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Towards Future Technological Developments/Potential of Shale Gas

Kurt M. Reinicke
Institut für Erdöl- und Erdgastechnik (ITE), TU Clausthal

Hearing on „Prospects for Shale Gas in the European Union“ organised by the European Parliament

Brussels, 05. October 2011

CONTENT

- Shale gas
  - What is it ?
  - Where is it ?
  - What is the potential ?
- Development
  - Wells and fracs
  - Technology development
  - Economics
- Environmental compatibility
  - Frac containment
  - Frac fluids
  - Foot print
- Conclusions

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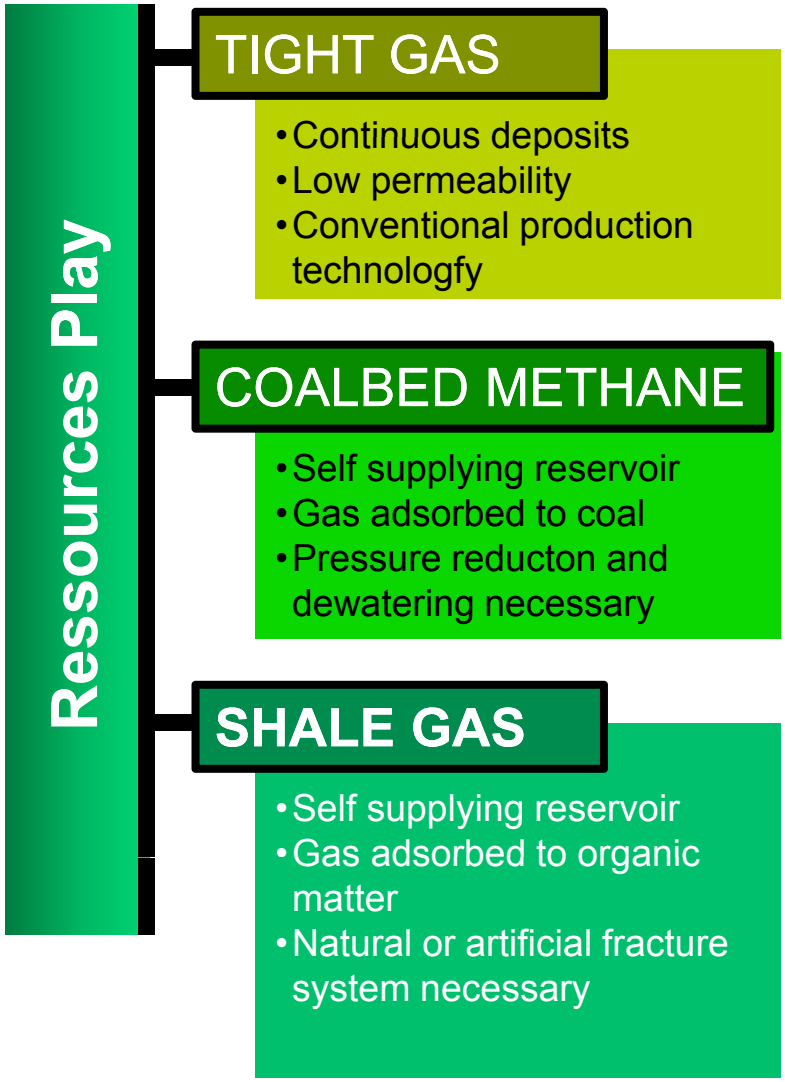
SHALE GAS IS A SO-CALLED UNCONVENTIONAL GAS



Unconventional Gas

- Not the gas is unconventional but the reservoirs

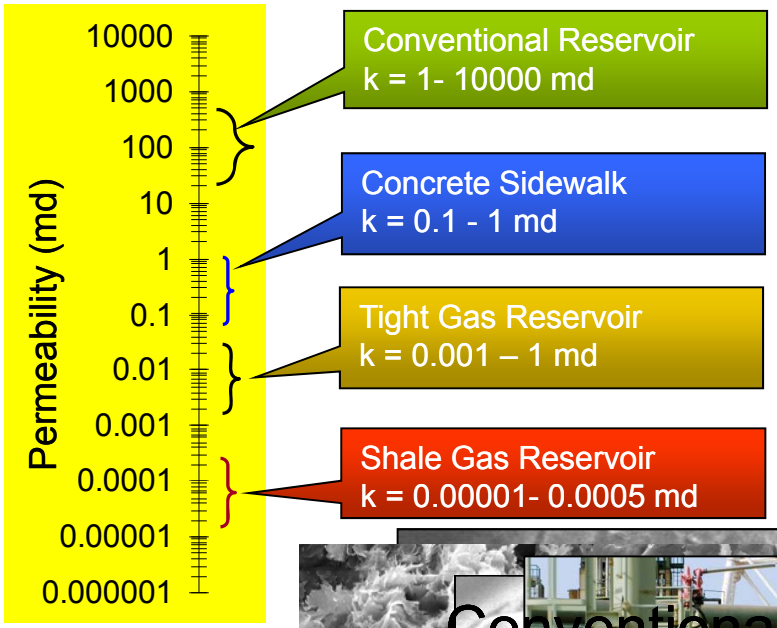
Conventional Reservoirs

- Discret accumulation of gas
- Reservoir rock with good flow properties
- High production capacities

Unconventional Reservoirs

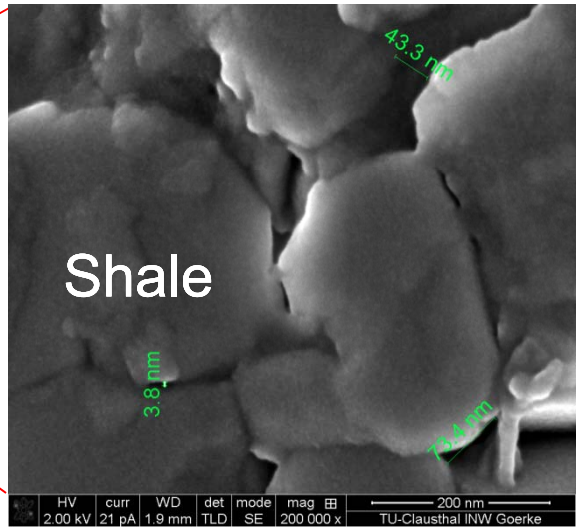
- Continuous deposits over large areas
- Extremely low permeabilities
- Low natural production capacities

SHALE GAS: *RESERVOIRS TIGHTER THAN CONCRETE PAVEMENTS*



- Unvonventional reservoirs
  - Extremely low permeabilities
  - Not recoverable without elaborate technology
  - Enormous potential

Source: ExxonMobil, 2009



Source: ITE, 2011

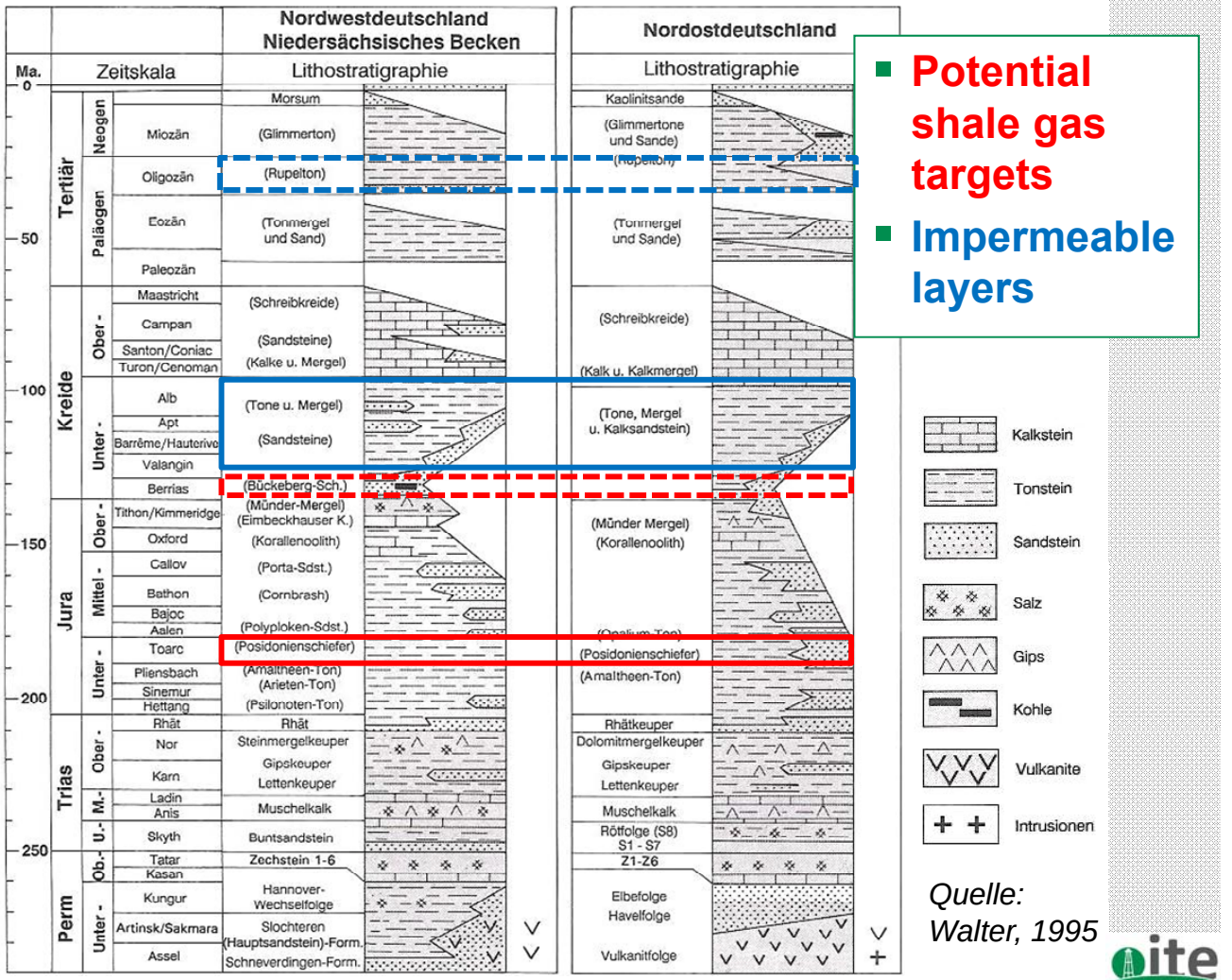
SHALE GAS: *IN BURRIED ROCK STRATA CAPPED BY IMPERMEALE LAYERS*

Shale gas is found

- In the North German Basin
- In the formations Wealden, Posidonia and Carboniferous
- In depths of approx. 800 - 3.000 m

