Challenges and Solutions in Drilling Fluid Technology for Gas Exploration, Production and Field Development

Dr. József Dormán

MOL Hungarian Oil and Gas Plc.

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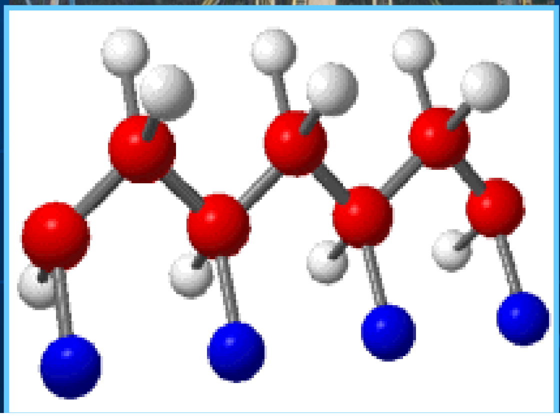
Outline


- ❑ The tasks
- ❑ Key issues in fluid technology
- ❑ Shallow gas operations
- ❑ Deep gas operations
- ❑ Field experience, results
- ❑ Summary and conclusions

The tasks

- ❑ Advanced DF/RDF technologies, excellent technical performance and operational flexibility
- ❑ Optimizing productivity
- ❑ Maximized formation damage control (in a complex manner)
- ❑ Design and engineering
- ❑ Need for continuous learning and development
- ❑ Environmental issues

The key issues

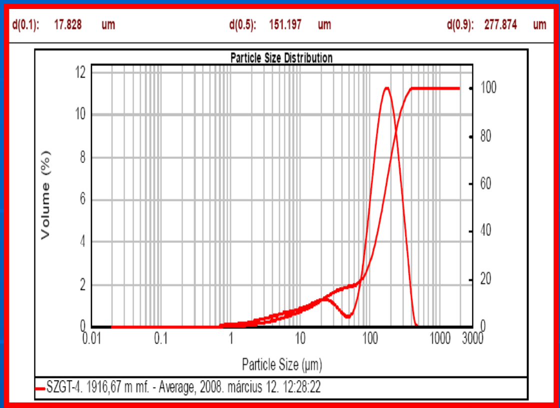


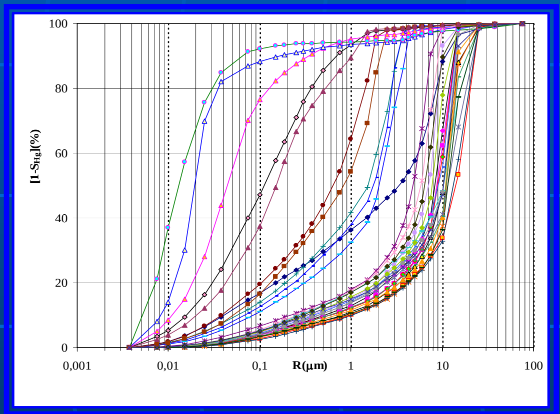
- ❑ Borehole stability and cuttings integrity (shale/clay inhibition)
- ❑ Optimized rheology, hydraulics (hole cleaning, ECD, Swab/Surge)
- ❑ Minimizing solid/fluid invasion
- ❑ Optimum fluid chemistry, stabilization of clays/fines
- ❑ High temperature stability, operational flexibility
- ❑ Minimum environmental impact

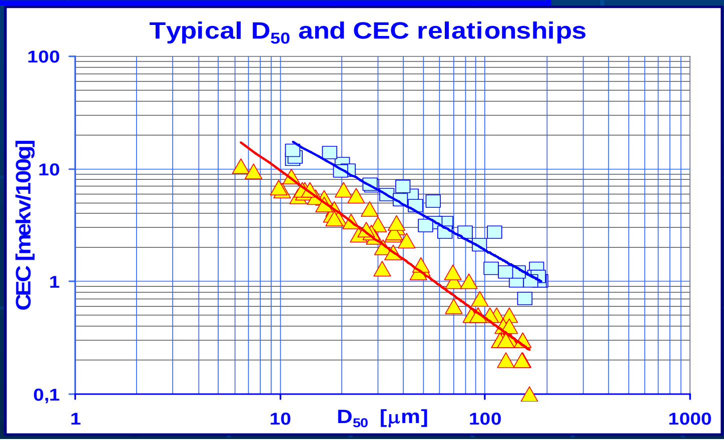
Shallow gas operations

- ❑ High-to-low permeability, shaly sandstones
- ❑ Heterogeneity, fresh-water sensitivity, underconsolidation
- ❑ Development of RDIFs, based on formation characterization and tailored fluid chemistry
- ❑ Maximized formation damage control (in a complex manner)
- ❑ Environmental issues

