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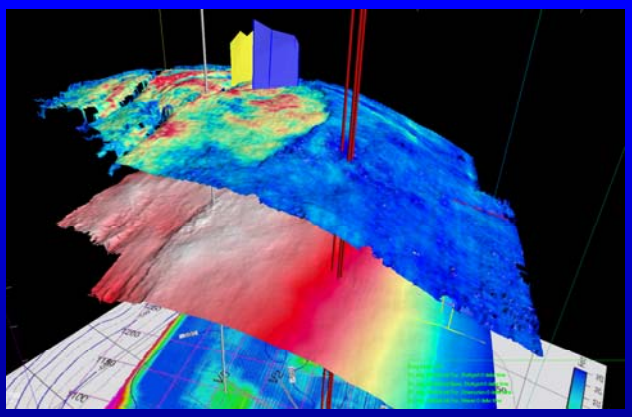
CO2SINK

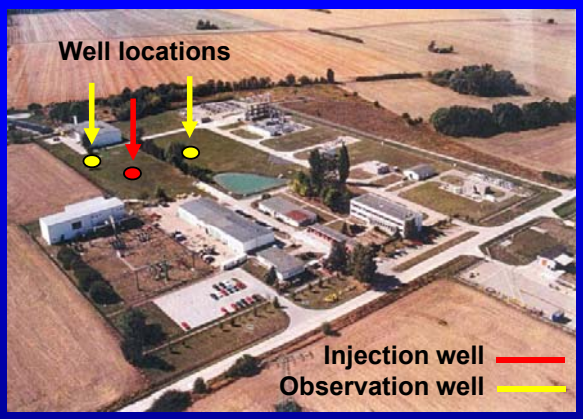
Site Studies – Ketzin

first on-shore CO_2 storage project of Europe

GeoForschungsZentrum Potsdam
Environmental Geotechnique

Frank Schilling / Michael Kühn





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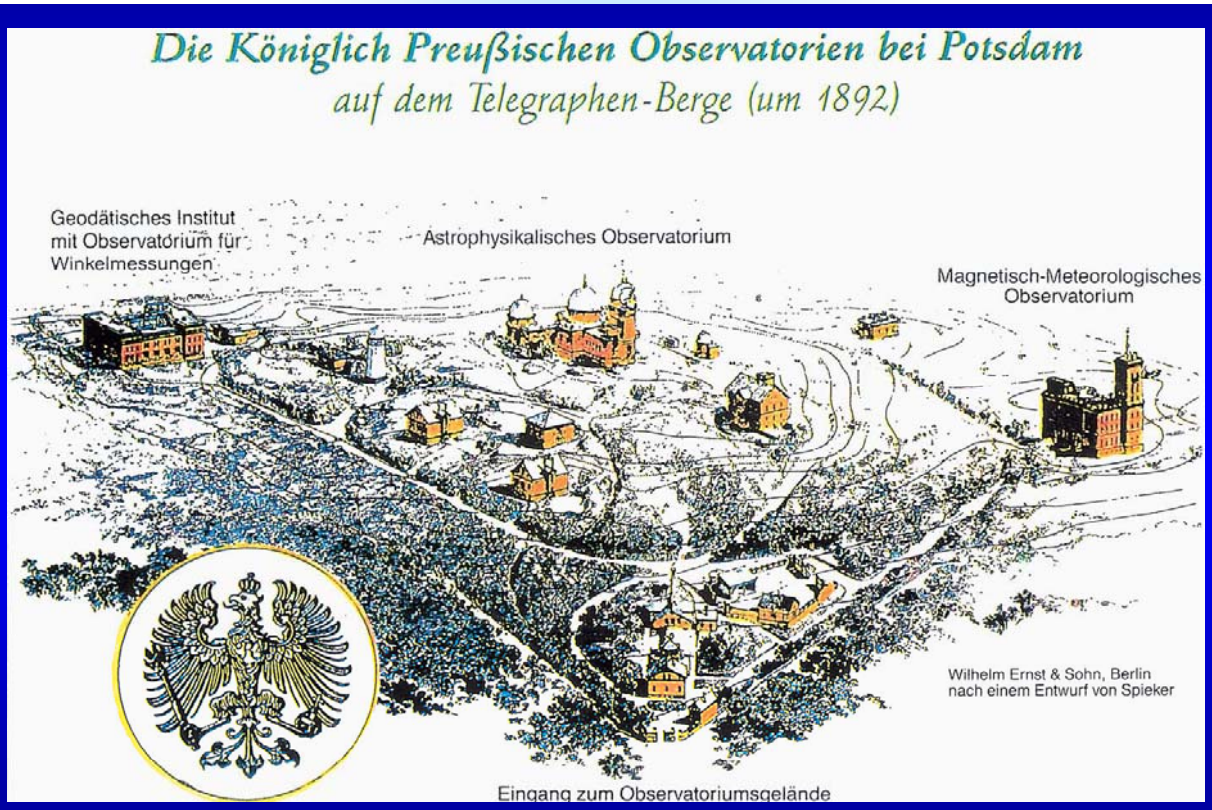
Telegrafenberg - History



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Telegrafenberg - History

- 1832: Named after a station of an optical telegraph line (Berlin-Potsdam-Koblenz)
- 1870: Royal Prussian Geodetic Institute founded to measure the figure of the Earth
- 1889: First teleseismic of an earthquake
- 1890: Geomagnetic Observatory founded
- 1898-1904: Measurement of the absolute gravity value accepted as international reference 1909
- ...
- 1.1.1992 Foundation of the GFZ

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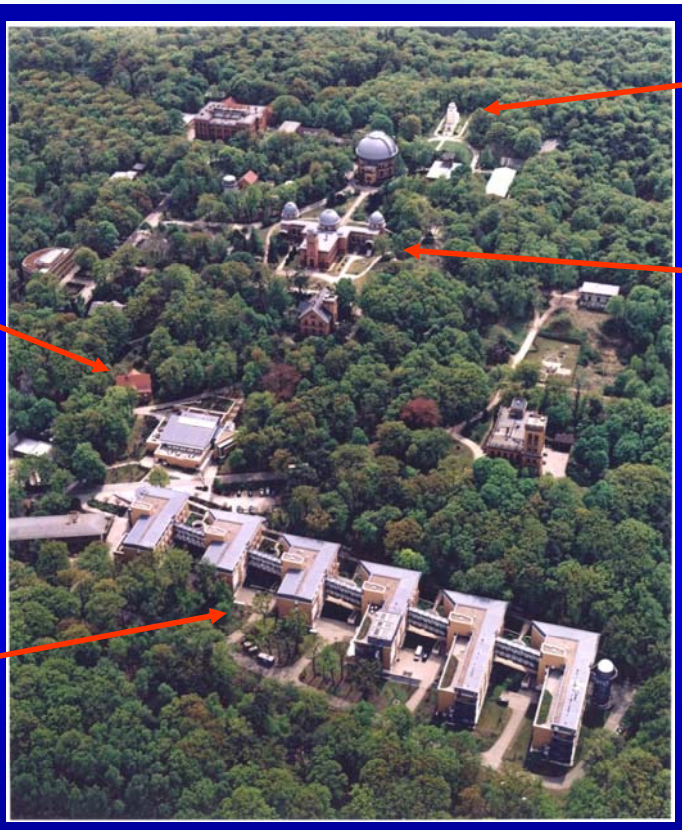
Telegrafenberg - Today



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Helmholtz Association

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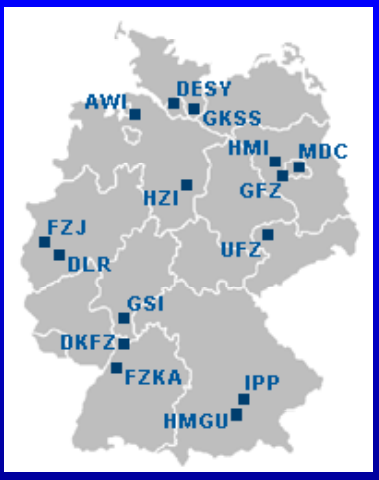
- Solving challenges facing society, science and the economy: Energy, earth and environment, health, key technologies, structure of matter, transport and space
- Helmholtz Association is Germany's largest scientific organisation
  - 26,500 employees
  - 15 research centres
- Large facilities

1821-1894



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GeoForschungsZentrum Potsdam