The cap rock contains impermeable layers

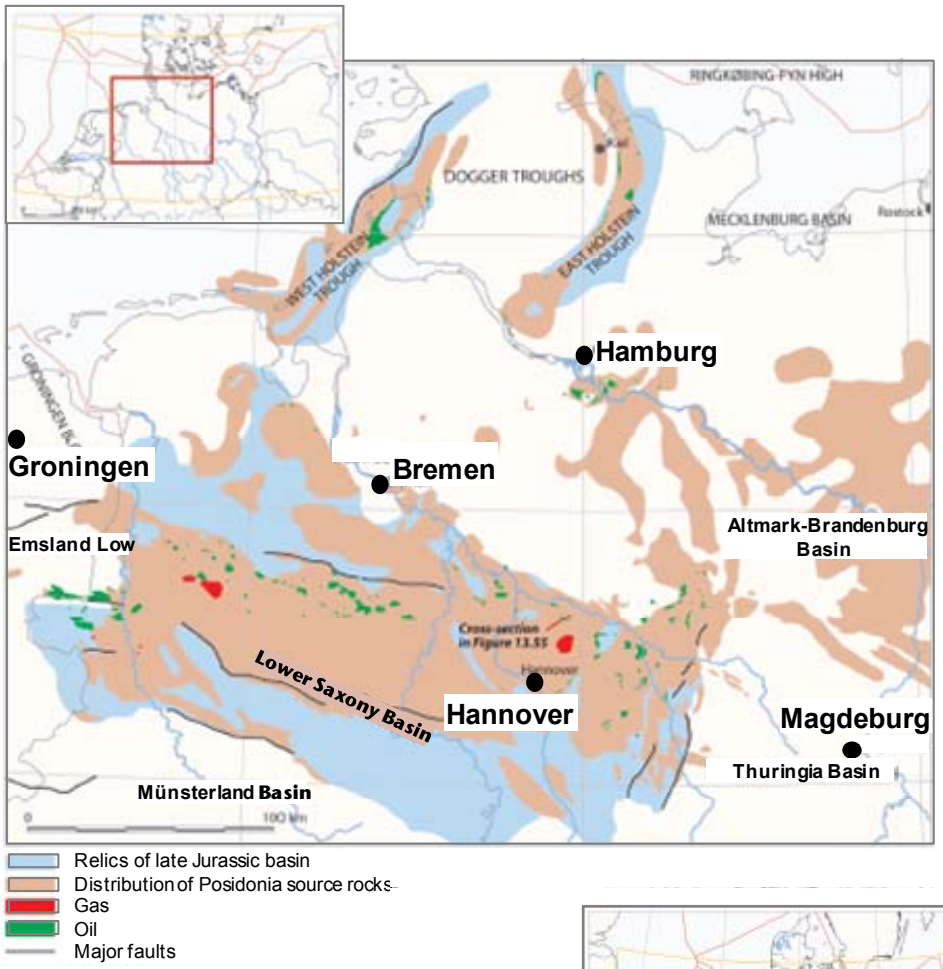
North German Basin Lithostratigraphy



- **Potential shale gas targets**
- **Impermeable layers**

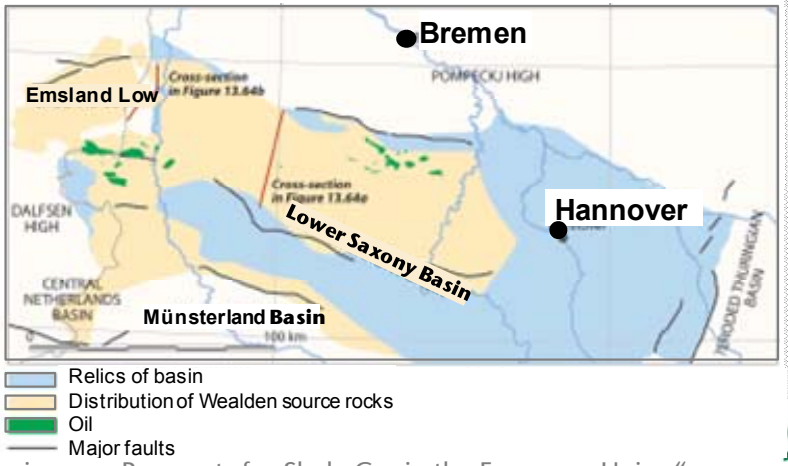
Quelle: Walter, 1995

SHALE GAS: *AREAL TARGET*

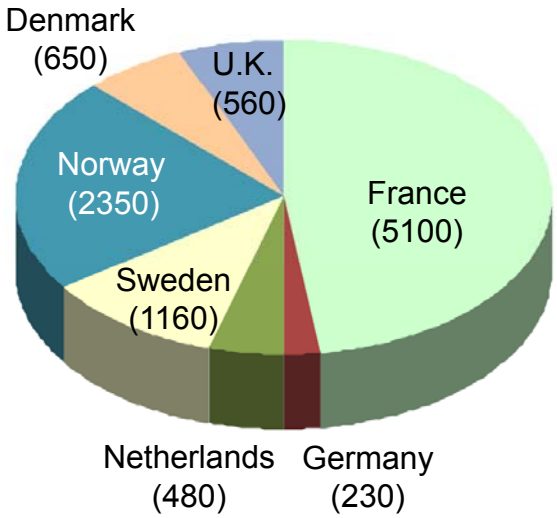


Quelle: Doornenbal & Stevenson (edts.), 2010

- Large areal extent of shale gas deposits
- Currently assessment of resources by BGR and GFZ
- Shale gas resources acc. to EIA 230 Milliard m^3 (recoverable)
- Unconventional resources equal 40-times of current yearly production



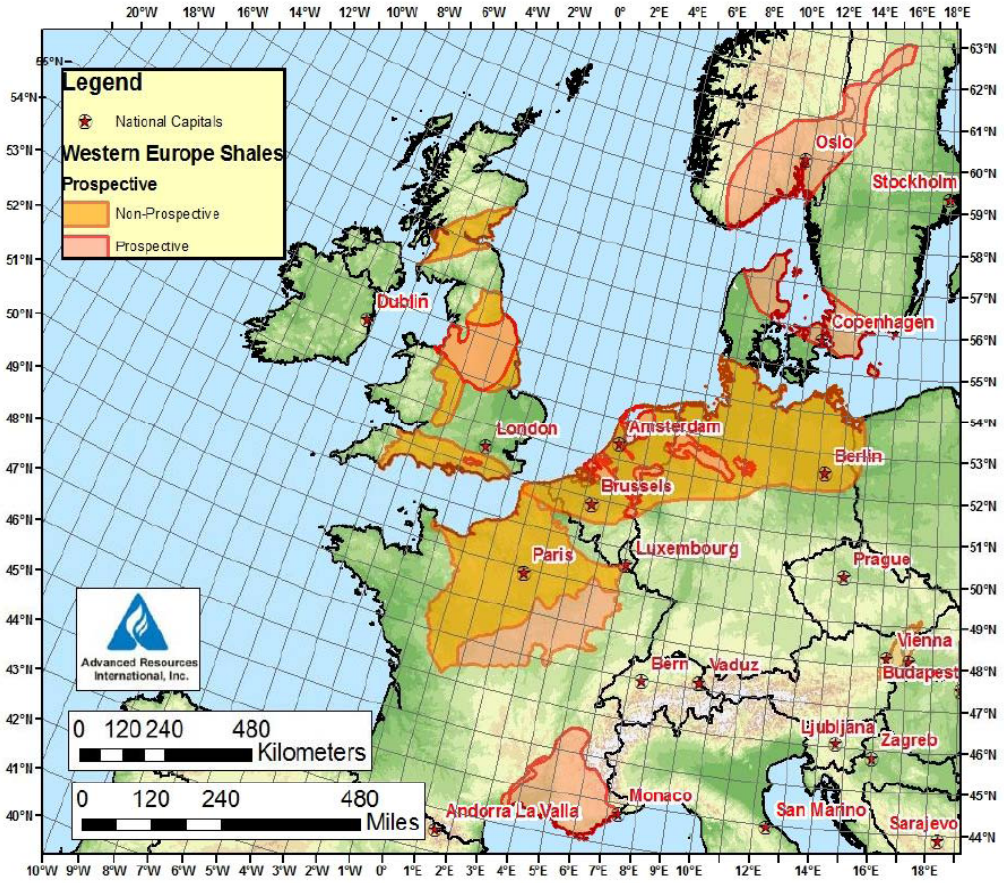
SHALE GAS: *WESTERN EUROPE SHALE GAS BASINS AND RESOURCES*



(Recoverable) Shale Gas Resource Estimates Western Europe (10.530 Mrd. m³)