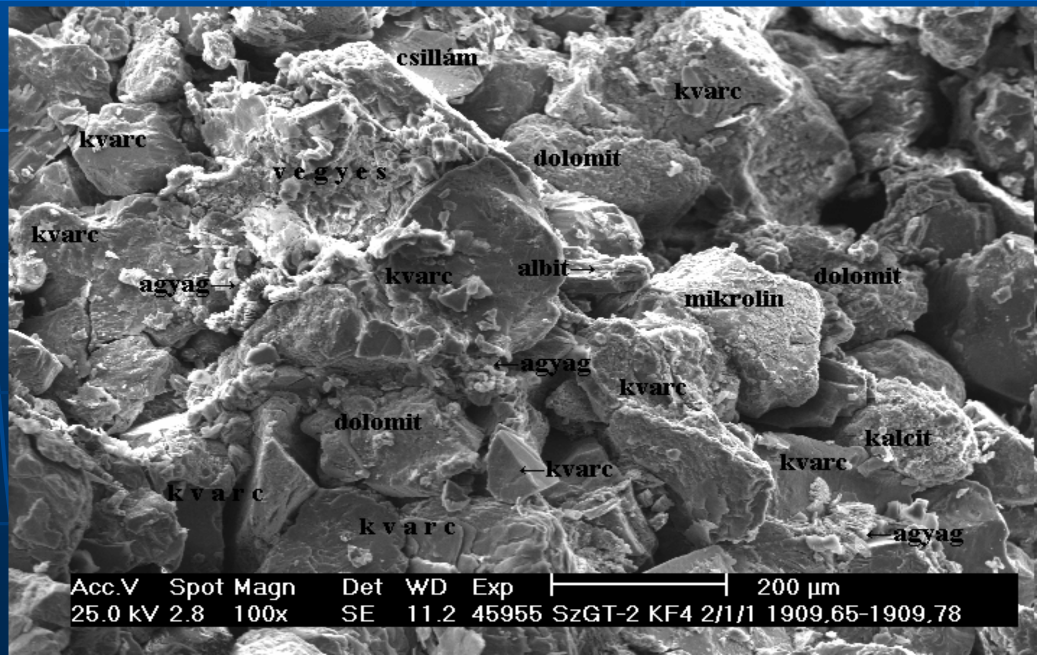
Formation characterization



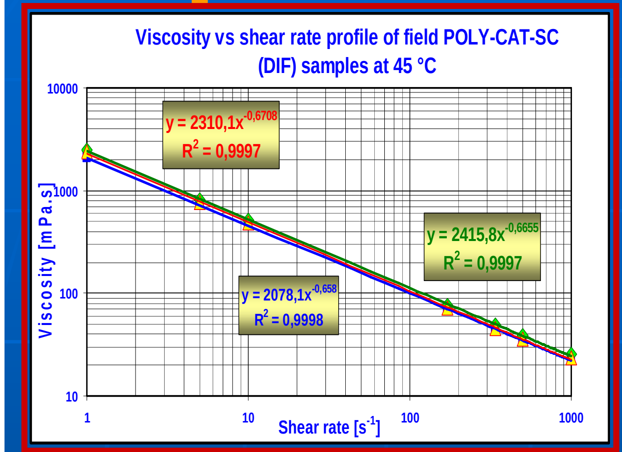


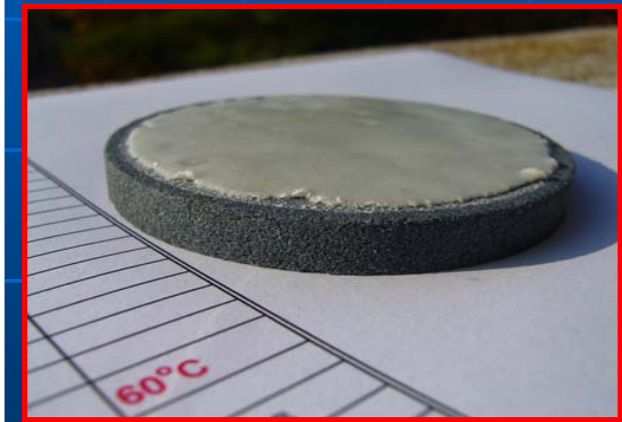


- Particle and pore size distribution
- Permeability, mineralogy (XRD), morphology (SEM)
- Clay content (CEC), core flow (clay stabilization) tests



