Webinars

Welcome!

The program will begin soon.

You will not hear audio until we begin.

SPE International

Organic Oil Recovery – A Revolutionary EOR Technology

Mr. Christopher Venske

31st October 2022

Webinars

SPE Webinars are Sponsored by:

SPE

SPE Foundation

SPE International

Contents

1. The Science
2. Technology introduction
3. Mechanism & process overview
4. MOL Hungary project
5. Wider Results

The Science

An Emerging Living Microbial Ecology that may be 9% of All Life on Earth by Mass

- Using Only Resident Microbiology
- Production Increases Through Applied Microbiology
- Sweetens Fields & Reduces H_2S, naturally
- Decrease Lifting Costs & Increase Recoverable Reserves
- Reduce H2S mitigation chemical spend
- Globally Proven, 500+ Applications over 5 Continents
- True Enhanced Production, NOT Only Accelerated

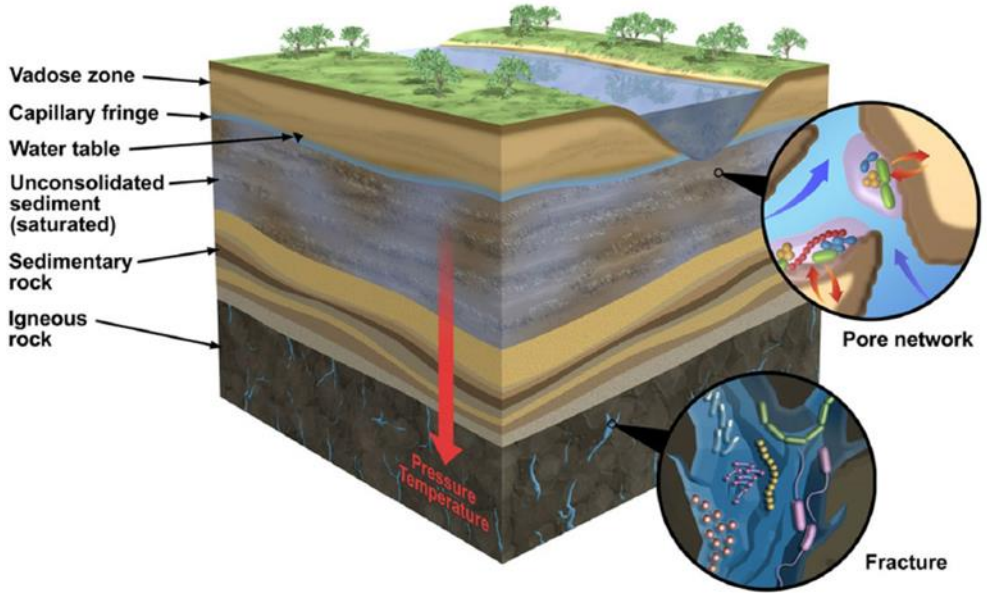


Figure 1. Habitable zones for microbial life in the terrestrial subsurface

Pressure and temperature increase with depth; water availability and porosity are the primary constraints on microbial life in deeper rock hosted systems

Technology introduction

Other EOR v OOR

Other EOR

- Large capex
- Lengthy implementation
- Issues with limited platform space
- Large volume of product
- Disposal and aquatic issues

Organic Oil Recovery

- No Capex
- As little as 6 Months to Implement
- Only Tanks and Pressure Pump Required
- Low Volume Supplemental
- Environmentally friendly, No Disposal or Aquatic Issues

Technology introduction

Field Screening of Reservoir Characteristics

The OOR 'Sweet Spot'

- Oil Gravity from **12-47 API**
- Water pH between **6-8**
- Reservoir Temperature Less than **105°C** (although successful treatments have taken place where the BHT was thought to be higher)
- Produced Water Salinity of less than **240,000ppm** TDS
- Reservoir Permeability of greater than **1mD** (higher the better in general)

