Innovative Applications For Stranded Barrels of Oil

Conference

Visegrád, 20 November 2014

Society of Petroleum Engineers

Evaluation of the polymer-tenside injection test in the Algyő field (Case study)

Tibor Bódi[1], István Lakatos[1], Ákos Pintér[1], Sándor Puskás[2], Árpád Vágó[2]

1. Research Institute of Applied Earth Sciences University of Miskolc
2 MOL PLc., E&P Division, Group Exploration & Business Development, Research & Development

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- Conclusions regarding the back-flow test of the INJ-1 well

Introduction

In the last years the RIAES cooperating MOL experts and other university researcher groups in the frame of a research project working on polymer-tenside EOR methods that can be applied in Hungarian depleted oil reservoir.

Aims of the research:

- ✓ Synthetizing domestically developed and produced surfactants which can be applied in order to enhance the recovery factor at domestic oil fields
- ✓ Elaboration of technological and technical protocol which can be successfully applied in new, water invaded or partly water invaded oil fields at Hungarian reservoir conditions

One of the important milestones of this research project is the polymer-tenside injection test

Preparation of the injection test

As a preparation of the test, the effect of splitting the industrially synthetized chemical agent into more slugs on the displacement efficiency and the pressure needed to move the slugs was investigated in different cases.

The effect of increasing the polymer content of the slug on the displacement efficiency was also investigated.

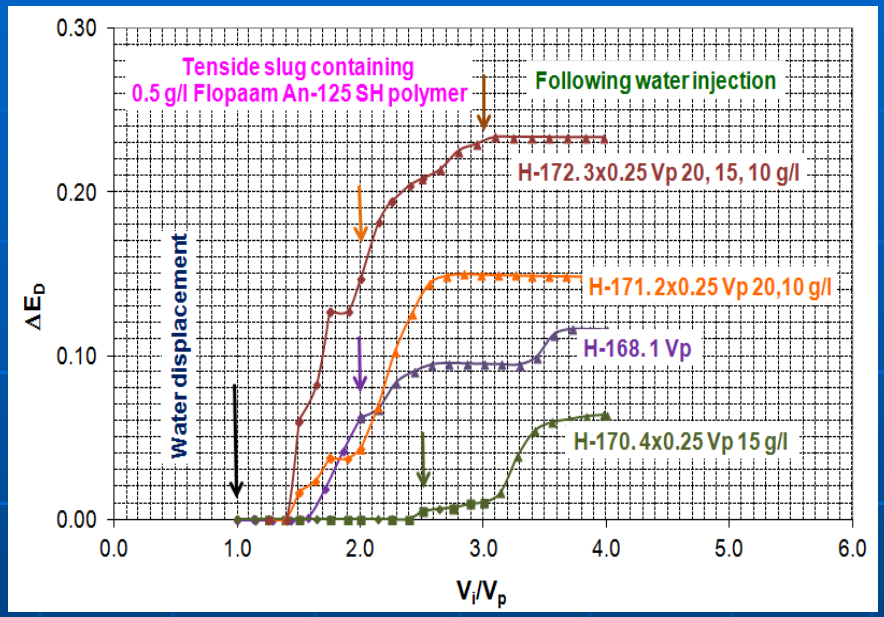
Preparation of the injection test

Effects of concentration, size, number of slug

Sample	ϕ	k_g	K_w (lab.)	k_w (res.)	Tenside concentration	Effective excess displacem. efficiency
		mD	mD	mD	g/l	
H-168.	0.3023	448.78	122.48	141.01	1 V_p, 15g/l	0.1163
H-170.	0.3046	520.03	263.84	80.62	4x0.25 V_p, 15g/l	0.0638
H-171.	0.3080	474.22	104.21	82.54	2x0.25 V_p 20,10 g/l	0.1486
H-172.	0.3002	320.05	39.10	40.86	3x0.25 V_p, 20, 15,10 V_p	0.2339

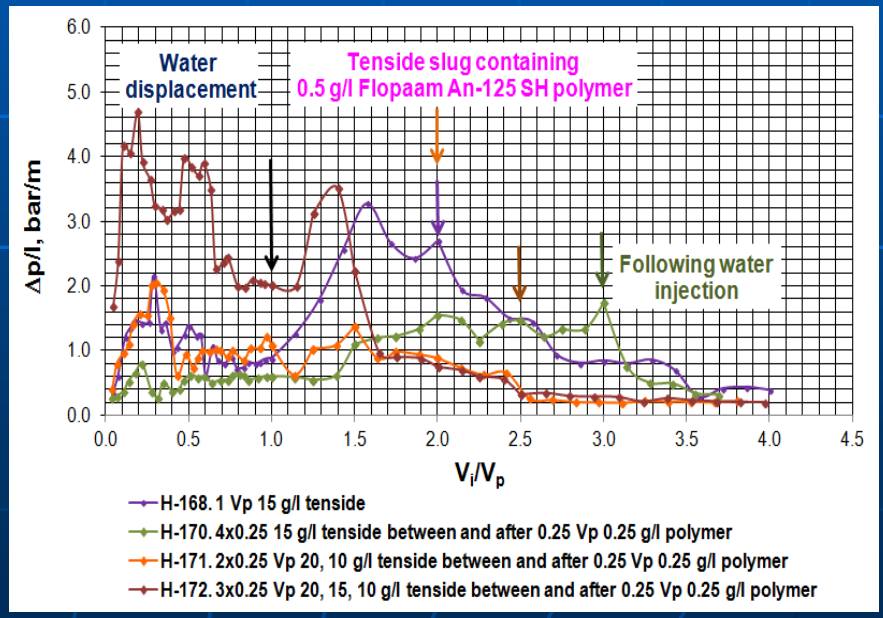
Preparation of the injection test

Effects of concentration, size, number of slug



Effective excess displacement efficiency

Change of pressure during the displacement



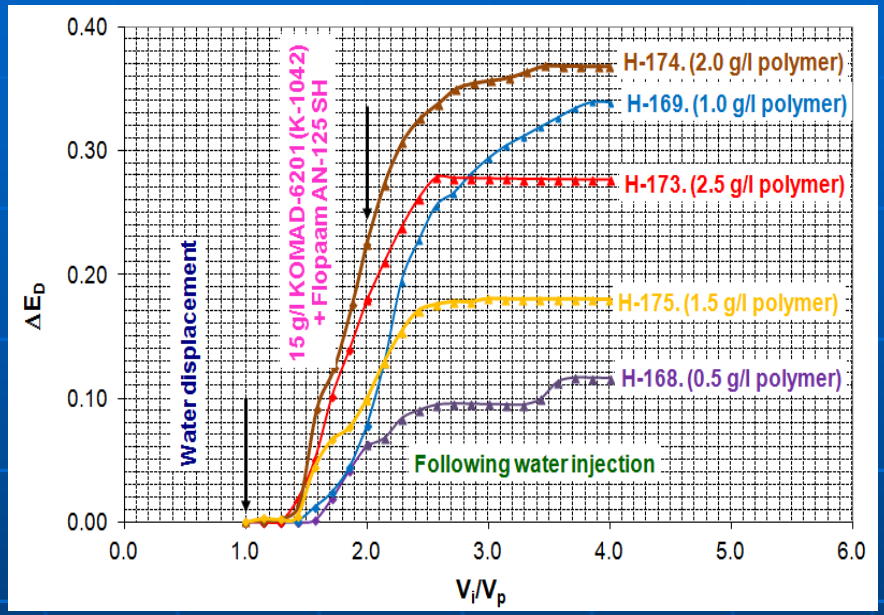
Preparation of the injection test

Effect of the polymer concentration of the slug

Sample	ϕ	k_g	K_w (lab.)	k_w (res.)	Polymer concentration	Effective excess displacemt efficiency
		mD	mD	mD	g/l	
H-168.	0.3023	448.78	122.48	141.01	0.5	0.1163
H-169.	0.2972	408.63	133.29	136.17	1.0	0.3397
H-175.	0.2995	593.30	132.78	125.17	1.5	0.1800
H-174.	0.2882	430.31	227.94	175.92	2.0	0.3681
H-173.	0.2985	550.04	106.02	60.07	2.5	0.2862

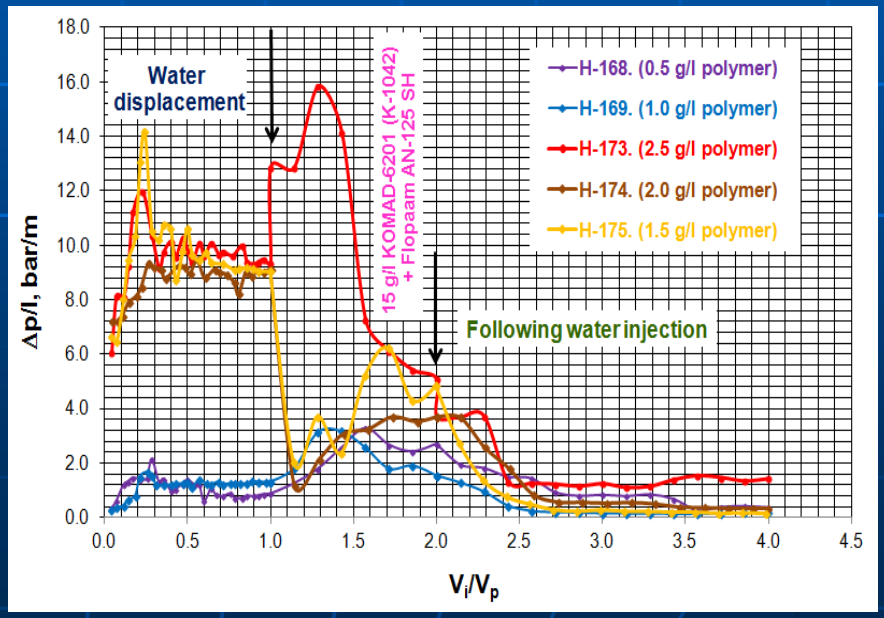
Preparation of the injection test

Effect of the polymer concentration of the slug



Effective excess displacement efficiency

Change of pressure during the displacement



Laboratory model of injection test

With a special reservoir condition displacement test, we inspected whether we can expect excess oil production during the injection test in the reproduction phase of the fluid injection or not.

