KMS Technologies – KJT Enterprises Inc.

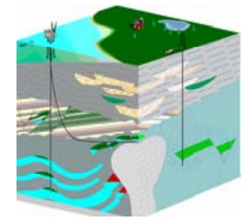
Presentation

Mirotchnik, K., Kryuchkov, S., Strack, K. – M.

2004

A novel method to determine NMR petrophysical parameters from drill cuttings

Transaction of the Society of Petrophysicists and Well Log Analysts, Annual Symposium, 45, MM



A novel method to determine NMR petrophysical parameters from drill cuttings

SPWLA 2004, The Netherlands

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NMR parms from cuttings

- Motivation
- Determining cutting size
- Estimating porosity
- Estimating permeabilities
- Summary & outlook

Outline

- **Motivation**
- Determining cutting size
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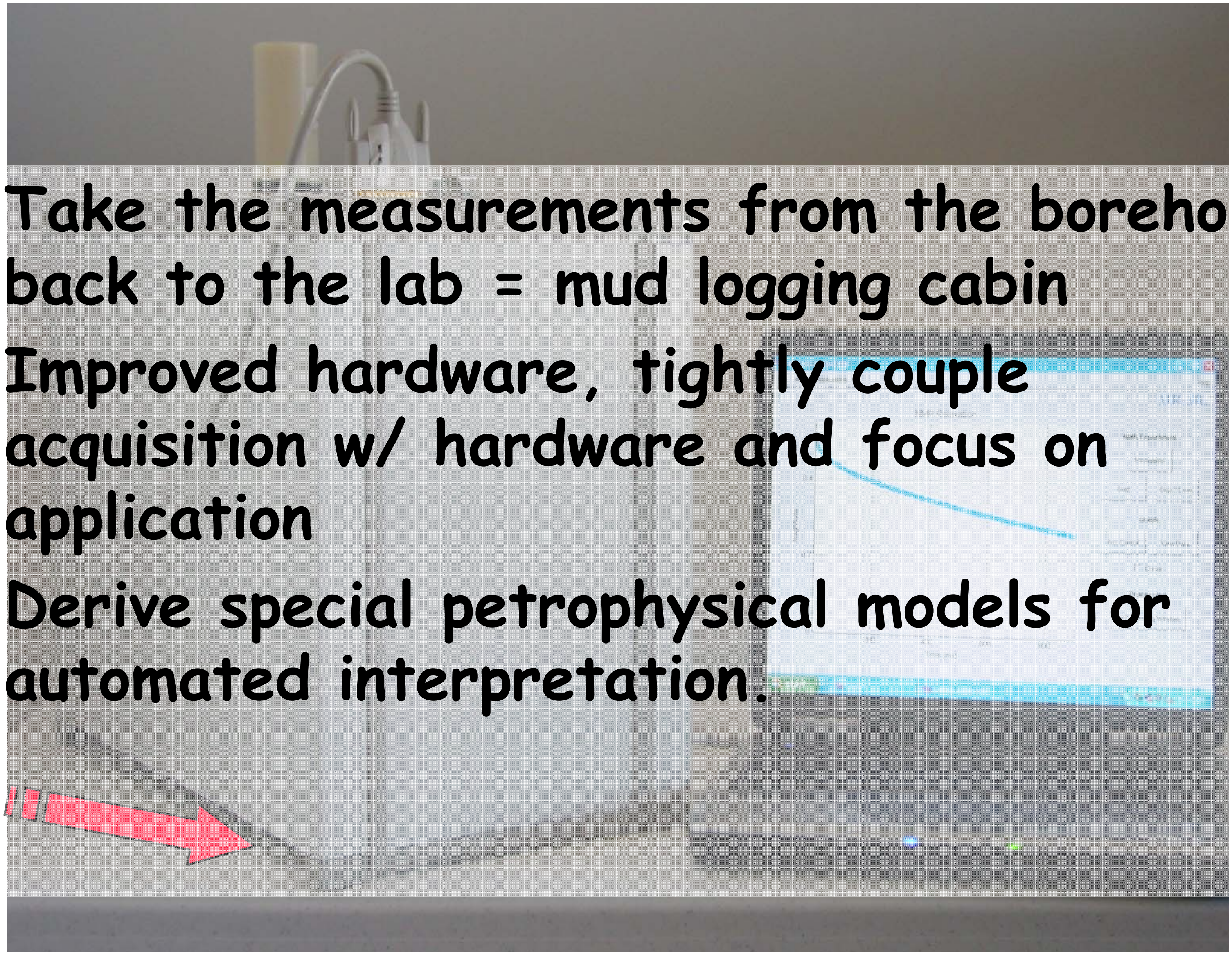
NMR measurements

- Have become a great contribution to medical science
- Allow petrophysical parameter derivations:
  - Logs (WL and LWD)
  - Cores
- Why not extend to low cost environments?

The trick in this presentation…



- Take the measurements from the borehole back to the lab = mud logging cabin
- Improved hardware, tightly couple acquisition w/ hardware and focus on application
- Derive special petrophysical models for automated interpretation.

NMR parameter from cores vs cuttings

Cores pro:

- Accurate NMR parameter estimation
- Work done in laboratory under controlled condition

Cores con:

- Characterizes only selected part of well
- Characterization after drilling
- Turn around time
- Cost

Why NMR parameters from drill cuttings?