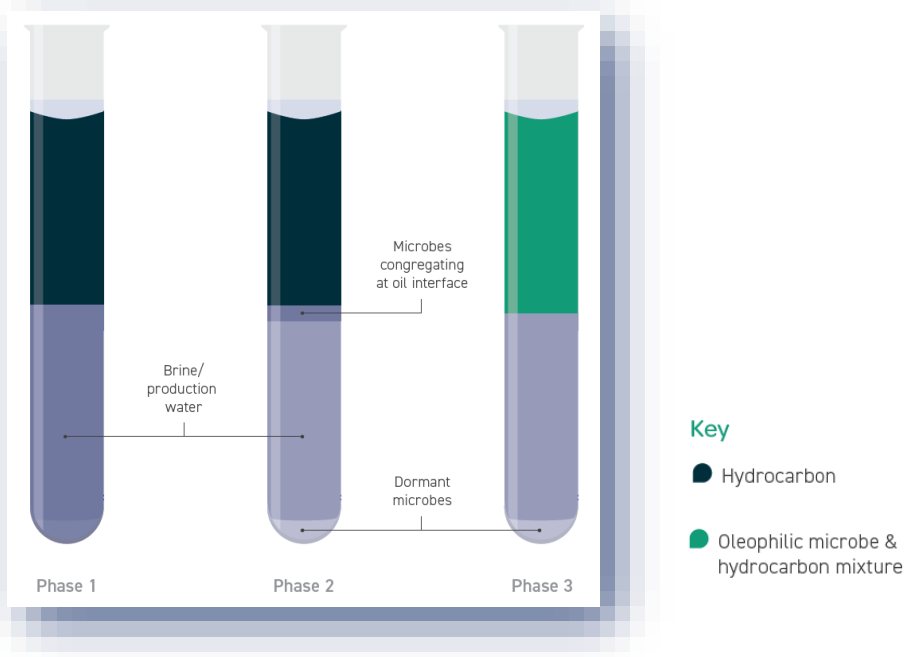
Ideal Data Profile

- Well Understood Geology (mapping)
- Good Water Injection History, indicated Response
- Current Well Completion Diagrams
- Oil and Water Production Records
- Chemical Treatment History
- Full H_2S History

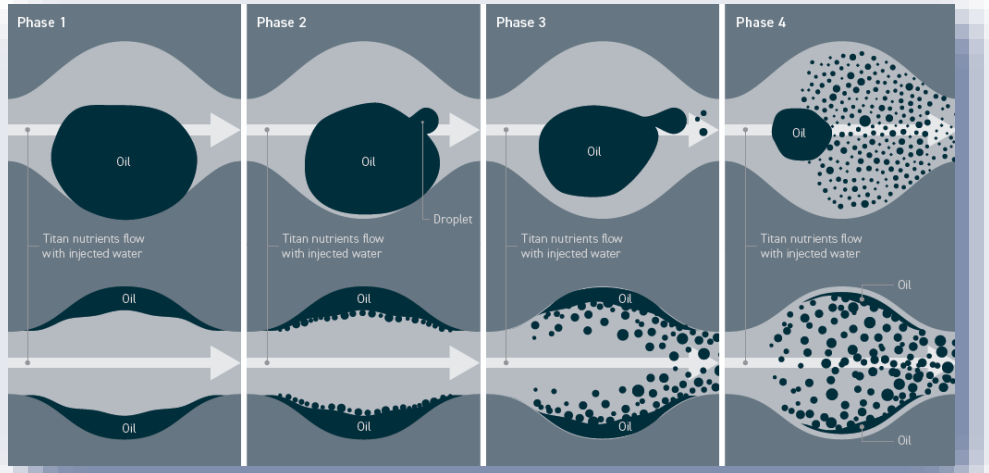
Mechanism

Oil/Water Interface

The TITAN Process® in the Lab
Showing Microbial Oil/Water Interaction



Oil Micro-Droplet Formation is the
Release Mechanism

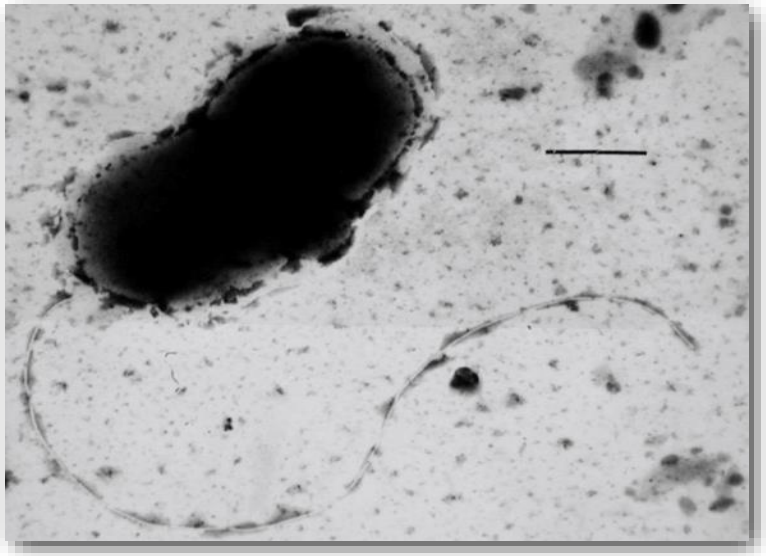


Micro Oil Droplets Can Now Flow Out of
Microscopic Reservoir Rock Pore Spaces

H_2S Reduction

By understanding the microbial ecology, OOR have studied the driving forces in the oil water interface and found nutrient issues that could be changed to enhance oil recovery and/or reduce H_2S production by changing the balance of microbe growth.

Micrograph of general Bacterial rods



Micrograph of Typical Sulphate Reducing Bacteria

H_2S Reduction

H_2S Reduction Results - CNOOC Scott (UK North Sea) – J17 Producer treatment

The graph below shows the H_2S readings from the producer before and after the OOR treatment. Full details in the EAGE paper.