During our tests:

- **0.5 V_p slug (K-987 tenside + Flopaam AN-125 SH polymer) was injected into the vertically drilled rock sample, from the top to the bottom, then, after 48 hours of break, it was displaced with 1 V_p formation brine from the bottom to the top (*Injection test and the following backflow)***
- **0.5 V_p slug (K-987 tenside + Flopaam AN-125 SH polymer) was injected into the vertically drilled rock sample, from the bottom to the top, then, after 48 hours of break, it was displaced with 1 V_p formation brine from the bottom to the top**

Laboratory model of injection test

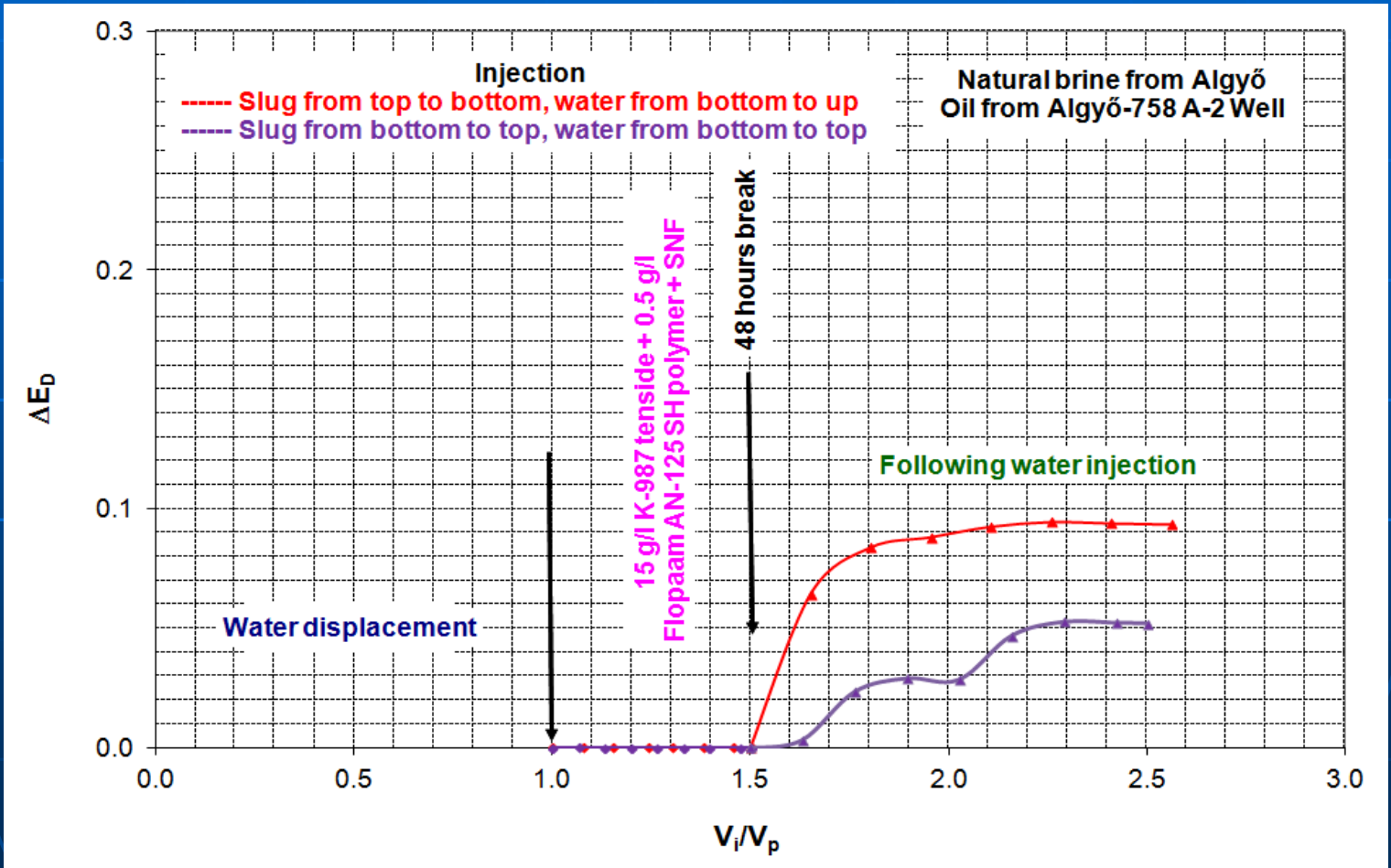
Composition of the slug:

0.5 V_p 15 g/l K-987 tenside+0.5 g/l Flopaam AN-125 SH polymer+SNF chemicals

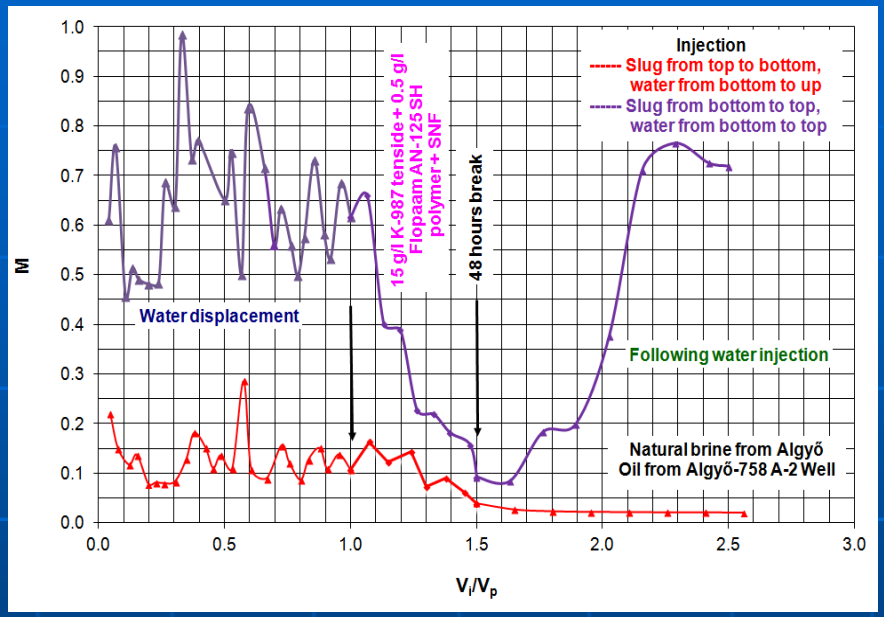
Sample	ϕ	k_g	K_w (lab.)	k_w (res.)	Polymer concentration	Effective excess displacem. efficiency
	%	mD	mD	mD	g/l	
Slug from the top to the bottom, water from the bottom to the top						
H-164.	32.09	442.24	122.60	129.31	0.5	0.0934
Slug from the bottom to the top, water from the bottom to the top						
H-165.	32.26	894.77	344.81	92.57	0.5	0.0519

Laboratory model of injection test

Effective excess displacement efficiency

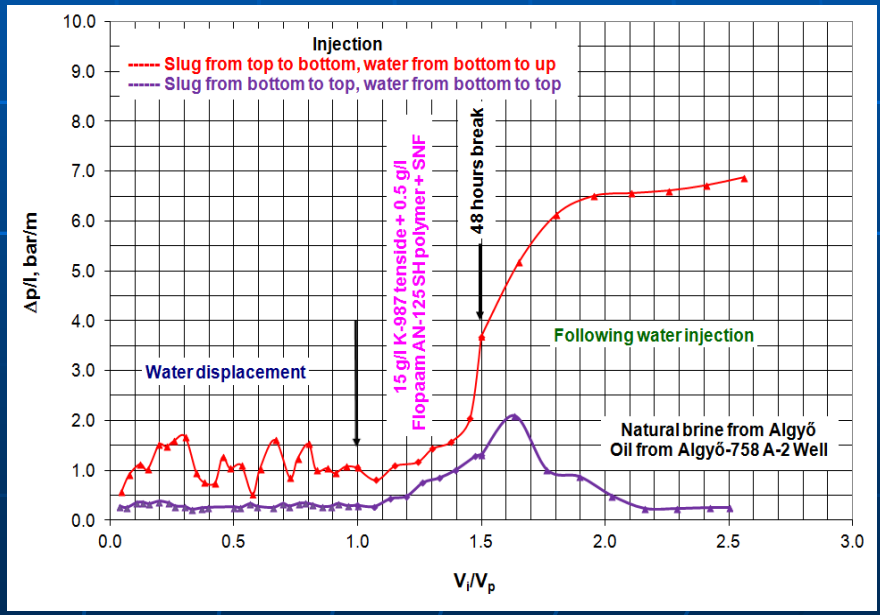


Laboratory model of injection test



Changes of mobility during the displacement

Change of pressure during the displacement

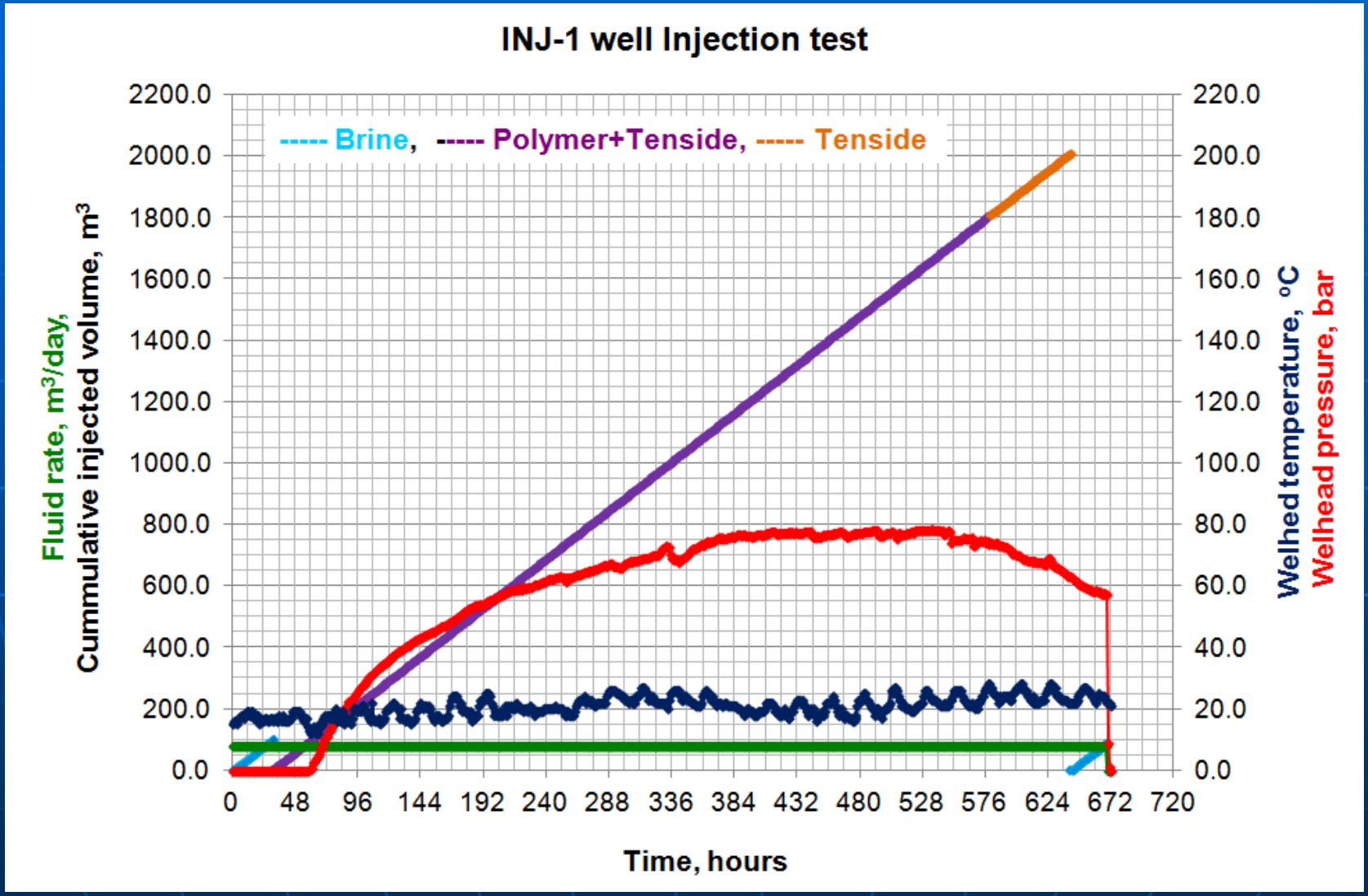


Preparation of the injection test

Since it could not be unambiguously decided whether the industrially synthetized chemicals can be injected or not (high pressure may occur), we decided to perform an injection test.