<u>In the past:</u>

- Small particles of cuttings – small signal – impossible to separate signal from noise
- Sample preparation took too much time for well site applications

<u>Suggested solution:</u>

- New tool has high signal-to-noise ratio >200
- Optimized workflows include preparation, measurement and interpretation procedures.
- Reduce turn-around time
- Reduce cost

Technology development process

- Market evaluation
- Feasibility study w/ cutting from 1 to 6.35 mm
- Pilot experiments with solid samples and synthetic cuttings
- Pilot measurements (Canada, Russia, US and China)

Results:

- Automated process integrated into one instrument

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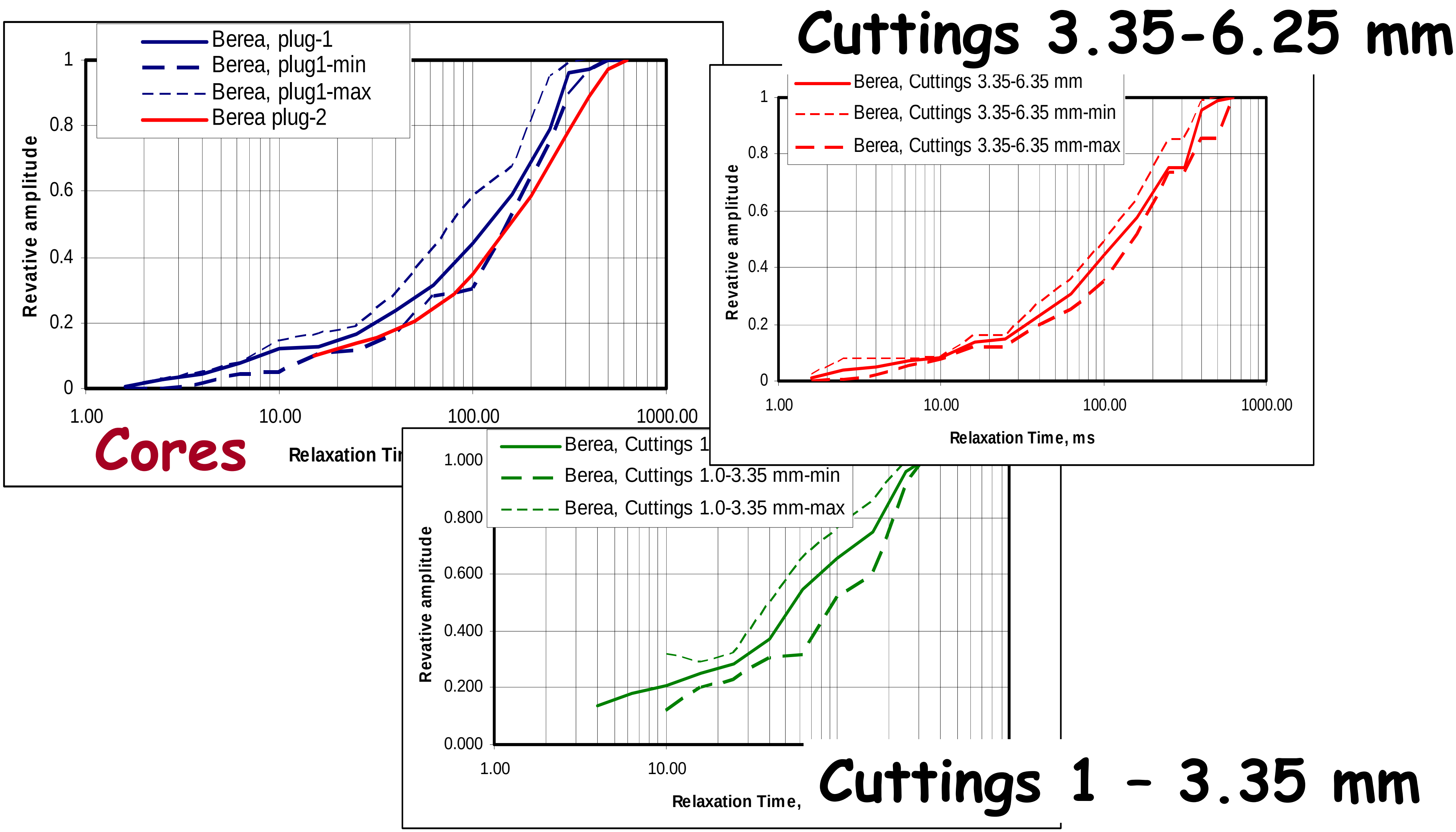
Process to find cutting size range

1. Obtain known rock samples
2. Plugs: determine total porosity, permeability and Swirr with direct methods.
3. Measure NMR parameters (Sw=100%)
4. Use similar samples for synthetic cuttings
5. Measure NMR parameters (Sw=100%)
6. Compare plug & cuttings results
7. Also group by filtration radius & grain size

Cumulative relaxation time
Berea SS (cores & cuttings).



