

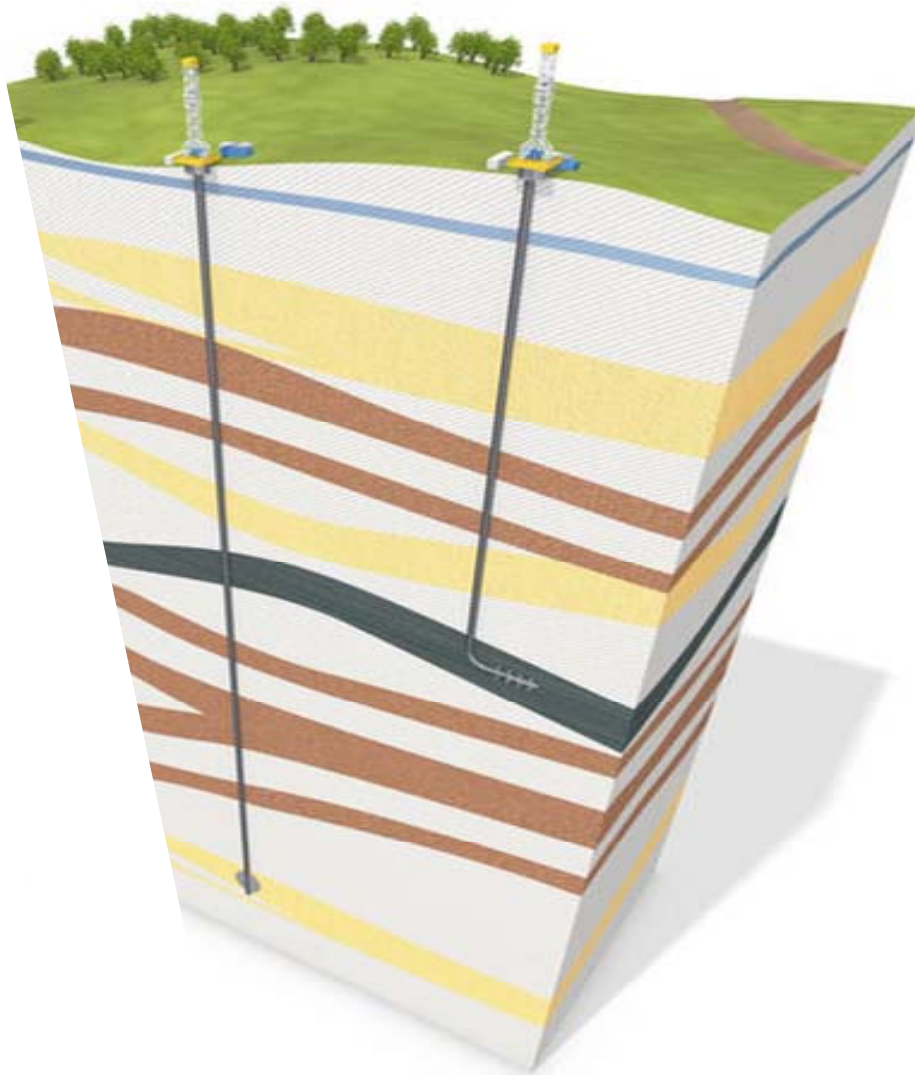


■ BASF Group

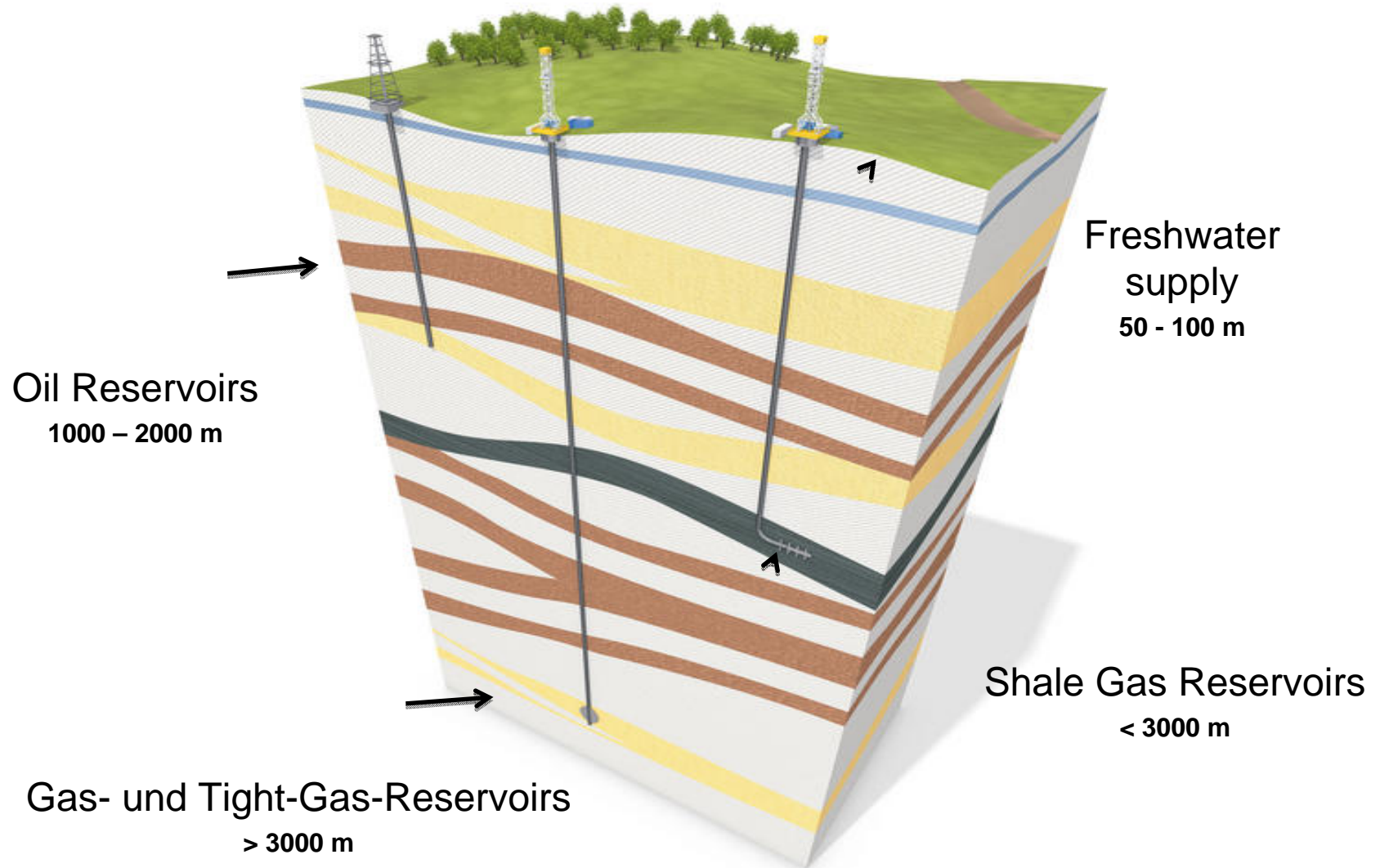
Hydraulic Fracturing

A well-tried technology in the public eye

Conventional Oil and Gas Reservoirs

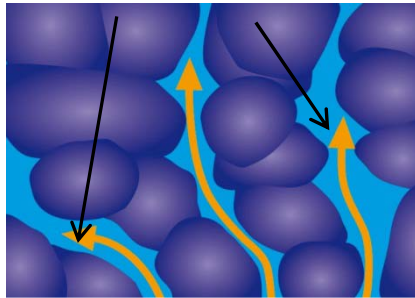


- Oil and gas not found in caverns or underground lakes as commonly believed.
- Oil and gas is found in the gaps between the grains in fluid bearing rocks. The most common reservoir rock is sandstone
- Oil and gas is formed in „source“ rocks and then migrates into the porous reservoir rock formations
- Conventional oil and gas reservoirs are always situated below an impermeable cap rock