IOR 2021 EAGE

59

Organic Oil Recovery - Resident Microbial Enhanced Production Pilot in the Scott Field (UKCS)

R. Fadley[1], A. Bostock[2], C. Hall[2], C. Vinake[2], M. Carroll[3]

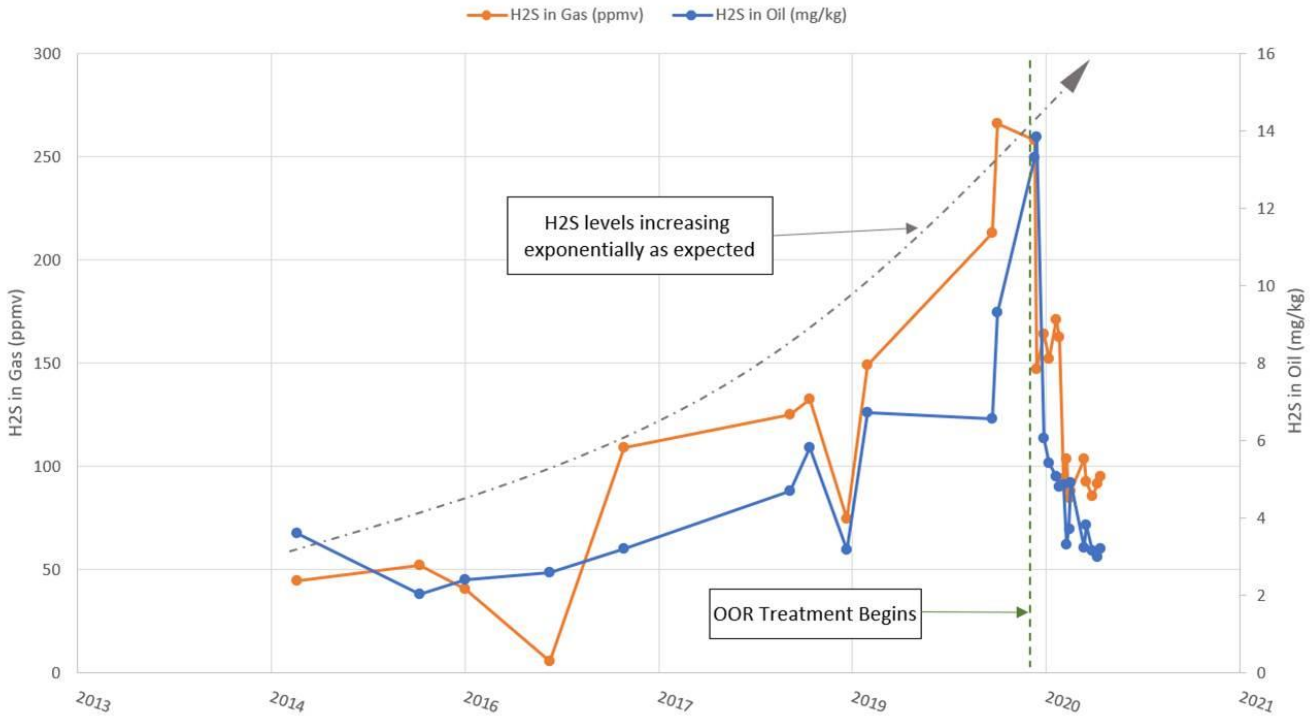
[1] Hearing Energy Services, [2] CNOOC Petroleum Europe Ltd, [3] Titan Oil Recovery Inc

Summary

Introduction:
CNOOC has been involved in a pilot study to determine the efficacy of Organic Oil Recovery (OOR, a unique form of microbial enhanced oil recovery) as a means of increasing oil recovery from its Scott field. CNOOC's operated Scott asset came on stream in 1993 and produces crude oil and natural gas from the Scott, Telford and Rochelle fields. Scott is located approximately 180 kilometers northeast of Aberdeen in 145 meters of water.

Methods, Procedures & Process:
Organic Oil Recovery harnesses microbial life already present in an oil-bearing reservoir to improve oil recovery through changes in interfacial tension increasing the oil's mobility and improving recovery rates and reservoir wettability. These changes could increase recoverable reserves and extend field life through improved oil recovery with negligible topsides modifications. The pilot injection is complemented by inserting a specific nutrient blend directly at the wellhead with ordinary pumping equipment. The well is then shut-in for an incubation period and thereafter returned to production.

Results, Observations & Conclusions:
During initial laboratory testing of two Scott target wells the reservoir showed a diverse and abundant microbial ecology which has been proven capable of undergoing the necessary characteristic changes to facilitate enhanced production. A pilot test was completed on well J17 in July 2020 and due to this application, both an ecology and production response has been proven. In addition to this response a drop in H_2S in both the Oil and Gas phase has been observed. The full method of implementation of the pilot test will also be discussed in detail and will include any challenges and/or successes in this area. The initial starting ecology of the wells will be characterized and compared to the ecology post-pilot. Additionally, a comparison of production and H_2S figures prior to and post the pilot implementation will be detailed. A correlation will be demonstrated between changes in ecology and an increase in production and a reduction in H_2S.