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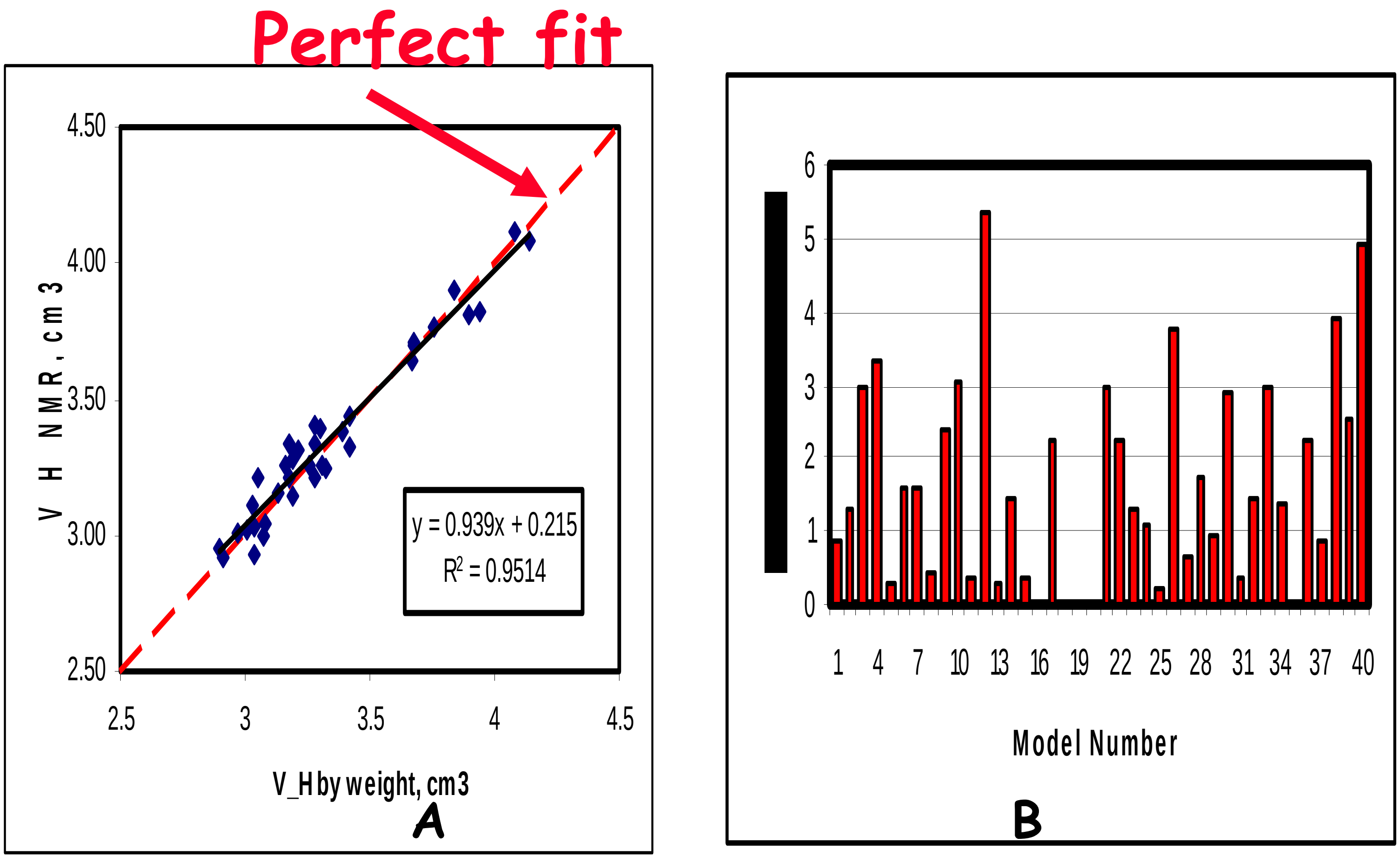
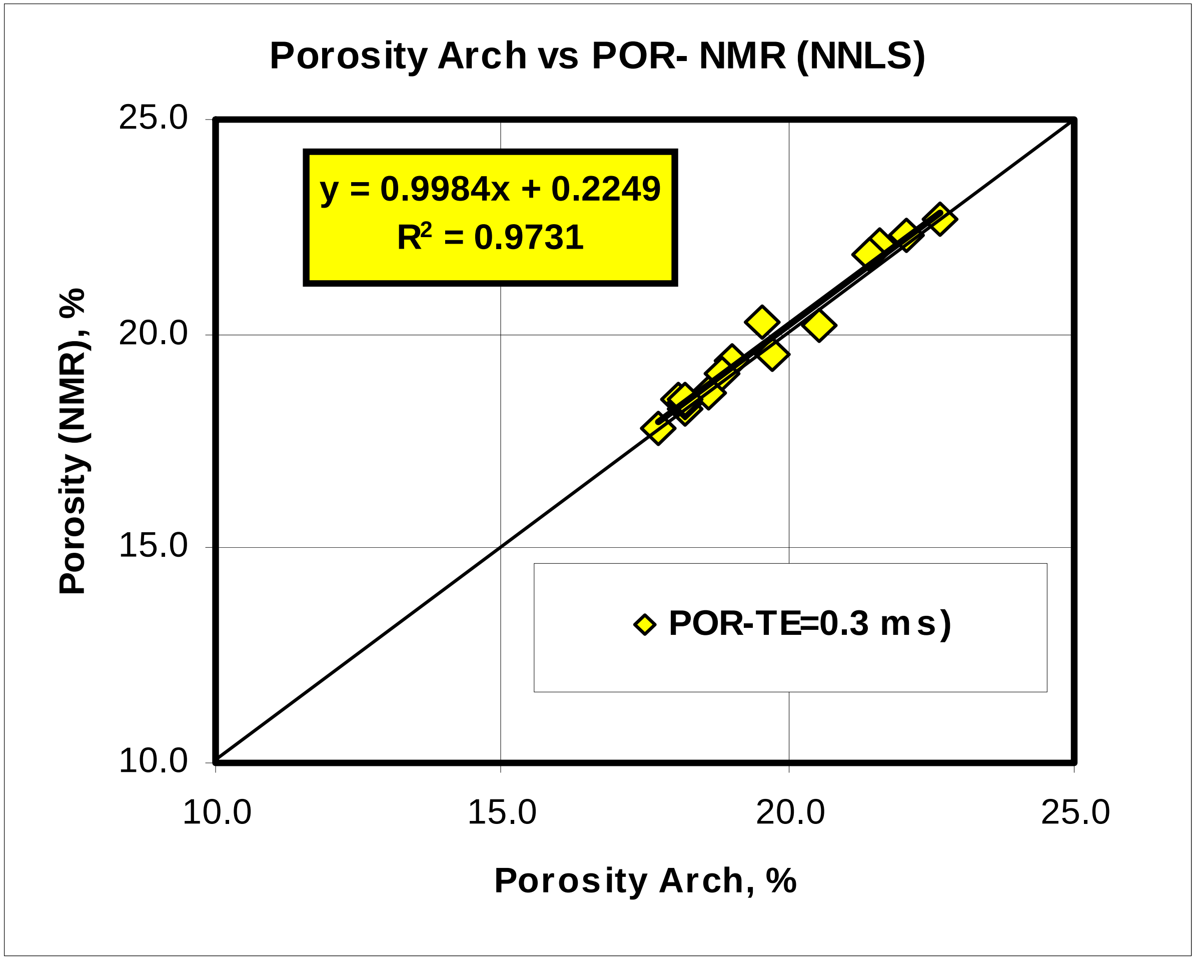
Porosity determination

