MANAGEMENT REPORT - NO 3

CONTRACT N°: ENK6-1999-00014

PROJECT N°:

ACRONYM: SACS2

TITLE: Saline Aquifer CO2 Storage

PROJECT CO-ORDINATOR : Statoil

PARTNERS : BP, ExxonMobil, Norsk Hydro, Vattenfall, BGS, BRGM, GEUS, IFP, SINTEF, NITG-TNO, IEA GHG, GECO

REPORTING PERIOD: FROM 1. January TO 30. June 2001

PROJECT START DATE : 1 April 2000 DURATION : 24 months

Date of issue of this report : 1.October 2001

Project funded by the European Community under the 'Energie' Programme (1998-2002)

1.Technical Overview

Highlights from the period of report no 3:

The project is now around mid-term, in steady progress, and no major results are presented.

Since the “Utsira” formation now, by and large, has been analysed, the interest has shifted towards the overlaying caprock. A workplan has been developed for the detailed analysis and characterisation of a caprock core, in the anticipation that this may be obtained later. Collecting a core from the caprock is, because of prohibitive costs, dependent of the next well to be drilled by the Sleipner licence. There are at present communication with the Sleipner licence about their drilling plans.

A central objective of the ongoing work is to interpret the size and shape of the injected CO2 “bubble”. This involves all work areas and makes close cooperation between the 7 institutes important. It is at present very active, but is time and resource consuming for the involved.

The geochemical work has now available material reacted for 24 months. Analysis is ongoing.

Geophysical Interpretation (WA 8-11) work has evaluated software for performing pre-stack velocity analysis in the CO2 injection area.

IMPORTANT MILESTONE:
Western Geco, as planned, shot the 3rd (2nd on SACS budget) seismic survey over the Sleipner CO2 “bubble” during a couple of days around 1 October 01. Very preliminary (QA check onboard) indicate the data collected were of high quality. Processed data, i.e. ready for interpretation and simulations, are expected delivered around New Year 2002.

1.1 Summary of Objectives

The goal of the project:
Beginning in 1996, 1 million tons of CO2 per year has been stored at the Sleipner Field in the North Sea. This is the first case of industrial scale CO2 storage in the world. Being the first case, careful monitoring is necessary of the behaviour of the CO2 storage facility - a thick saltwater-bearing sandstone at a depth of approximately 1 kilometer. Data will be collected to model and verify the distribution of the CO2 'bubble' for three years, and methods will be demonstrated for prediction of the destiny of the CO2 thousands of years into the future.

In addition to demonstrating the long term feasibility of storage of CO2 in the Sleipner field case, it is a particular aim of the project also to provide a solid scientific documentation of CO2 storage as a method. This may be applied in other geographical areas, and in other industries such as power generation.

Expected Results:
*A best-practices-manual comprising evaluation procedures on the feasibility of CO2 storage in other geographical areas or large point sources in other industries.
* The project will generate a working methodology for evaluation of subsurface CO2 storage from a technical and an environmental point of view, in order to satisfy authorities and the general public as to the feasibility, safety, and reliability of the CO2 storage process.

The project consists of these Work Packages (WP):

WP 1 – Geology	lead by BGS
WP 2 – Reservoir Simulation	lead by SINTEF
WP 3 – Geochemistry	lead by BRGM
WP 4 – Monitoring Well Asess.	lead by SINTEF
WP 5 – Geophysical Monitoring	lead by TNO
WP 6 – Reports & "Best-Practice."	lead by Statoil
WP 7 – Petro-Acoustic…	lead by IFP
WP 8 – Base Interpretation	lead by Geco
WP 9 – Time Lapse 1 Interpret.	lead by Geco
WP 10 – Time Lapse 2 Interpret.	lead by Geco
WP 11 – Synchronisation Res.Sim.	lead by Geco
WP 12 – Steering Committee	lead by Statoil

1.2 Technical Progress and Main Results

WP 1 – Geology lead by BGS and support by GEUS and SINTEF

Summary

In the reporting period work has continued on the following tasks:

- Task 1.4 Characterise Caprock
- Task 1.7 Iterative Development of full Regional Geological Model

Task 1.4. Characterise caprock

Work carried out during the reporting period

Caprock cuttings from the Norwegian (report completed) and UK sectors (report in preparation) have been analysed by SEM and XRD, including determinations of grain size, quartz content, total organic carbon and cation exchange capacity. Results have been interpreted in terms of the Krushin sealing capacity.