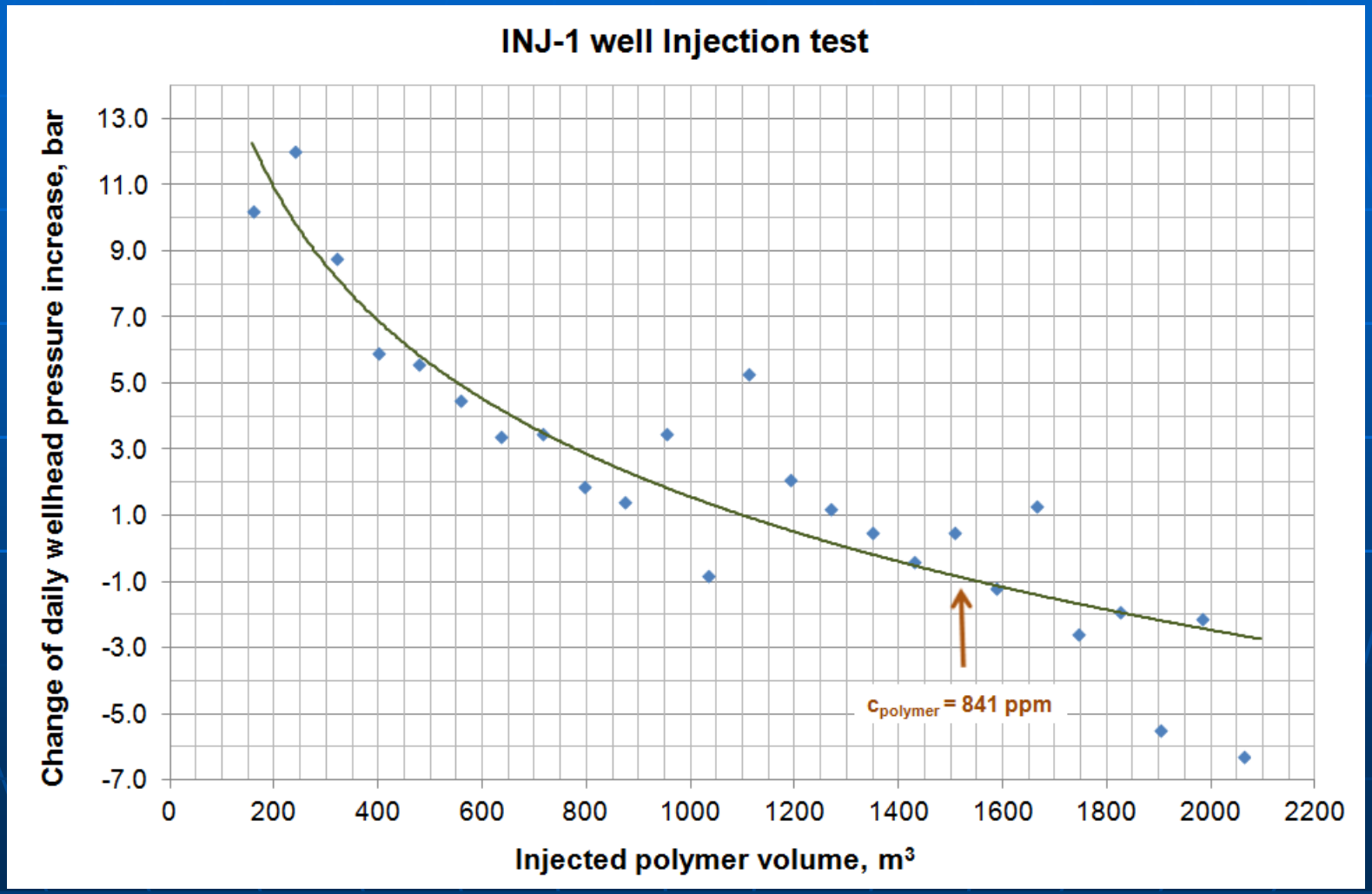
Its main aim is to ascertain the exact injectivity of the chemical slug at Algyő reservoir conditions.

