical monitoring methods and allow an initial calibration of numerical models. However, detailed investigations using fresh cores are needed to substantiate the first results.

Numerical Simulations

Simulations of CO_2 injection at Ketzin rely heavily on the geological information. Modelers and geologists are working very closely. Several injection scenarios have been simulated and are providing constraints on the injection pressure for CO_2 as well as on the quantity of CO_2 that needs to be injected to be detected by well instruments and surface surveys. Further-

more, depending on the permeability distribution that will be encountered in the wells, the time frame for injected CO_2 to reach observation wells can vary widely. It is important that well and field experiments can be planned accordingly.

Different simulation tools are being employed and a set of simulation problems have been to compare different modeling codes such as MUFTE_UG, ECLIPSE etc.

Preliminary 3D modeling of the natural temperature and flow in the reservoir in the absence of CO_2 has been completed . The results agree well with a recently taken temperature log and also indicate a very small natural fluid flow in the storage reservoir of about 0.5 meters every 1000 years. After injection very slow migration of the CO_2 to the NE is predicted. The largest driver for the subsurface flow of CO_2, however, is expected to be the buoyancy of CO_2, because its density is much less than that of the saline brine already residing in the reservoir.

Regulations and Permitting

On the regulatory front, preparations for the submission of the basic schedule of operations (Hauptbetriebsplan) to the regional mining authority (Bergamt) are well underway. However, for future commercial operations, clarification is being sought as to which other authorities will need to be involved and which authority will have overall responsibility for plan approval.

CO_2 Supply

The EU-funded portion of the project is limited to the injection and basic monitoring of CO_2 storage. The supply of CO_2 is to be funded separately, and there has been extensive investigation of a number of options. The CO_2 will be transported in liquid phase to the storage site by road tankers. Final plannings on CO_2 supply and on joint financing by industry and government are underway. A proposal to the CO-ORETEC Program of the German Ministry of Economy and Employment (BMWA) has been prepared emphasising R&D in the following areas:

- Purity specifications for CO_2 storage
- Separation and liquefaction of CO_2 from refinery exhaust gases
- Optimisation of truck transport and temporary storage
- Surface Operation of CO_2 injection

Other Activities

A number of additional research activities, with funding from other sources, are expected to be added to the scientific investigations at Ketzin. Final agreements have yet to be made, but the trend towards more extensive use of the Ketzin site for CO_2 capture and storage technology development is most encouraging.

In summary, the CO_2SINK at Ketzin has been moving forward on all fronts during the first year. The project is attracting more support and is starting to act as an international catalyst for scientific research in the area of CO_2 capture and storage.

Further information is available at http://www.co2sink.org.