The Process

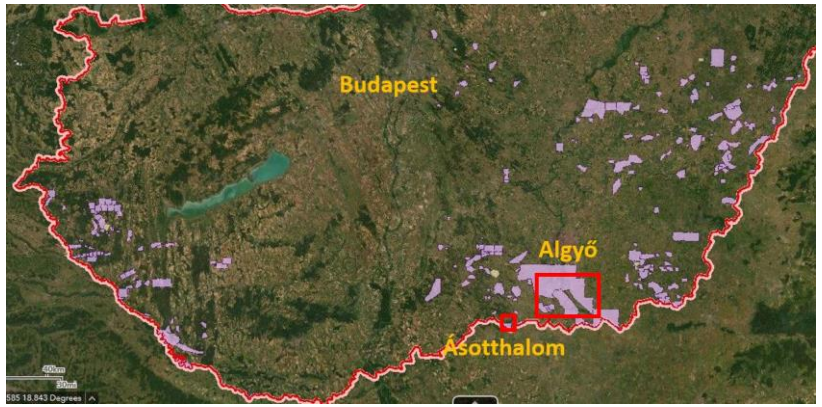
OOR – The 5 Step Process

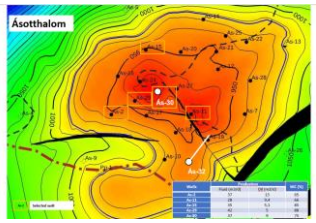
1. Field Screening of Reservoir Characteristics
2. Laboratory/DNA Analysis
3. **Pilot Test - In-Situ Microbial Response Analysis (ISMRA)**
4. Targeted Water Flood Implementation
5. Full Field Application

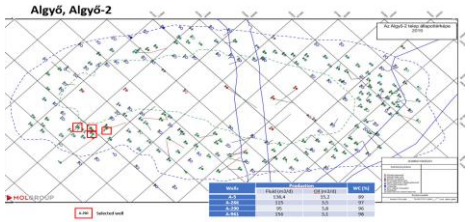
MOL Hungary project

Road from idea to pilots

- Candidate fields and wells selected
- Water sampling of wells and lab analysis
- Internal technical review and IPP preparation
- Budget allocation
- Injectivity tests
- Purchase Order Final Pilot Program Preparation







Selecting candidate fields and pilot wells

Main considerations:

- Meet the screening criteria
- Producing field/well
- Low-cost pilot preparation if possible
- Easy to take water samples
- Sufficient number of wells
- Injecting fluid to the well technically possible

Selected fields and wells:

- Algyő-1 reservoir: A-84, A-484
- Algyő-2 reservoir: A-266, A-290
- Ásotthalom field: Ás-15, Ás-29

MOL Hungary project

Water sampling and lab work results

- Strict and well-defined procedure for sampling
- Sampling work completed successfully on 10th Dec 2020
- Samples shipped by DHL to OOR lab in California on 12th Dec 2020
- Lab report received on 19th March 2021
- Analysis showed strong growth & activation of microbes with nutrients – 5 wells recommended for pilot
- MOL decided to complete pilot on all 6 wells

Sampling in Algyő field

Injectivity tests

- Needed to make sure that nutrient-formation water mixture can be injected into the reservoir
- Due to sand plug in A-266 the well was excluded
- All other 5 injectivity tests were successful

MOL Hungary Microbial counts

Counts as collected (Initial Samples)

Well	Spin & Stain	Microbe count in field	Microbe count/ml
A-84	Initial Sample	25	1,562,500
A-266	Initial Sample	32	2,000,000
A-290	Initial Sample	17	1,062,500
A-484	Initial Sample (2)	15	937,500
As-15	Initial Sample	47	2,937,500
As-29	Initial Sample	9	562,500

Counts post incubation, with & without OOR nutrient

Well	Full Work-up tube	Microbe count in field	Microbe count/ml
A-84	1	11	6,875,000
	3	22	13,750,000
	5 (2)	73	45,625,000
A-266	1	15	9,375,000
	3	33	20,625,000
	5	22	13,750,000
A-290	1	23	14,375,000
	3	25	15,625,000
	5	25	15,625,000
A-484	1	23	14,375,000
	3	69	43,125,000
	5	35	21,875,000
	6	46	28,750,000
As-15	1	32	20,000,000
	3	27	16,875,000
	5	72	45,000,000
As-29	1	14	8,750,000
	3	39	24,375,000
	5	35	21,875,000