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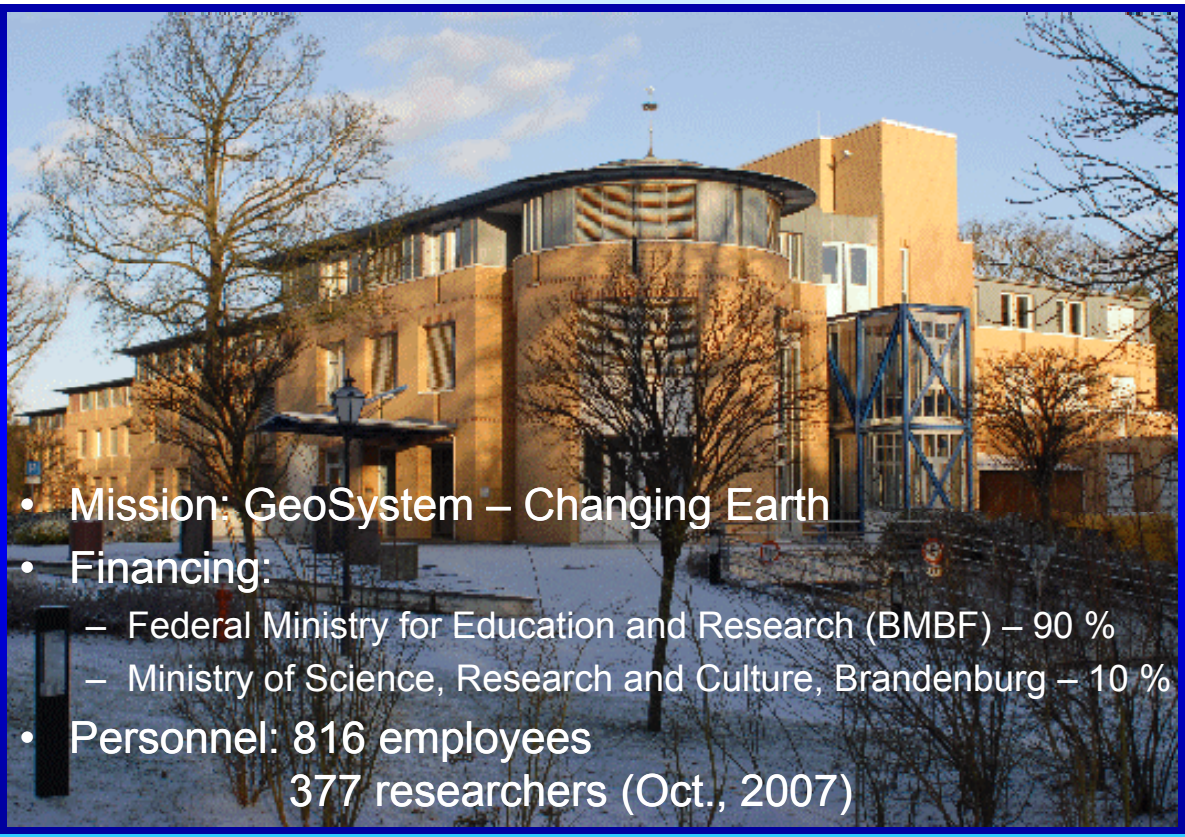

- Mission: GeoSystem – Changing Earth
- Financing:
  - Federal Ministry for Education and Research (BMBF) – 90 %
  - Ministry of Science, Research and Culture, Brandenburg – 10 %
- Personnel: 816 employees
  377 researchers (Oct., 2007)

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Expertise - Departments

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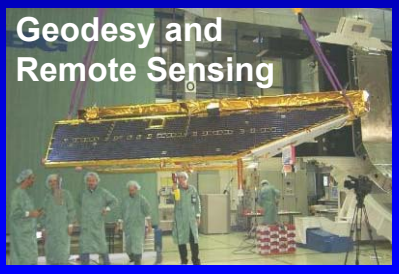

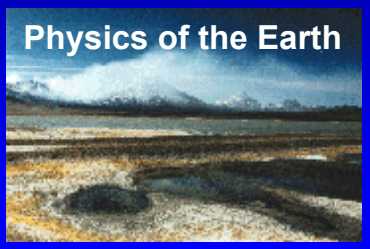

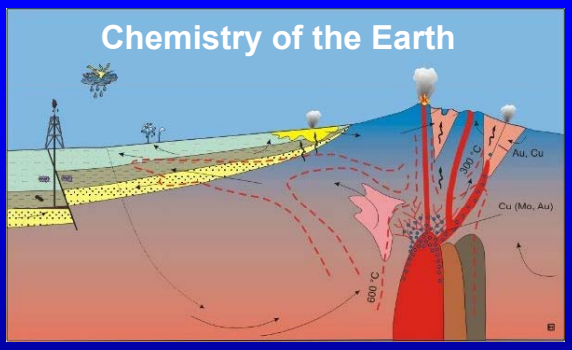

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CO_2 Storage activities at Ketzin

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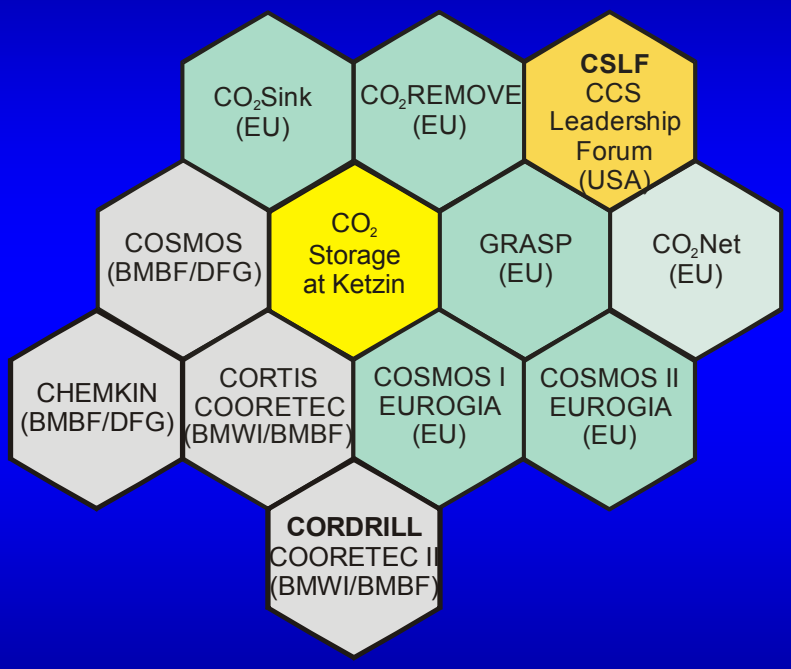

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In-situ R&D Laboratory for Geological Storage of CO_2 - CO_2SINK Integrated Project -

CO2SINK

GeoForschungsZentrum Potsdam (D)
G.E.O.S. Freiberg Ingenieurgesellschaft (D)
Geological Survey of Denmark and Greenland (DK)
Mineral and Energy Economy Research Institute (PL)
Det Norske Veritas (N)
Statoil (N)
Shell International Exploration and Production (NL)
University of Stuttgart (D)
Vibrometric Finland (SF)
University of Kent (GB)
Uppsala University (S)
RWE Power AG (D)
International Energy Agency – Greenhouse Gas Programme (GB)
Vattenfall Europe Generation (D)
Verbundnetz Gas AG (D)
Siemens AG Power Generation (D)
E.ON Energie AG (D)
Schlumberger Carbon Services (Fr)

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CO_2SINK Components / Objectives

CO2SINK

1) Advance understanding of science and practical processes of underground CO_2 storage

2) build confidence toward future European CO_2 geological storage

3) provide operational field experience to aid development of regulatory frameworks and standards for CO_2 geological storage.

