TNO | Knowledge for business

K12-B, CO_2 storage and enhanced gas recovery

The mature gas field K12-B is selected as a demonstration site for offshore injection of CO_2. The project is aimed at investigating the feasibility of CO_2 injection and storage in depleted natural gas fields on the Dutch continental shelf, with the objective to realize a permanent CO_2 injection facility in the near future. It is being subsidized by the Dutch Ministry of Economic Affairs and carried out by Gaz de France Production Nederland B.V., the operator of the K12-B platform. The data collected during the test phases of CO_2 injection are currently being assessed by European research institutes cooperating in several CO_2 storage research programs.

Figure 1.
K12-B platform and location.

Introduction

The K12-B gas field is located in the Dutch sector of the North Sea, some 150 km northwest of Amsterdam (Figure 1). It has been producing from the Upper Slochteren Member (Rotliegend) since 1987. The natural gas produced has a relatively high CO_2 content (13%) and the CO_2 is separated from the production stream prior to gas transport to shore. The CO_2 used to be vented into the atmosphere but is now injected into the field above the gas_water contact; at a depth of approximately 4000 m. K12-B is the first site in the world where CO_2 is injected into the same reservoir from which it originated. The CO_2 injection started May 2004. At the same time extensive measurement programs have started to take place. These programs are dedicated to determining the potential for both CO_2 storage and enhanced gas recovery (EGR). Furthermore measurements have been taken to assess the corrosion of the injection tubing caused by the CO_2. The average CO_2 injection rate can reach 30,000 Nm^3 CO_2 per day, which is approximately 20 kt per year. This paper presents the preliminary results of the measurements from K12-B. The data is currently being interpreted in several research programs, such as MONK, CATO, CASTOR and CO_2GEONET.

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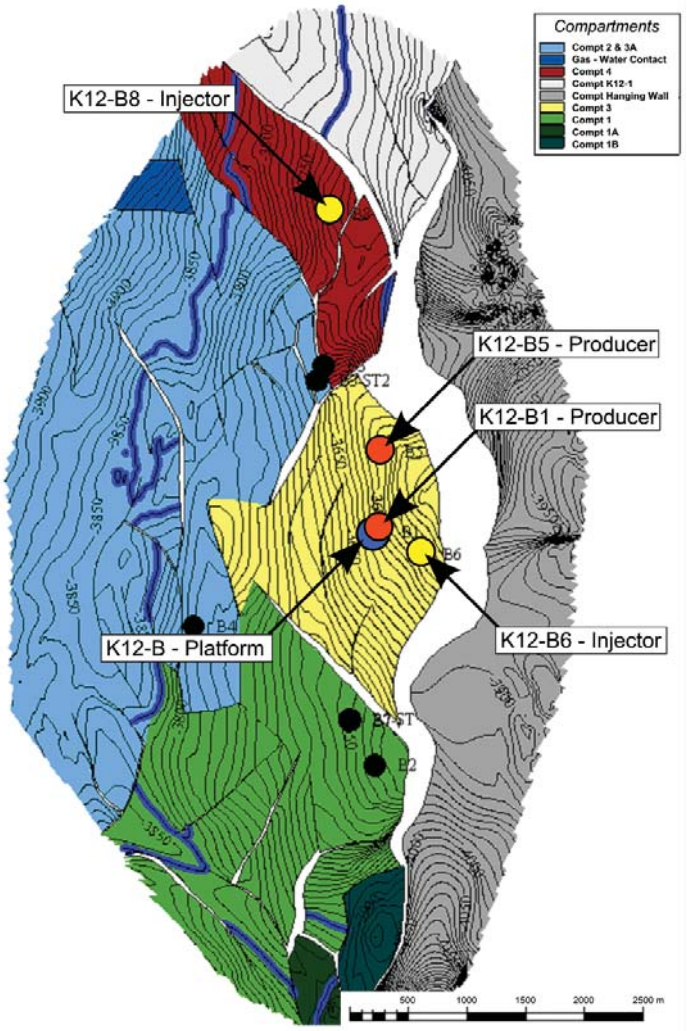

Figure 2. K12-B reservoir compartments and well locations.