Core material from a suitable cap rock analogue has been identified from the Ekofisk area in well 2/4-C-11. XRD clay mineralogy is similar to that of Sleipner caprock (report in preparation).

A workplan has been developed for the detailed analysis and characterisation of a caprock core, in the anticipation that this may be obtained later in the summer.

Problems and difficulties encountered

Ekofisk samples suitable for analysis of physical properties were not obtainable from NPD, this affected amount of analysis possible.

Task 1.7 Iterative development of full regional geological model

Work carried out during the reporting period

Regional interpretation of the Utsira Sand has been finalised. This incorporates additional well data in the north and infill seismic data to the NW of Sleipner (in an area of predicted long term CO_2 migration). These additional data have been interpreted and integrated into the regional interpretation. Prior to depth conversion the regional interpretation has been merged with the detailed interpretation of the Utsira Sand based on the Sleipner 3D survey (from Work Package 5).

Depth conversion of the Utsira Sand interpretation is underway.

The regional seismic stratigraphy of the caprock succession has been interpreted and work has commenced on constructing stratigraphical sections to characterise regional properties of the caprock.

Seismic amplitude anomalies have been mapped around Sleipner and preliminary interpretation of the continuity cube has begun.

Problems and difficulties encountered

The depth conversion, which utilises both seismic and well data, was held up by the fact that many wells still had slightly incorrect picks for top and base Utsira Sand. Correction of this was quite time consuming. Excepting this, only minor problems have been encountered which have been overcome.

WP 2 –Reservoir Simulation lead by SINTEF and supported by TNO

Within Work Area 2 – Reservoir Simulation of the SACS2 project TNO NITG and SINTEF have been involved in the following subtask in this period:

2.1 Fluid properties of the fluid brine system (SINTEF)
2.2 Relative permeability measurements (SINTEF)
2.5 Simulation of present history (TNO NITG and SINTEF)
2.6 Numerical simulation of the long term fate of CO_2 (TNO NITG and SINTEF)
2.7 Raleigh convection (SINTEF)
2.9 Escape of CO_2 from a fault or spill point (TNO NITG and SINTEF)
2.10 Limitations and improvements of reservoir simulators. (TNO NITG)

Co-operation is especially important to get comparable results via different methods and tools. A discussion to redistribute of the workload for subtask 2.5 and 2.6 between SINTEF and TNO.NITRG is going on.

We still are waiting for the completion of 3 types of geological models: a coarse regional model, an intermediate detailed storage reservoir model, and a detailed well model. Furthermore, the interpretation of the time-lapse seismic is completed at the end of the reporting period.

Task 2.1 Fluid properties of the fluid brine system (SINTEF)

Work carried out

The density of CO_2 is very dependent of the temperature profile in the reservoir and very few temperature measurements in the Utsira formation exists. A suggestion that an apparent discrepancy between the modelled volume of CO_2 and the estimated amount of CO_2 obtained from the analysis from the seismic is due to unceartainty on the simulated results has started a discussion on this specific topic. Both SINTEF and TNO NITG are taking part in the ongoing discussion that has so far been non-conclusive, but uncertainties have been narrowed down to the uncertainties reservoir temperature and other factors related to seismic interpretation rather than fluid properties.

This work is completed

Task 2.2 Relative permeability measurements (SINTEF)

Work carried out

A special prepared core has been prepared by first saturating the 4” barrel core with brine and then freezing it to -40°C. From this core 1.2 meter 1.5” core were drilled under air-cooling (-190°C). The core has been mounted in a sleeve with a metal diffusion barrier. Introductory measurement of permeability and permeability as function of overburden pressure has been performed.