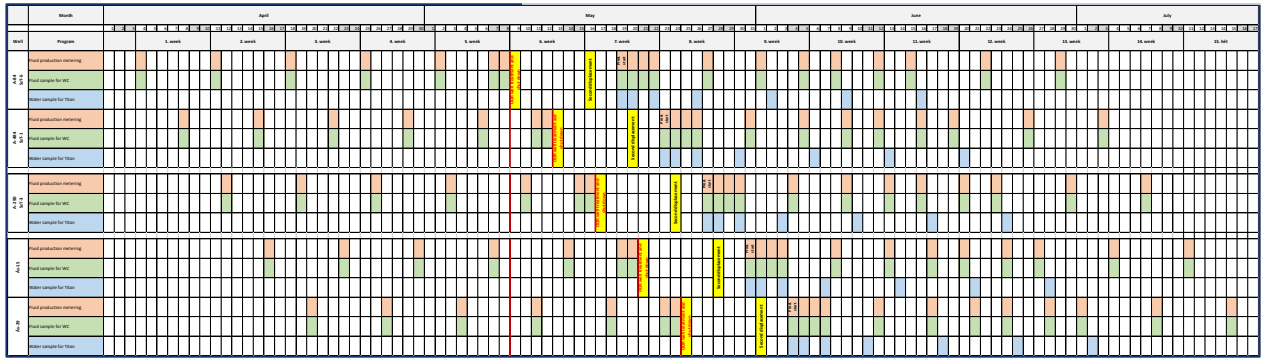
MOL Hungary project

Pre and Post Pilot Activities, Logistics

- Accurately measuring fluid production and WC once a week before OOR treatment
- Mixing nutrient and formation water immediately before injection
- OOR treatment, then 7 days shut down, then 2nd displacement, then 3 days shut down
- Reopen the well, measure fluid production and WC twice a week for 3 weeks, then once a week
- Water sampling to a defined schedule
- Samples analysed at the OOR lab
- Project results analysed

Mixing unit in Algyő Mud Plant

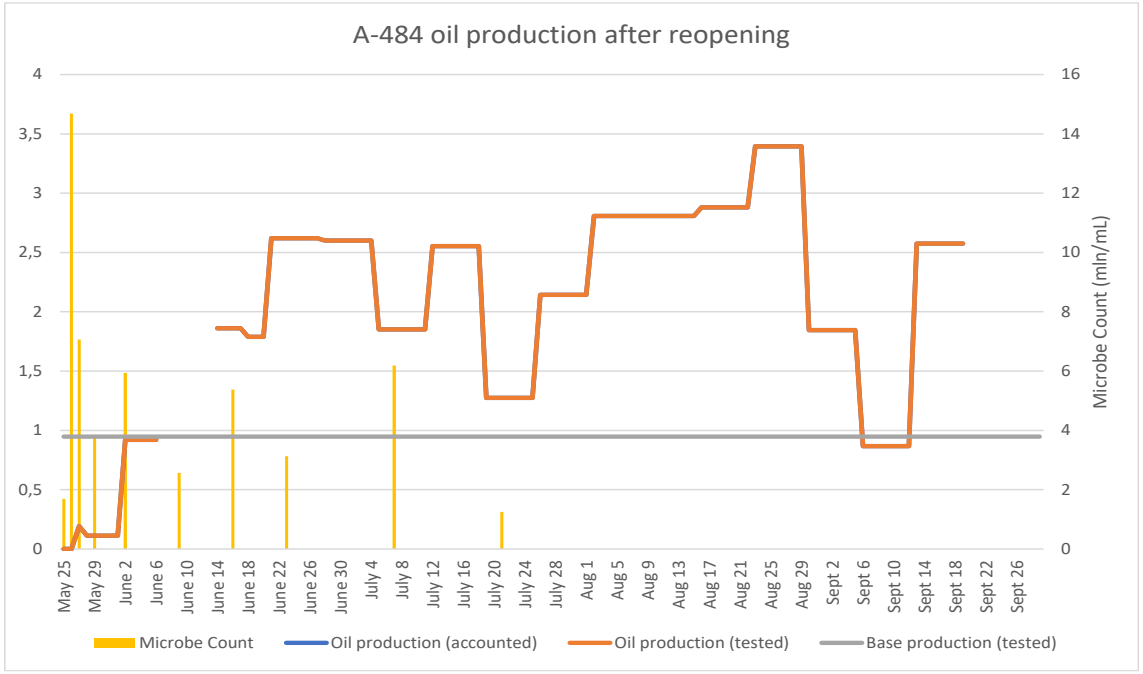
Schedule of metering, sampling and OOR treatments

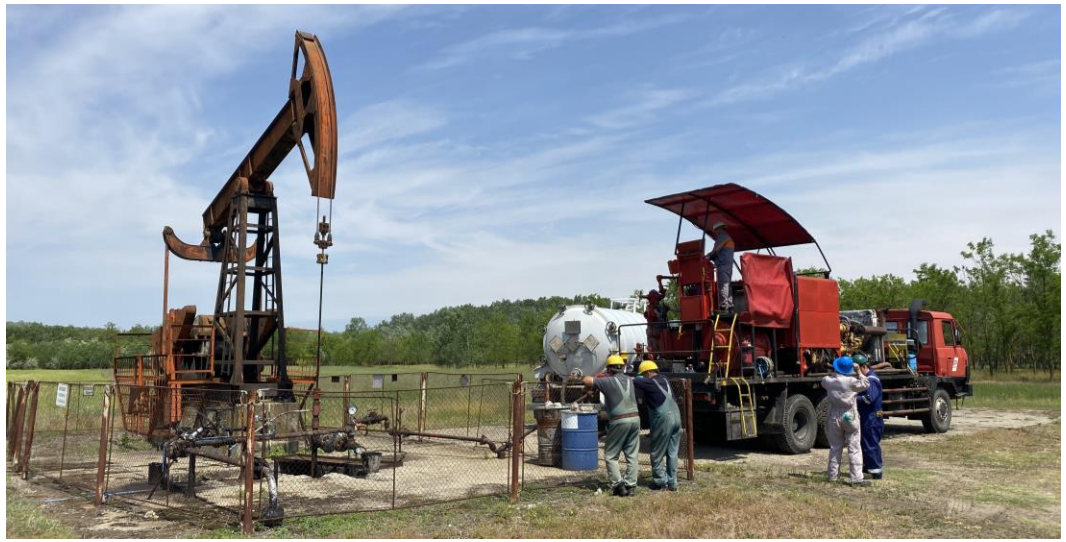


MOL Hungary project

Post Pilot Results

- Three out of five wells showed positive response to OOR treatment
- No significant reaction in A-84 probably due to too low residual oil saturation
- No reaction in Ás-15 due to technical failure during nutrient injection