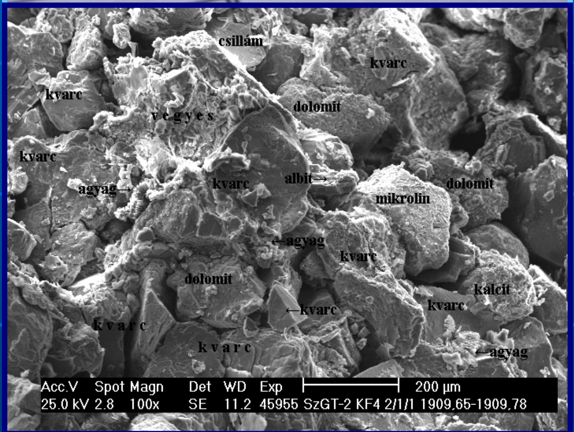
Optimized RDIF properties





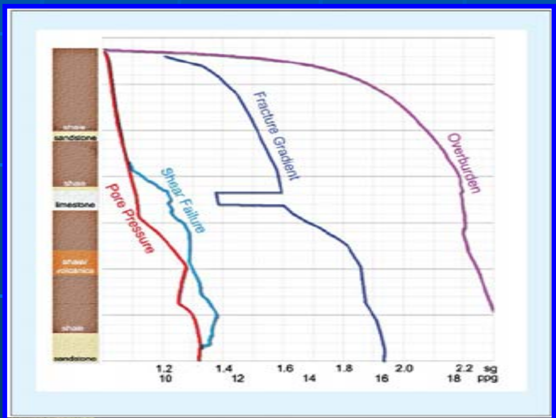
- ❑ **Optimized combination of selected polymers to optimize rheology and to minimize fluid loss**
- ❑ **Bridging agents (salt, marble, limestone) of optimized PSD (fit to pore size distribution)**
- ❑ **Cationic polymers, clay stabilization**
- ❑ **Optimization using advanced testing techniques (ceramic and synthetic sand discs, core samples)**
- ❑ **Support/feedback by quite a lot field and lab measurements**

Formation damage control



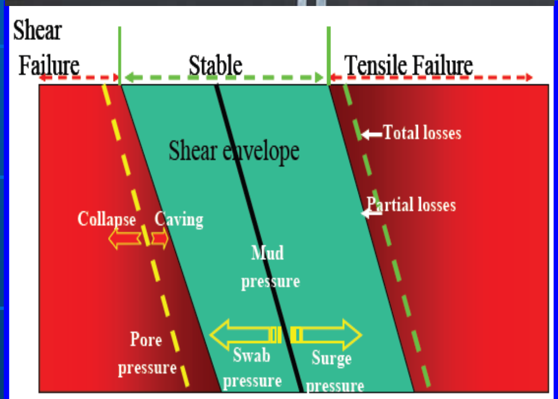
- ❑ **Optimized, clean fluid (RDIF)**
- ❑ **Efficient bridging, low invasion**
- ❑ **Controlled non-soluble (drilled) solids content (< 40 kg/m3)**
- ❑ **Designed fluid/filtrate chemistry (based on complex studies)**
- ❑ **Using the same fluid chemistry for each fluid sequence**
- ❑ **Tailored filter cake removal, acid compositions (SC), oxidizers (SS)**
- ❑ **Mild acid and delayed oxidizer (build up into the filter cake)**