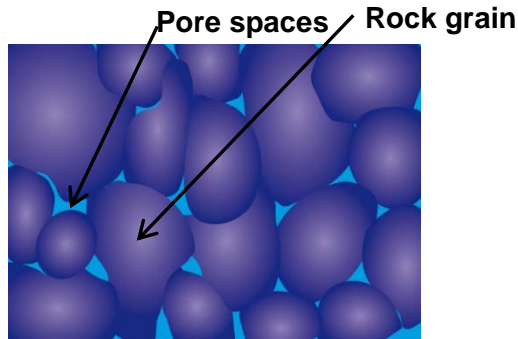


Different Reservoir Types

Connected pore spaces give rocks their permeability

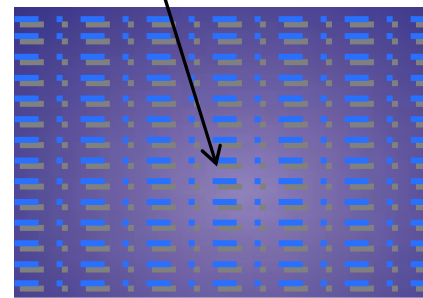


Conventional gas reservoir rocks



Tight Gas Reservoir rocks

Gas bound to the rock surfaces



Unconventional Gas Reservoirs

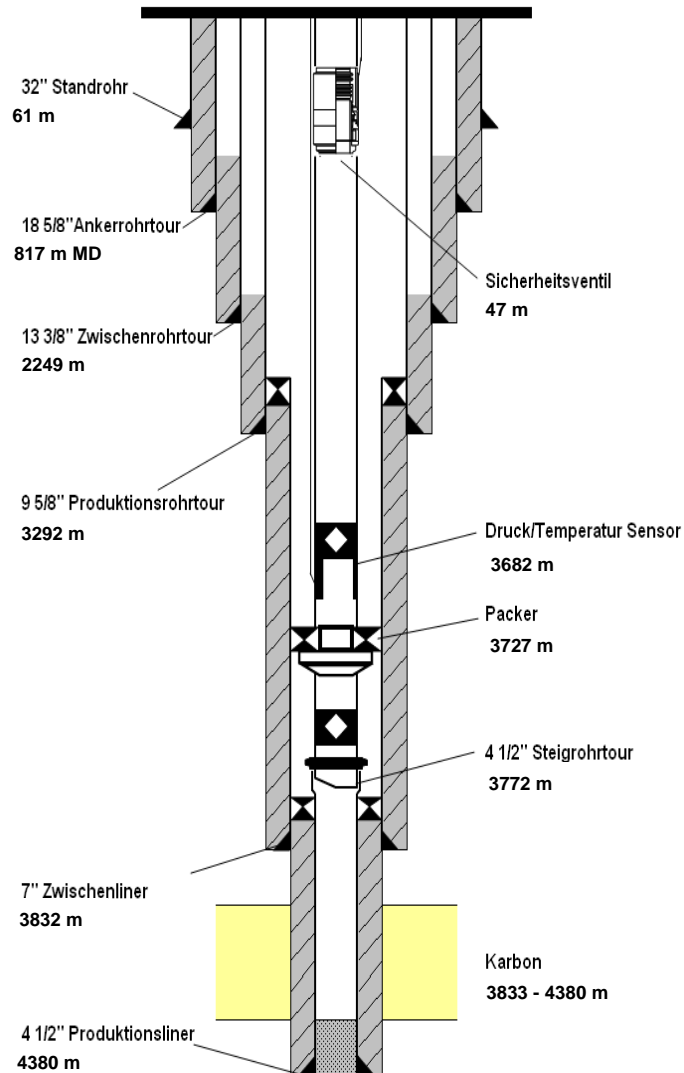
Gas from the source rock has migrated into the reservoir rock and is stored in the pore spaces.	
High permeability	Low permeability
Impermeable sealing cap-rock above rock structure	
3000 – 5000 m deep	
Economics production rates	Production rates uneconomic without fracking
60 years of production experience	30 years production experience

Gas molecules are bound to the surface of the source rocks
Virtually Impermeable
Cap rock not required
Over 2000m deep in Germany
No gas production without fracs
No production in Germany