Task 2.5 – Simulation of present history

Work carried out

Activities have been performed to gain an understanding of all physical processes involved. The available tools to simulate these processes have been selected.

A conclusion from the previous period was that the migration of CO_2 between the accumulating shales must be governed by distinct high permeable holes the shales. These cannot be seen directly from the seismic images, but their presence have been predicted (Lindeberg *et al.* 2000). The nature

of these pathways can also be reviled by stochastically distributed heterogeneities in the reservoir models. A systematic study based on several realisations has been performed and an upper and lower boundary of the hole frequency and permeability has been determined. These results will be used as input when reservoir properties will be up-scaled in task 2.6.

Some CO_2 has also been seen in the seismic images above the Top Utsira in a sand wedge with a thickness between 0 and 30 meters. These seal are not parallel and since there exists seismic of the topography of both of the Top Utsira and the top of the sand wedge, it will be possible to predict the alternative migration paths depending of which of these layers will become the controlling seal. The permeability of the Top Utsira will determine which seal will be dominating and therefore the emphasis has been put on this.

The result of the history simulation was used as basis for the parameters chosen when the next seismic survey in the fall 2001 was planned.

Task 2.6 Numerical simulation of the long term fate of CO_2

Work carried out

A 3D reservoir model for a 12 x 15 km area has been built based on up-scaling of the parameters obtained form the mimicking simulations of the historical migration.

Task 2.7 Diffusion-induced convection. (Was: Raleigh convection, SINTEF)

Work carried out

This work was almost completed in last period. Reporting remains.

Task 2.9 Escape of CO_2 from a fault or spill point

Work carried out

From seismic and geological work there are no evidence found of faults. On the other hand evidence are found of a sand wedge on top of the Utsira formation, which are separated by a ca. 5 m thick shale unit. The time-lapse seismic survey indicates that this shale unit is possibly penetrated by the CO_2. In order to investigate the sealing capacity of the Utsira cap rock the topography of this sand wedge and shale unit is under study.

SINTEF has developed a model with “synthetic “ fractures and tested it on various fracture sizes to obtain realistic escape scenarios. The work continues.

Task 2.10 Limitations and improvements of reservoir simulators

Work carried out

With the utilisation of the SIMED II gas/water simulator for the simulation of CO_2 storage problem TNO NITG has created a unique opportunity to create a dedicated CO_2 storage simulator. The component solubility option into this model has been included. Furthermore, in close co-operation with SINTEF it was concluded that during the CO_2 injection time frame the temperature plays an important role on the density of the injected CO_2 and consequently on the *in situ* volume. SIMED is a simulator based on the principle of isothermal behaviour with only one average reservoir temperature to be supplied for a successful run. In case of CO_2 storage in a relative thick formation in combination with the injection in the lower part of this formation the natural temperature gradient in the reservoir could be important. For this reason a depth dependent temperature function will be implemented in SIMED. The programming work is in progress to implement this function.

References:

Erik Lindeberg, Peter Zweigel, Per Bergmo, Amir Ghaderi, Ane Lothe: PREDICTION OF CO_2 DISPERSAL PATTERN IMPROVED BY GEOLOGY AND RESERVOIR SIMULATION AND

VERIFIED BY TIME LAPSE SEISMIC, presented at the Fifth International Conference on Greenhouse Gas Control Technologies, held in Cairns, Australia 13th-16th August 2000.

WP 3 – Geochemistry lead by BRGM and supported by BGS, GEUS and IFP

Summary

The objective of the geochemical work within the SACS2 project is to characterise the initial geochemical conditions within the Utsira formation (Task 3.1) and assess the changes that would be caused by CO_2 injection. Present work is based on laboratory experiments for timescales up to 24 months (Task 3.2). Numerical modelling is then used to interpret the experimental data by considering thermodynamic, kinetic and transport processes (Task 3.3).