- Most critical parameter is volume determination
- Determine hydrogen volume from weight/porosity measurements
- Compare with NMR measurements
- Repeat for light & heavy oil saturations

Hydrogen volume: weight versus NMR



Porosity by Archimedes vs. NMR Porosity.



Biggest error sources

- Accurate volume measurement

Porosity error

- ± 1.2 % literature (Kenyon, 1992; Vinegar, 1995, Coates et al., 1999)
- Approx. 1% NMR from cuttings

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Process

- Determine Perm using standard models (i.e. Mean T_2 Model; Free Fluid Model)

$$Lg(PERM) = a * \Phi eff + b$$

Pore size distrubition and grain size dependent

Where a, b are constants Khannin (1976)

We based our values for filtration radii between 5 and 2 μm and rock type (172 samples)

Verification of permeability models

- Models from samples from 6 fields
- Samples from different saturations

  water, oil $+S_{wirr}$, water+ S_{oil_res}.
- Oils saturated samples contained hydrocarbons with Visc<20cPs.
- The pore surface wettability was water wet, mixed and non-water wet.

Basics of MR-ML™ Model

PERM= a* $\varnothing_{eff}$ + b
a and b – Gs dependant coefficients

Four models were developed:

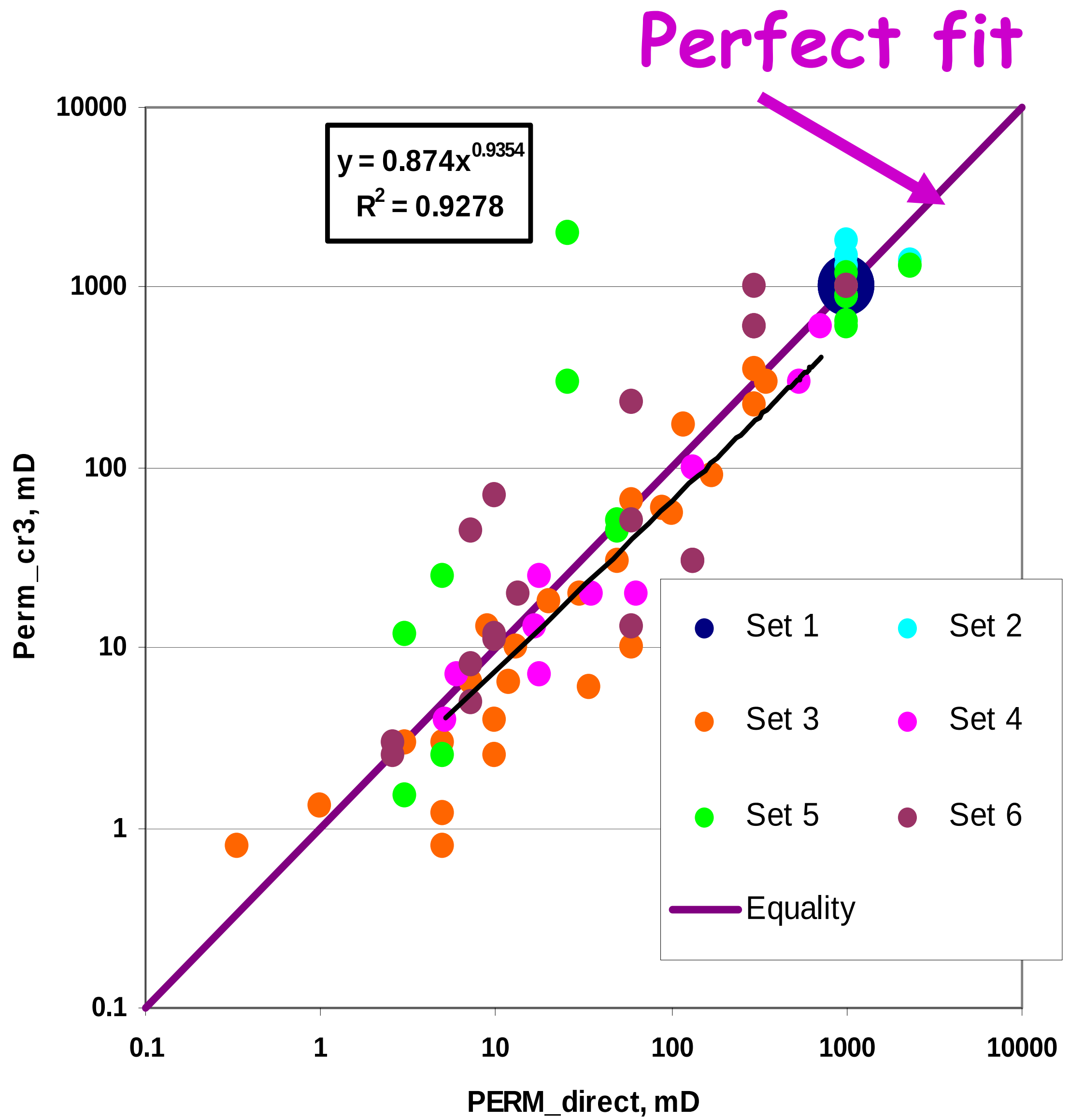
	Lithology	Grain size, mm	Grade	a, b
1	Sandstone	0.25-0.5	coarse	a_1, b_1
2	Sandstone	0.1-0.25	medium	a_2, b_2
3	Siltstone	0.05-0.1	fine	a_3, b_3
4	Siltstone	0.01-0.05	very fine	a_4, b_4