Plus Poland : 5.300 Mrd. m³

Source: EIA ARI World Shale Gas Resources, 2011



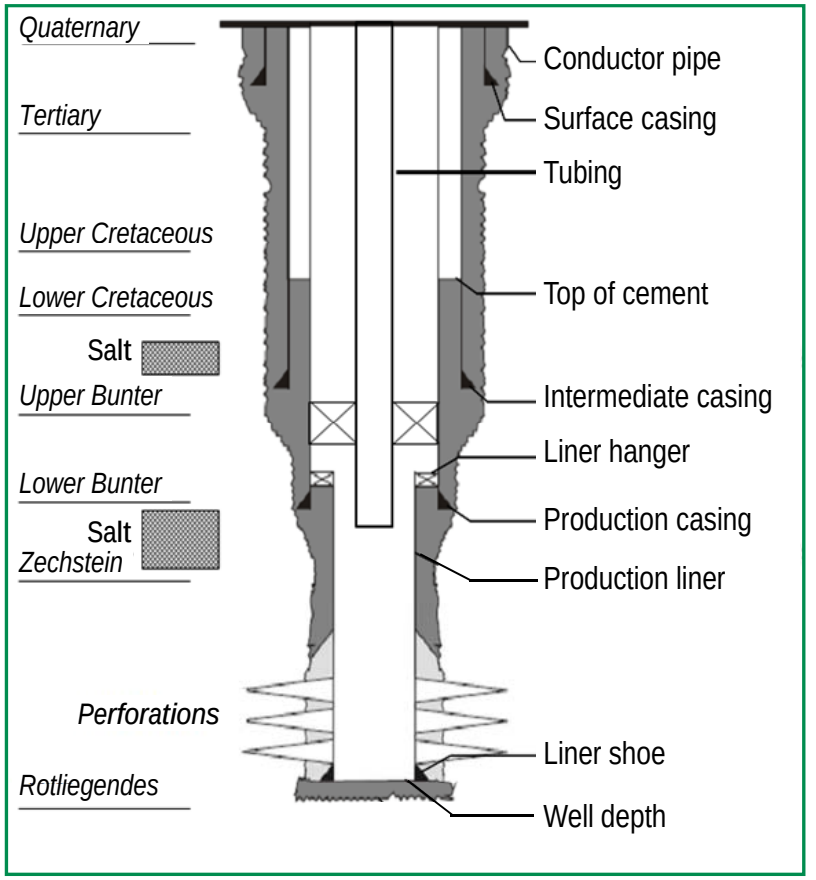
(Conv.) Gas Reserves Europe: 4.550 Mrd. m³, *Source: EIA, 2010*

CONTENT: *Summary I*

- **Shale gas …**
  - **is a natural gas in rock formations with high resistance to flow**
  - **is far below drinking water horizons in approx. 800 – 3.000 m**
  - **bearing rocks are overlain by impermeable layers**
  - **potential is larger than the currently known reserves**
- Development
  - Wells and fracs
  - Technology development
  - Economics
- Environmental compatibility
  - Frac containment
  - Frac fluids
  - Foot print

DEVELOPMENT: *WELLS*

- Wells are constructed to …
  - provide a tight connection between the surface and the reservoirs
  - high construction standard
- Well design
  - Sectional introduction of steel pipe
  - Annulus cementation
- Quality assurance
  - Pressure tests
  - Acoustic well logging
    = Cement Bond Log (CBL)

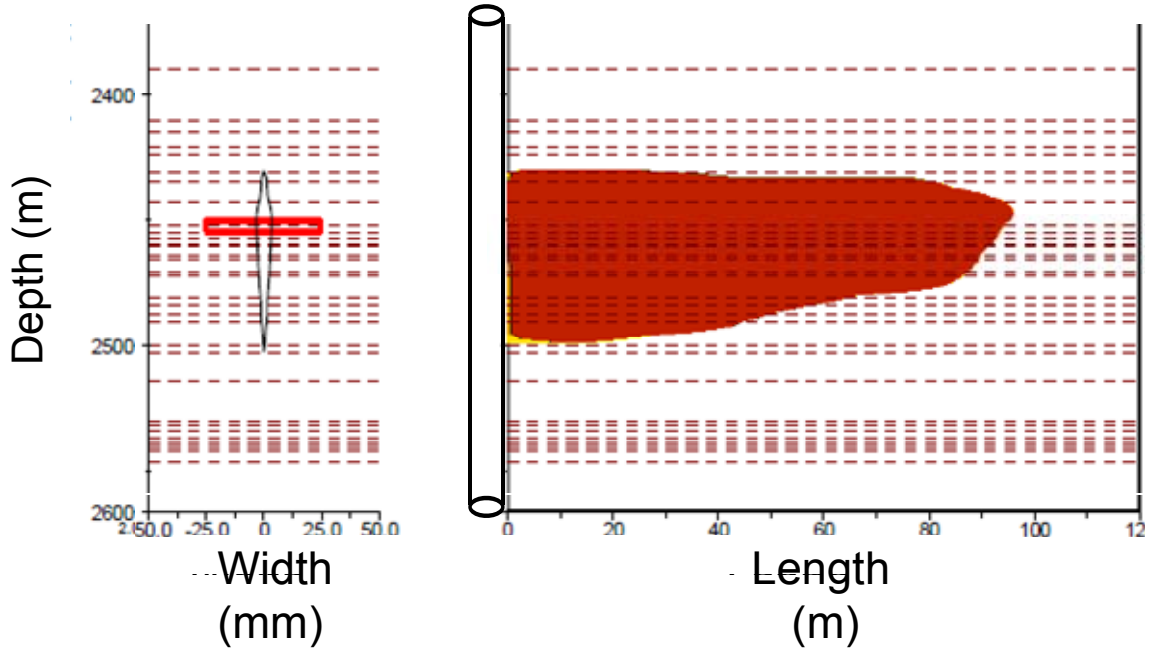


Well bore schematic

Source: Reinicke et al., 2011

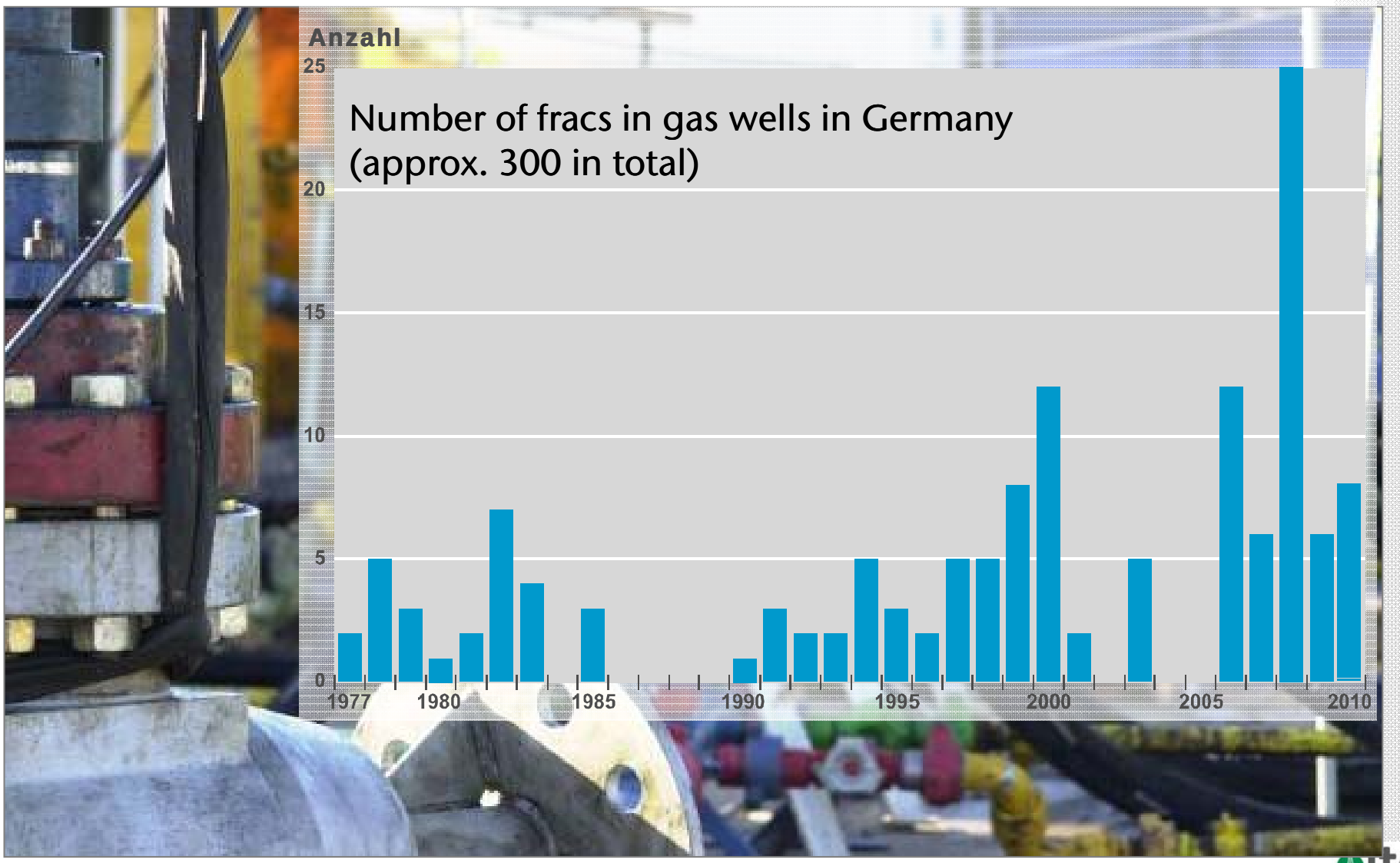
DEVELOPMENT: *FRACTURING*

- Hydraulic fracturing
  - Process of initiating and propagating a fracture in a rock layer, employing the pressure of a fluid as the source of energy
  - Technology used since 1949 in >1 million U.S. wells (in D since 1961)
  - Ca. 90 % of U.S. gas wells have been fraced
  - Fractures are typically contained within the formation fraced