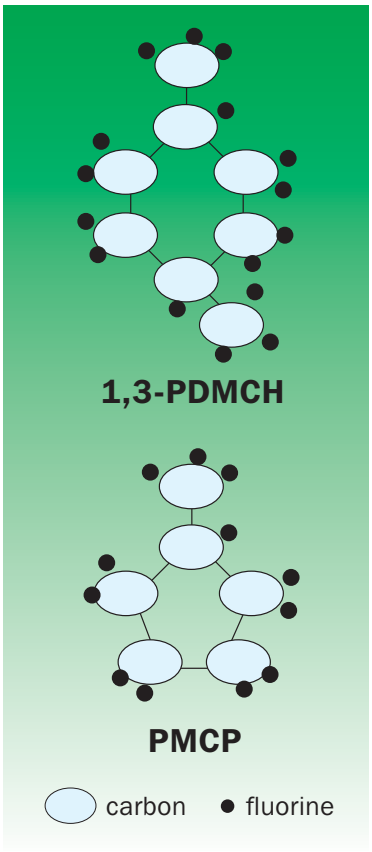

Figure 3. Injected tracers for K12-B.

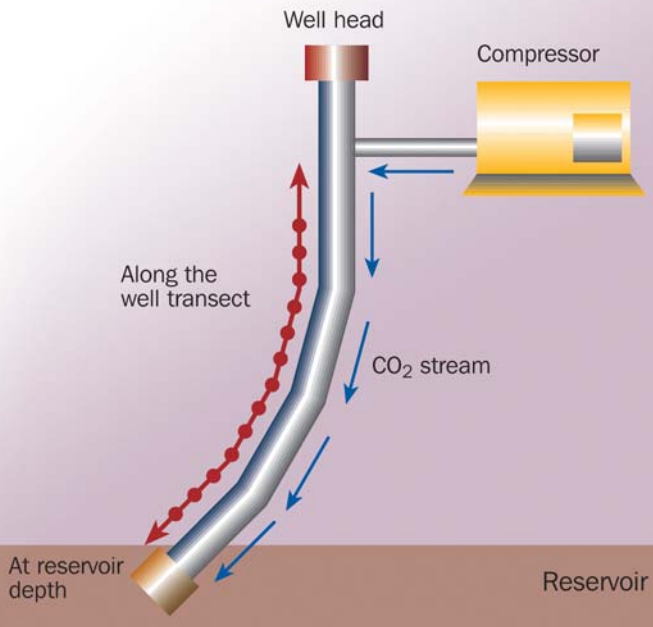

Figure 4. Schematic representation of measurement locations of pressure and temperature. Figure is not to scale.