Perm results comparison

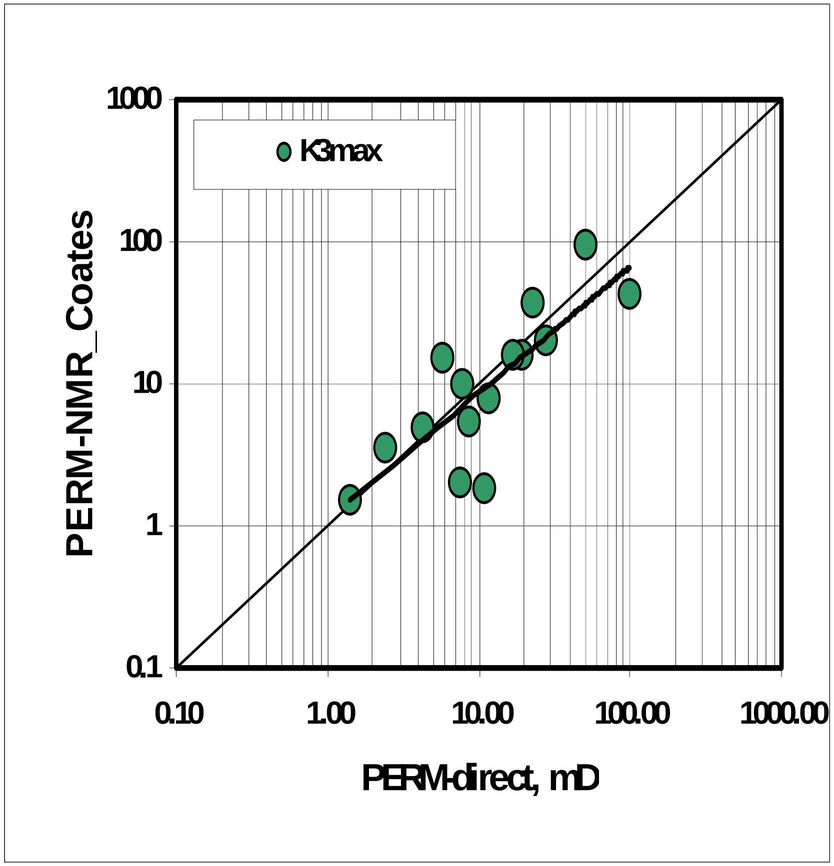
Core

	Direct Perm	Porosity Min.	Porosity Max.	NMR Perm Min.	NMR Perm Max.	Cutting Size
Sample/cutting	K*, mD	%	%	Kmin, mD	mD	
Sample Berea-1	38	9.6	13.1	18	70	
Sample Berea-2	70.5	12	14	45	100	
Cutting Berea	38-70.5	9.2	13.5	15	80	3.3 – 6.3
Cutting Berea	38-70.5	7.3	10.8	7.5	30	1.0 – 3.3
Sample FCR	12.7	8.3	11.1	10	32	
Cutting FCR	12.7	6.8	10.2	6	22	3.3 – 6.3
Cutting FCR	12.7	7.5	11.4	8	35	1.0 – 3.3