INJ-1 well injection test

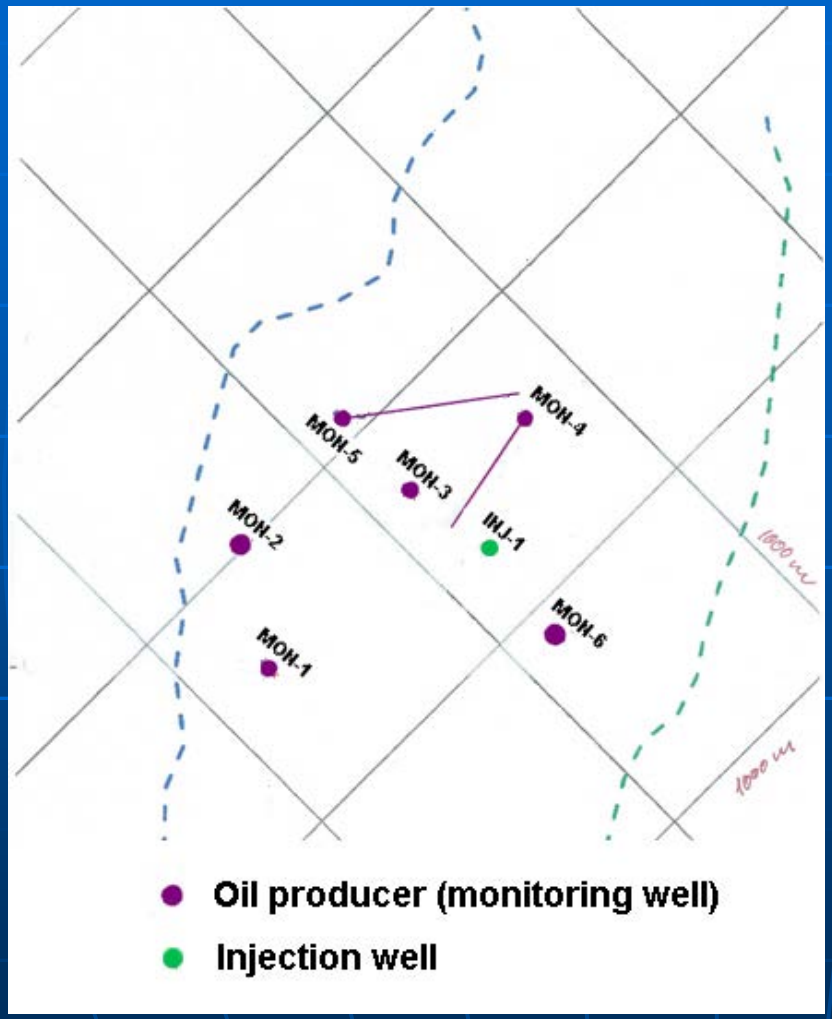


INJ-1 well injection test

Pressure change during injection



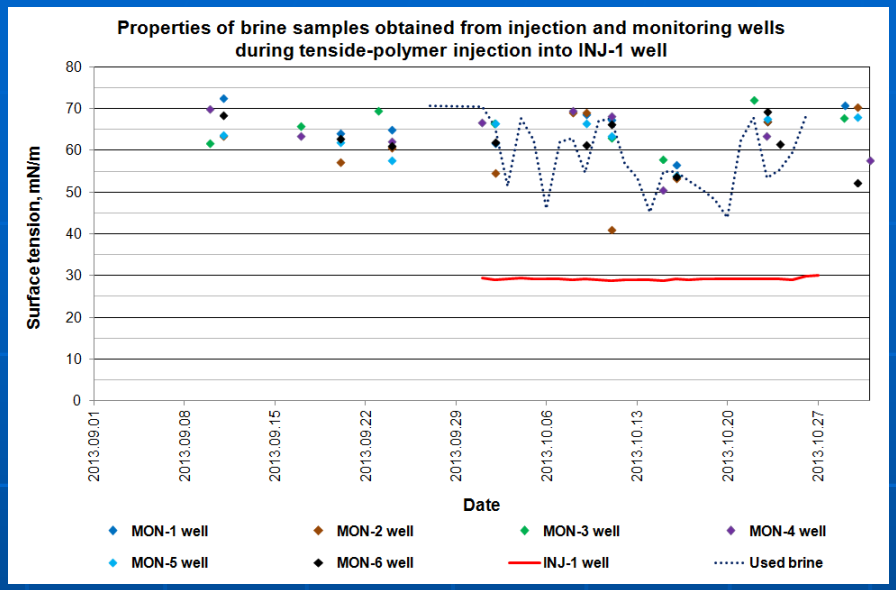
INJ-1 well injection test

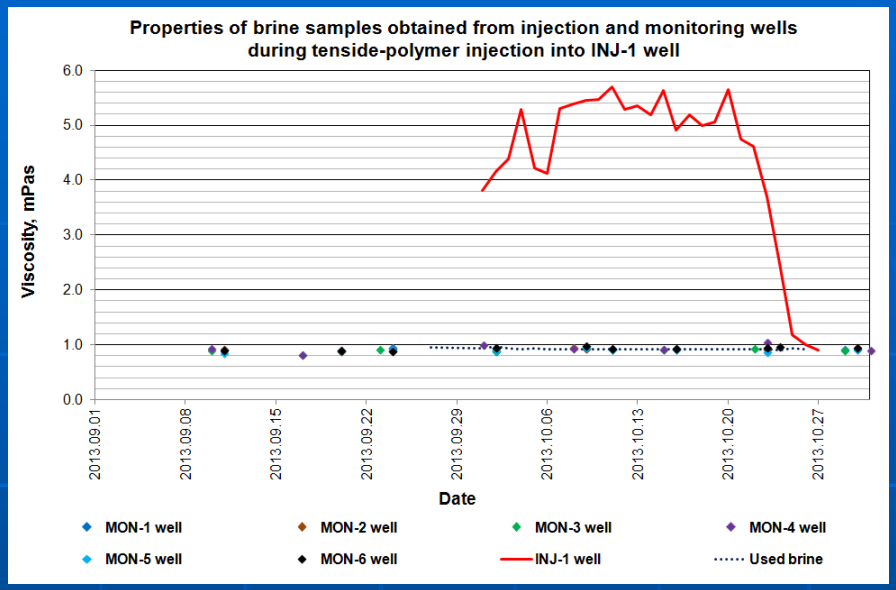


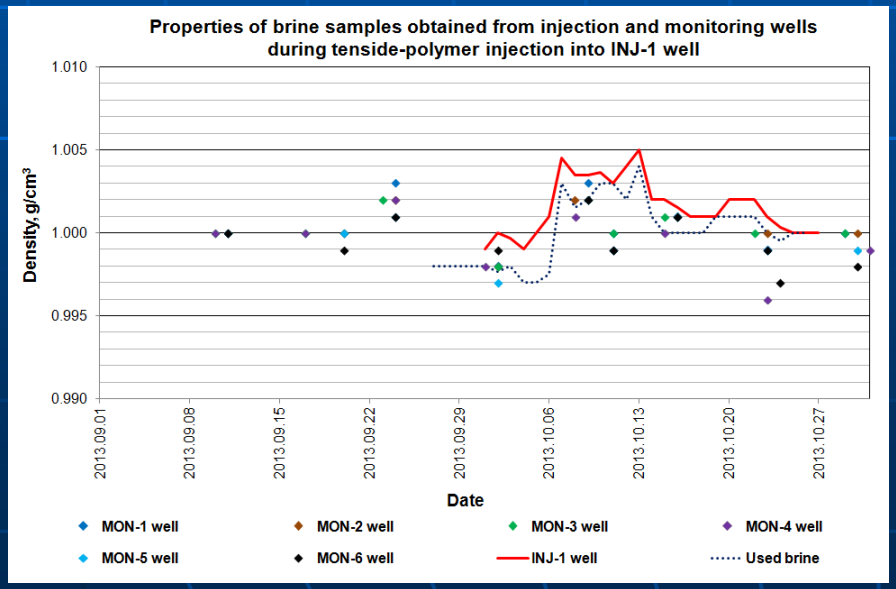
Location of the test area

Special monitoring program were applied during the injection and back-flow tests

INJ-1 well injection test



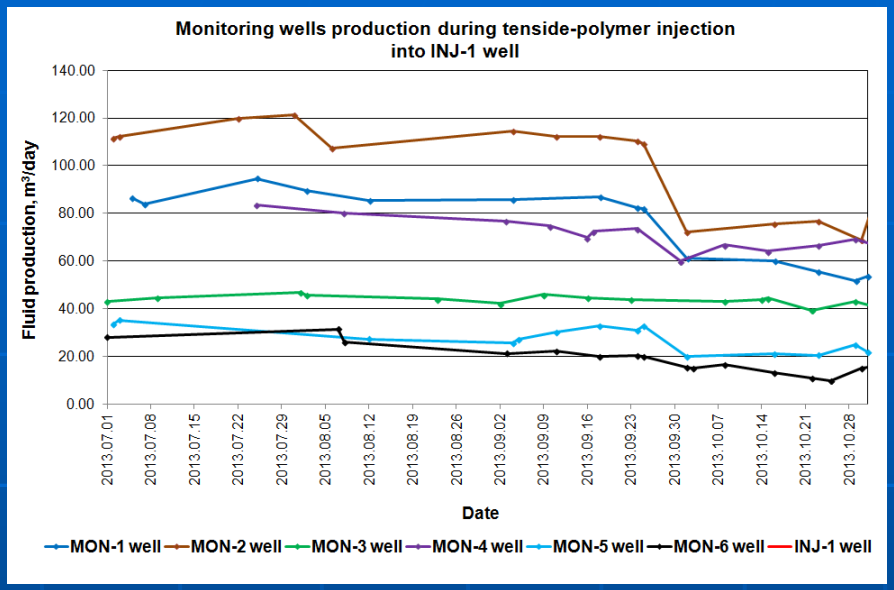


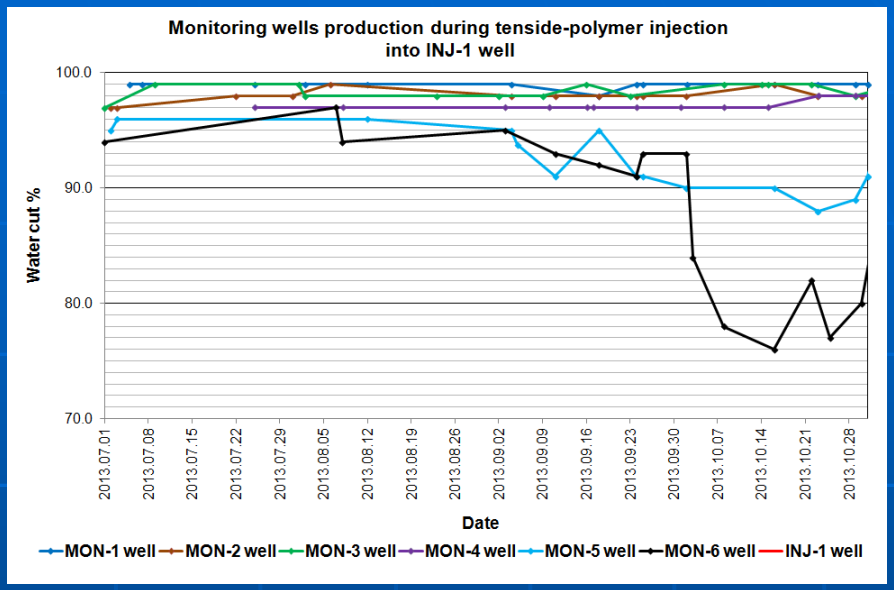


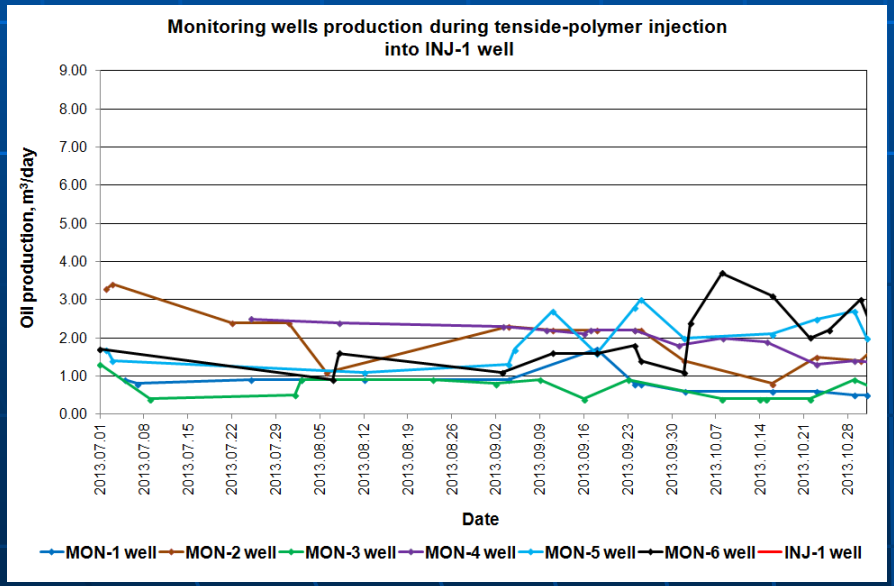
No breakthrough of the injected solution in the monitoring wells

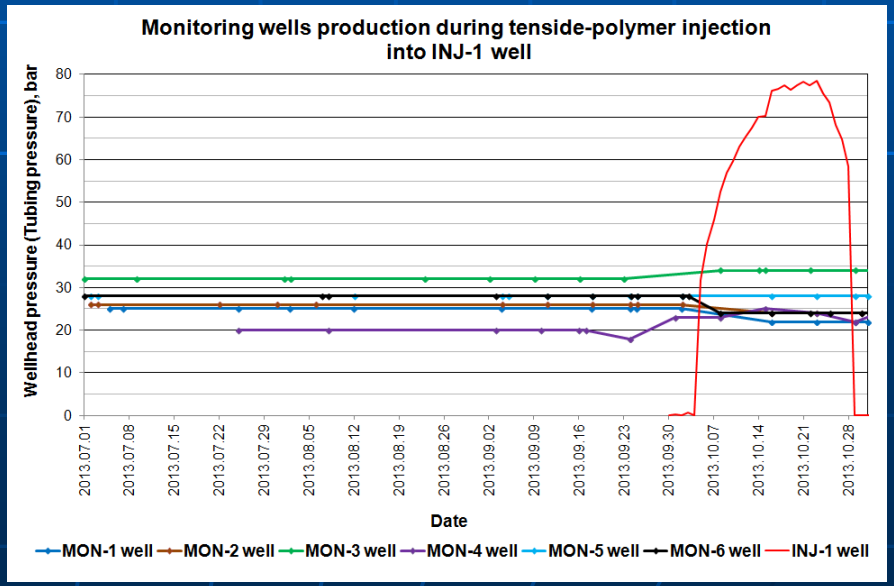
Measurements were performed at the University of Szeged

INJ-1 well injection test









Conclusion regarding the injection test in the INJ-1 well

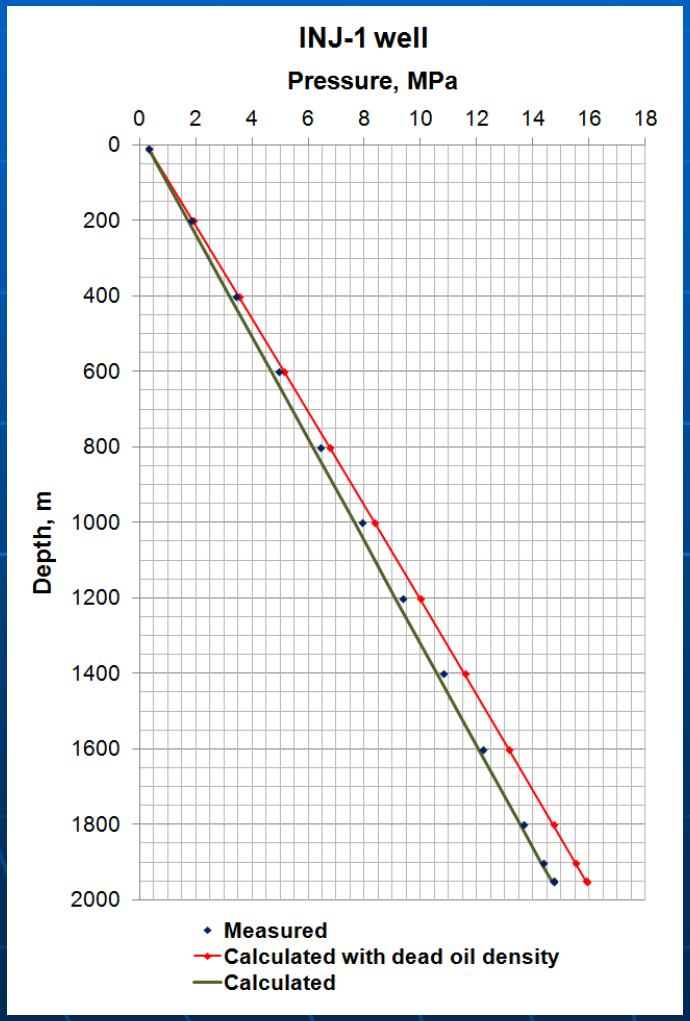
On the basis of the production rate and water analysis measurements at the surrounding wells it could be assessed that during the injection, there was no breakthrough towards the surrounding wells. This fact matched the previous expectations.