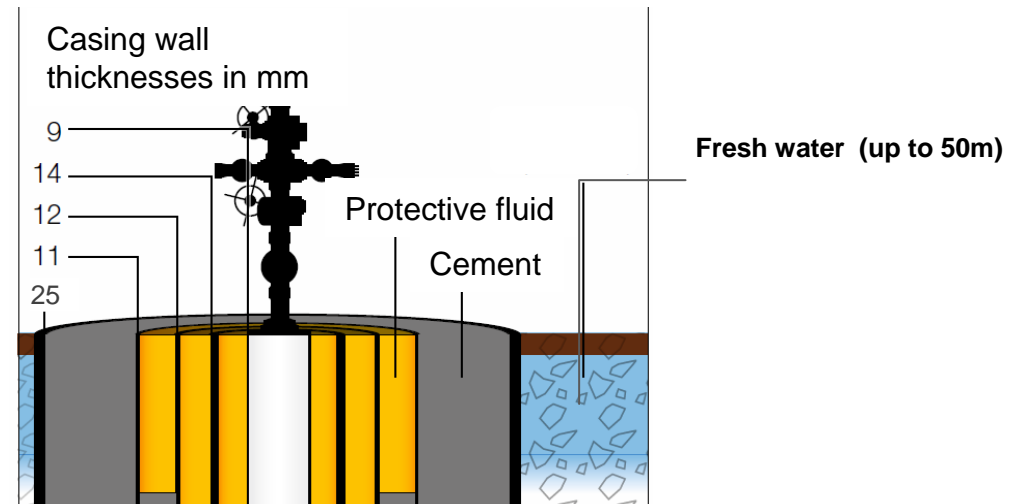
Safety Measures Well Design



Typical Well Design

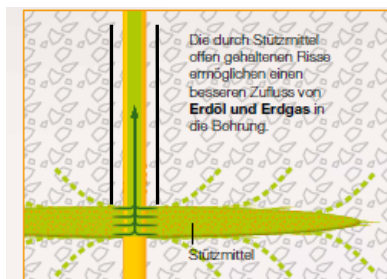
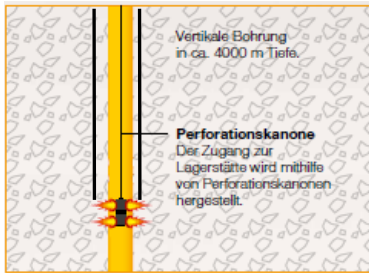


Casing scheme in drinking water depths



- Standpipe is hammered into the ground for freshwater protection
- Sealed system of steel pipes and cement
- All equipment has high safety margins
- Continuous proof of the well integrity through pressure monitoring