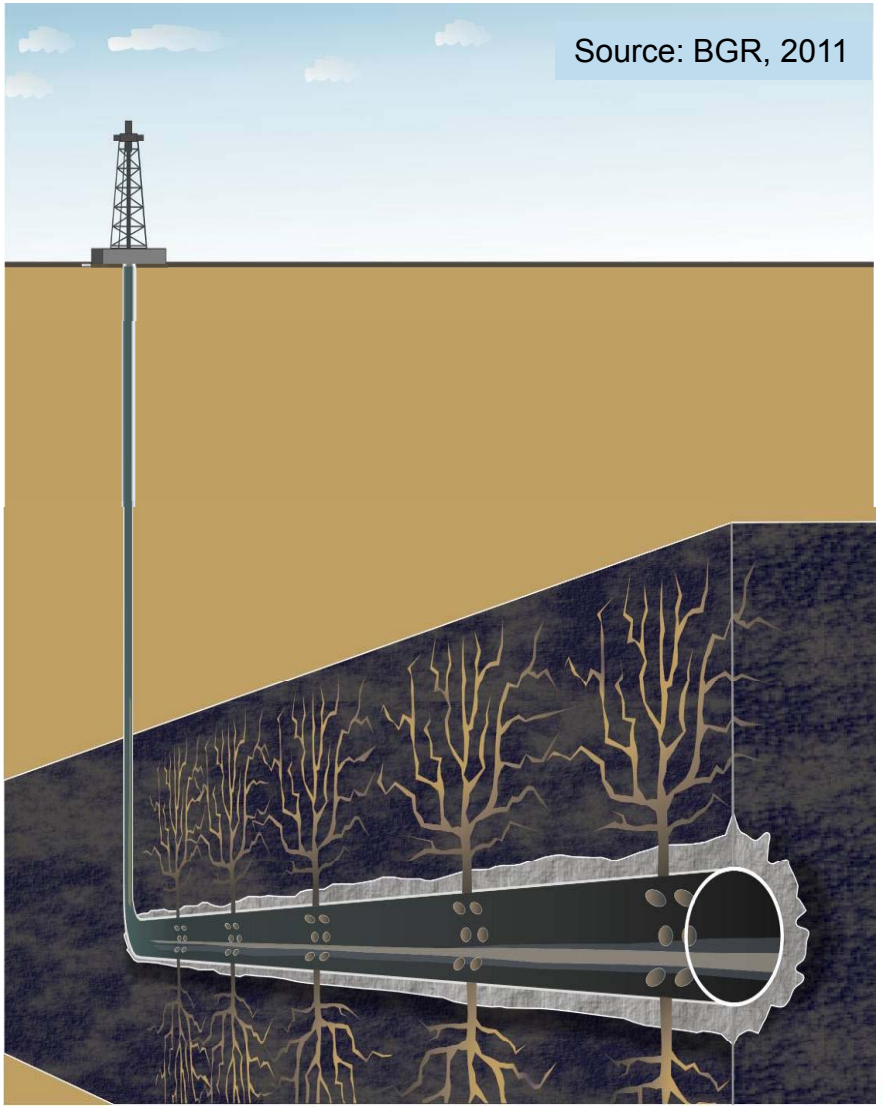
Typical Gasfrac

DEVELOPMENT: *FRACS IN GERMANY*



DEVELOPMENT: *KEY TECHNOLOGIES*

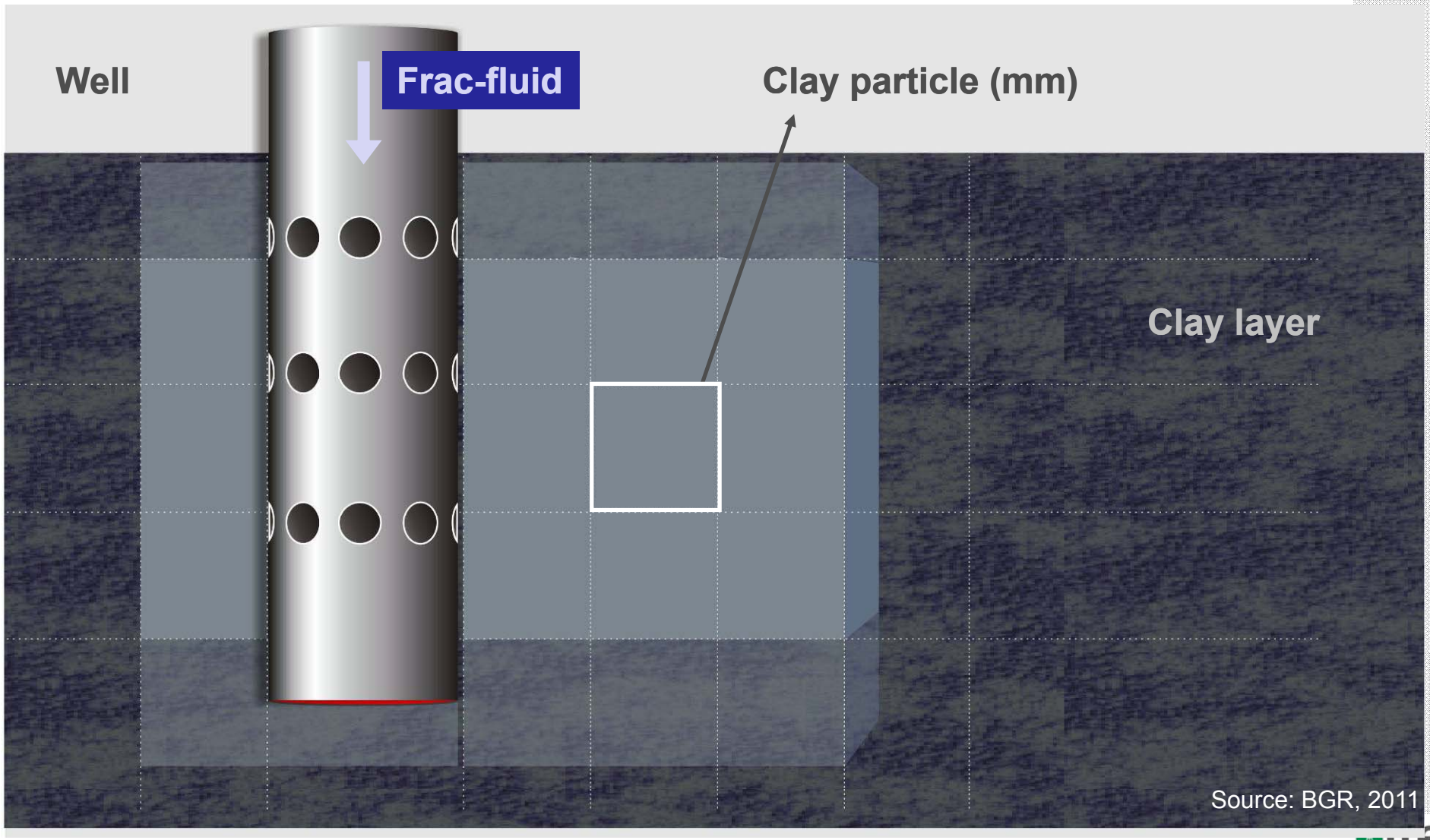
- USA
  - 2005: more than 35.000 shale gas wells → ca. 17 Milliard (10^9) m^3/a
  - Initial shale gas production from deposits with natural fractures
  - Recent shale gas boom technology driven
- Key Technologies
  - Horizontal drilling
  - Frac/multifrac technology
  - Recently multilateral-/ horizontal well and multifrac technology



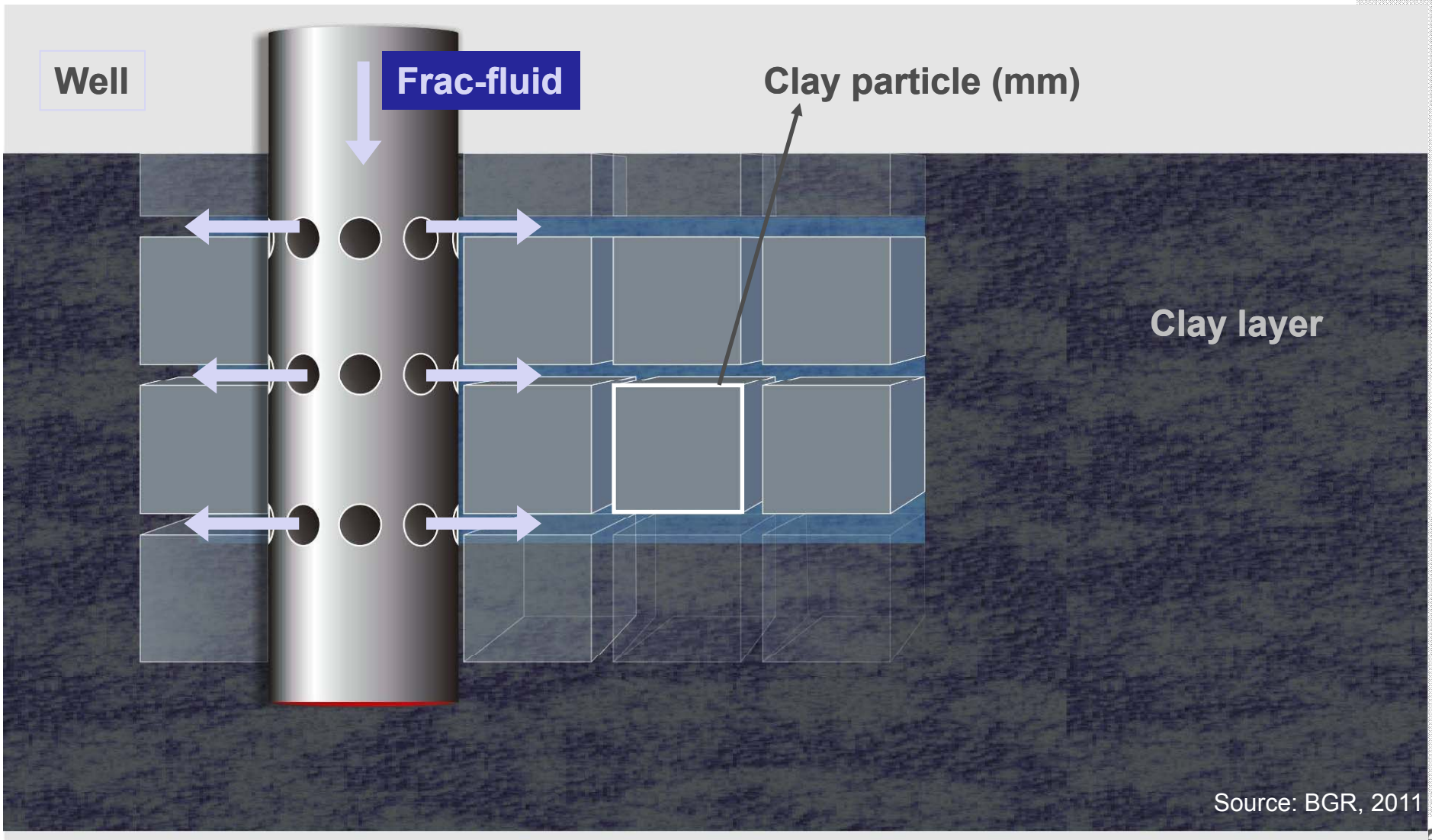
DEVELOPMENT: *OUTCROP OF SHALE GAS RESERVOIR*