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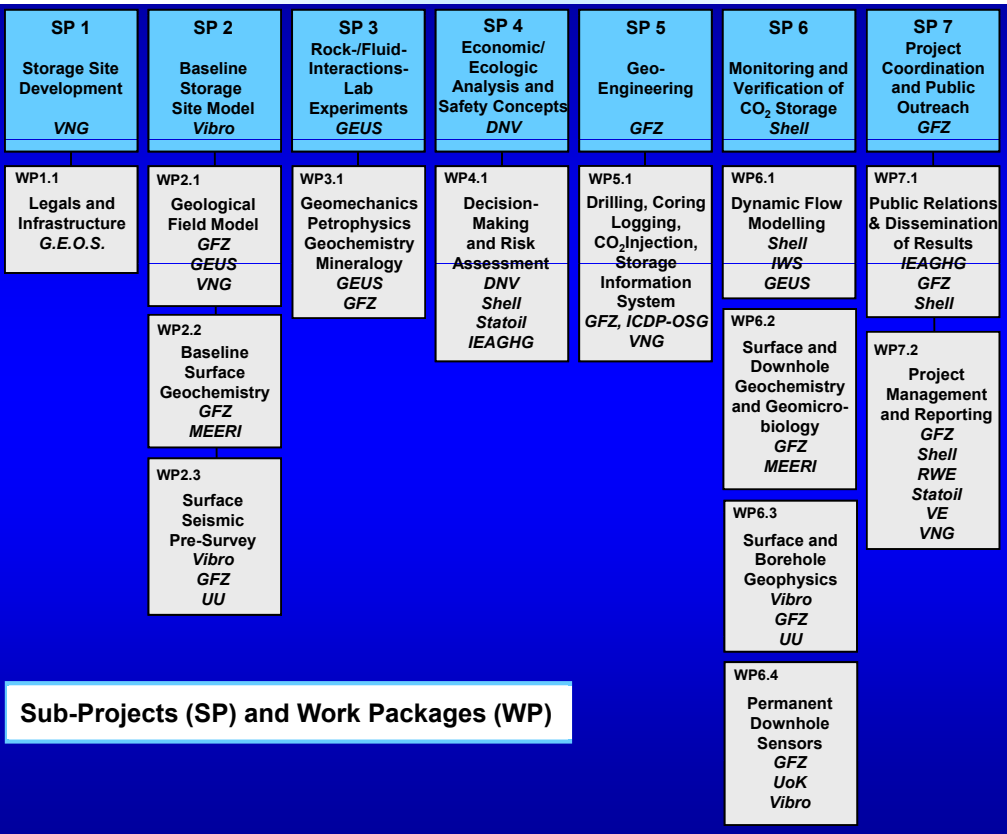
Structuring of CO_2SINK



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CO_2 storage under German law

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CO_2 Storage Directive of EU

- Proposal of a directive from the European Parliament and Council (23rd of January)
- Aimed not only to regulate but more importantly to remove barriers in existing legislation
- Situation uncertain (legislation on waste, water, industrial emissions, ...)

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CO_2 storage under German law

- CO_2 Storage operation regulated by at least nine federal acts and regulations and beyond by several acts / regulations from states:
  - Federal mining act
  - Recycling and waste act
  - Federal pollution control act
  - Water resource act
  - Regional development planning act
  - Federal law concerning examination of the environmental tolerance
  - Bylaw regarding environmental assessment in mining projects
  - Bylaw for the execution of plants
  - Administrative proceedings act

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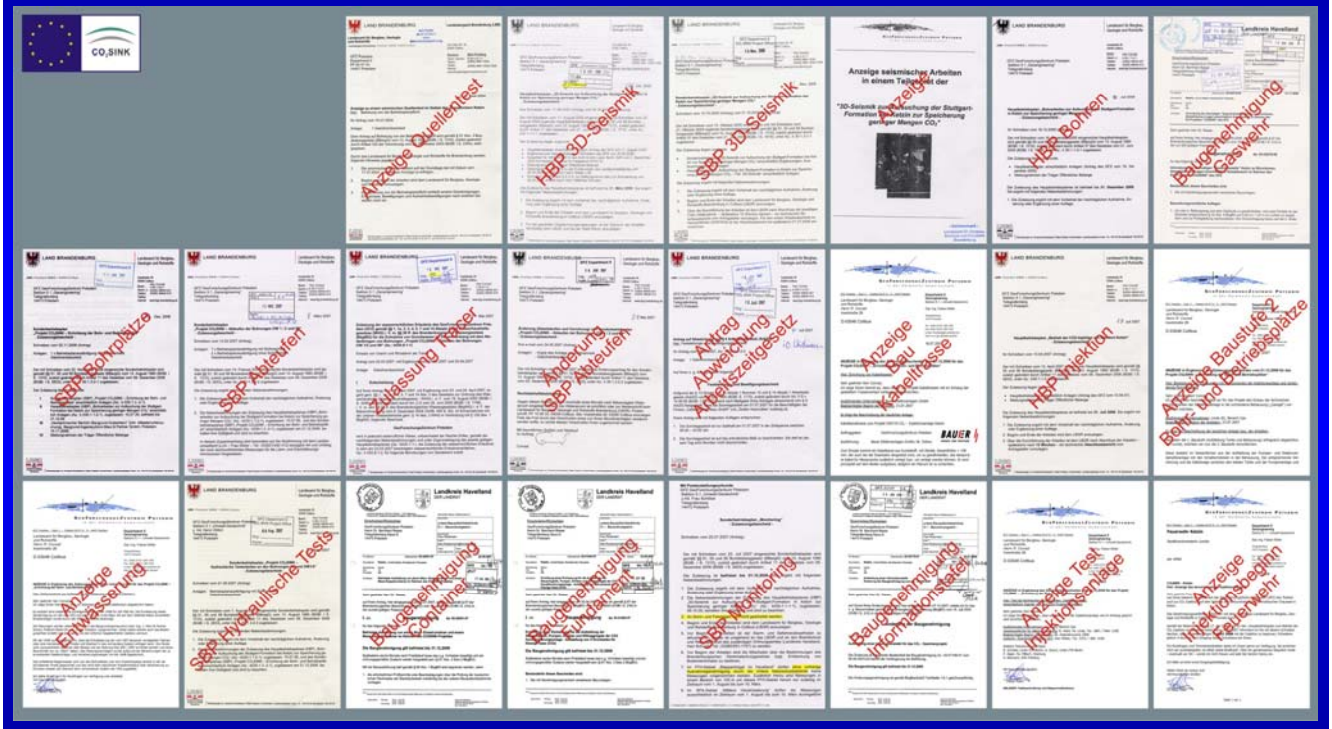
Required Permissions



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Schedule of Operation

No.	Activity	Duration	Plan	Actual
1	Report on site exploration	3 months	09-2004	
2	Formulation of main operation plan	2 months	02-2005	
3	Formation of an operating company	0 days	03-2005	
4	Permit procedure of the basic schedule of operation	3 months	03-2005	06-2006
5	Planning of drilling	4 months	02-2005	
6	Formulation of drilling operation plans	0.5 months	06-2005	
7	Permit procedure of drilling operation plans	1.5 months	06-2005	
8	Tender procedure	2 months	08-2005	
9	Earliest delivery date	0 days	03-2006	
10	Drilling Well 1	1.5 months	03-2006	15.3.-20.5.2007
11	Interpretation of data (well 1)	1.5 months	04-2006	
12	Drilling Well 2	1 month	04-2006	20.5.-19.7.2007
13	Interpretation of data (well 2)	1.5 months	05-2006	
14	Drilling Well 3	1 month	05-2006	21.7.-10.9.2007
15	Interpretation of data (well 3)	1.5 months	06-2006	
16	Verification of suitablility Stuttgart Formation	1.5 months	06-2006	
17	Formulation main operation plan for CO_2 storage	2 months	07-2006	
18	Permit procedure of the main operation plan CO_2	3 months	08-2006	
19	Start of CO_2 injection	0 days	11-2006	**April / May 2008**

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Reasons for Delay

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- Permit procedure took longer than expected
- No drill rig available (fossil fuel boom)
- No tubing (increased steel costs)
- Obtaining well heads equally difficult
- Injectivity problems

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Location

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Old Gas Storage Facility

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- In 1960s facility for natural gas storage imported from Siberia installed
- Thoroughly modernised in 1990s
- Facility now redundant (closed 2004)
- Natural gas was stored in sandstones at shallow depth (250 – 400 metres)

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In-situ R&D Laboratory for Geological Storage of CO_2