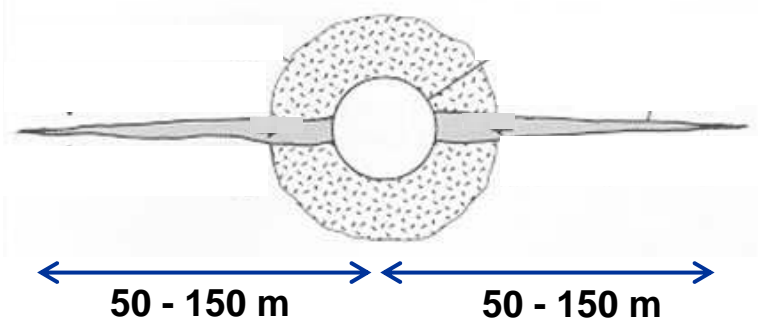
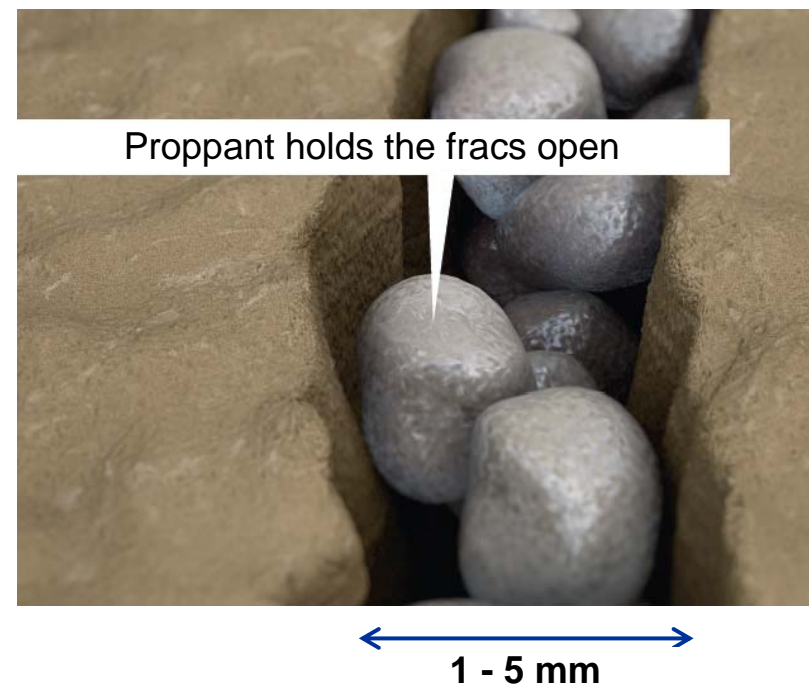
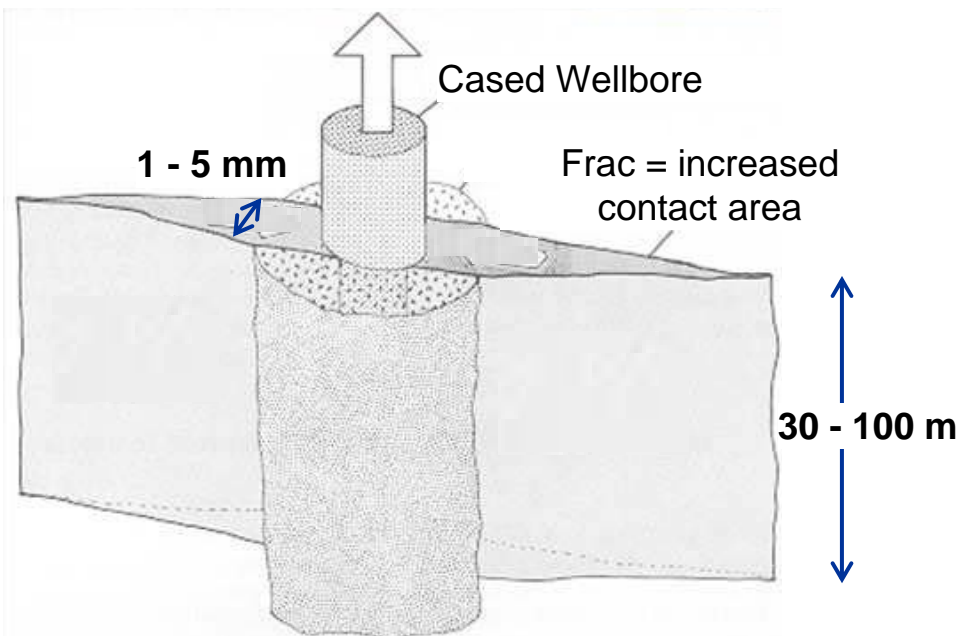
Hydraulic Fracturing – Well-ried Technologie



- Communication between the rock and the well bore is generated
- A water and sand mixture is pumped into the well at high pressure
- Thin (~5mm) fractures are created in the rocks in a controlled fashion. These fractures are filled with proppant (sand) to hold them open
- Production rates are improved by the increased rock surface area that is exposed to the wellbore

Hydraulic Fracturing

How big is a frac?

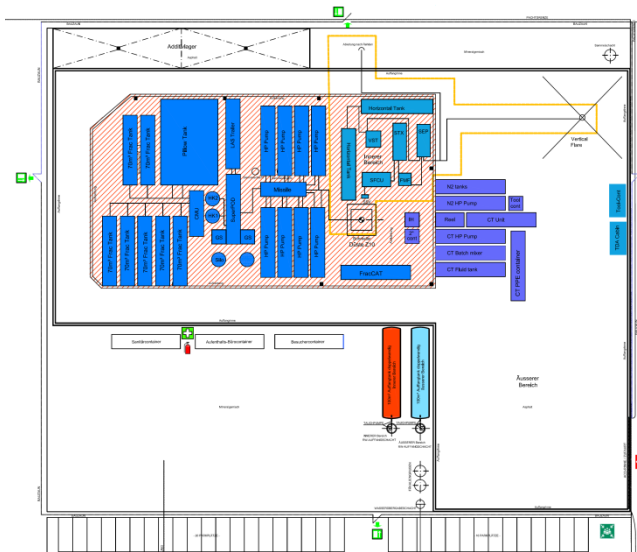


Material requirements per frac	Tight-Gas	Shale-Gas
Liquid	200 - 600 m ³	2000 - 4000 m ³
Proppant	50 - 150 t	0 - 150 t