Source: USGS, 2011

DEVELOPMENT: *SHALE GAS DEGASSING*



DEVELOPMENT: *SHALE GAS DEGASSING*



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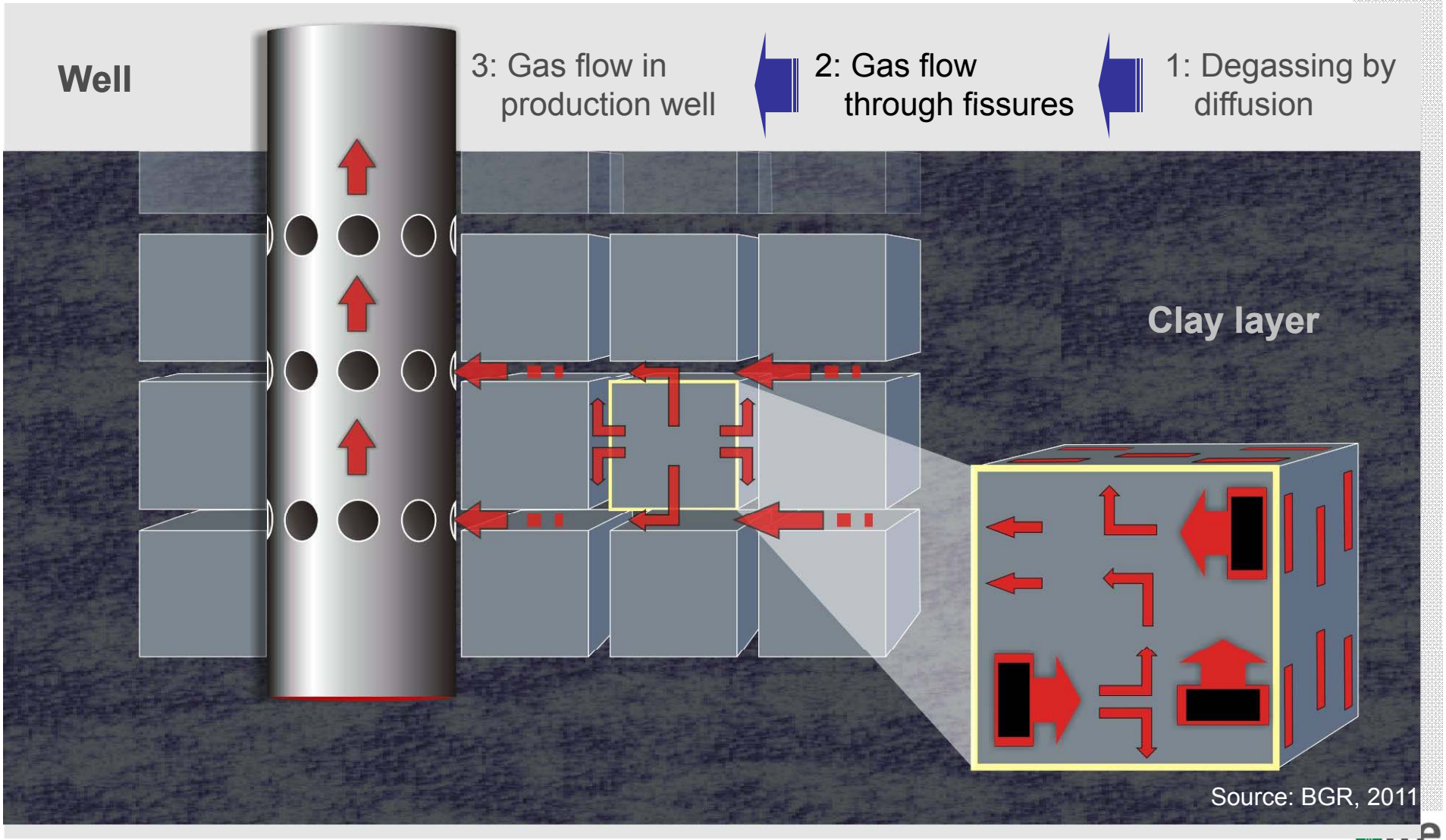
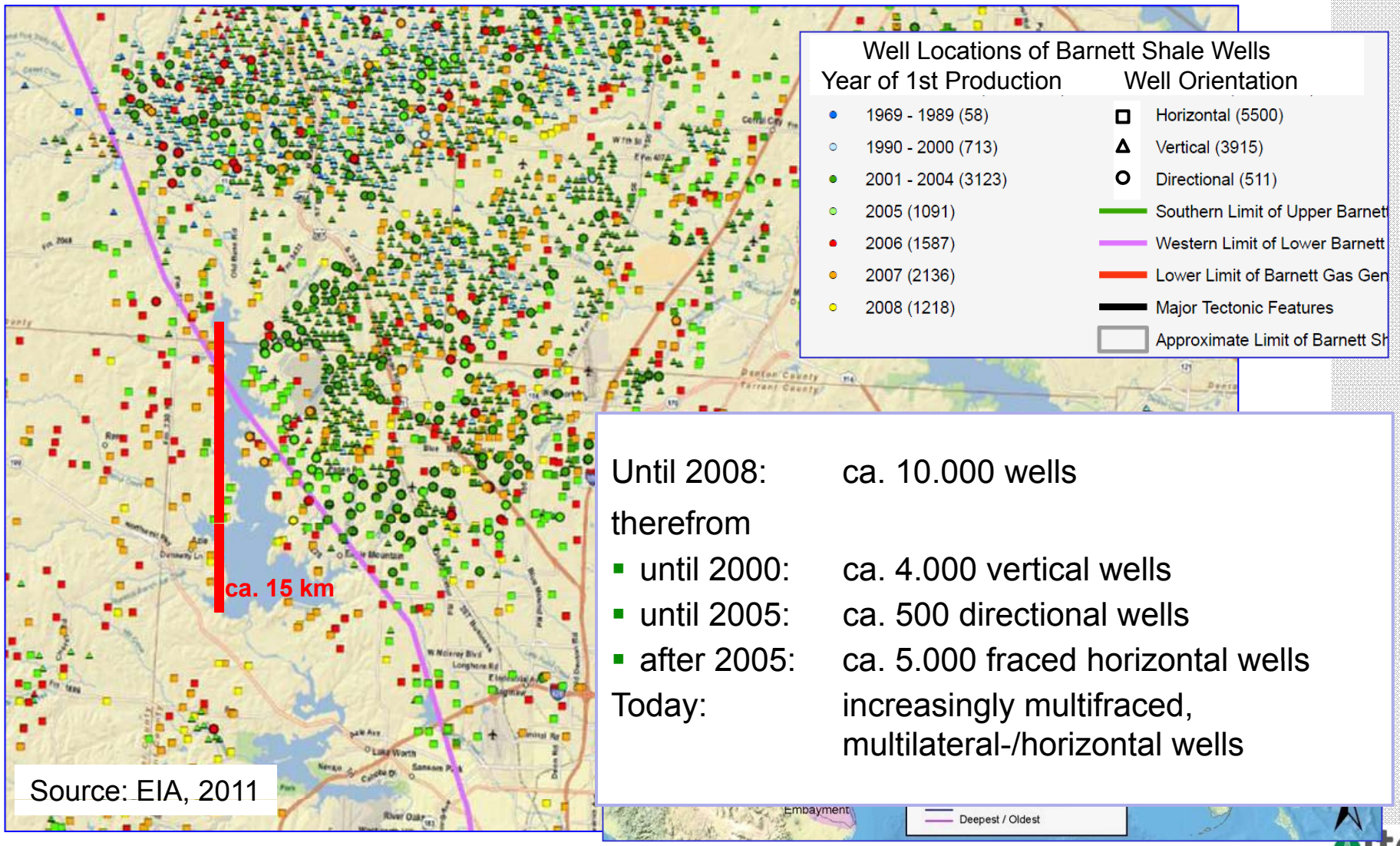
DEVELOPMENT: *SHALE GAS DEGASSING*