Post Pilot Results – A-484 well

- ***Microbe count*:** 1,6 mln/mL before pilot, increased significantly
- ***Average oil production before treatment*:** 0,95 m3/d (grey line)

Conclusions

- Microbes were activated in situ resulting in a decrease in water cut. Consequently oil production increased during the first 3 month after OOR treatment. Peak 350% increase observed.

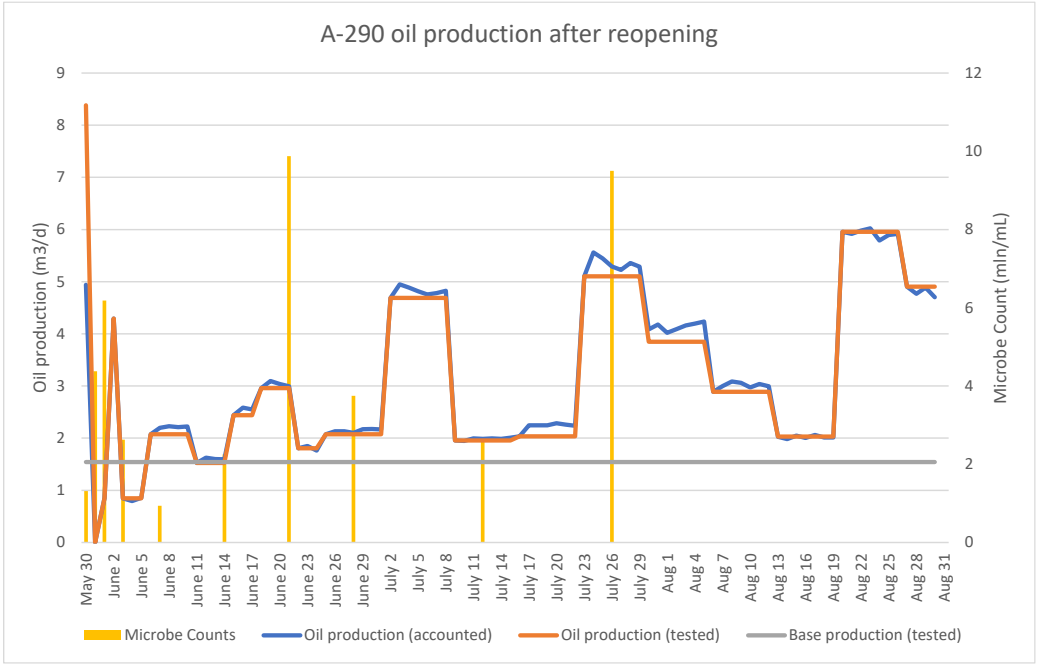
MOL Hungary project

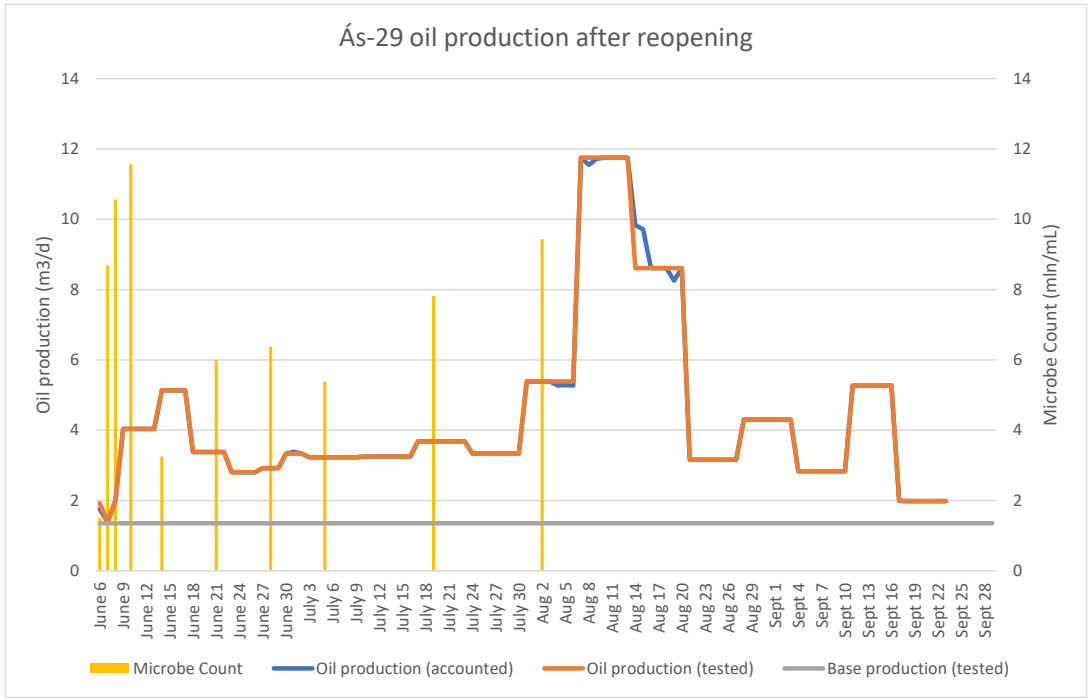
Post Pilot Results – A-290 well

- ***Microbe count***: 1,3 mln/mL before pilot, increased 9-fold
- ***Average oil production before treatment***: 1,5 m3/d (grey line)