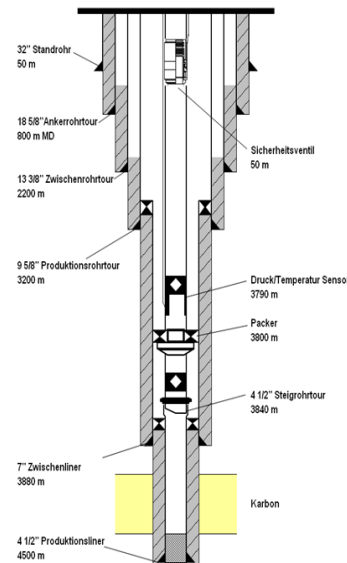
Tight Gas Projekt Düste Z 10 Grundwasserschutz



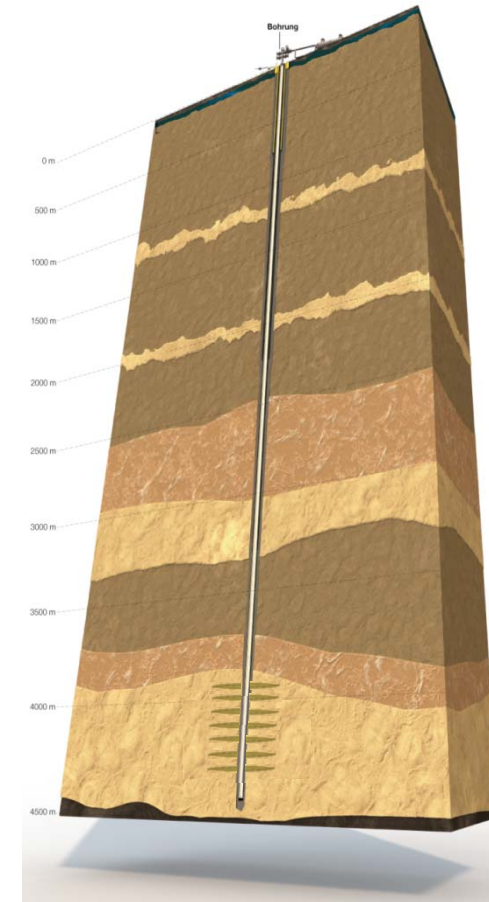
Wellsite with a sealed surface



Casing and Cementation



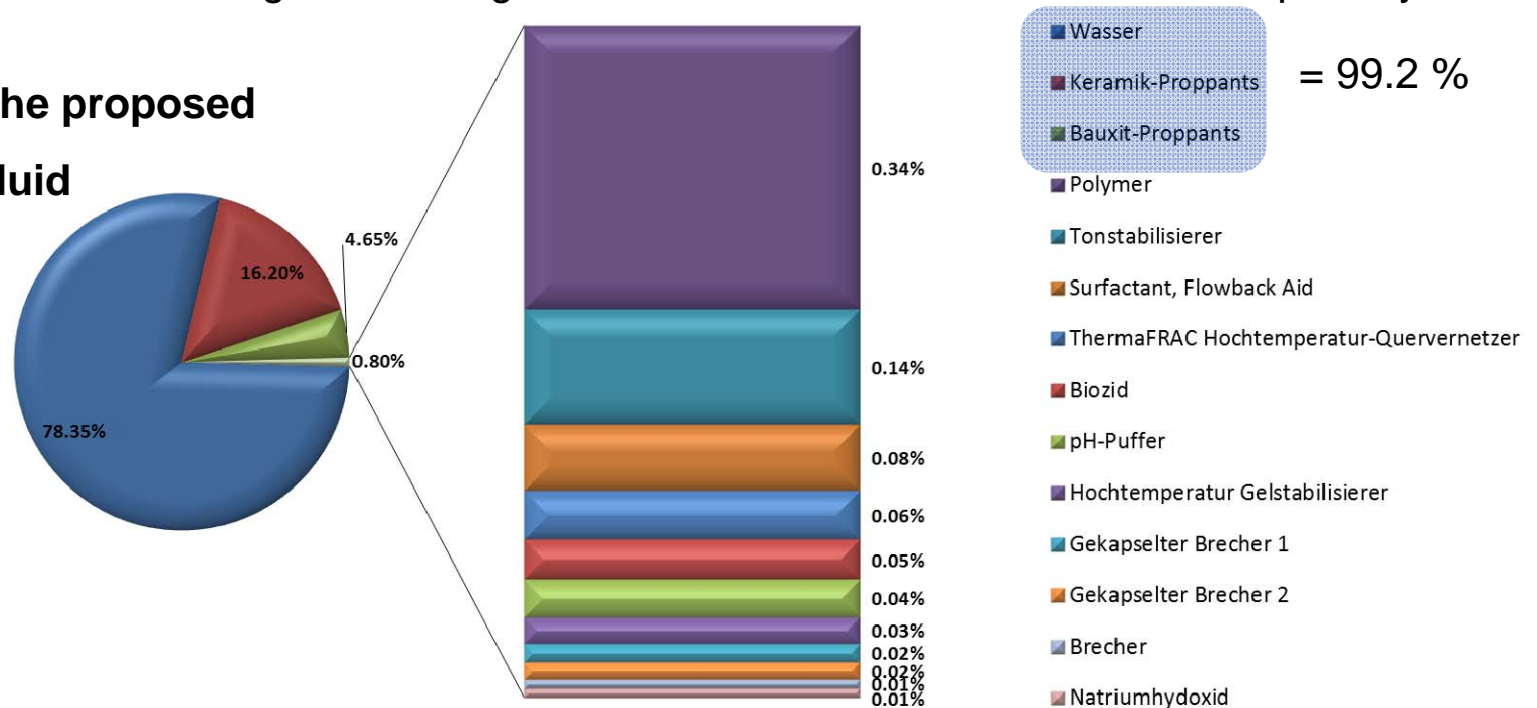
Geological Barriers



The components of fracking fluids

- 99.2% of frac fluids comprise of water and proppant. 0.8% is additives.
- Individual components are classed as being low level contaminants (**schwachwassergefährdend - WGK 1**) according to German law (VwVws). This also applies to the complete mixture
- The liquid is classed as being a non-dangerous mixture that does not need to be specially labelled

Composition of the proposed Düste Z-10 frac fluid



Additives in Fracing Fluids

None of the components have a water-protection level high than 1

#	Purpose	Additive	GHS	Conc.	Qty per frac	Also found in common products
1	Carrier Fluid	Water	-	78,35 %	563 t	-
2	Proppant	Aluminium Oxide, Mullite, Bauxite	-	20,85 %	150 t	Porcelain, roof tile manufacture, aluminium production
3	Gelling agent	Polysaccharide Derivative	-	0,34 %	2,4 t	Edible emulsifier (E 412)
4	Clay stabiliser	Choline Chloride	-	0,14 %	978 kg	In cattle liver up to 0,5%; Vitamin B