Specific objectives for the relevant period were:
- Refinements of the initial geochemical conditions at Sleipner
- Continuation of batch and flow experiments involving Utsira sand, synthetic Utsira porewater and CO_2
- Repeat CO_2 solubility experiments
- Modelling of (i) the batch experiments up to 14 months, (ii) the flooding experiments, (iii) the CO_2 solubility experiments
- Discussions on the interpretation of the modelled experiments

Task 3.1. Initial fluid/rock equilibrium state of the Utsira formation BRGM

- The assessment of fluid chemistry at Sleipner lies on 2 chemical analyses of Utsira formation fluid at the Oseberg and Brage fields, some 200 km north of Sleipner.
- Assumption of homogeneous chemical composition of the Utsira formation fluid
- However need to be cautious as Sleipner is far from Oseberg, and at least temperature, GWR and gas content are different
- Still no usable data for Al and Si concentrations
- The need for getting new Utsira fluid samples or data at Sleipner, Brage or elsewhere was emphasized. Possibilities are under consideration.

Task 3.2. Geochemical laboratory experiments *BGS, GEUS*

Long term batch experiments under in-situ conditions (37°C and 10 MPa) BGS
- Representative of in-situ conditions
- All experiments now completed
- Timescales completed = 1, 3 weeks; 1, 2, 3, 4, 14, 21, 25 months
- Analytical results so far - some fluids and mineralogical data
- All of the remaining analyses are underway

Long term batch experiments at a temperature above in-situ conditions (70°C and 10 MPa) BGS
- Done at in-situ pressures, but about twice the typical in-situ temperature
- This should cause dissolution reactions to proceed about 10 times faster than under in-situ temperatures
- All experiments now completed
- Timescales completed = 1, 2 weeks; 1.5, 3.5, 9 months
- Fluid chemical analyses and mineralogical analyses currently underway

CO_2 solubility measurements (37-70°C and 8-12 MPa) BGS
- A few further experiments have been undertaken to check the results already obtained. This is because some results were not as expected, with concentrations lower than in previous studies, suggesting that suspect sampling has led to some degassing and loss of CO_2.

- All repeat experiments now completed
- Analyses of repeat experiments now underway
- Preliminary report on CO_2 solubility being prepared

CO_2 long term, long pathlength flow experiment (2.4 m long, 10 month duration, 70°C and 10 MPa) BGS

- Started in late June 2000, terminated early May 2001. Samples of output fluid were taken weekly. Mineralogical sampling was carried out in May at the end of the experiment.
- Fluid chemical analyses and mineralogical analysis are underway

Assessment of in-situ pH measuring technique BGS

- Further development of this technique within the SACS project would have consumed too many resources to be worthwhile continuing as part of SACS2. However, a collaboration between BGS and Nottingham University has allowed development of this technique outside the SACS2 programme. A useable (though somewhat slow) technique has been developed.
- A small number of experiments have been analysed for pH under in-situ pressure and temperature conditions. Data have been obtained, but assessment of what they mean is still underway.

CO_2 flooding experiments at reservoir conditions (37°C and 10 MPa) GEUS

- Three experiments were carried out during the last reported period using samples *70 mm long and 38 mm diameter*:

1- *A23.5 – Blind run*: Utsira sand sample A23.5 flooded by Synthetic Utsira fluid, 2 weeks duration, high flow rate (1.9 ml/h). 11 brine aliquots were extracted and later analyzed by BGS.
2- *A23.5 – CO2 run*: same conditions as above but using CO_2-saturated Synthetic Utsira fluid.
3- *A23.6 – CO2 run*: CO_2 -saturated Synthetic Utsira fluid was flooded on sample A23.6, 1 month duration, medium flow rate (0.57 ml/h). 10 brine aliquots were extracted and later analyzed by BGS.

The mineralogical analysis of the samples after experiment are presently under consideration and compared with an unreacted reference sample.