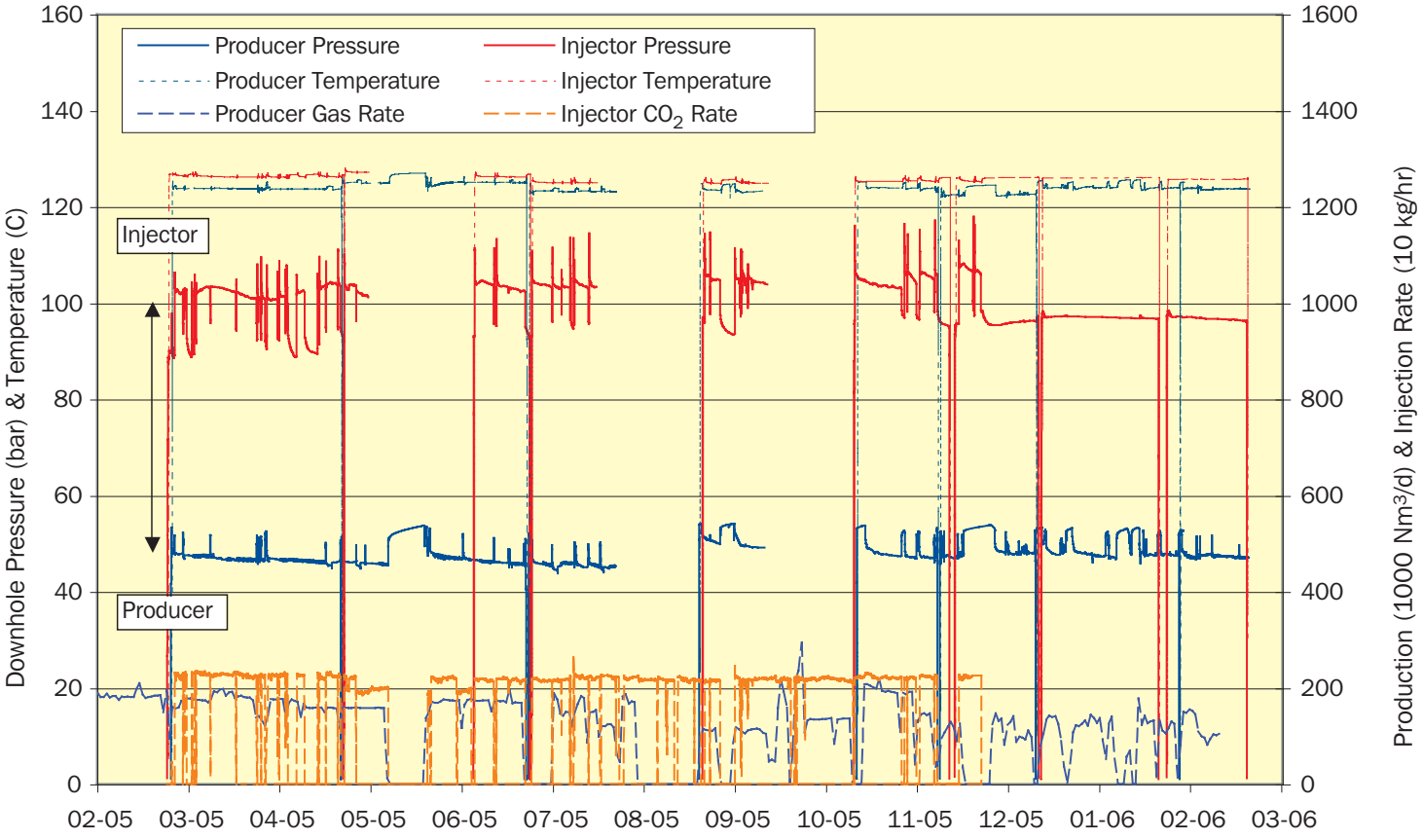

Figure 5. Down-hole pressure, temperature, injection and production data.

Measurement Program

The CO_2 injection program comprises multiple phases in different locations at the K12-B reservoir (Figure 2):

- Phase 1, CO_2 injection into a fully depleted, single well reservoir compartment (compartment 4). This phase was carried out from May 2004 until January 2005.
- Phase 2, CO_2 injection into a nearly depleted reservoir compartment (compartment 3) still under production. The wells under investigation are two gas production wells (K12-B1 and K12-B5) and one CO_2 injection well (K12-B6). This test commenced in February 2005 and is still continuing up to the time of writing.

At the start of phase 2, 2 tracers were injected (Figure 3). The total volume of each tracer injected in well K12-B6 was 1 dm^3. The tracers allow for an accurate assessment of the flow behavior in the reservoir and the associated sweep efficiency of the injected CO_2. Without the tracers it would be difficult to accurately determine the physical communication between injector and producers because the injected CO_2 originates from the reservoir gas and therefore cannot be distinguished from the naturally occurring CO_2 in the reservoir gas. Additionally the following is also measured during phase 2:

- Injection rate of the CO_2
- Composition (purity) of the injected CO_2
- Pressure and temperature at various locations (Figure 4):
  - In the compressor
  - At the wellhead
  - Along the well trajectory
  - At reservoir depth
- Composition of the produced gas and water, incl. tracer concentrations
- CO_2 injection tubing integrity
- Cement bond quality of the injection well
- Base line conditions for CO_2 and CH_4 compositions and concentrations in the biosphere

Results

The measurements from phase 1 could easily be interpreted and were used to assess the infectivity in reservoir compartment 4. It was concluded that the observed phase behavior of CO_2 and the reservoir response during injection were within the expected range, validating existing correlations and reservoir simulation predictions.

The interpretations of the measurements from phase 2 are more complicated for

several reasons. An unexpected large down-hole pressure difference was observed between the injection and production wells, for a reservoir compartment that is believed to be in full communication (Figure 5). No obvious pressure interference between injector and producers could be detected. Pressure disturbances are measured in the injector and nearest producer. At this time, the cause of these disturbances is unknown. Additionally, the down-hole memory gauges failed several times during surveys, which caused gaps in the data set. The above factors complicate the assessment of the CO_2 storage capacity and the potential for enhanced gas recovery in compartment 3. These aspects are currently under investigation in the MONK, CATO and CASTOR research programs, measurements continue.