5	Lubricant	Polyethylen Glycol Monohexyl Ether	Xi	0,08 %	569 kg	In household detergents up to 5%
6	Cross-linking agent	Triethanolamin (126 kg)	-	0,06 %	422 kg	In cosmetics up to 2.5%
		Borax (30 kg) – 0,004% in Fracing liquid	T			Preservative in foodstuffs (E 285) up to 0,4%, in washing powder, in fireproofing materials for Cellulose-insulation up to 20%
		Zirkoniumdichloridoxide (30 kg)	C			Industrial Catalvsts

Additive in Frac Fluids

None of the components have a water-protection level higher than 1

#	Purpose	Additive	GHS	Conc.	Qty per frac	Also found in common products
7	Gel breaker	Ammoniumperoxodisulphate, Sodiumbromate	Xn, O	0,05 %	384 kg	In hair blonding agent up to 60%, hair perm fixing agent bis zu 15%
8	Preservatives	Ethylendioxydimethanol	Xn, O	0,05 %	342 kg	Disinfectant cleaners up to 20%
9	pH reducer	Sodiumhydrogen-carbonate	-	0,04 %	320 kg	Baking powder
10	Gel stabiliser	Sodiumthiosulfate-Pentahydrate	-	0,03 %	230 kg	Used in heated cushions and as antidote for poisoning up to 25%
11	pH-regulation	Sodiumhydroxide	C	0,01 %	77 kg	Used in the food industry to control acidity(E 524), in drain cleaner up to 30%