The injection test was successful. The preferred injection rate (80 m^3/d) could be sustained without any changes during the whole injection period. During the test, the injection wellhead pressure approached the technical limitation value of the water injection system (80-90 bar), however, it did not reach that.

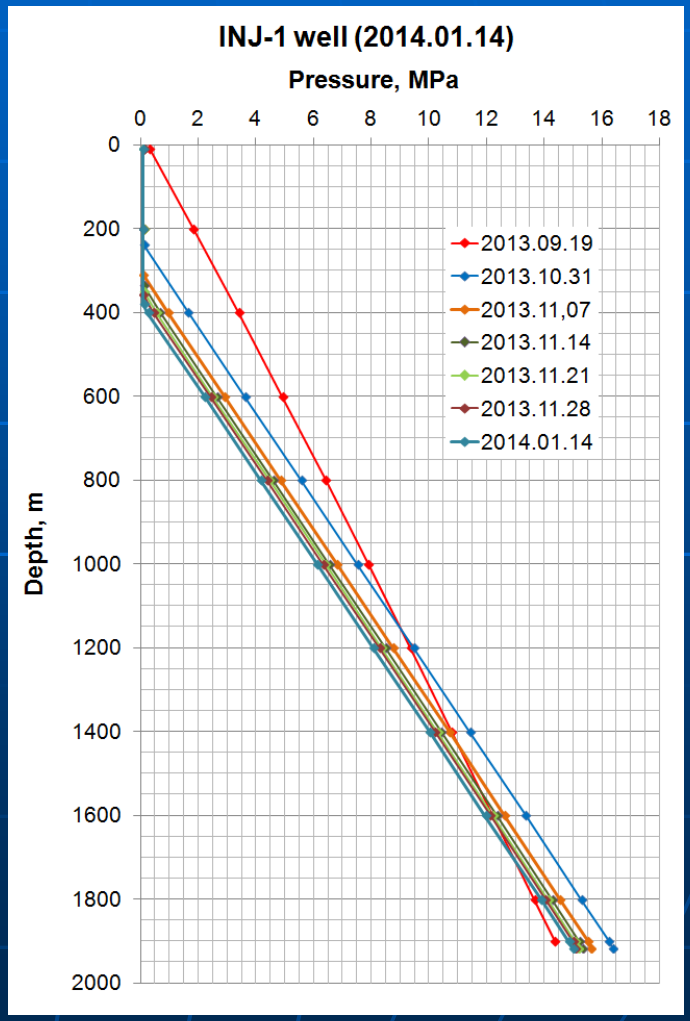
The injection wellhead pressure decrease, which was a result of the polymer concentration decrease, pointed at the fact that in the future, if the wellhead pressure exceeds the technical pressure limit, the injection problems might get solved with an applied polymer concentration decrease.

Local reservoir pressure changes in the INJ-1 well during production break

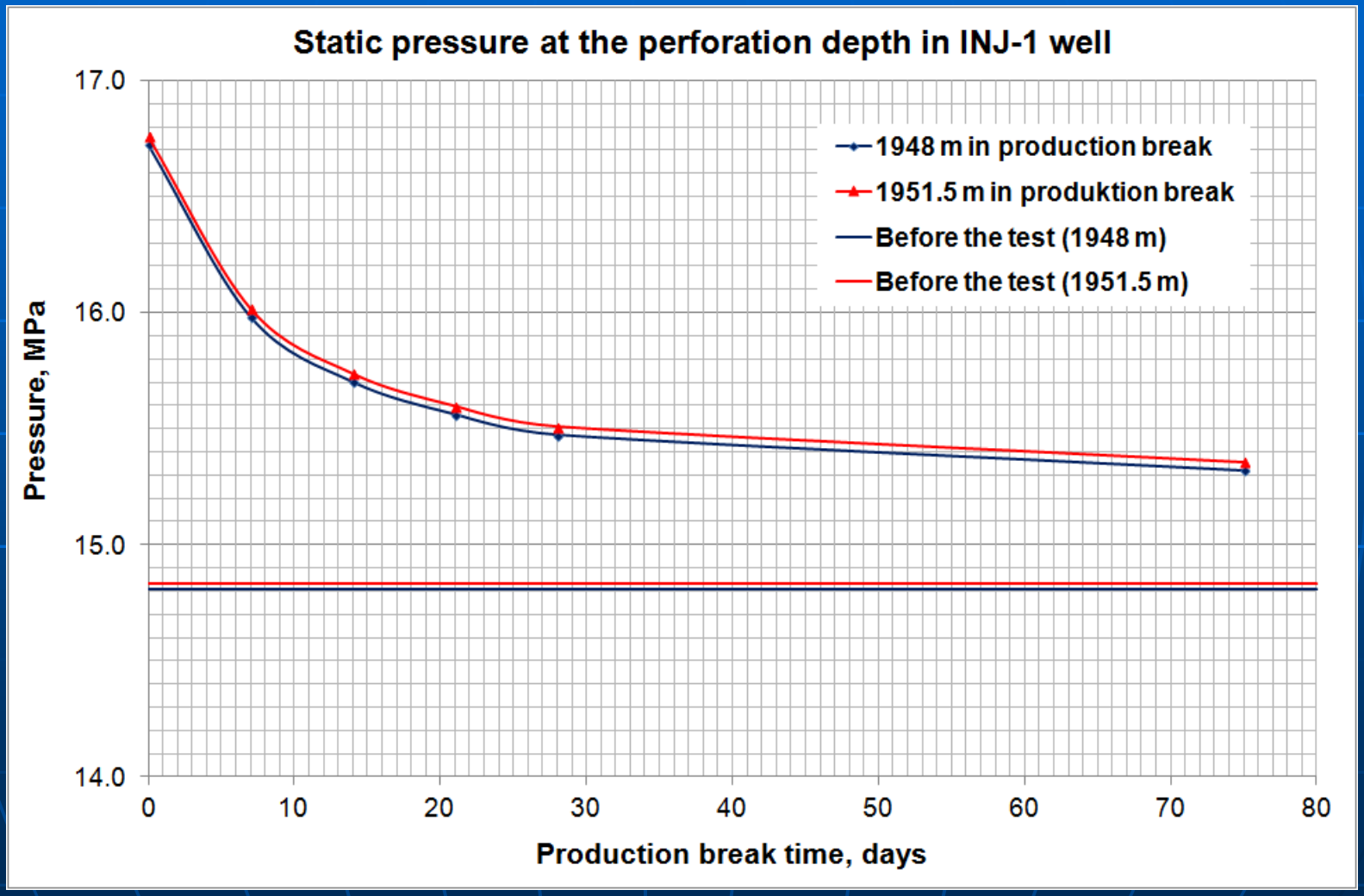
Before the injection 19.09.2013



After injection in production break



Local reservoir pressure changes in the INJ-1 well during production break



Back-flow test of in INJ-1 well

A special monitoring program were applied: wellhead samples were taken daily and transferred to the RIAES laboratory

The viscosity, concentration of the anionic tenside, concentration of the polymer and the approximate oil content of the samples were measured

Special measurement were developed to determine the polymer concentration of the fluid samples

Production parameters of the monitoring well were also registered in the company files

Well head fluid samples from INJ-1 well

Original samples

2014.01.17-01.23.

2014.01.30-02.04.

After emulsion breaking

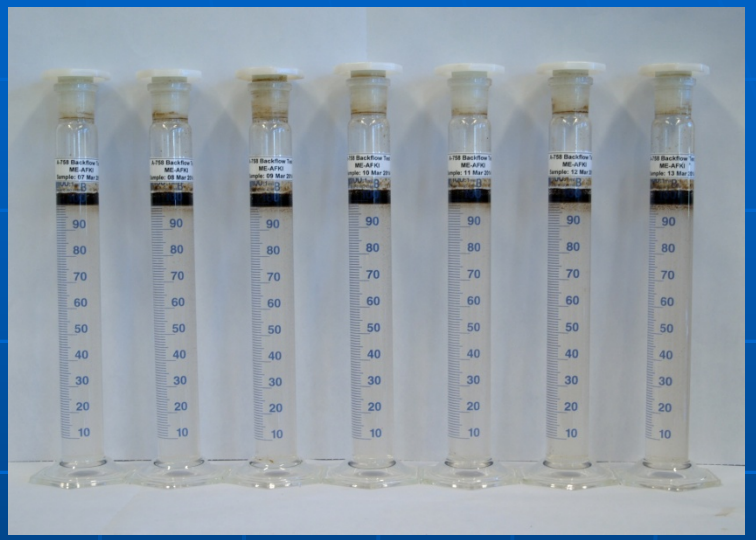
Well head fluid samples from INJ-1 well

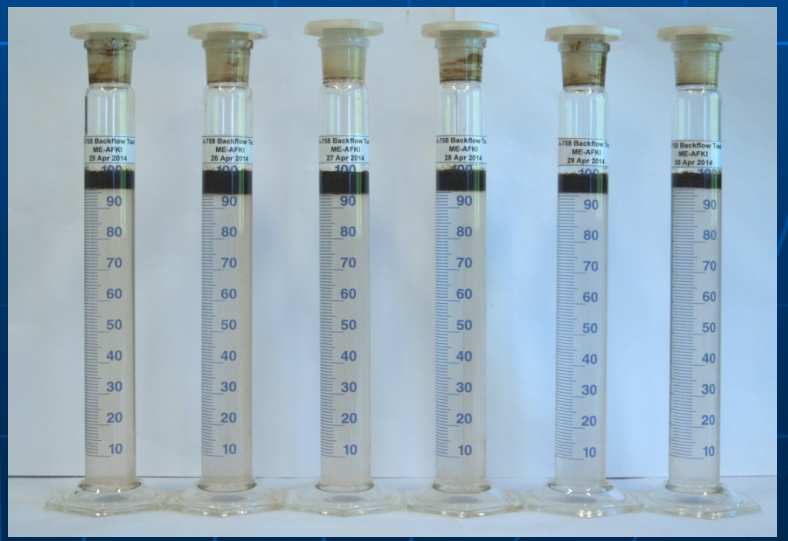
Original samples

2014.03.07-03.13.