- During the reporting period, the experimental rig was modified for 2 reasons: 1) to allow to take "pulseless" liquid samples and then avoid this experimental artefact, 2) to allow for a long core holder (for samples *up to 500 mm in length and with diameter reduced to 25 mm*) and then to enable reliable permeability measurements as the differential pressure is enhanced 40 times compared to earlier experiments.
- Determination of reliable gas and liquid permeability data for the Utsira sand was carried out at reservoir overburden conditions from long core samples
- Blind and CO_2 experiments on long core samples (0.4 meter) for 8 weeks at elevated temperature (70°C) are underway.

Task 3.3. Interpret the geochemical experiments *BRGM, IFP*

Main activities during the relevant period were focused on the modelling of the batch and CO_2 solubility experiments, for which some experimental results on fluid chemistry are available. However mineralogical analyses are still underway and cannot be yet compared to modelling results. Some simulations of the coreflood experiments were also initiated, the input conditions being the experimental conditions. However no experimental results are available up to now.
This gave rise to model comparison between modellers and to many discussions between modellers and experimentalists in order to try to reach a consensus on the interpretation of the experiments.

Modelling the batch experiments for 1, 2, 3 and 14 month durations

The 4 pairs of experiments (pressurised with 'CO_2', 'experimental blank' pressurised with N_2) were modelled by BRGM using the UTSIRA simulator and by IFP using the DIAPHORE model. Comparisons between models are still underway as well as discussions with experimentalists on the interpretation. Some initial results were presented orally during the EUG conference in Strasbourg in April 2001.

Modelling the CO_2 solubility experiments
Experimental results were available in May 2001. IFP has started the modelling of these experiments using the Diaphore-gas model and had some discussions with the experimentalists.

Modelling the CO_2 long term, long pathlength flow experiment
IFP has started the modelling of these experiments and had some discussions with the experimentalists.

Conference attended:
8 – 12 April 2001, EUG XI Conference in Strasbourg.

Paper presented/published:
Czernichowski-Lauriol I., Rochelle C.A., Brosse E., Springer N., Pearce J.M., Bateman K.A., Sanjuan B., Kervevan C. (2001) - Disposal of CO_2 in deep aquifers: geochemical investigations of water-rock-CO_2 interactions at Sleipner (North Sea) as part of the SACS project. Abstract submitted for presentation at the EUG XI conference, Session D1 "Greenhouse Gas Disposal", Strasbourg, April 8th – 12th 2001. Abstract volume, p.172.

WP 4 – Monitoring Well Asses. Lead by Statoil and support by SINTEF

The work: Monitoring well scenarios for the Sleipner field CO_2 storage have been evaluated. Wells provide the only means for direct information access to storage aquifer and overburden parameters. Major objectives are to provide data for improved storage facility characterisation, as input to simulations and to calibrate and complement the time-lapse seismic measurements. Well information will contribute to secure that recommendations and measures are met for a safe and environmentally acceptable gas storage.

Conclusions: A program of two subsea vertical wells (No.1 and No.2) are proposed – one penetrating the gas cloud above the injection point (No.1) and one drilled into a connecting aquifer (No. 2) not yet reached by the injected gas. Both wells will have a comprehensive logging and sampling program. Well No.1 will be plugged and permanently abandoned after data collection. Well No. 2 will also be prepared for permanent monitoring purposes controlling lateral spreading of the injected gas. A system with resistivity sensors for saturation measurements will be established in addition to a system for pressure and temperature gradient measurements. Sonic and 3D component seismic sensors are optional to add information to the surface seismic monitoring system. Monitoring of the storage reservoir pressure is not a key issue due to the shape and size of the reservoir cap with the associated low pressure build up.

Subsea wells give most observation options and will not interfere with the Sleipner A platform operations. A slender well programme is proposed with a 9 5/8" surface casing into the top Utsira storage formation allowing an option of a 7" liner and/or an instrumented tubing to be installed. A capital cost of 4.5 million Euro (NOK 35 mill) for well No.1 and 9 million Euro (70 MNOK) for well No.2 is anticipated.

The work was carried out by SINTEF Petroleum Research, Subsea and Well Technology during autumn 2000 - winter 2001. Report authors are Svein Mjaaland, Inge Carlsen and Fridtjof Nyhavn.