Conclusions

- Microbes were activated in situ what decreased water cut. Gross production also increased due to organic wellbore cleaning effect. These effects resulted in incremental oil production during the first 3 month after OOR treatment. Peak increase of 660% observed.





Post Pilot Results – Ás-29 well

- ***Microbe count***: 1,5 mln/mL before pilot, increased 4-7-fold
- ***Average oil production before treatment***: 1,35 m3/d (grey line)

Conclusions

- Microbes were highly activated in situ which caused a measurable decrease in water cut. Oil production more than doubled during the first three months after OOR treatment. Peak increase of 300% increase observed.

Wider Results

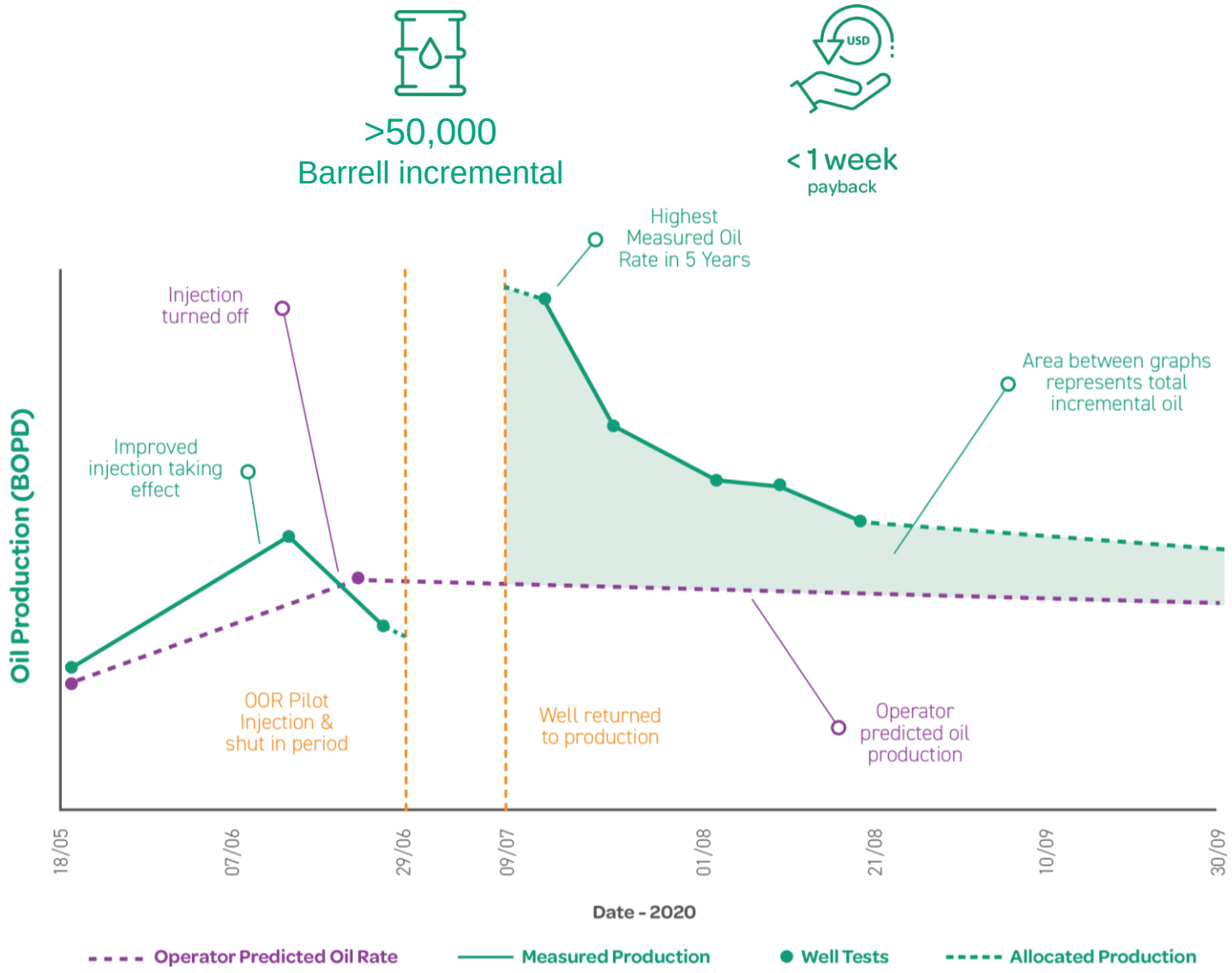
Producer Pilot Test– well #J17 CNOOC Scott (North Sea)

- ***Microbe count*:** 930k/mL before pilot, increased 20 fold
- ***Average oil production post-treatment*:** 1,100 BOPD , 2,358 BOPD (post-treatment)

Conclusions

- Microbes successfully stimulated post-pilot within reservoir which decreased water cut and significantly improved oil production levels. Encouraging results gave confidence to operator to move to targeted water flood implementation in Q4 2022.