DEVELOPMENT: *BARNETT SHALE DEVELOPMENT*



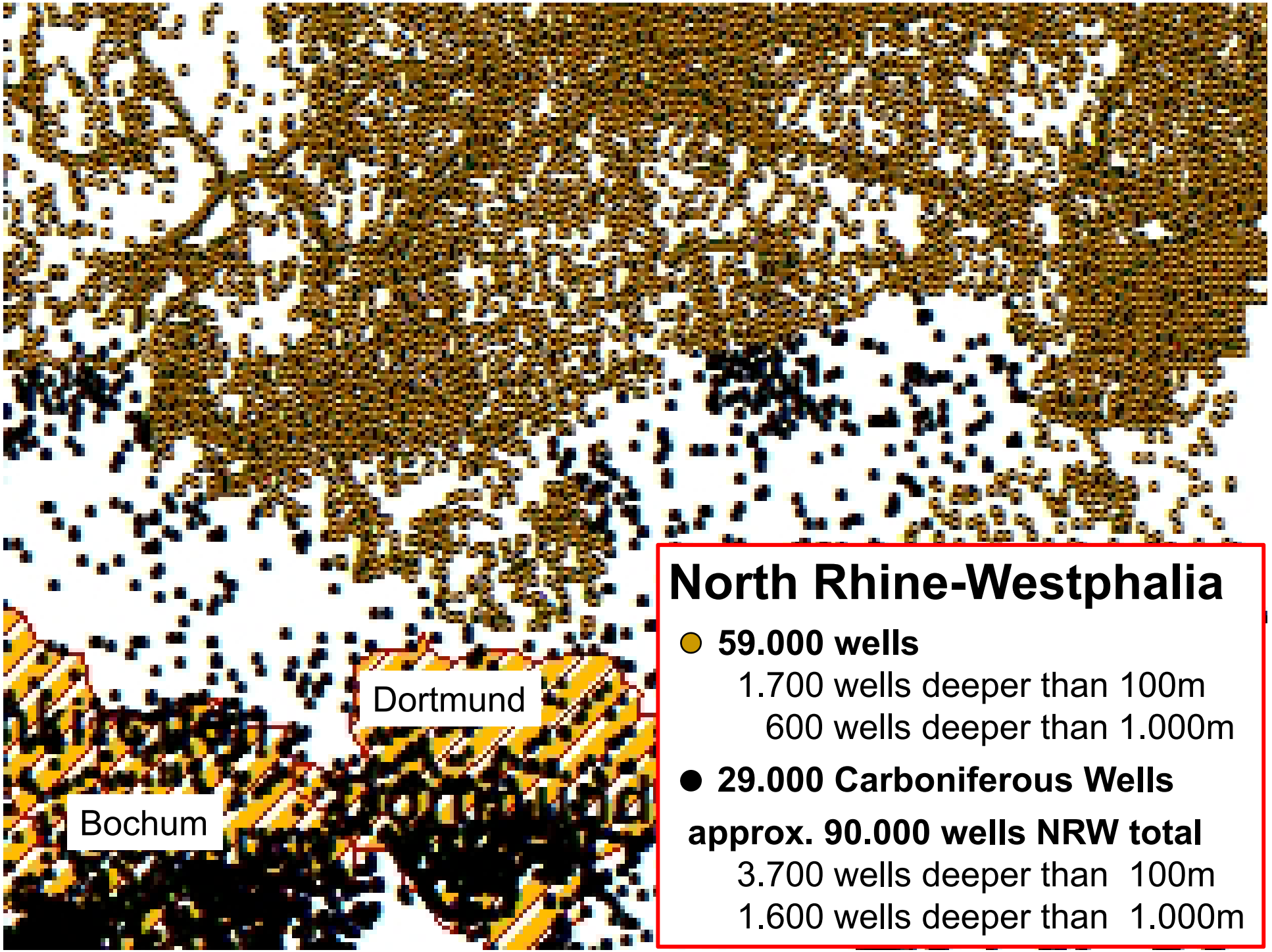
Source: EIA, 2011

Until 2008: ca. 10.000 wells

therefrom

- until 2000: ca. 4.000 vertical wells
- until 2005: ca. 500 directional wells
- after 2005: ca. 5.000 fraced horizontal wells

Today: increasingly multifraced, multilateral-/horizontal wells



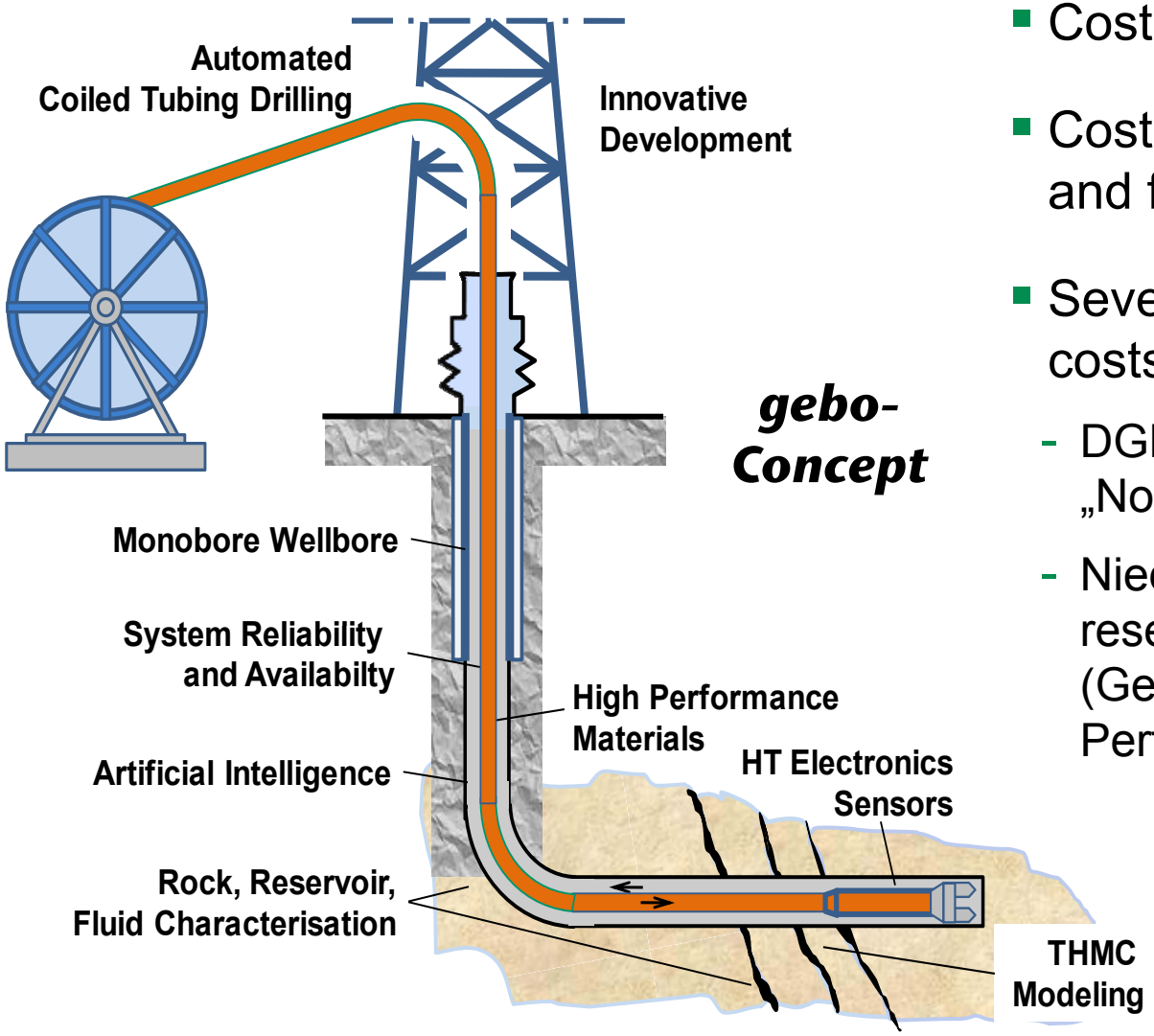
North Rhine-Westphalia

- **59.000 wells**
  - 1.700 wells deeper than 100m
  - 600 wells deeper than 1.000m
- **29.000 Carboniferous Wells**

approx. 90.000 wells NRW total

- 3.700 wells deeper than 100m
- 1.600 wells deeper than 1.000m

DEVELOPMENT: *ECONOMICS*

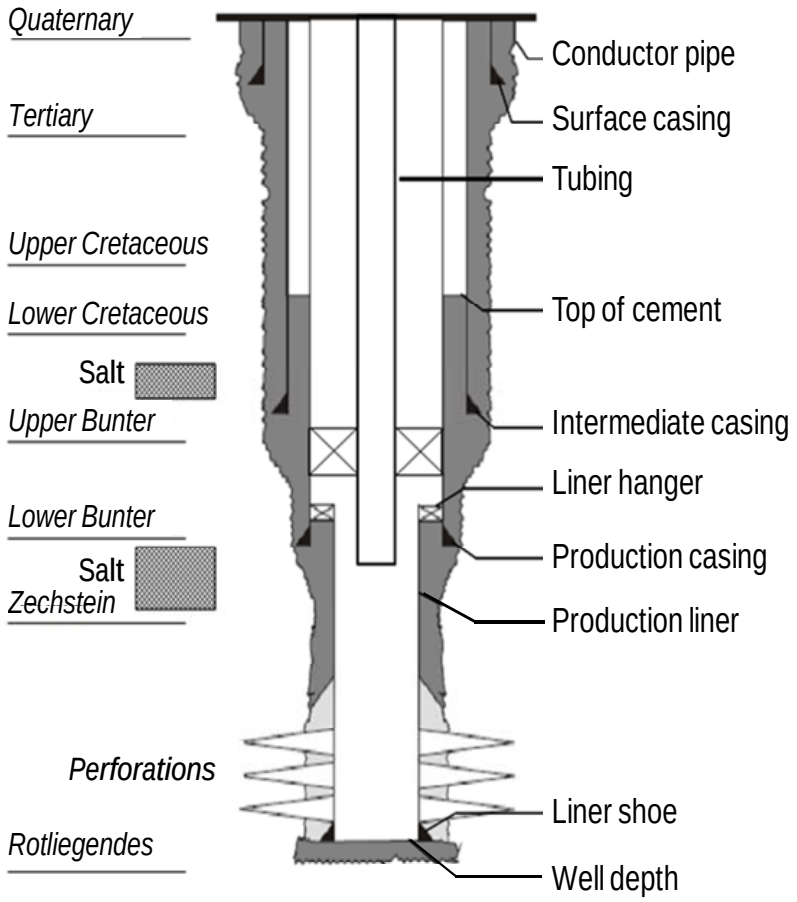


- Cost reduction is key
- Costs for well construction and fracturing dominate
- Several initiatives to cut costs under way in Germany
  - DGMK joint industry initiative „Novel Ideas in Drilling“
  - Niedersachsen collaborative research program gebo (Geothermics- and High Performance Drilling)