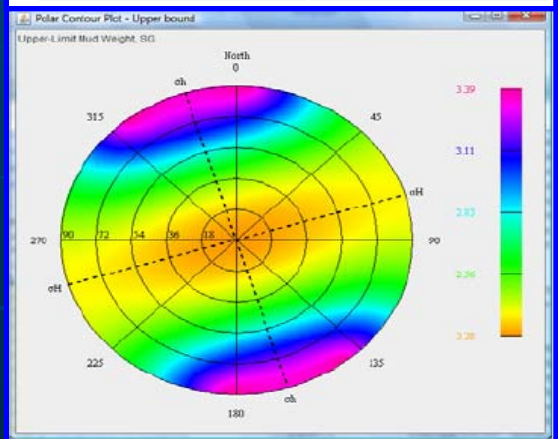
Deep gas operations



- ❑ High-to-ultra-high temperature (160 – 220 °C+)
- ❑ Drilling of long shale sections
- ❑ High pore pressure intervals (1800 – 2300 kg/m^3)
- ❑ Narrow operating window
- ❑ Complex geology, mineralogy, low permeability
- ❑ Environmental issues

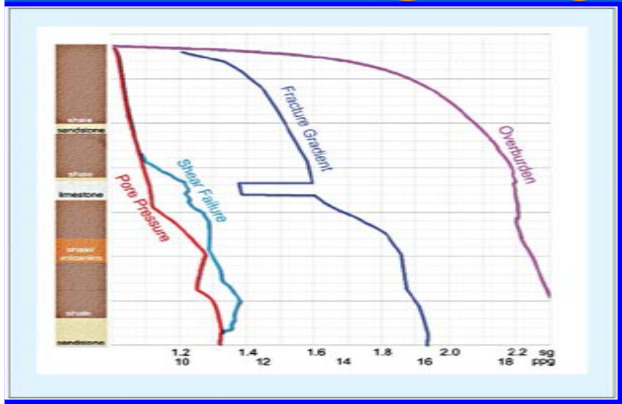
Advanced planning



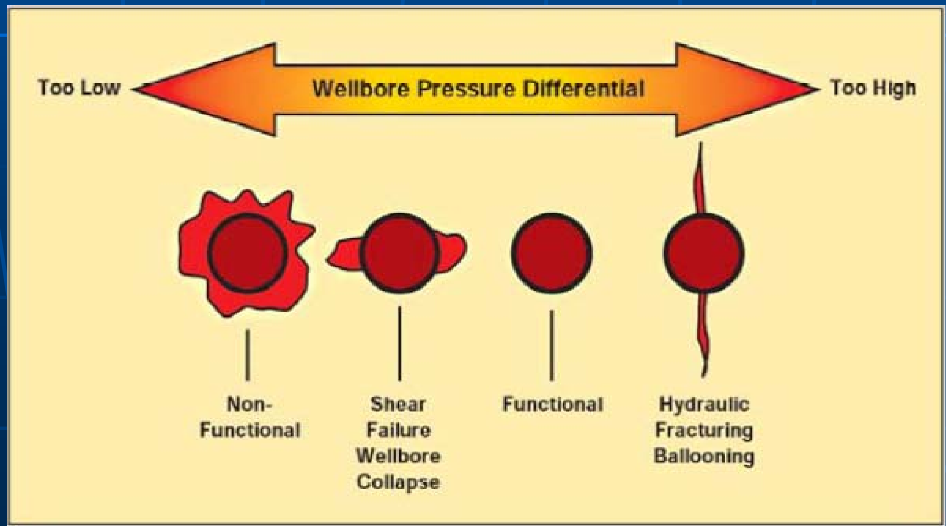


- ❑ Use all the informations we have ever learnt
- ❑ Consider the technology gap at U-HTHP conditions
- ❑ The need for detailed geo-mechanical analysis
- ❑ Continuous technology development (at leading edge)
- ❑ Maximized performance and formation damage control
- ❑ Minimum risks, environmental impact