Hydraulic Fracturing Fracking in Germany since 1958

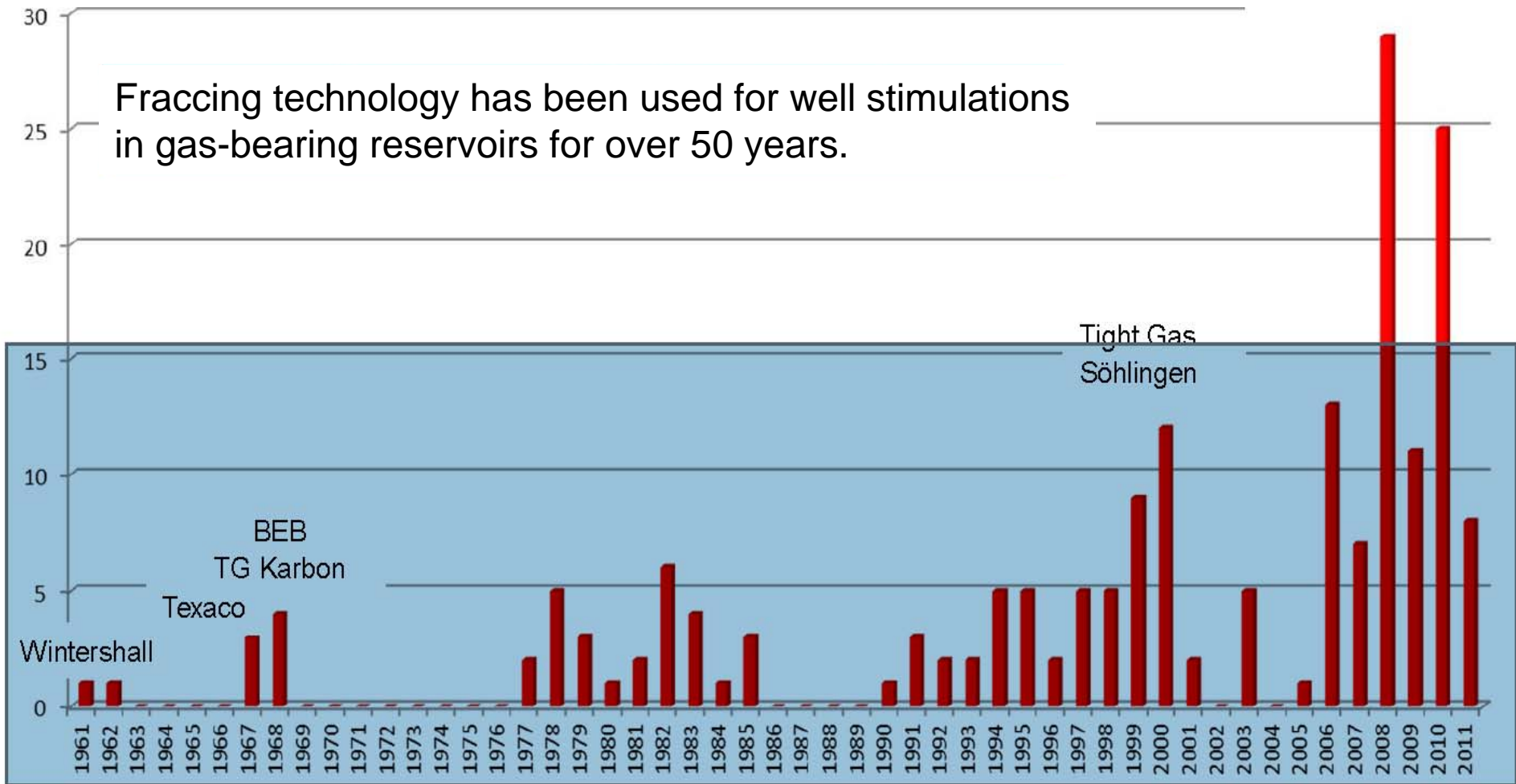


Source: RWE Dea

Fracs in Germany



Fracking technology has been used for well stimulations in gas-bearing reservoirs for over 50 years.



Over 50 years experience

Modern Tight-Gas Frac in Germany