WP 5 – Geophysical Monitoring Lead by TNO and support by SINTEF, BGS, BRGM and Statoil

Summary
In the reporting period work has continued on the following tasks:

- Task 5.4 Interpretation time-lapse data
- Task 5.5 and 5.7 Seismic inversion (AVO) and forward modelling
- Task 5.8 Feasibility micro-seismic monitoring

A 2-days meeting of the seismic Work Package partners was held in Trondheim at June 26th and 27th, where final deliverables and responsibilities were agreed.

Task 5.4 Interpretation time-lapse data

Work carried out during the reporting period
Interpretation of the CO_2 captured under the thin intra-Utsira shale layers has been refined. By assuming a relation between the seismic amplitudes at the different depth levels and the thickness of the different CO_2 accumulations a more detailed image of the distribution has been acquired. From this more detailed interpretation again volume calculations of the CO_2 in situ have been carried out and compared to the actual injected volume. The results are sensitive to a number of parameters such as the rock- and CO_2-properties, but in fairly good agreement. The volume of CO_2 estimated from the seismic data tends to be too large (factor 1 to 2) with respect to the actual injected volume, however not in contradiction with respect to the uncertainty margins. A lot of effort has been put (and is still ongoing) on the sensitivity analysis and the reduction of the uncertainty margins.

Problems and difficulties encountered

The discussion on the density of the CO_2 under reservoir conditions has continued amongst partners for a while. Discrepancies were mainly due to uncertainties on and about the reservoir temperature measurements. Finally the uncertainty margin has been narrowed down to values on which reasonable consensus exists now.

Task 5.5 and 5.7 Seismic inversion (AVO) and forward modelling

Work carried out during the reporting period
Post-stack inversion has been carried out over the 3D seismic data. Pre-stack inversion has been tested on a selected 2D line and is still ongoing for the remainder of the seismic survey. The results look promising leading to a higher resolution, though they suffer from the sea-bottom multiples present in the data.

Problems and difficulties encountered

Obtaining the seismic pre-stack data from the seismic contractor (Geco) in a proper format has been tedious and too long. This has delayed the start of the pre-stack inversion process considerably.

Task 5.8 Feasibility micro-seismic monitoring

Work carried out during the reporting period
The finalisation of the report is still ongoing.

Problems and difficulties encountered
None.

WP 6 – Reports & "Best-Practice." Lead by Statoil and support by BGS

Mid-Term Report no 2 for SACS2 project was published – somewhat delayed – May 2001.

Objective for "Best-Practice-Manual" task.
Produce a 'Best Practice Manual for CO2 Storage Underground'.

Status
A scoping study for the Best Practice Manual (BPM) was made in April 2001. This was discussed at the project technical meeting in Trondheim, in May 2001.

Initially it was considered that the European Standards for natural gas storage underground (EN 1918) might provide a useful template for the BPM. Whilst significant parts of these Standards can be adapted for use in the manual, it was agreed that the BPM should not follow the format of a 'European Standard' too closely. This is because underground gas storage is a widely used technology, with a track record from which Standard Procedures can be developed, whereas it is too early to develop a set of standard procedures for the newly emerging technology of underground carbon dioxide storage. Any attempt to do so would be inappropriate until we are sure about the issues and most cost-effective methods of achieving underground storage across *a wide range* of geological settings. Whilst we may be able to draw some generic conclusions from experience at Sleipner, other conclusions are likely to be case specific, or specific only to a certain range of geological settings.

A brief note asking the partners for ideas on the format for the BPM was circulated in May 2001.
It was considered that the best approach would be to describe:
- what was done at Sleipner
- what we have learnt from the SACS project
- how this can be applied to future underground CO2 storage projects.

Difficulties encountered
If significant parts of the European Standards for natural gas storage underground are to be adapted for use in the Best Practice Manual, there may be copyright issues to be resolved.