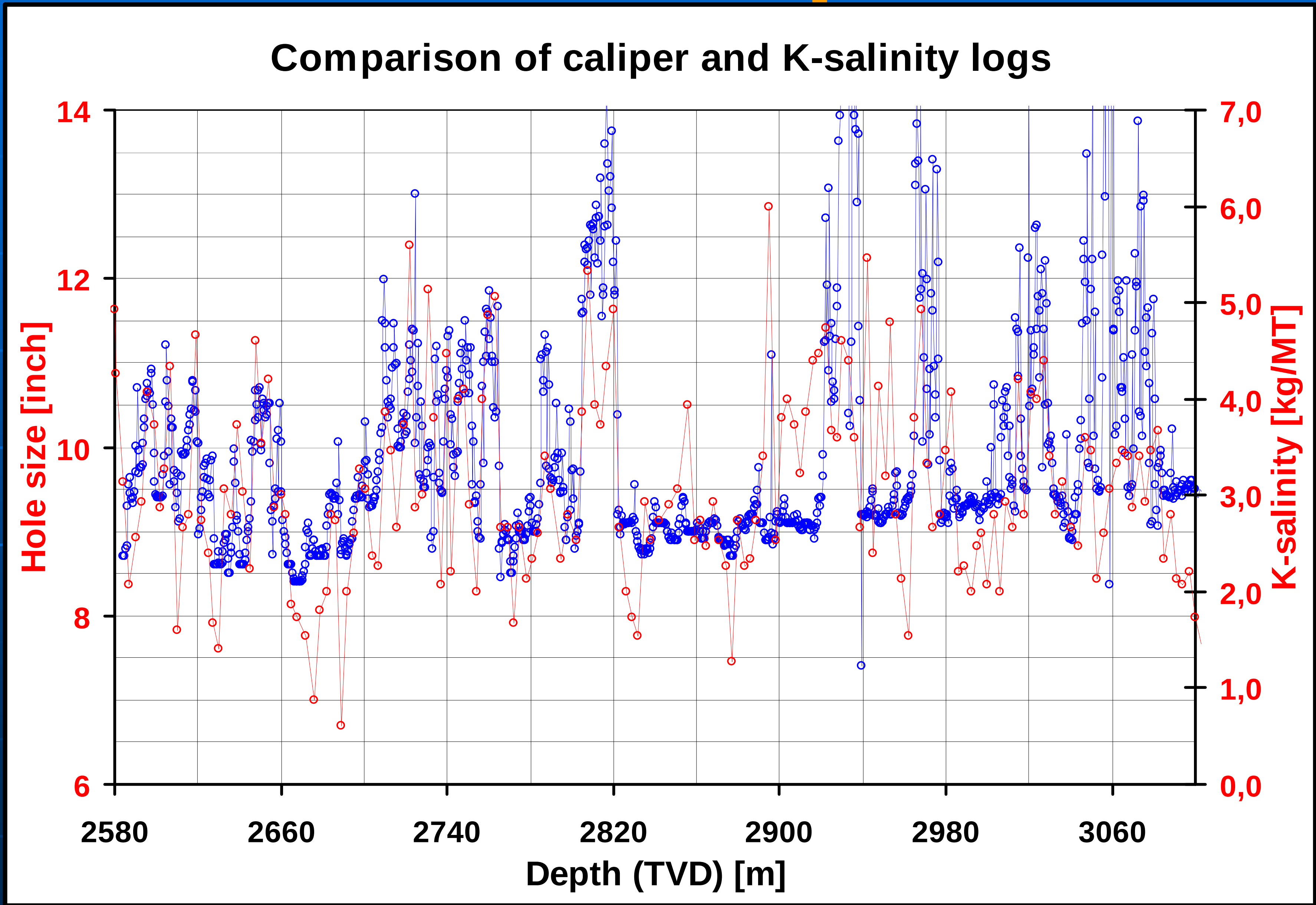
Wellbore shear failure



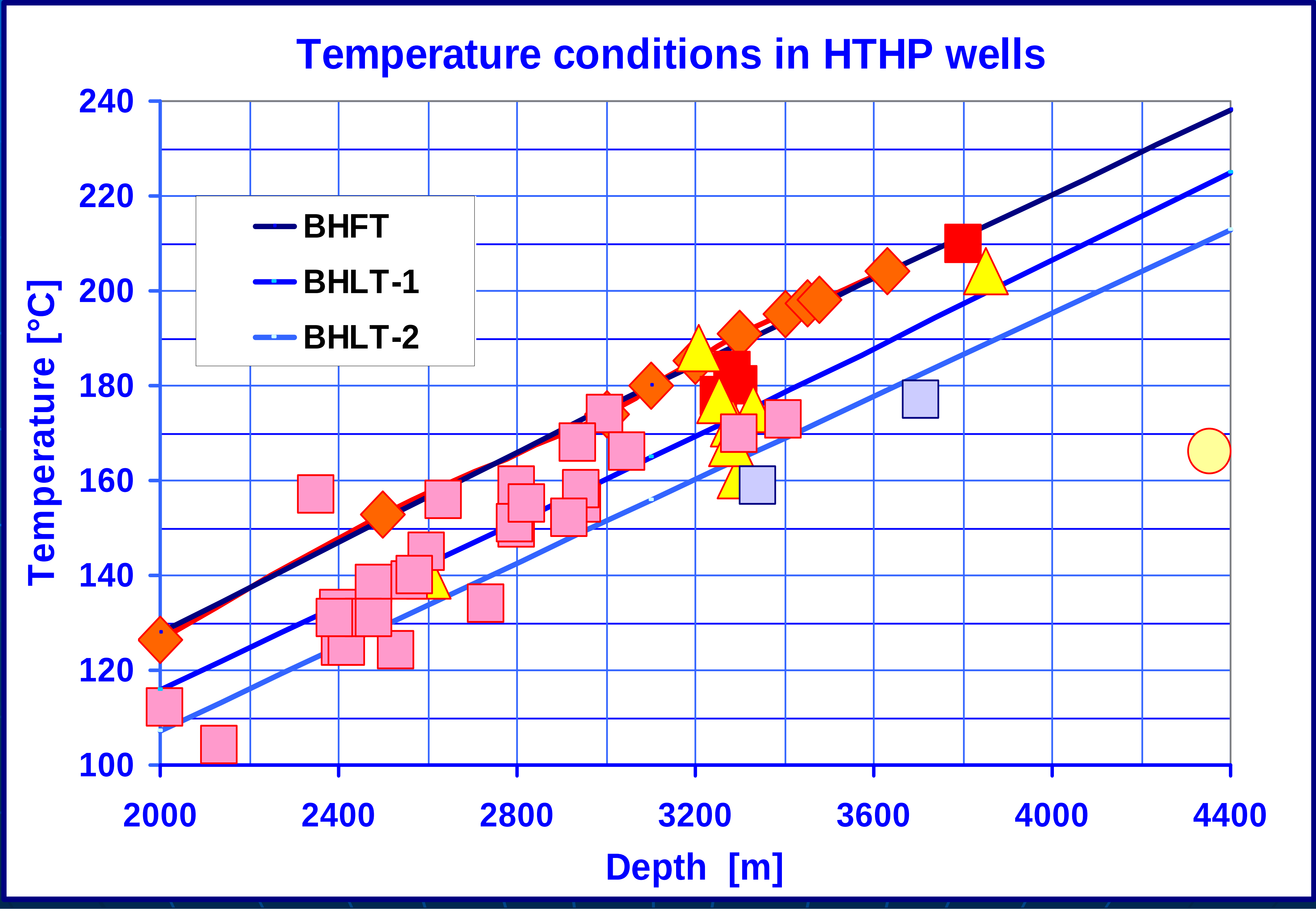
- ❑ **Underbalanced conditions can lead to wellbore shear failure**
- ❑ **Overbalanced conditions can lead to wellbore tensile failure**
- ❑ **Narrow operating window, low**
- ❑ **ECD, hydraulic simulation**