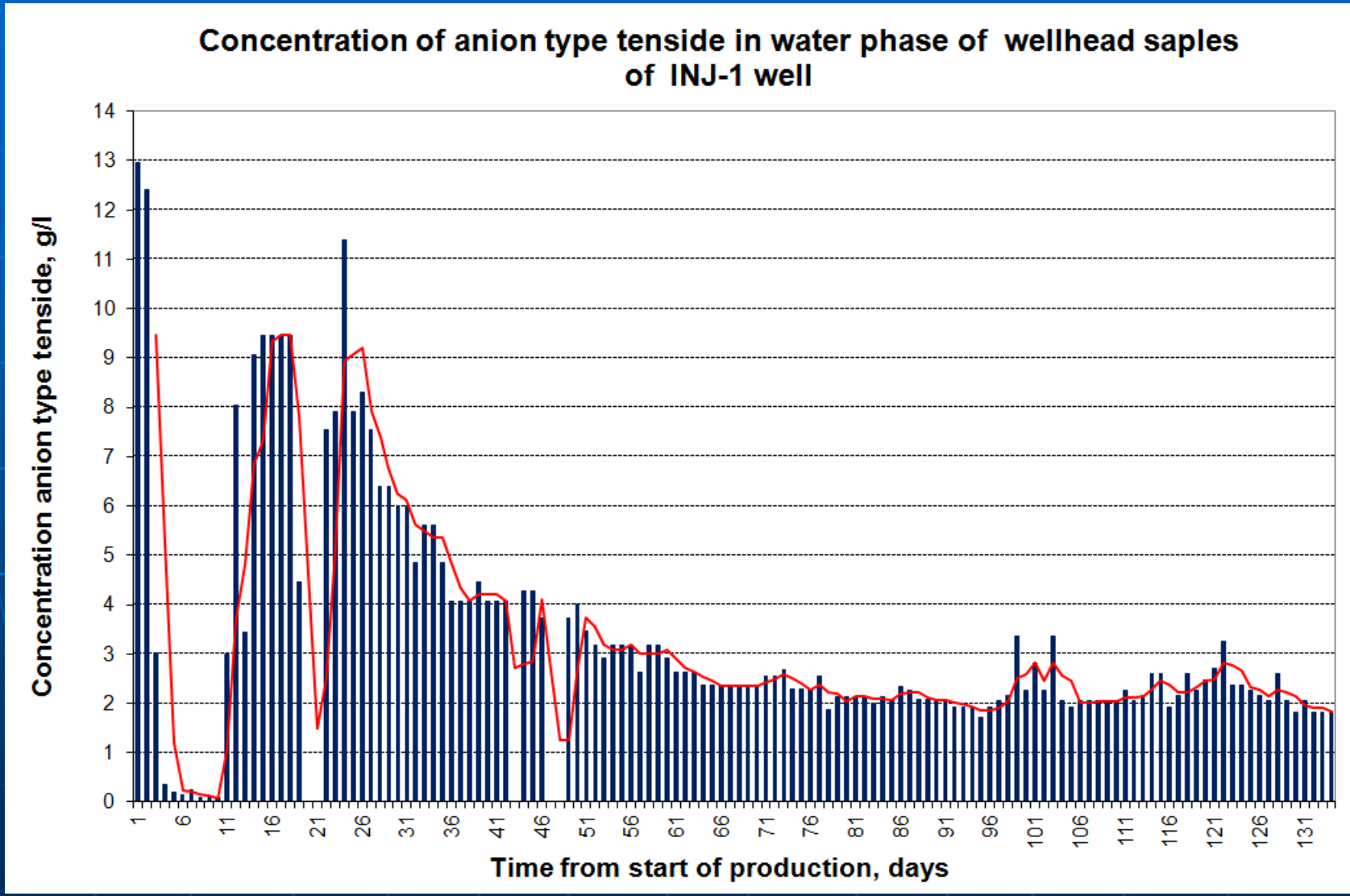
2014.04.25-04.30.

After emulsion breaking





Back-flow test of in INJ-1 well



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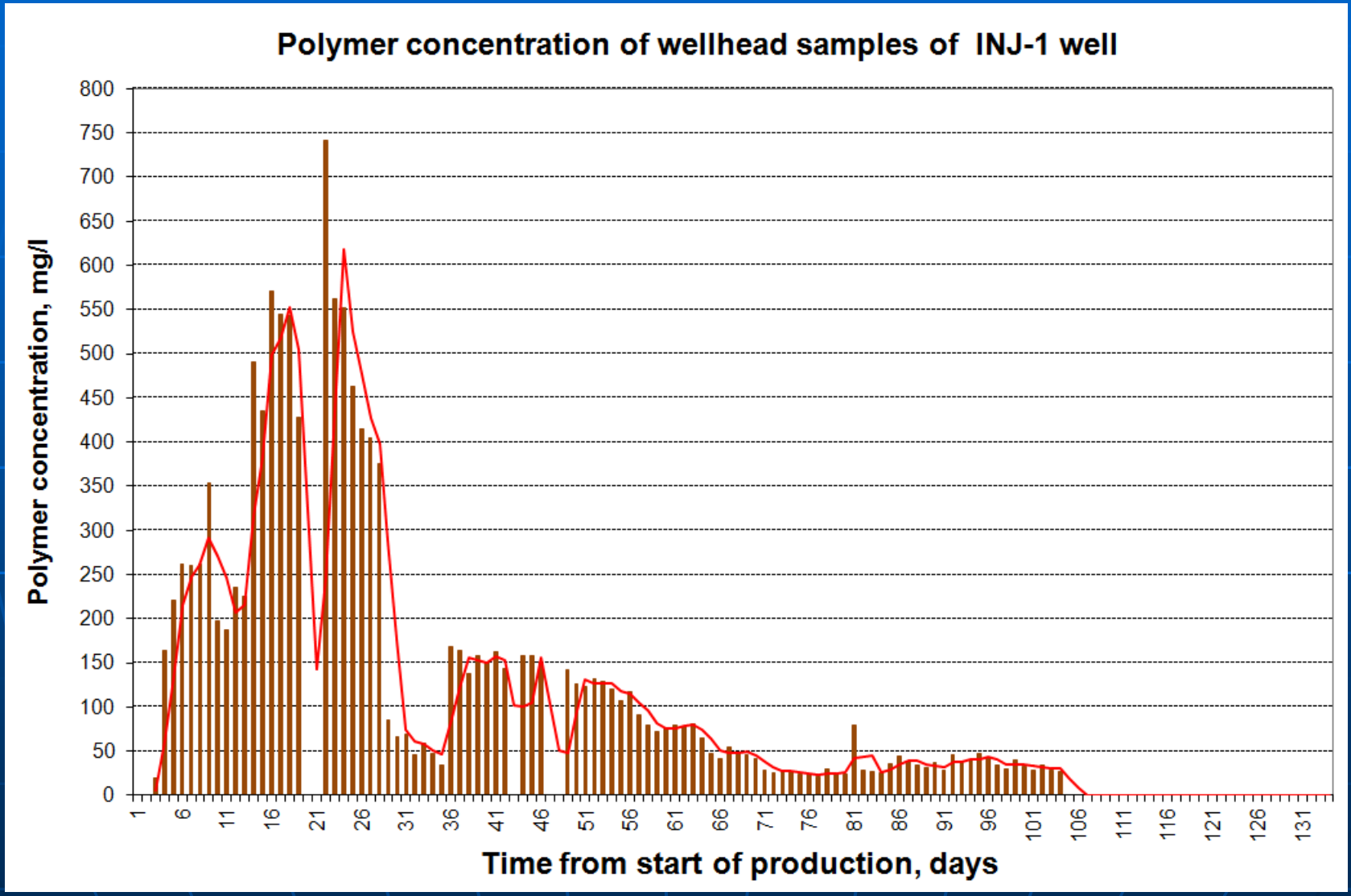

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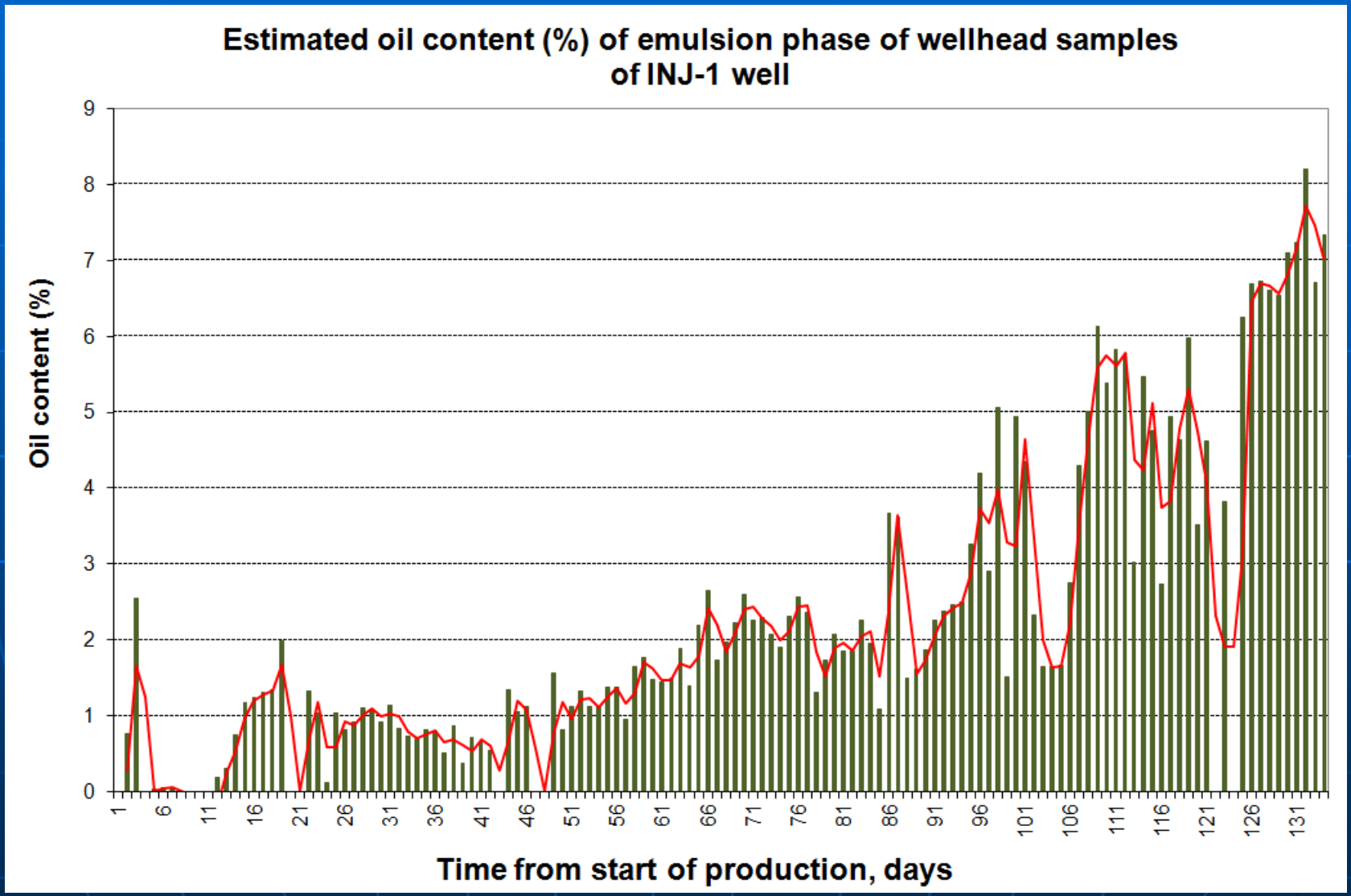