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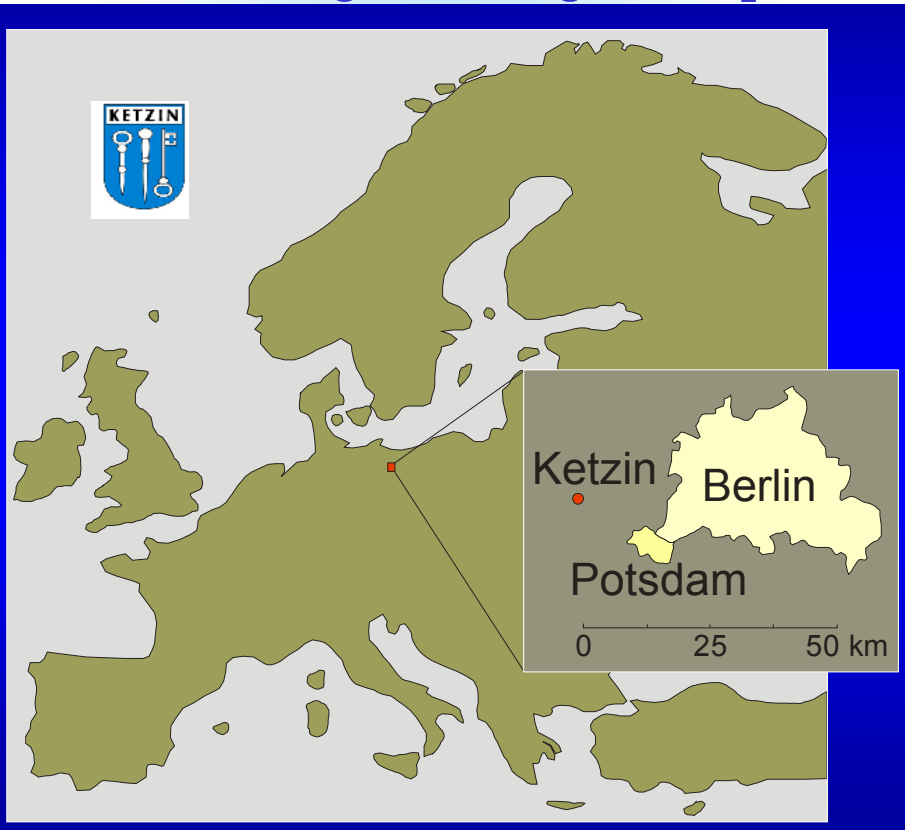

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Strings of Lakes, Rivers and Canals

Ketzin was first mentioned in records in 1197 and has long been noted as a fishing village

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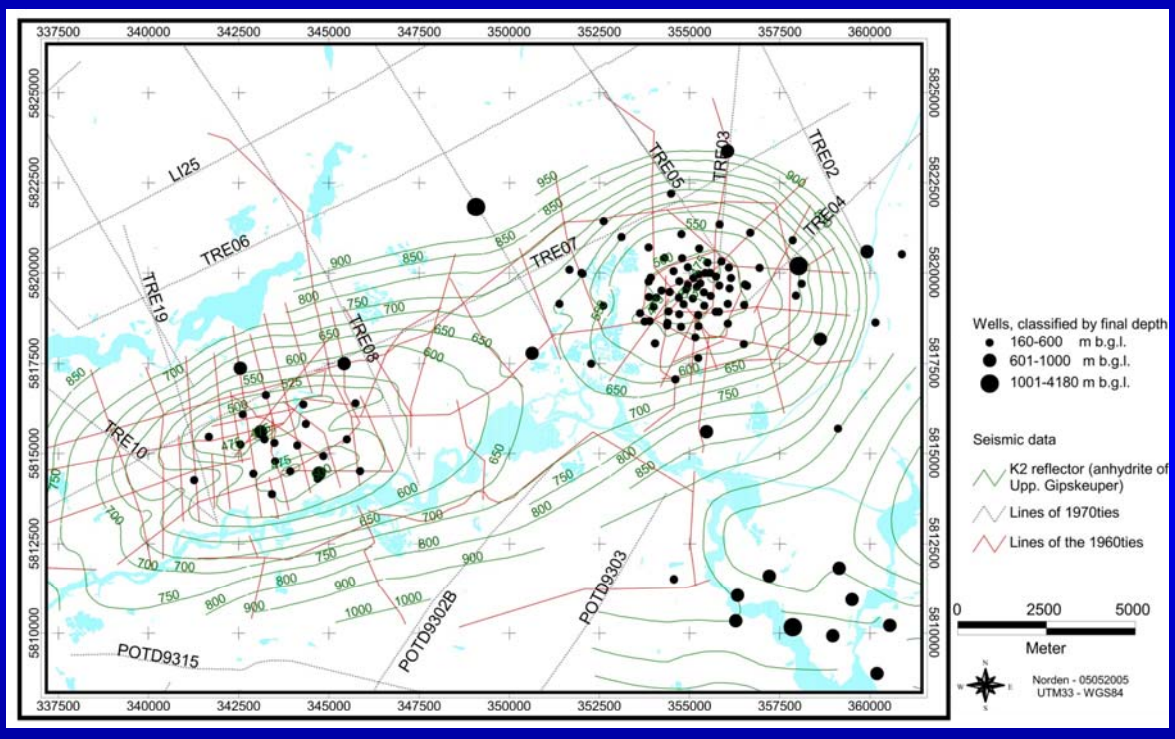
Status of Previous Exploration



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Aerial view of gas storage site

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Storage Site – Operational Plan

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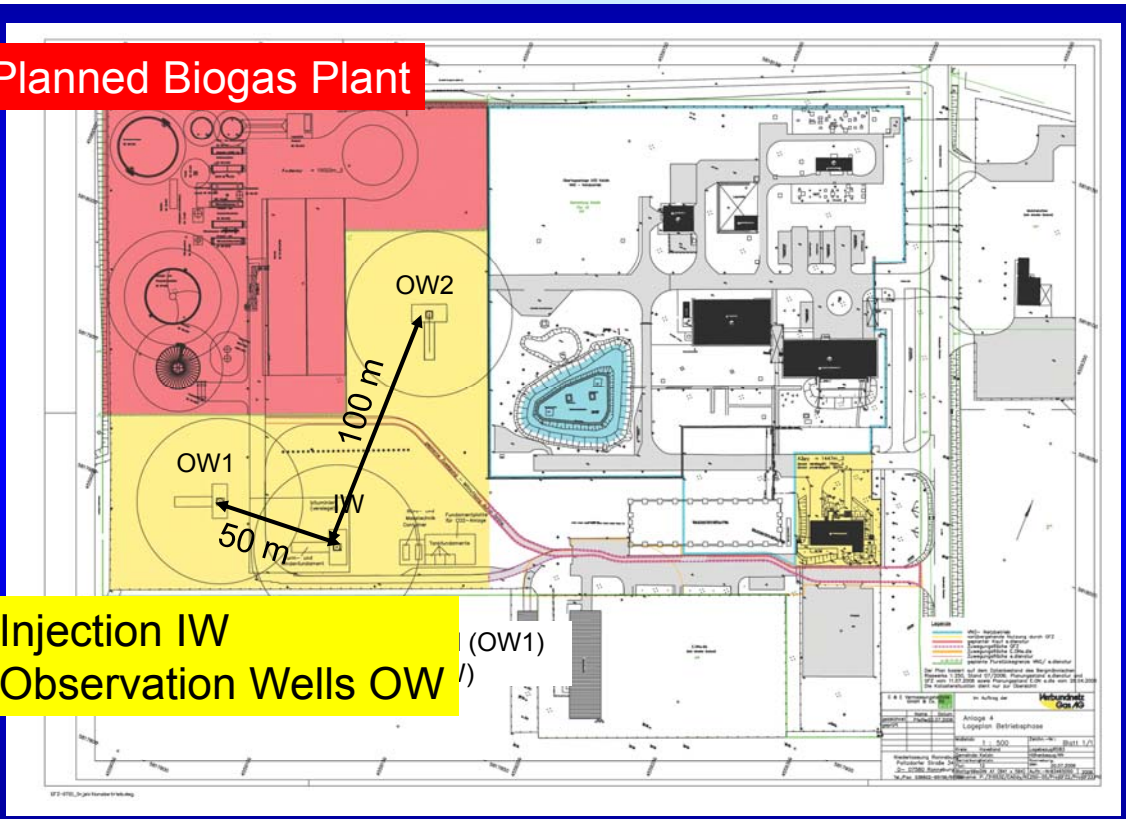

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Geology

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Salt Tectonics – NE German Basin