In July 2005 physical communication between K12-B6 (the CO_2 injection well) and K12-B1 the (nearest producer well) was demonstrated with the detection of both tracers in the gas stream of K12-B1 (Figure 6). The arrival of the tracers was about 4 months after the start of CO_2 injection. The lateral distance at reservoir depth between K12-B1 and K12-B6 is 420 m. So far no apparent increase in the CO_2 concentration has been observed in the production wells, but detailed sample analysis has to confirm this.
Tracer detection has taken place in the K12-B5, the second production well in compartment 3, during April 2006 (Figure 7). This well is positioned at a distance of about 1000 m from the CO_2 injection point.
In the case of K12-B the use of tracers has significally contributed to an improved understanding of the reservoir and how the pressure data could best be interpreted. The tracer observations are currently being investigated in order to assess the potential for enhanced gas recovery (EGR) and the tracer performance is being evaluated in CO2GEONET. Tracer analysis continues.

Conclusions

K12-B is the first site in the world where CO_2 is being injected into the same reservoir from which it originated. Observations of the unique measurement program are difficult to interpret because of some unexpected features in the down-hole pressure data, but additional data is being gathered which might clarify these anomalies. The use of tracers has contributed to an improved understanding of how these data should be interpreted. The storage potential and potential for enhanced gas recovery are currently still under investigation.

Geo energy and Geo information

TNO Built Environment and Geosciences *Geological Survey of the Netherlands* is the central geoscience centre in the Netherlands for information and research to promote the sustainable management and use of the sub-surface and its natural resources.

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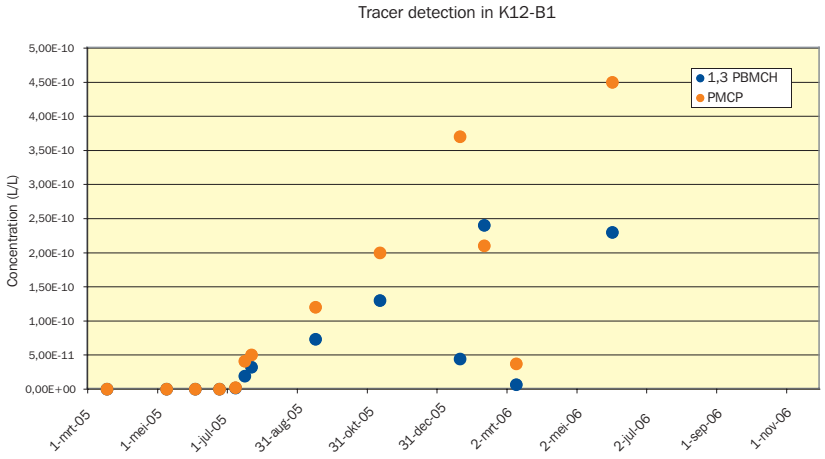

Figure 6. Tracer concentration measured in the gas stream of well K12-B1.

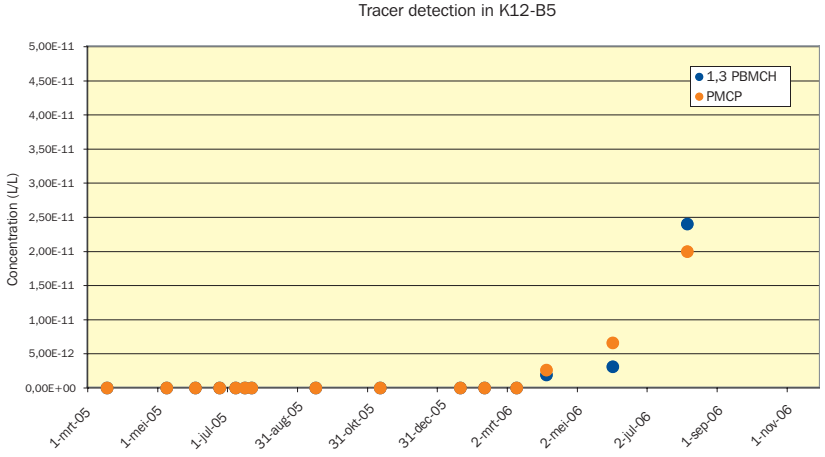

Figure 7. Tracer concentration measured in the gas stream of well K12-B5.