PERM results comparison

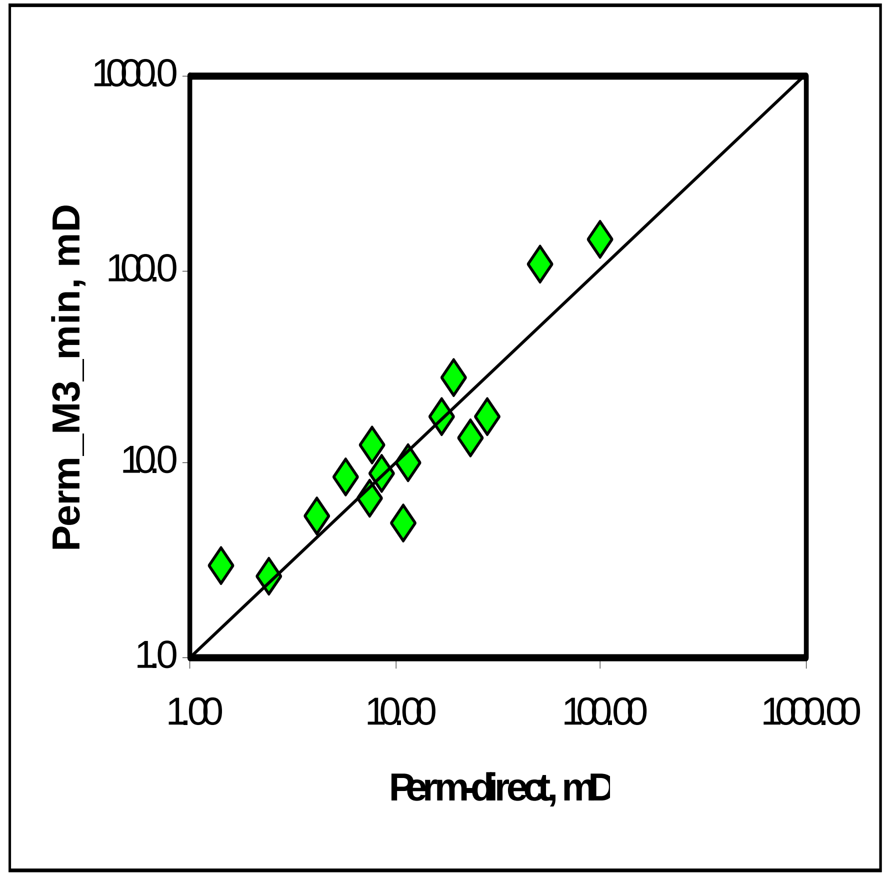


Perm comparison



A

100% water saturation



B

Water & oil mixed

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