WP 7 – Thermodynamic and petro-acoustic lab lead by IFP

Work carried out during the reporting period
The methodology of measuring Gassmann's parameters in the lab by di-phasic fluid substitution has been completed. The report will be distributed soon.
Furthermore an Excel Dynamic Library enabling an easy computation of the density and the compressibility of CO_2 containing CH_4 traces for a wide range of P-T conditions has been constructed and distributed among the partners.
Finally the impact of freezing on acoustic properties of saturated loose sands has been tested: a first experiment tends to show that after a freezing/defreezing cycle the acoustic properties are not too much disturbed (surprising and encouraging for future work on frozen cores).

Problems and difficulties encountered

Transport of the frozen core from Norway to France was not straightforward.

WP 8-11 – Geopysical Interpretation lead by GECO

Efforts have been made in order to build a model for performing a pre-stack, tomographic velocity inversion of the 1994 and the 1999 data sets, with the aim to relate velocity changes to CO2 saturation changes between the two time lapses.

A new software prototype has been evaluated in this work. It has become increasingly clear that this software prototype is not yet ready for performing the tasks at hand, and a new alternative approach will be sought in the next reporting period.

Task 8.3 Comparison of planned work with actual work
The work has been delayed compared to the planned activities. However, this is not critical, as the 2001seismic survey has not been acquired yet.

Task 8.5 Brief forecast of the next six months activities and work
In the next six month period, efforts will be spent in order to find an alternative way in which to perform the pre-stack tomographic velocity inversion. As the new seismic survey is acquired, efforts will be spent on undertaking the analysis of the new data.

WP 12 – Steering Committee lead by Statoil

Steering Committee Meetings were held in Bergen (Norsk Hydro) 8. February and
in Trondheim (SINTEF) 23. May 2001.
Next Steering Committee Meeting is planned in Copenhagen 25. October 2001.

As previous periods the SC has been consulting and co-ordinating by E-mails and decided matters as acceptance of conference presentations, publishing etc.

1.3 Comparison of planned and actual work

Generally the work areas are running as planned, and should be completed on schedule.
Access to test material has been limiting some tasks and objectives, most so in WA1 Geology.

Work Area 3 Geochemistry activities are running as expected compared to the work plan for geochemistry dated April 11, 2000.

Work Areas 8 – 11 Geophysical Interpretation are lagging behind plans, particularly WA 9-11. It is hoped to be able to complete on schedule.

1.4 Planned activities for next period

- **WP 1 – Geology**

Task 1.4. Characterise caprock
- Complete and report on the cuttings analysis and the Ekofisk core.

Task 1.7 Iterative development of full regional geological model

- Complete Utsira Sand depth conversion.
- Build attributed 3D model of Utsira Sand.
- Complete account of depositional model for the Utsira Sand.
- Complete regional caprock stratigraphy study.
- Commence Final Work Area 1 Report.

- **WP 2 – Reservoir Simulation**

- Investigate if the SIMED gas/rock absorption option can be used to model the possible CO_2-rock interaction.
- Test the implemented CO_2-water solubility option of SIMED II.
- Test the depth dependent temperature function.

- Mapping of the sand wedge and shale unit.
- Incorporating these features in the 3D-simulation model.

- An alternative method to measure capillary pressure and a full relative permeability curve will be obtained at reservoir condition by a steady-state method.

- An iterative analysis between the Long-term simulation and this task has to be performed to fine-tune the convection parameters in the large reservoir model.
- The possibility to get extra financial support to publish the results will be investigated.

- History Matching of 3D full field model to the second time-lapse seismic respons.
- Uncertainty estimation of relevant reservoir parameters.
- Simulation of past reservoir performance including a sensitivity analysis of simulations performed with the results of the uncertainty estimation activity.

- Simulation of a long storage cycle. (Heavy duty simulations)

- Start preparing the final Work Area 2 Report.

- **WP 3 – Geochemistry**

- Refinements of the initial geochemical conditions at Sleipner
- Finalyse analyses of experimental reaction products
- Tracer tests on long core samples
- Modelling of (i) the batch experiments integrating the 21 and 24 months duration results, (ii) the flooding experiments, (iii) the CO_2 solubility experiments. The modelling will base on the experimental results on fluid samples. Mineralogical observations may not be available at the time of modelling.
- Discussions on the interpretation of the modelled experiments

- **WP 4 – Monitoring Well Asessment**

- Task was finished and reported spring 2001.