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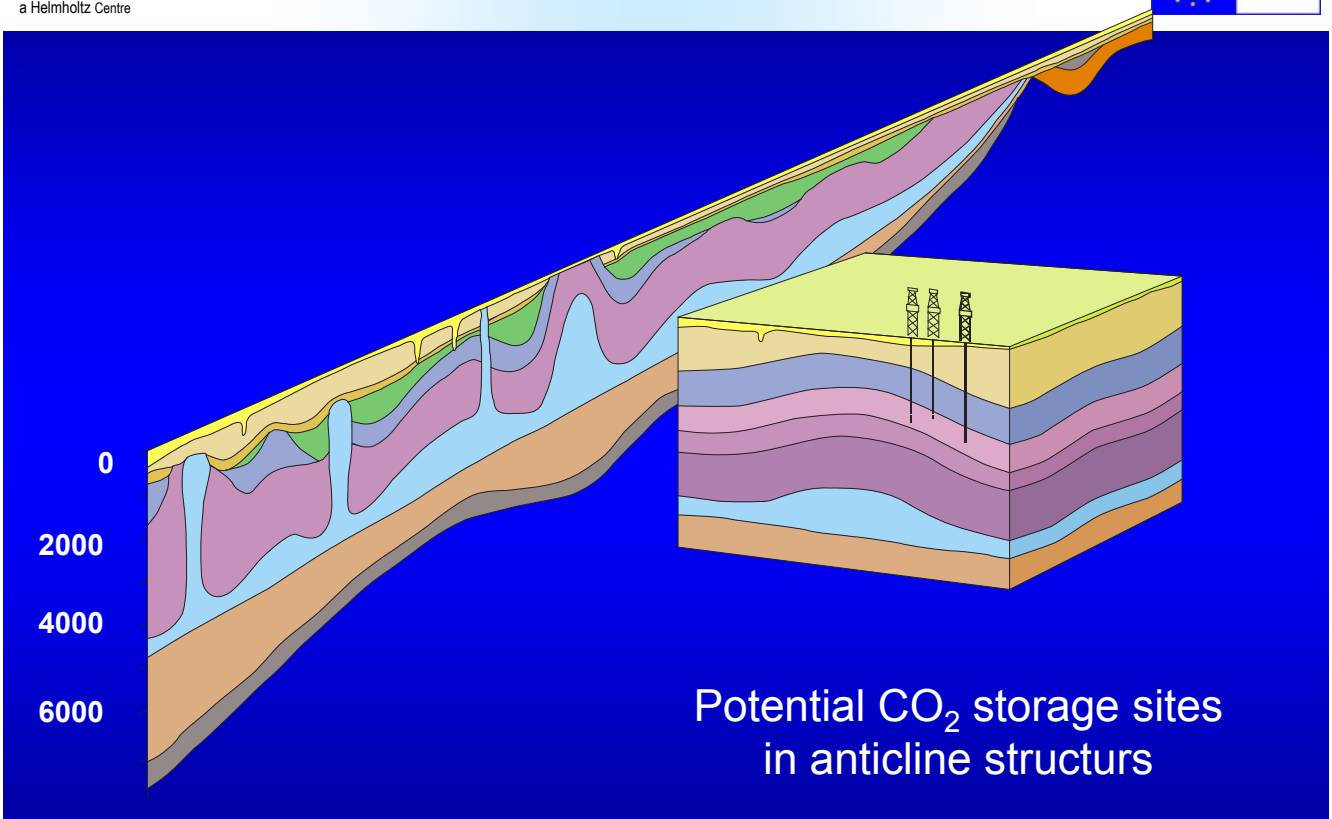
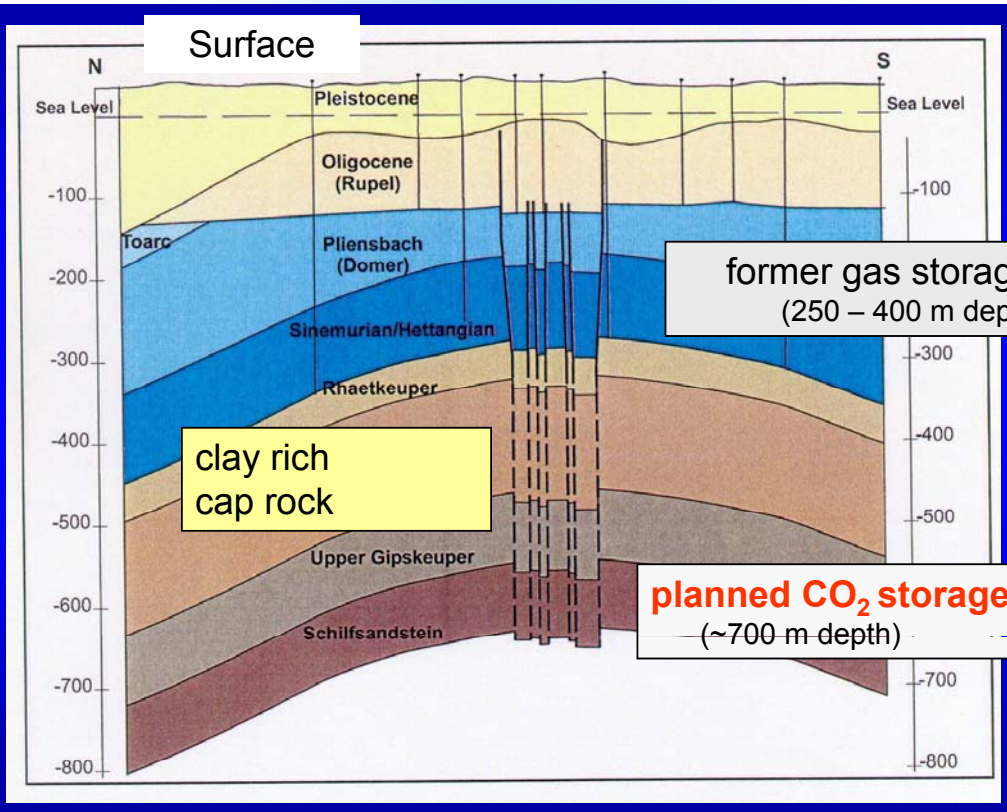


Potential CO_2 storage sites in anticline structurs

Förster et al. 2006

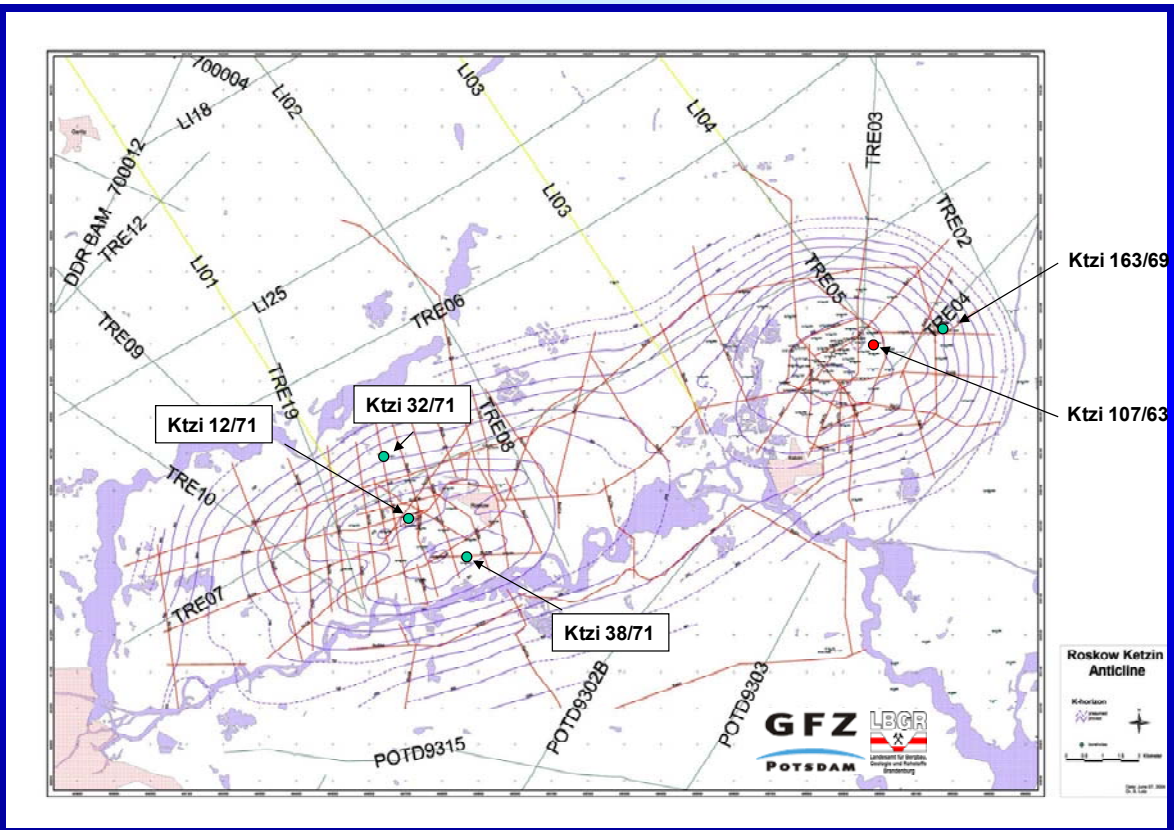
Frontiers in Geosciences 2007-2008, IPGP Paris, 19.03.2008