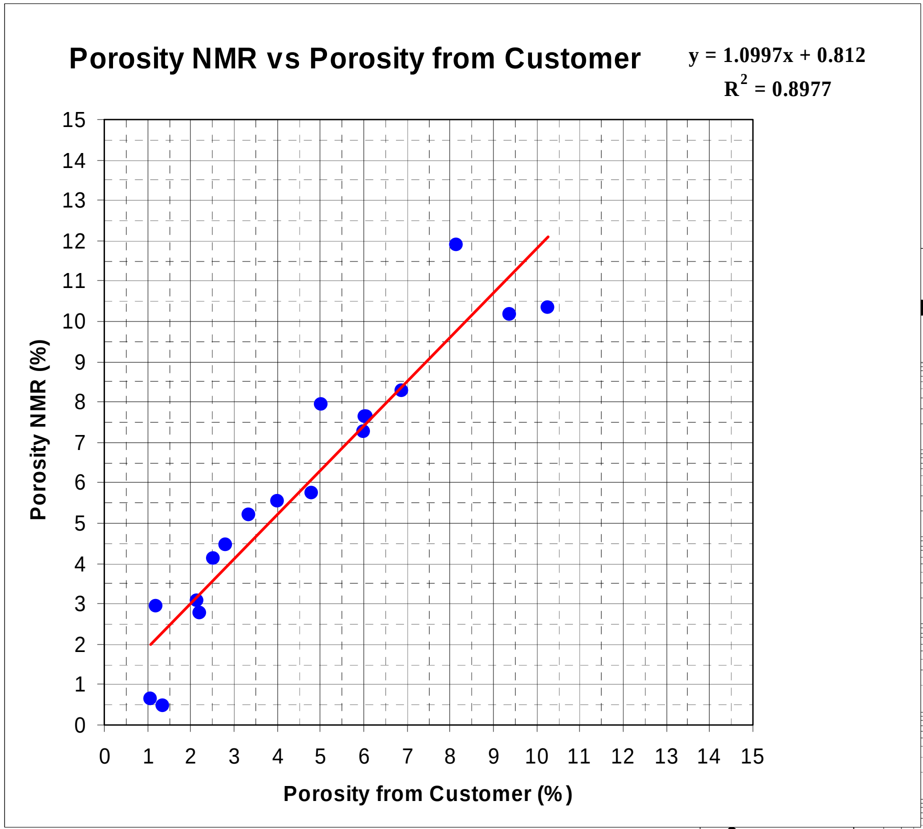
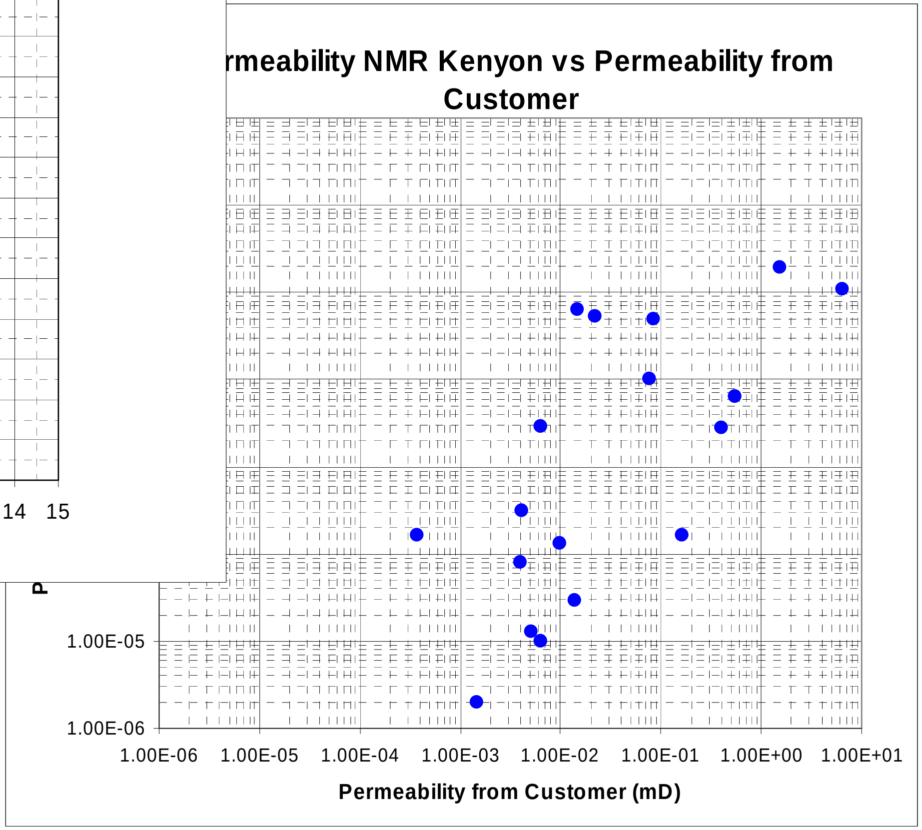
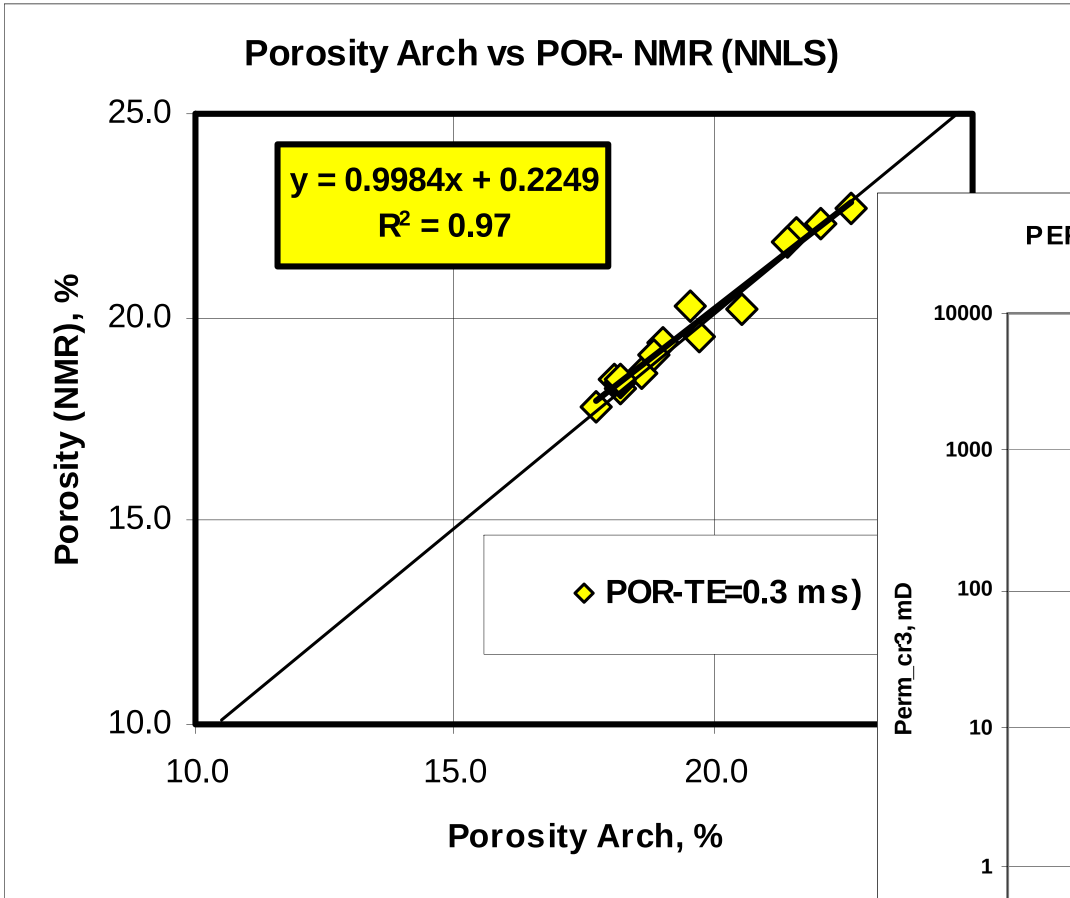
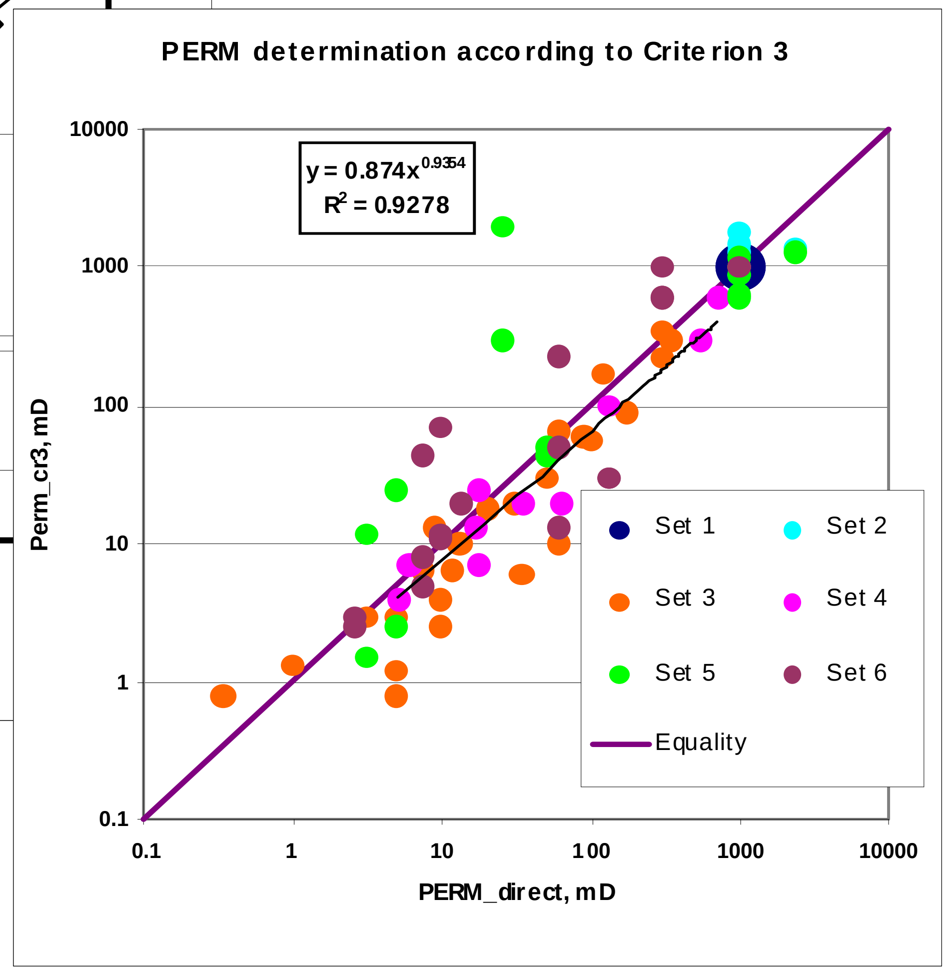
Results from China