CONTENT: *Summary II*

- Target shale gas
  - Shale Gas is natural gas in rock formations with high resistance to flow
  - Targets are far below drinking water horizons in approx. 1.000 – 3.000 m
  - There are tight rock formations drinking water horizons and targets
  - The potential is larger than the currently known reserves
- **Development**
  - **Wells are constructed to provide a tight connection to the reservoirs**
  - **“Fracking” is a tested and proven technology used since 60 years**
  - **Horizontal well and frac technology provide a means to economically develop shale gas resources also in the EU**
- Environmental compatibility
  - Frac containment
  - Frac fluids
  - Foot print

ENVIRONMENTAL COMPATIBILITY: *CONTAINMENT*



Source: ITE, 2011

Cap rock

- Overburden must contain barriers to flow

Wells

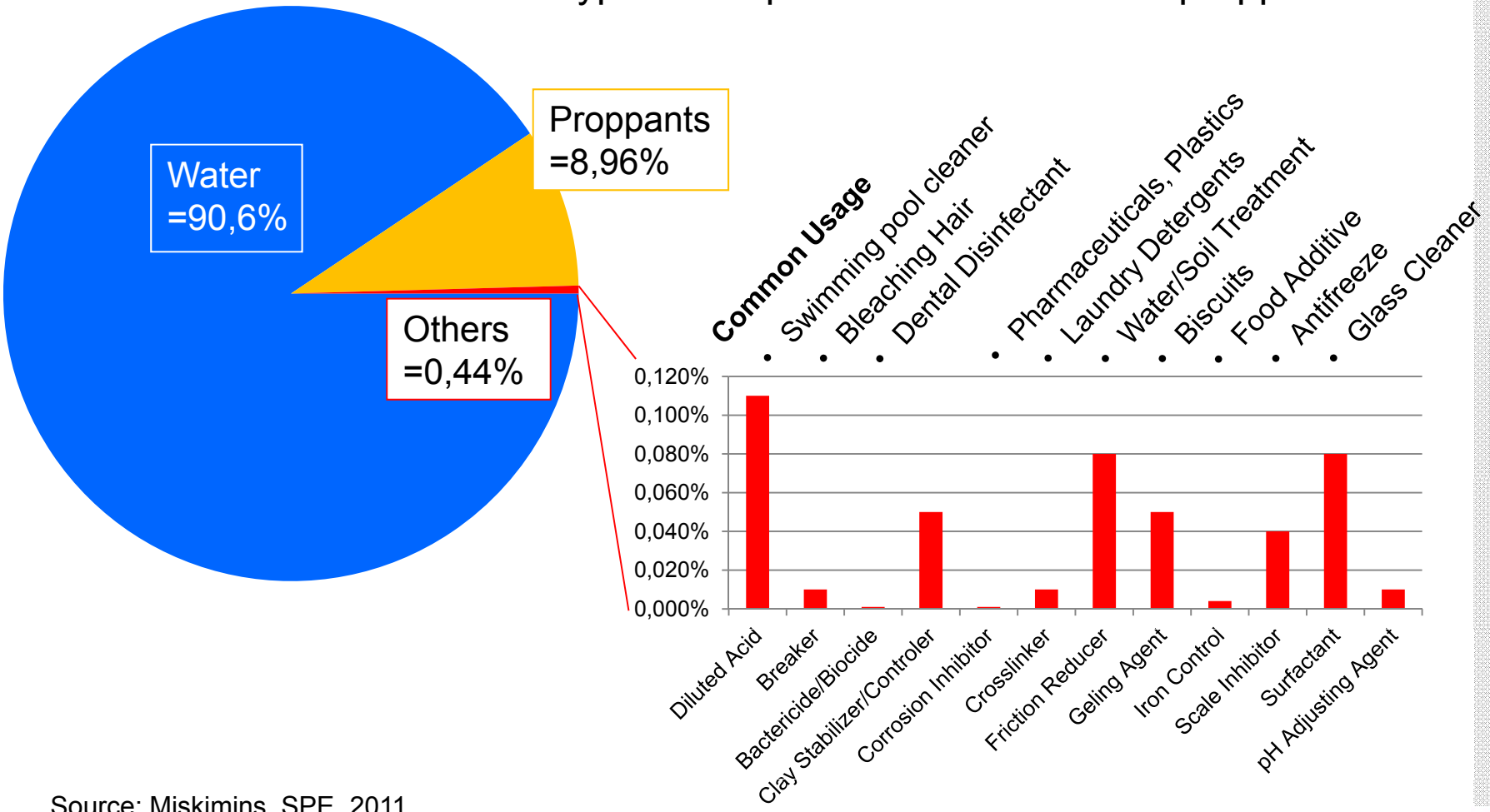
- Well must provide a gas tight connection to the reservoir

Fracs

- Fracs must be contained
- Frac fluids must be compatible with the respective environment

ENVIRONMENTAL COMPATIBILITY: *FRAC FLUIDS*

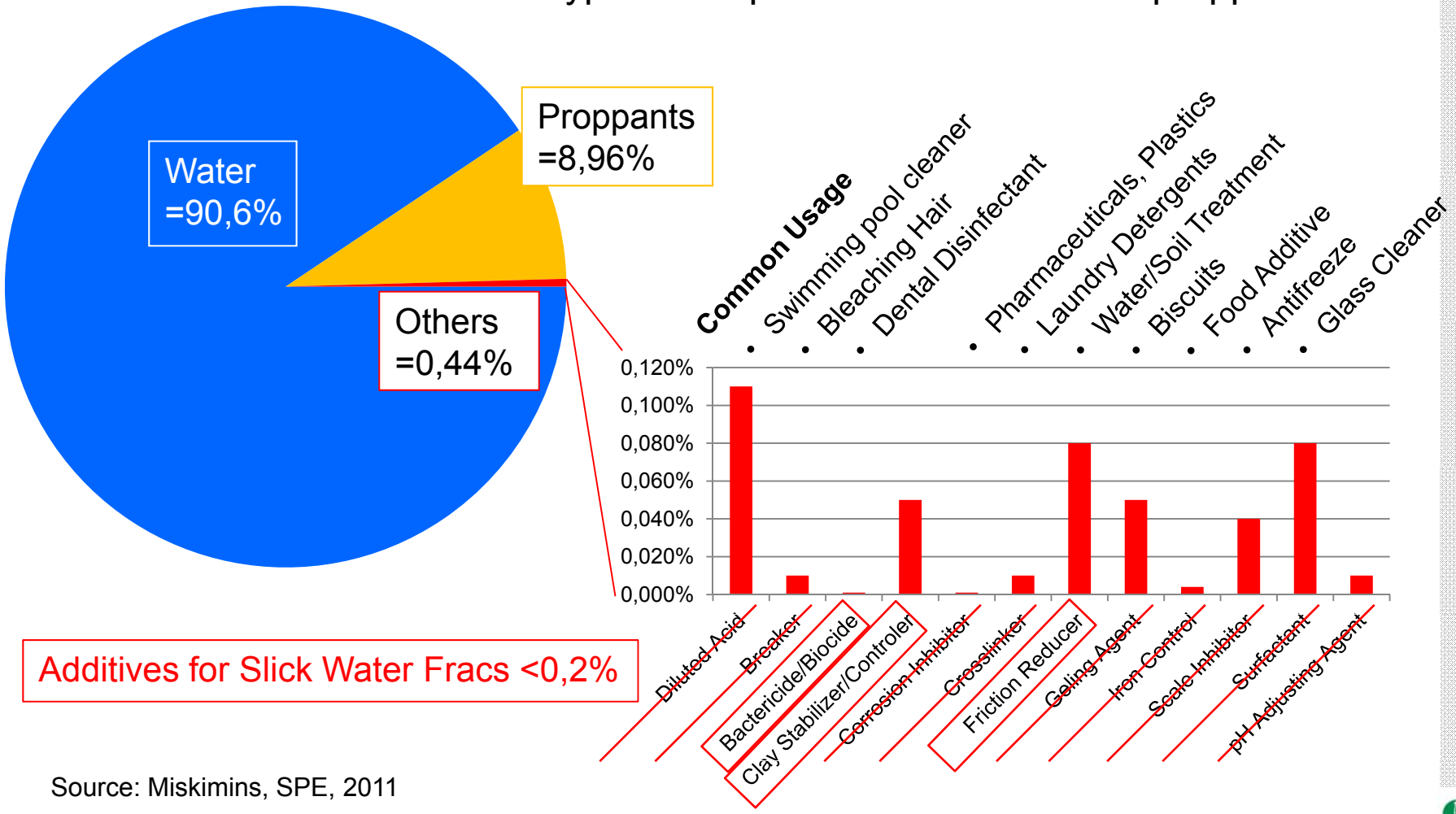
Typical composition of frac fluid for proppant frac