Geological Cross-Section



Förster et al. 2006

Roskow – Ketzin Anticline



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Geological Field Model

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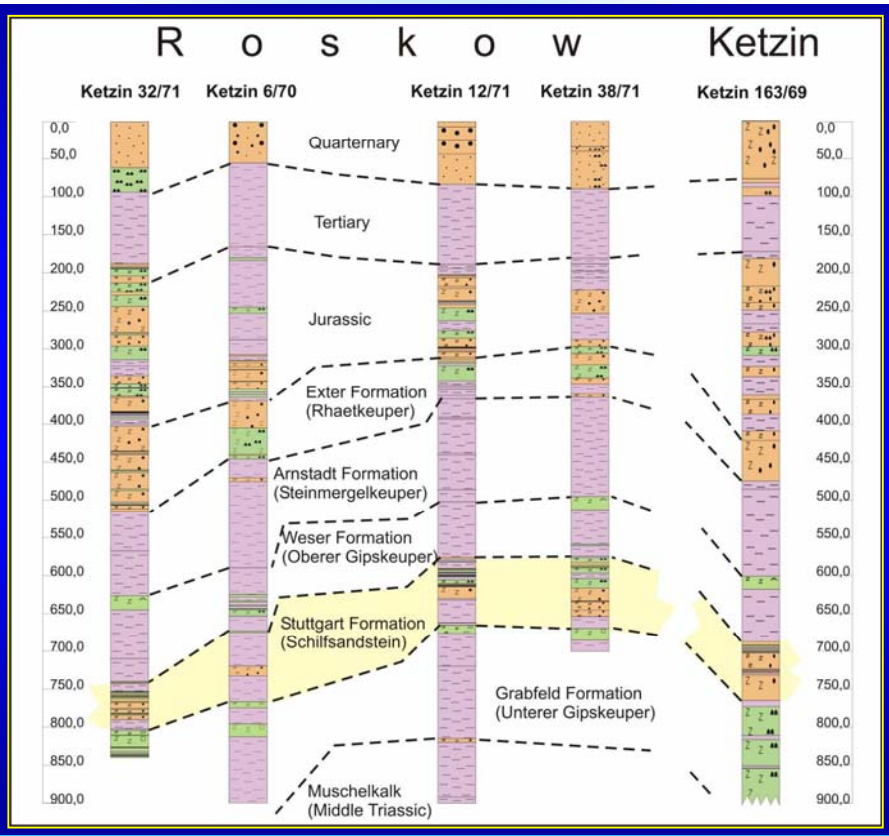

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Stuttgart Formation Facies Map

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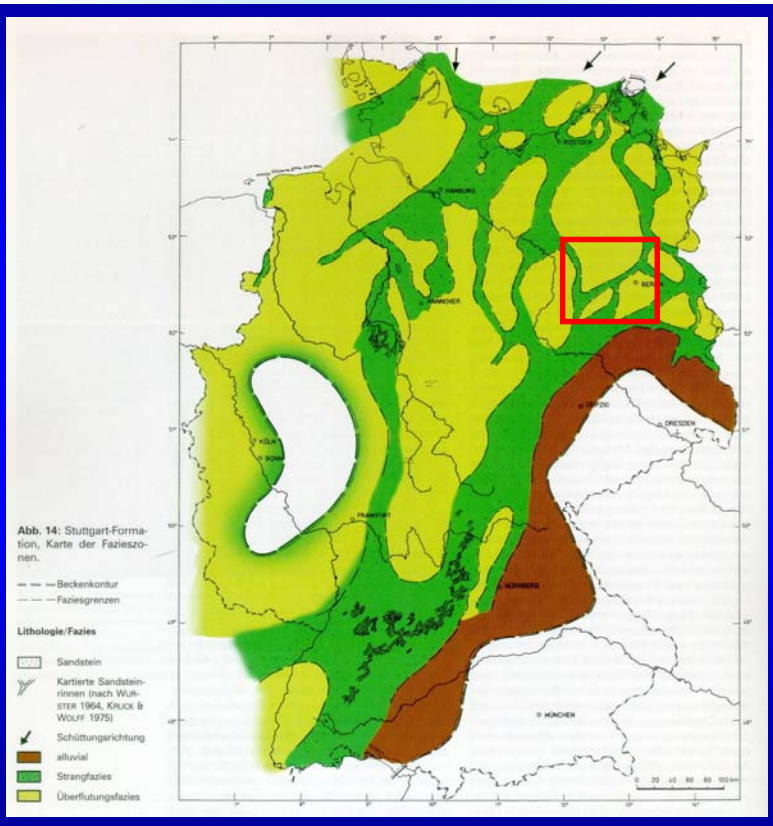
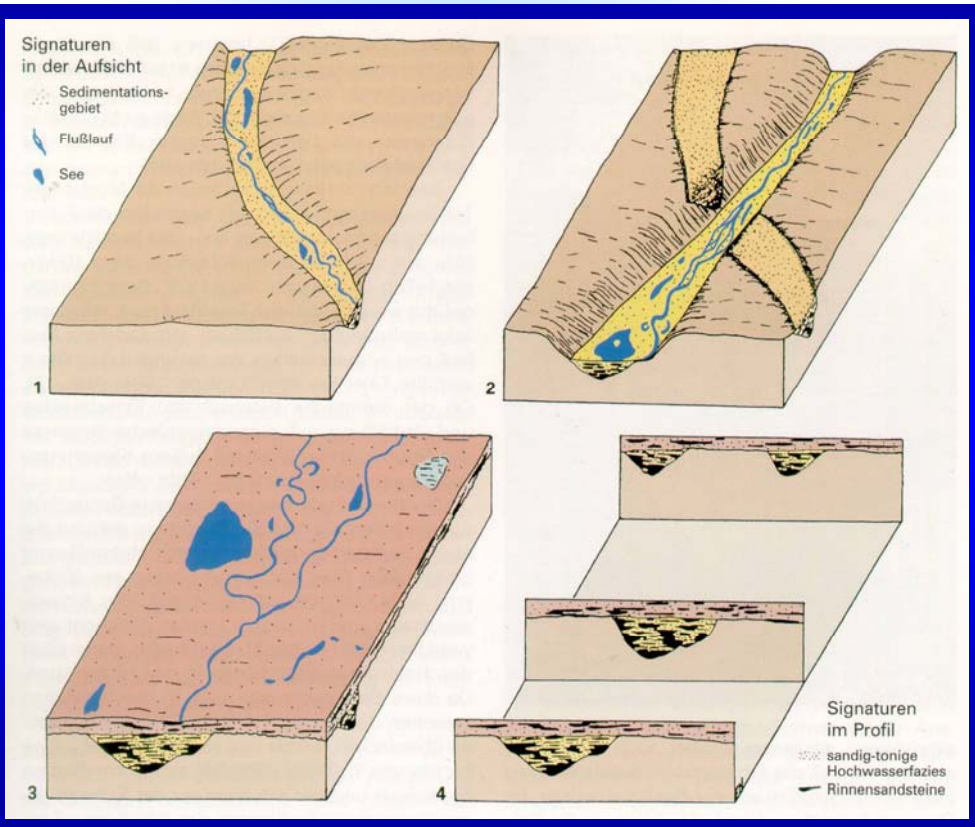