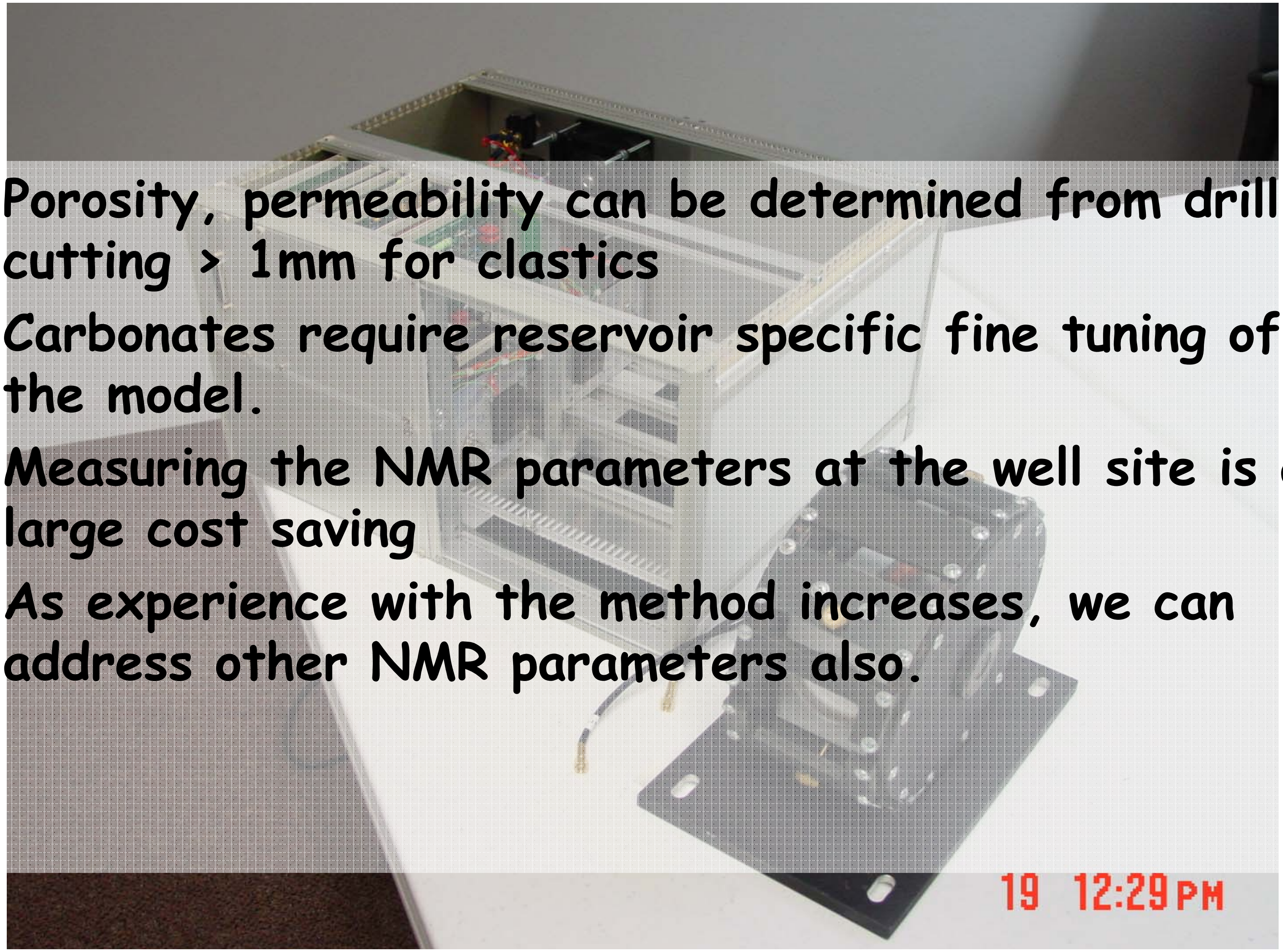


Results from Siberia





Conclusion



- Porosity, permeability can be determined from drill cutting > 1mm for clastics
- Carbonates require reservoir specific fine tuning of the model.
- Measuring the NMR parameters at the well site is a large cost saving
- As experience with the method increases, we can address other NMR parameters also.

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