Screening criteria	Scott Field	OOR technical criteria
Oil Gravity (API)	35	12 – 42
Produced Water pH	6.7	6 - 8
Reservoir Temperature (°C)	121*	<105
Produced Water Salinity (TDS)	134,000	<215,000
Reservoir Permeability (mD)	500	> 1



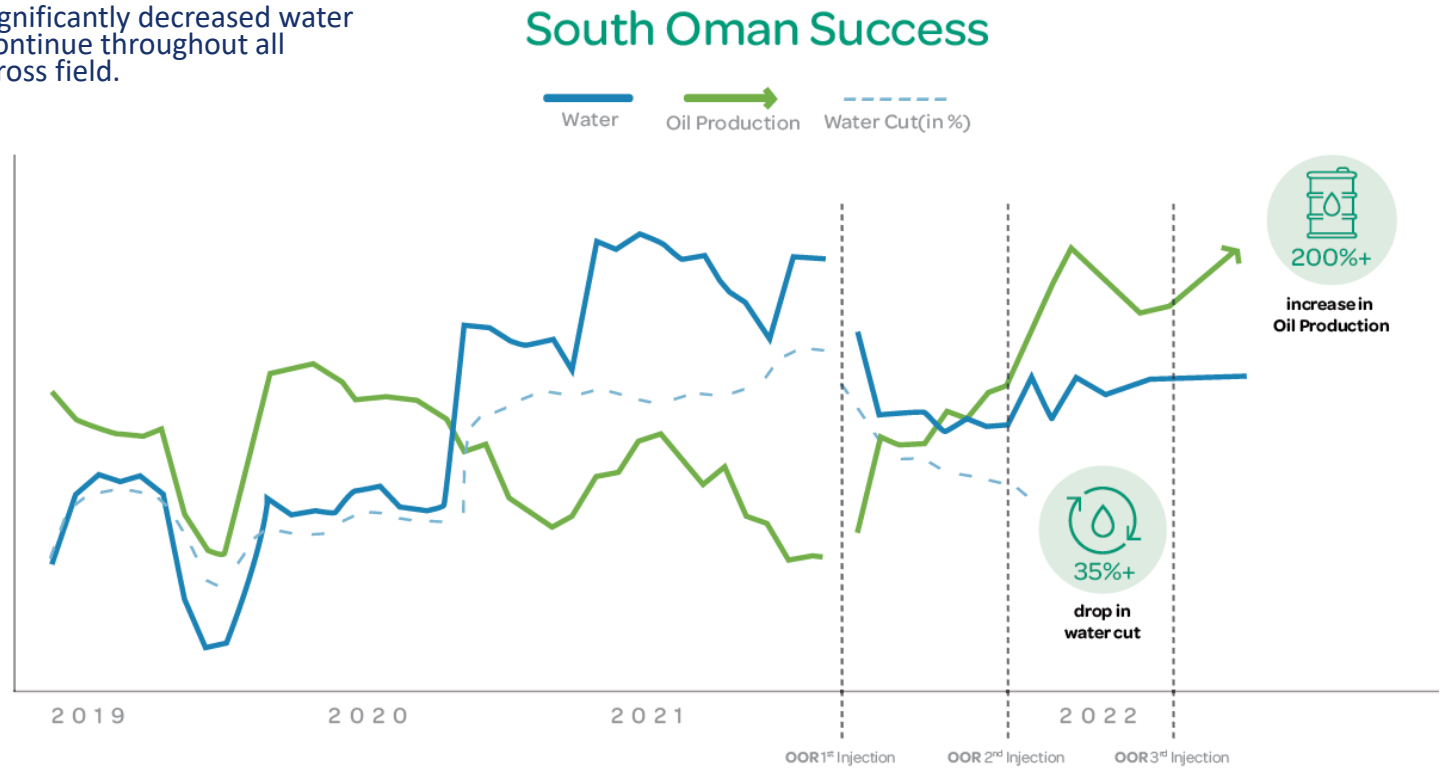
Wider Results

Target Water Flood Implementation – Single Injector Supporting 4 Producers

- ***Microbe count*:** 813k/mL before pilot, increased 4-5 fold
- ***Average oil production post-treatment*:** 200%+ (still increasing)

Conclusions

- Microbes activated widely throughout reservoir which significantly decreased water cut. Early results are very encouraging, monitoring will continue throughout all supported injectors. Plan to move to further injectors across field.



Any Questions?

Thank you..

MOL Hungary – János Szelényi (Production Technology Specialist) & Christian Wilms (SVP Subsurface & Field Development)

CNOOC UK Ltd

Hunting Energy Services

SPE