Beutler et al. 1999

Facies Type



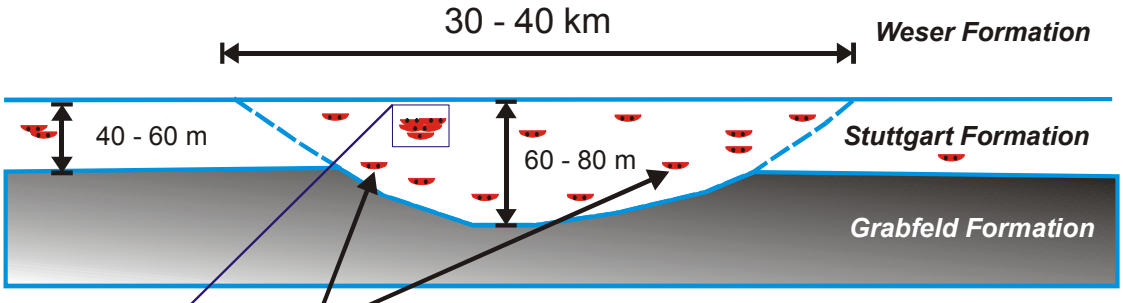
Beutler et al. 1999

„Sand“ channels in channel facies

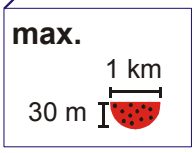
flooding facies
(Überflutungsfazies)

channel facies
(Strangfazies)

flooding facies
(Überflutungsfazies)



channel sandstone
(Rinnensandstein)



internal structure ?

- **fluviatile origin**
- **channel systems follow depression zones -> thickness minimum for geological highs**
- **thick sandstone bodies apart from structural highs**
- **large lateral and vertical variations of the reservoir conditions in the Stuttgart formation**

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Geology / Monitoring

3D Seismic Baseline

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3D Seismic Baseline

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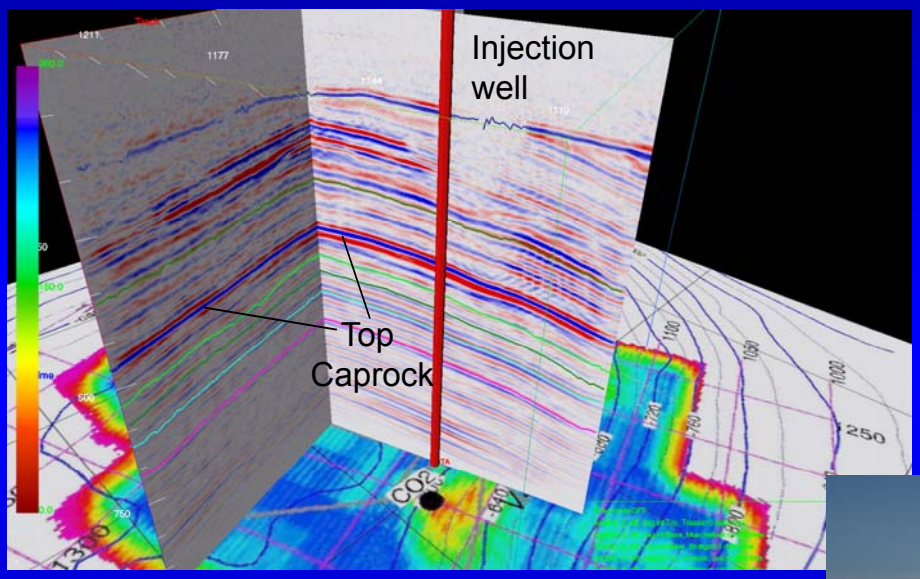
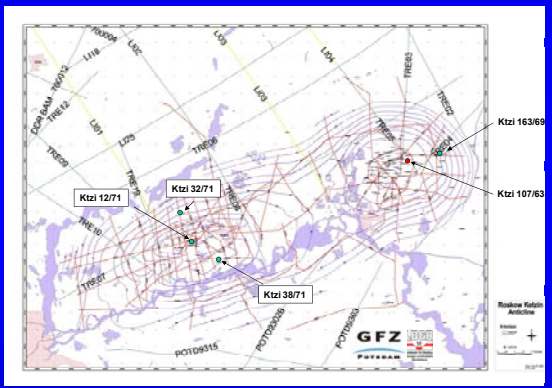
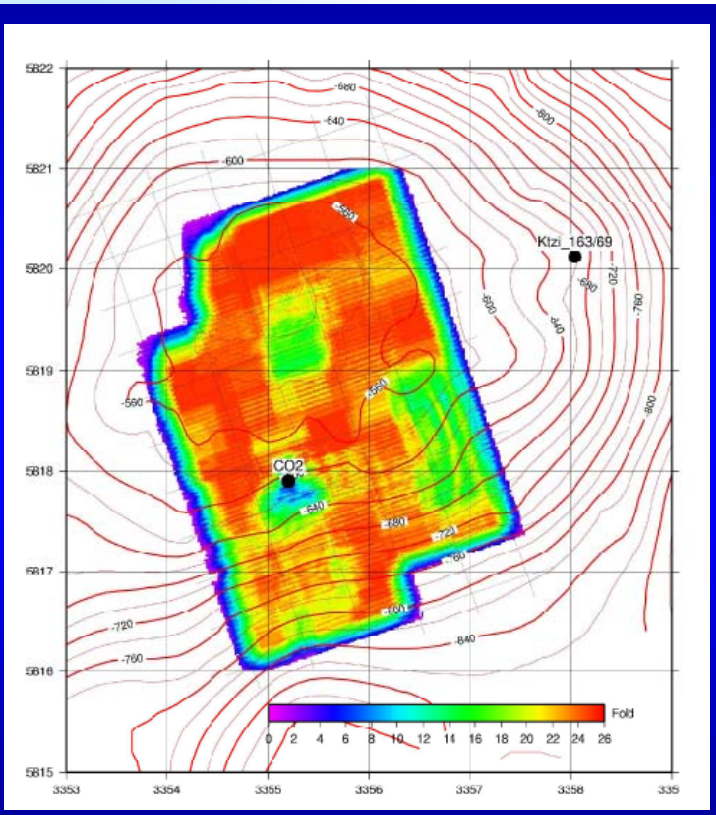
3D Seismic Baseline



Area Covered by Seismic Survey





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Horizon and Fault Mapping

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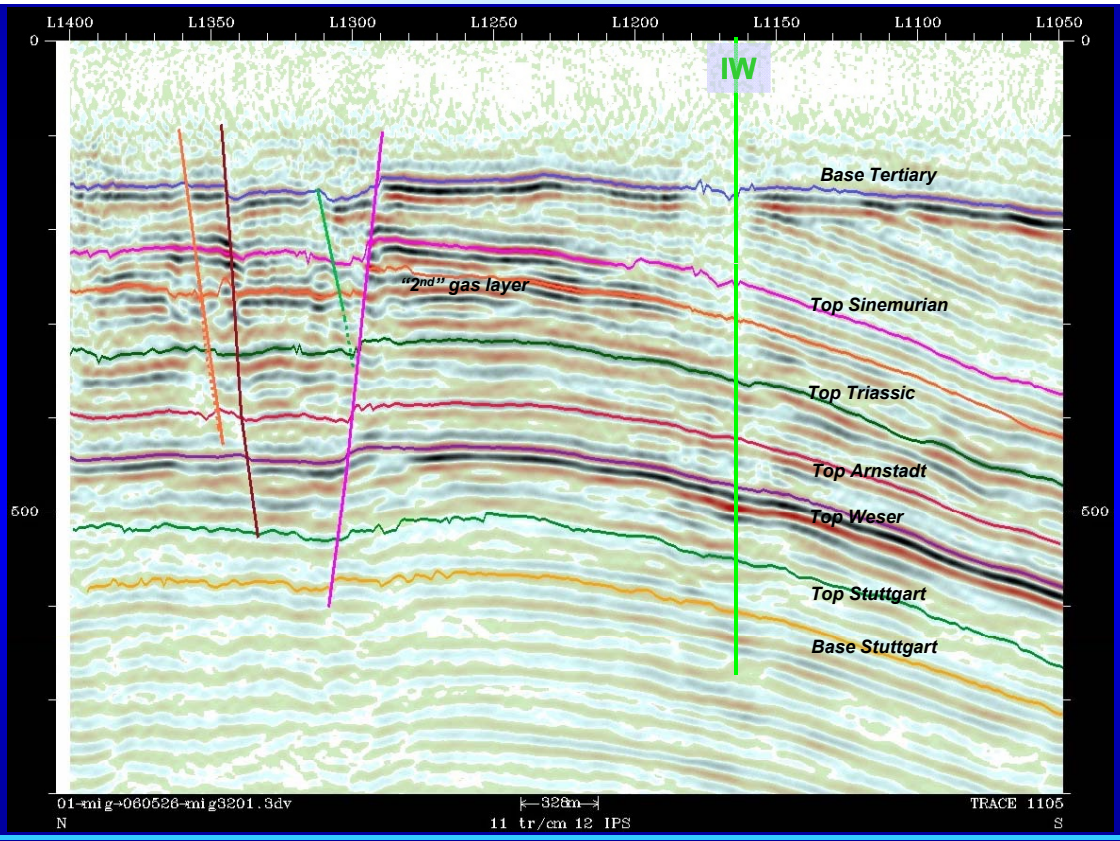