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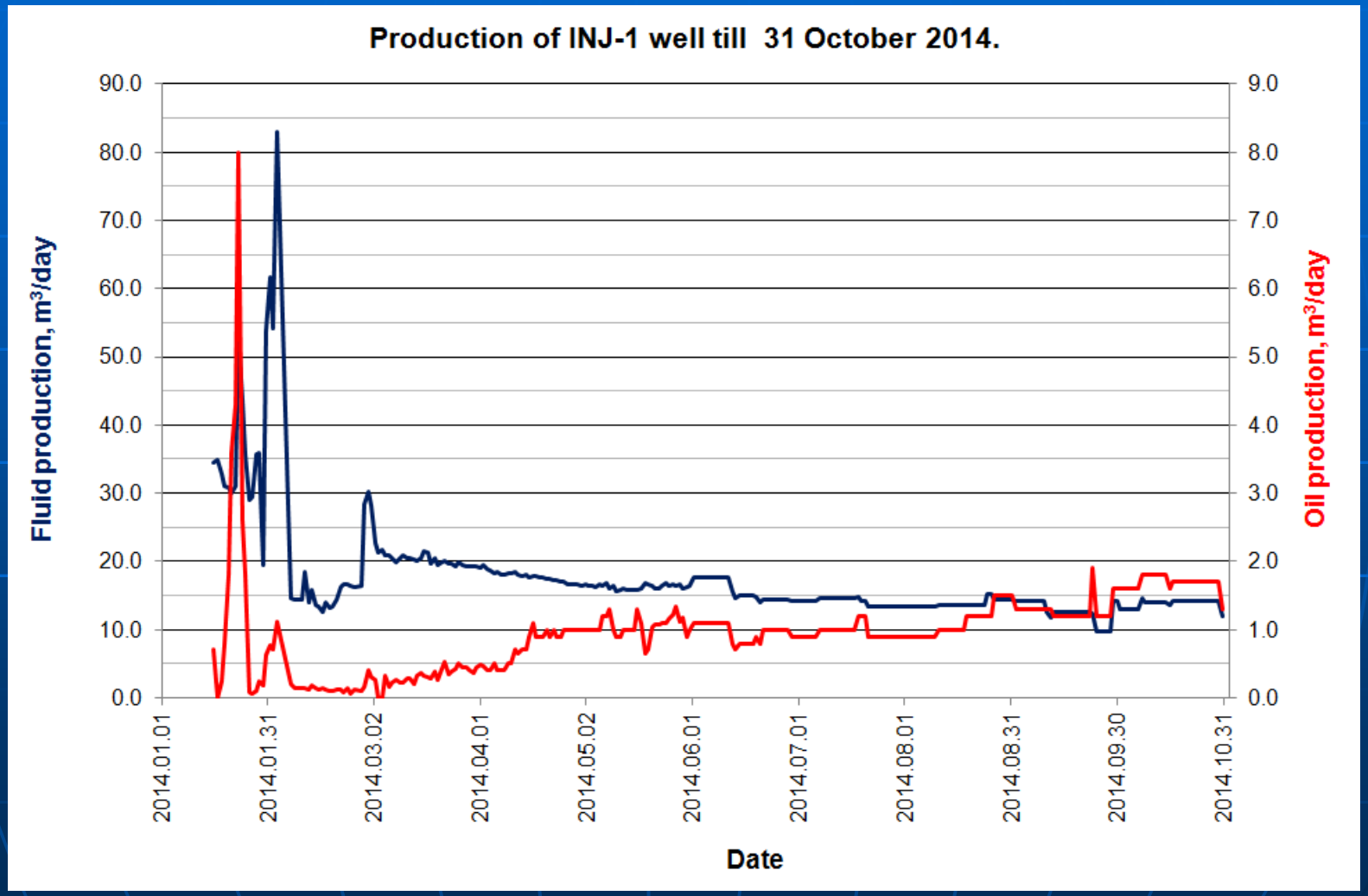

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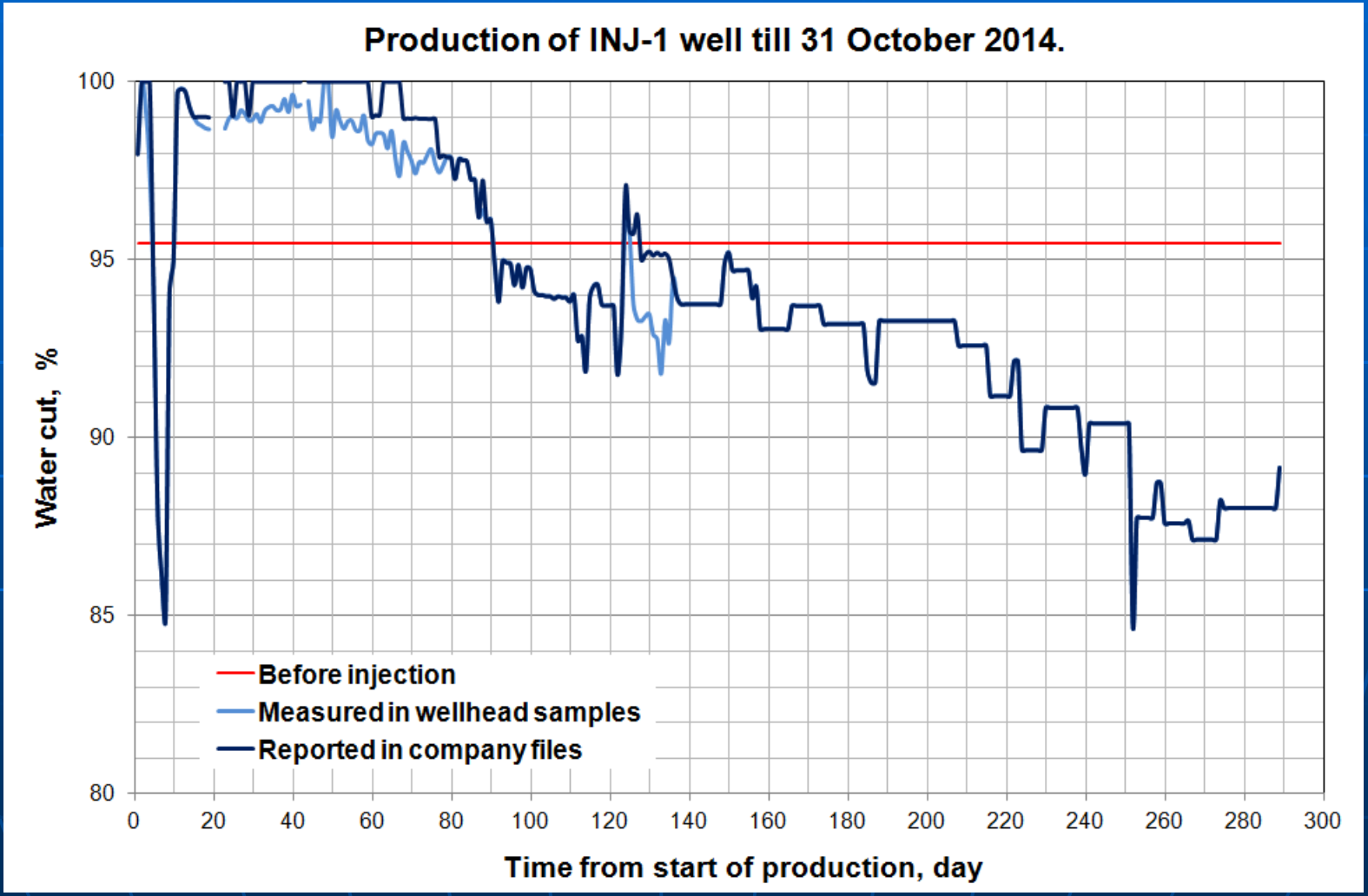
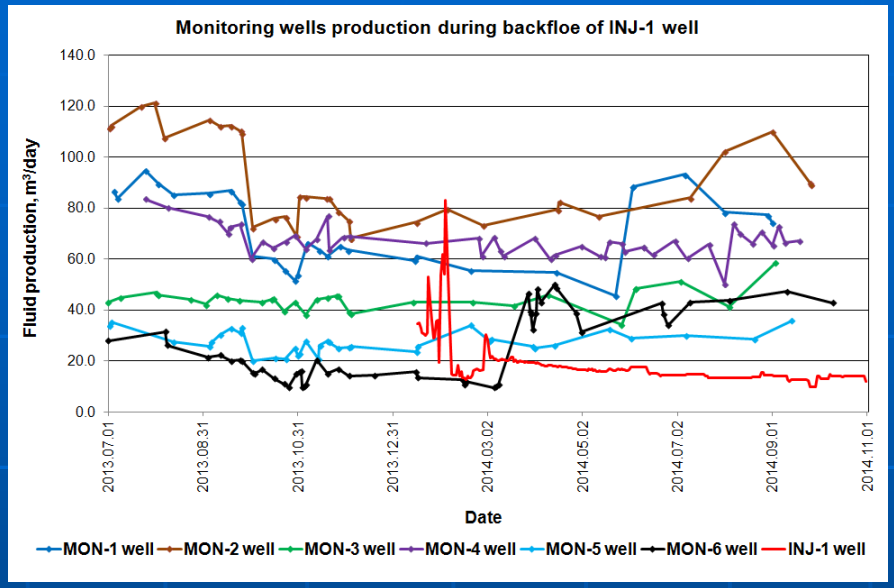
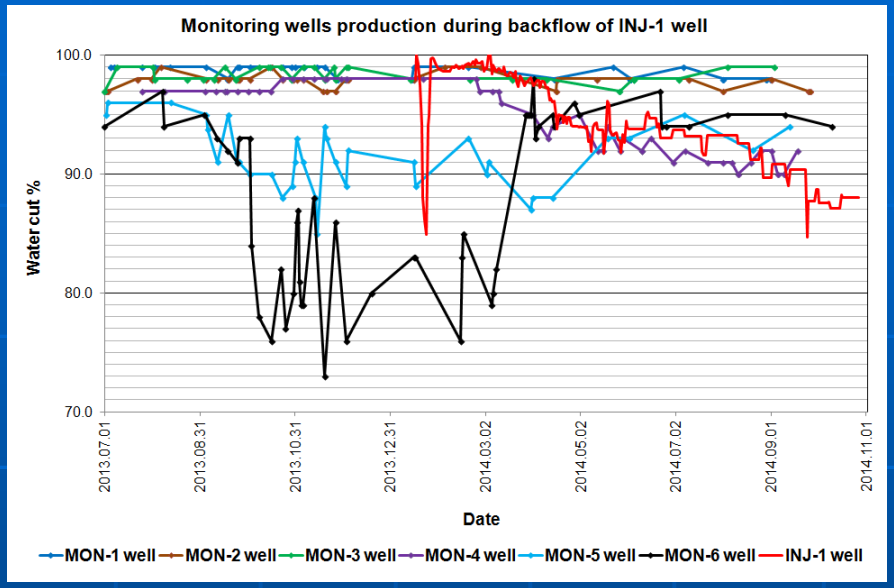
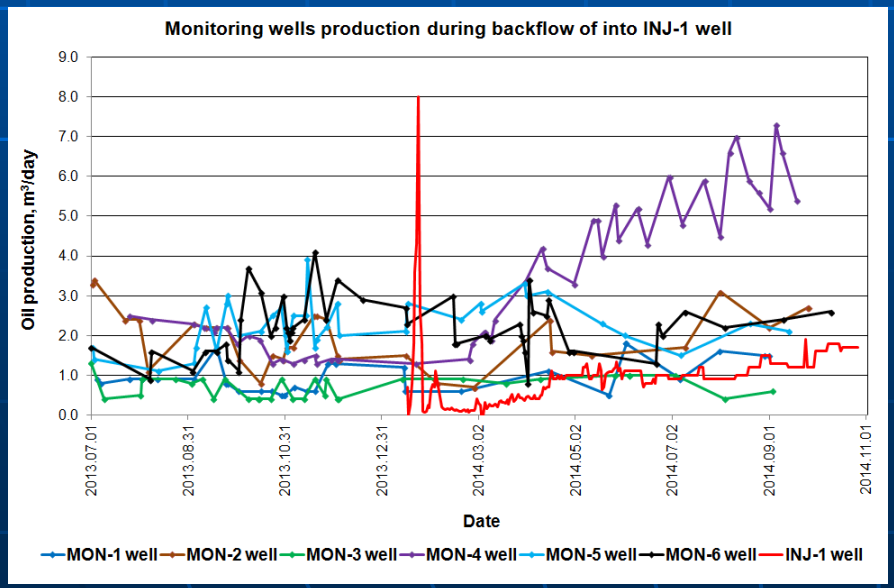
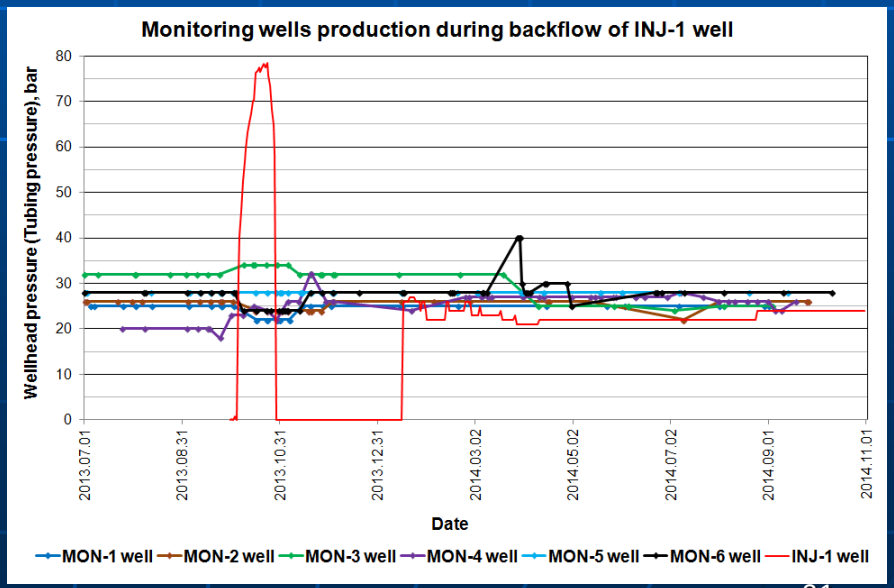