- **WP 5 – Geophysical Monitoring**

- Commence Final Work Area 5 Report.

Task 5.4

- Interpretation of the 2001 survey
- Volume estimate based on amplitudes only

- Volume calculation including saturation function
- Study push-down effect (near-offset interpretation)

Task 5.5 and 5.7
- 3-D pre-stack inversion (incl. Required velocity model) on different time-lapse surveys
- Volume calculation from pre-stack inversion

Task 5.8
- Finalisation of the task report

- **WP 6 – Reports & Best Practice Manual**

- Management Report no 3 to be edited and distributed.

- A draft manual (some parts will consist only of a set of headings at this stage) will be prepared and circulated amongst the partners prior to discussion at the next technical meeting, in Copenhagen on 23-25 October 2001.

- **WP 7 – Thermodynamics and petro-accoustic lab**

- Test of geophysical impact of CO_2 phase change under reservoir conditions (P-T)

- **WP 8 – 11 – Geophysical Interpretations**

- It is the aim to complete all the project deliverables of WP 8 to WP 11 of the project in the next reporting period.

- **WP 12 – Steering Committee & Project management**

- Technical Session and Steering Committee is planned at GUES, Copenhagen 23. - 25. October 01. SACS will be presented at the "1. Annual European Energy and Transport Conference" organised by the DG TREN in Barcelona 17. – 19. October 01. It will also be part of the parallel Exhibition, with posters and brochures.

2. Management and Co-ordination aspects

Technical and Financial Reports for period 1 January – 30 June has been compiled.

2.1 Technical Meetings

SACS technical meetings on geochemistry in Paris, 19 January 2001 with the whole geochemical team (BRGM, IFP, BGS, GEUS) to discuss the work achieved so far and next activities

Technical Session over two days took place at SINTEF, Trondheim 21. – 23. May 01.
At approximately mid-term the project work was assessed and plans for the remaining ¾ of a year were discussed between the different Work Area groups. A special session was dedicated to the principles for the "Best-Practice-Manual".

A 2-days meeting of the seismic Work Package partners (BGS, BRGM, IFP, SINTEF, TNO and Statoil) was held in Trondheim June 26th and 27th, where final deliverables and responsibilities were agreed.

2.2 Technical Dissemination

The Sleipner CO2 injection, the concept of underground storage of CO2 and the SACS project has been presented in several workshops and seminars, including two major events organised by the EU-sponsored “CO2NET”. Two others, one organised by UK Department of Industry, London and one by the AIM, Liege was targeting the power industry; both equipment suppliers and the power station operators.

Scientific publications were given at the Conference of European Union of Geosciences in Strasbourg, France in April 2001. See Work Area 3 Geochemistry above.

The interest from media is increasing; the Danish Jyllandsposten had a major article resulting in a debate in the Danish parliament, Folketinget. The Bayerische Rundfunk visited Statoil and the Sleipner field, and made a broad presentation. We have received favourable feedback from readers and viewers. French daily “Liberation” had a full page presentation on 29 June. Later two French TV channels interviewed BRGM project participant in connection with COP6 in Bonn.

BBC is planning to include this theme in an upcoming series about energy in the long perspective.

The periodical, “Greenhouse Issues” by IEA Greenhouse Gas R&D Programme has again disseminated the last SACS publications (EUG Conference in Strasbourg), plus giving a brief SACS update, by mailing 6500 copies to 35 countries. IEA Greenhouse Gas R&D Programme put colourful pictures of the “Utsira” CO2 bubble both on front and back page of their “Annual Report 2000”, as well as an update of the SACS project in the text (page 11).

A package of SACS presentations are expected to be given at the coming Green House Gas mitigation Technology Conference – GHGT-7 in Kyoto, October 2002, for which call-for-papers are out these days.

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