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Former Gas Storage Site

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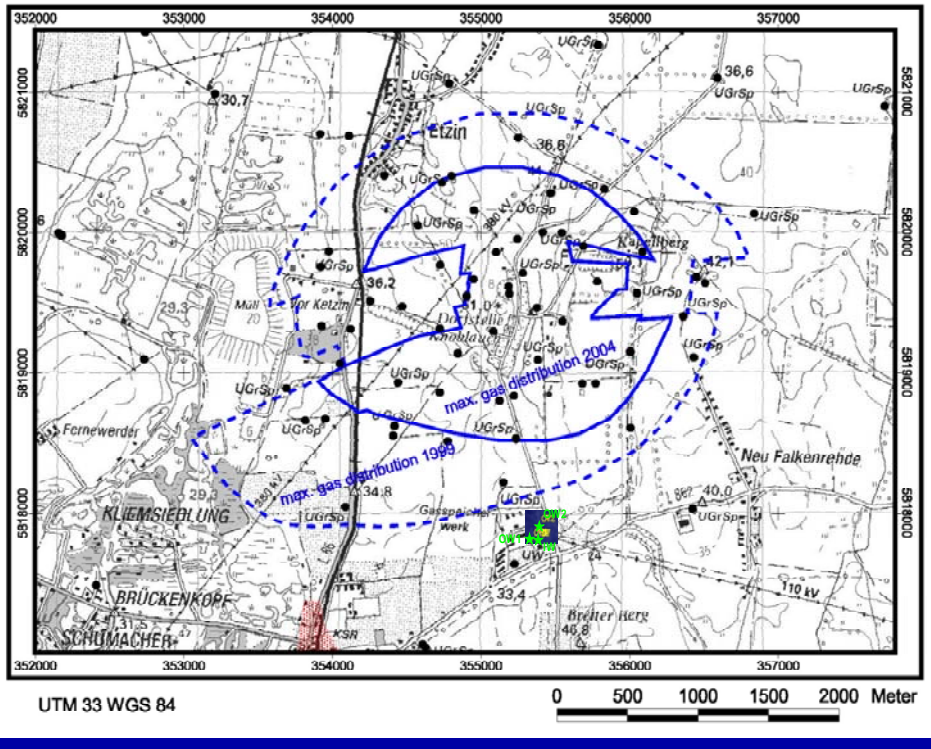
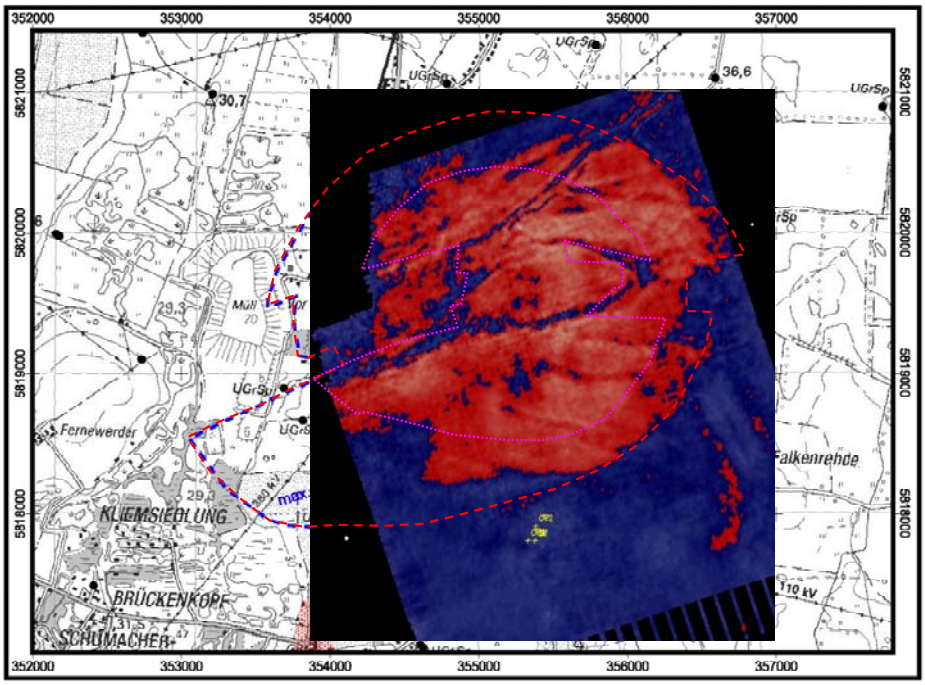
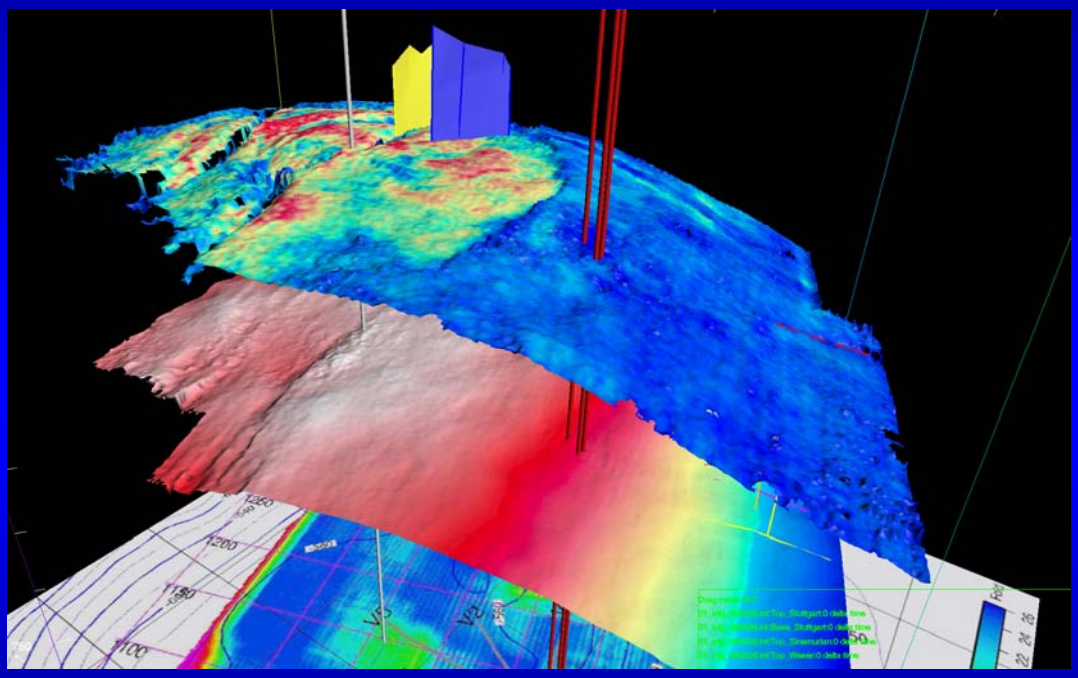


Residual Gas Mapping



Zinck-Jørgensen et al. 2006 Frontiers in Geosciences 2007-2008, IPGP Paris, 19.03.2008

Mapping Gas Saturations



It does seem that the highest amplitudes correspond to local highs and therefore may represent the highest gas saturations.

Zinck-Jørgensen et al. 2006 Frontiers in Geosciences 2007-2008, IPGP Paris, 19.03.2008