Back-flow test of in INJ-1 well

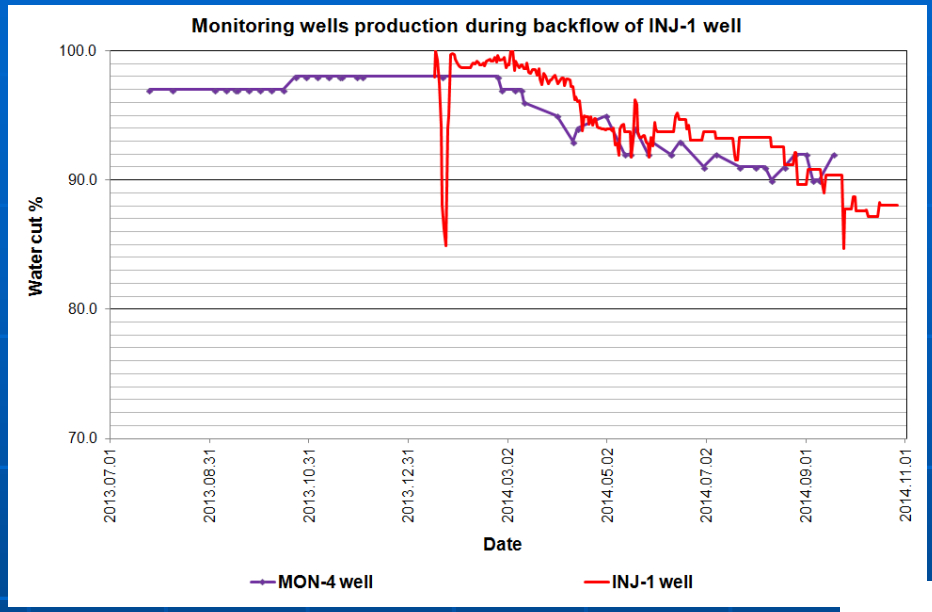


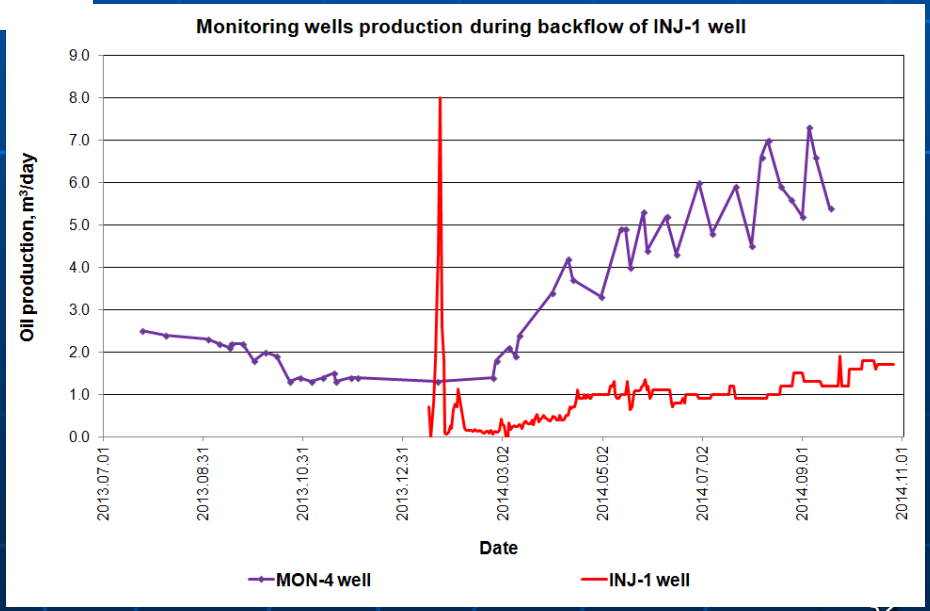






Back-flow test of in INJ-1 well





Back-flow test of in INJ-1 well

- The possible cumulative oil production (222.38 m^3) were calculated considering the average water cut before the injection test and the fluid production during the backflow.

- The cumulative oil production of INJ-1 well reported in company files from 16 January 2014 till 31 October 2014 was 262.7 m^3

  The extra oil production in this case is 40.3 m^3 and this is 18.12 % of the possible cumulative oil production.

- The corrected cumulative oil production (according to the laboratory oil content measurement) of INJ-1 well from 16 January 2014 till 31 October 2014 was 278.75 m^3

  The extra oil production in this case is 56.37 m^3 and this is 25.3 % of the possible cumulative oil production.

Conclusions regarding the back-flow test of the INJ-1 well

- We developed a detailed and very elaborate polymer-tenside EOR technology application procedure for the Algyő field.
- The backflow of the INJ-1 well proved that the polymer content of the injected fluid took its expected profile control effect.

  First, at unchanged (pre-injection test) technical conditions, the gross fluid production of the well was around the half or the third of the earlier production rate, i.e. the polymer changed the permeability and flow conditions of the wellbore zone

  Second, the measurement of the polymer content of the re-produced fluid proved that only a part of the polymer was re-produced.

Conclusions regarding the back-flow test of the INJ-1 well

- The production data of the INJ-1 well proved that the tenside content of the injected fluid took its effect, as a result of the production of the residual oil by the tenside, the water cut of the produced fluid gradually decreased, after 3 months of production (2046 m^3), it reached the pre-injection average value (95.5%), moreover, by the end of the test period (31st October 2014), it dropped to ~88%. According to the production data, as a result of the injection test, the fluid produced by the well contained more and more oil.

Conclusions regarding the back-flow test of the INJ-1 well

- One of the wells around the injection well, the MON-4 well, which is a horizontal well, showed a significant oil production increase. From the 1.5-2-0 m^3/d value of April 2014, the oil production rate increased to 6-7 m^3/d till September 2014. In this well, the trend of the water cut decrease showed similarities to the trend observed at the INJ-1 well, more and more oil was produced.

  In our opinion, this is also a result of the injection test performed with the polymer-tenside solution on the INJ-1 well. This well has the bottom hole closest to the bottom hole of the injection well (166.7 m), thus, it may happen that the residual oil collected by the polymer-tenside solution filtrates to the dainage area of the well, and it appears in the produced fluid as well.

Thank you for your attention and patience!

Acknowledgements
This research was (partially) carried out in the framework of the Center of Excellence of Sustainable Resource Management at the University of Miskolc