Source: Miskimins, SPE, 2011

ENVIRONMENTAL COMPATIBILITY: *FRAC FLUIDS*

Typical composition of frac fluid for proppant frac



Additives for Slick Water Fracs <0,2%

Source: Miskimins, SPE, 2011

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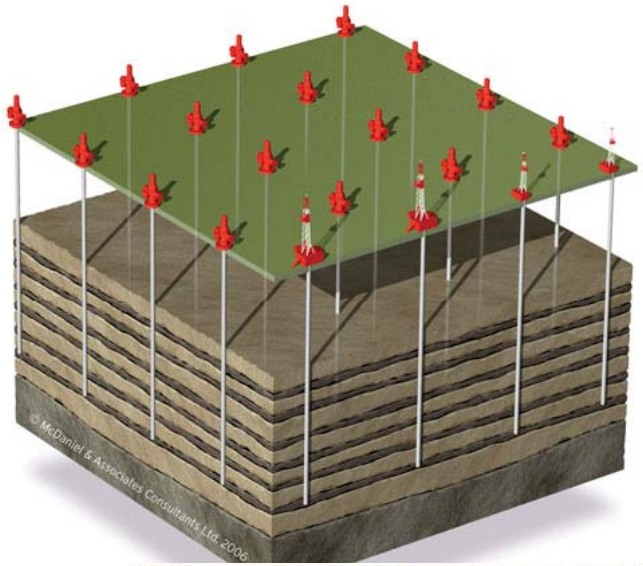
ENVIRONMENTAL COMPATIBILITY: *FOOT PRINT*



Cap rock

- Overburden must contain barriers to flow

Wells

- Well must provide a gas tight connection to the reservoir

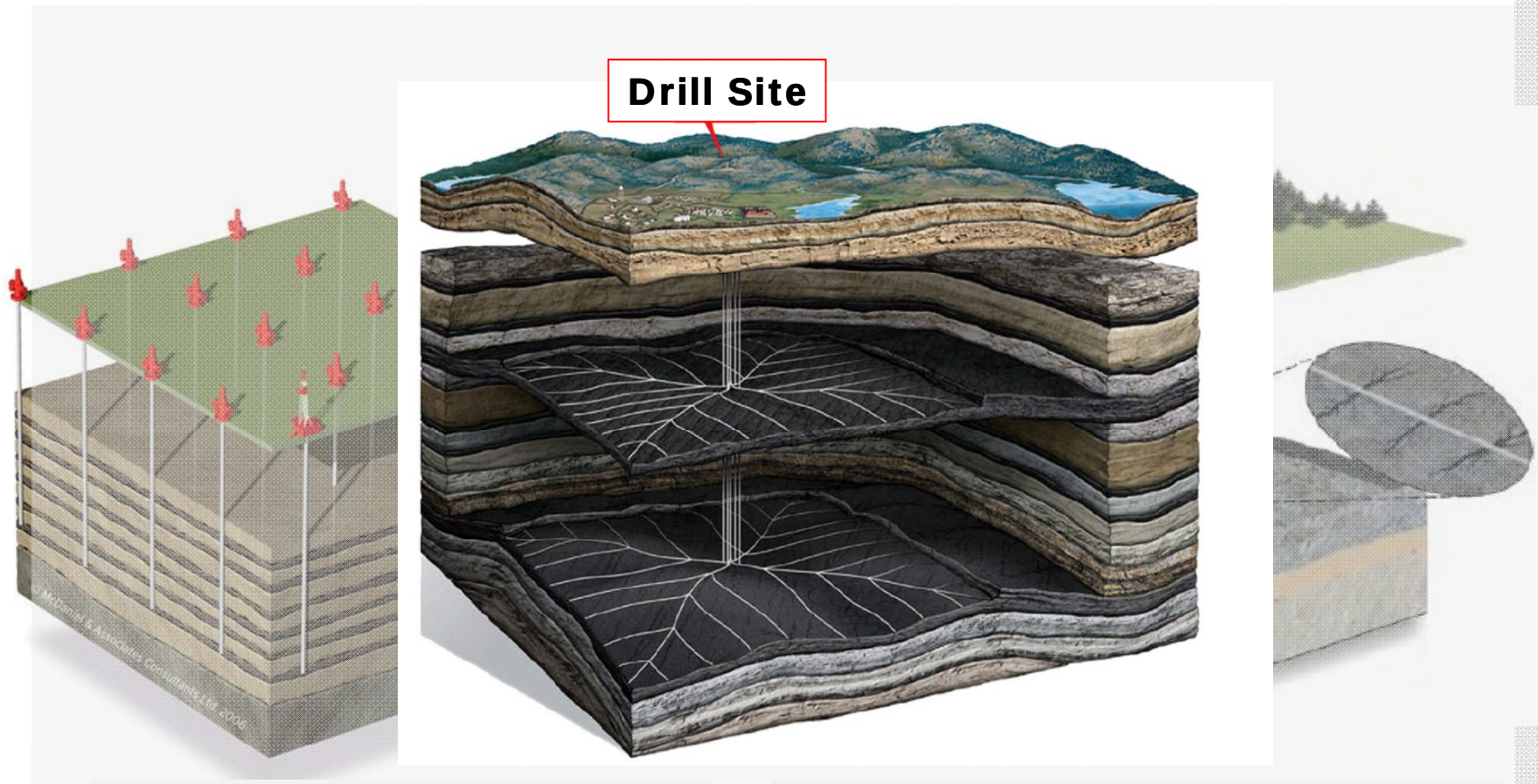
Fracs

- Fracs must be contained
- Frac fluids must be compatible with the respective environment

Foot Print

- Foot print must be reduced by innovative subsurface development

ENVIRONMENTAL COMPATIBILITY: *FOOT PRINT*



“Classical” Vertical Well Technology

“Multilateral Well- and Multifrac Technology”

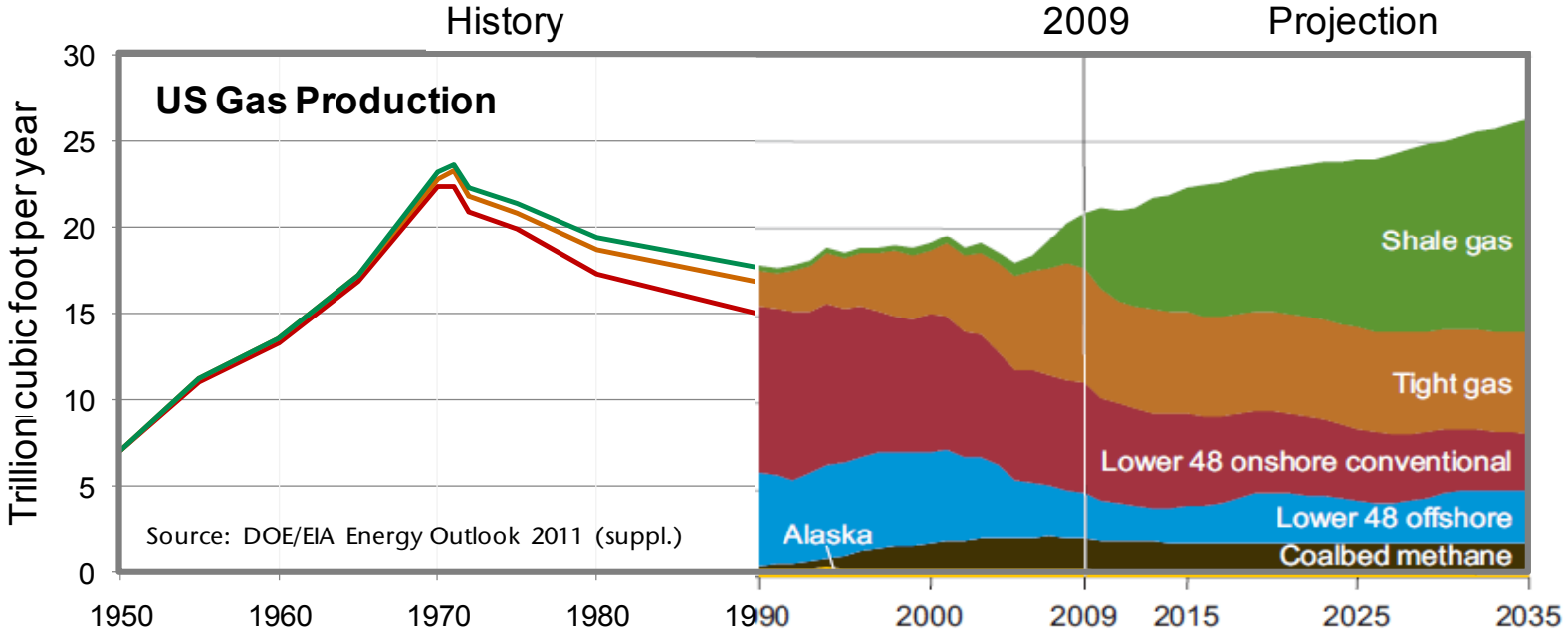
Canadian Association of Petroleum Producers, 2010

CONTENT: *Summary III*

- Target shale gas
  - Shale Gas is natural gas in rock formations with high resistance to flow
  - Targets are far below drinking water horizons in approx. 1.000 – 3.000 m
  - There are tight rock formations drinking water horizons and targets
  - The potential is larger than the currently known reserves
- Development
  - Wells are constructed to provide a tight connection to the reservoirs
  - “Fracking” is a tested and proven technology used since 60 years
  - Novel technologies provide a means to economically develop shale gas resources also in the EU
- **Environmental compatibility**
  - **Safe execution of wells and fracs to contain fracs fluids and gas**
  - **Further improvement of frac fluid compatibility**
  - **Innovative technology use to reduce foot print**

SHALE GAS POTENTIAL

- Current conventional gas reserves in Europe are less than 5.000 billion (10^9) m^3
- Shale gas resources in Europe are estimated to be larger than 15.000 billion (10^9) m^3
- Shale gas resource estimate equals 50-times the current European gas production



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Thank you
for your attention