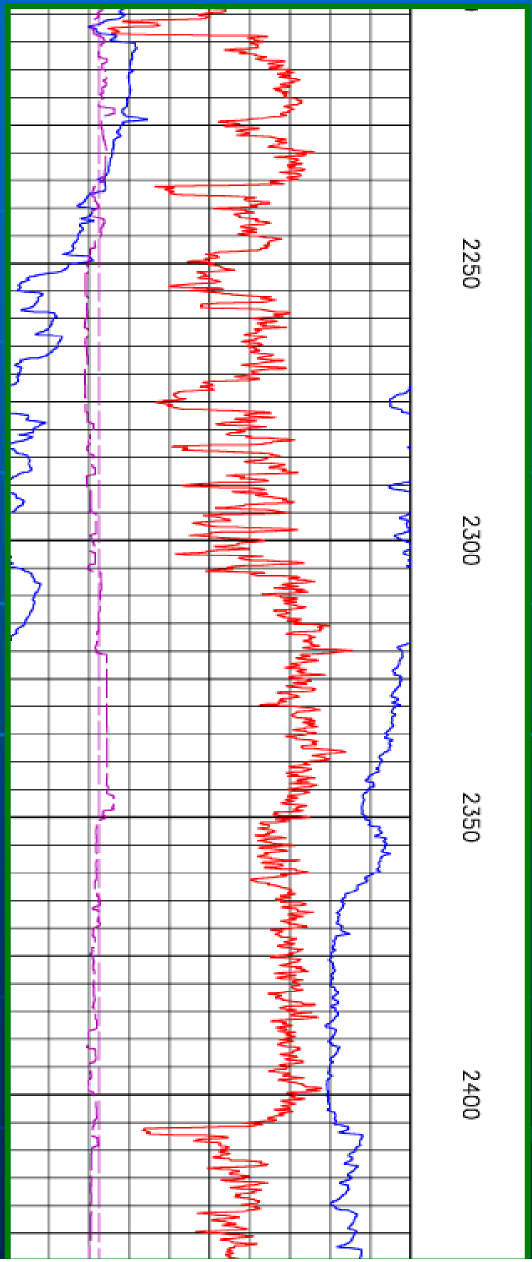
The role of overpressure



Temperature conditions



HTHP Drilling Fluids



- „Single" fluid type (Ca-based)
- Improved shale inhibition (< 5% borehole enlargement)
- Improved temperature stability (field proven at 200 °C+)
- Good solids tolerance, flexibility, high density (2300 kg/m³+), low ECD
- Good tolerance against contaminants (acid gases, salt, etc.)

WBM aged at 215 °C

Composition	Base	20 % dilution (treatment)	20 % dilution (treatment)	30 % dilution (treatment)	30 % dilution (treatment)	30 % dilution (treatment)
Properties	After aging	After aging	+ 96 hrs aging	After aging	+ 24 hrs aging	+ 96 hrs aging
Fann readings						
600	152	65	67	54	56	66
300	115	39	43	30	31	41
200	96	29	34	23	23	32
100	78	19	23	14	14	22
6	54	6	9	2	1,5	8
3	54	4	8	1	1	7
Gel 10” [Pa]	32,19	1,53	2,55	0,51	0,51	1,79
Gel 10’ [Pa]	-	29,13	12,77	11,75	9,71	10,22
pH [-]	9,50	9,98	10,07	9,92	9,91	10,06
Filtrate[cm^3]	5,2	-	5,0	-	-	4,5

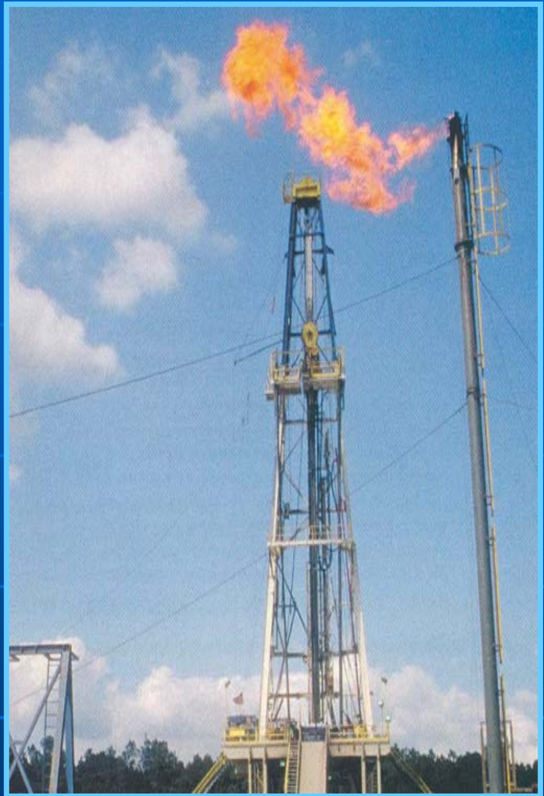
Future technical issues

- Further development and optimization of filter cake removal technologies
- Further development and optimization of shale/clay/fines stabilization techniques and chemistry
- Filtration studies of HTHP fluids (shale pore plugging approach)
- Advanced geo-mechanical studies and wellbore pressure prediction
- Overlapping the technology gap (considering extreme temperatures)
- Better planning, cooperation

Fluid Engineer – The key of success

- Responsible to prepare and maintain clean fluid and clean circulating system (while working in harsh conditions)
- Testing, controlling, monitoring, sampling, reporting, documenting
- Feedback, learning
- Special training

Summary and Conclusions



- More than 60 shallow gas wells were drilled and completed successfully in the last 2 years
- Wells have shown expected production rate
- Drilling and completion of deep gas wells have created several operational challenges and being successfully solved by advanced engineering approaches
- Continuous fluid technology and planning methodology developments are required based on optimization issues (shallow gas) and considering technology gap issues (deep gas)

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Thank you for your kind attention!