DEVEX 2021

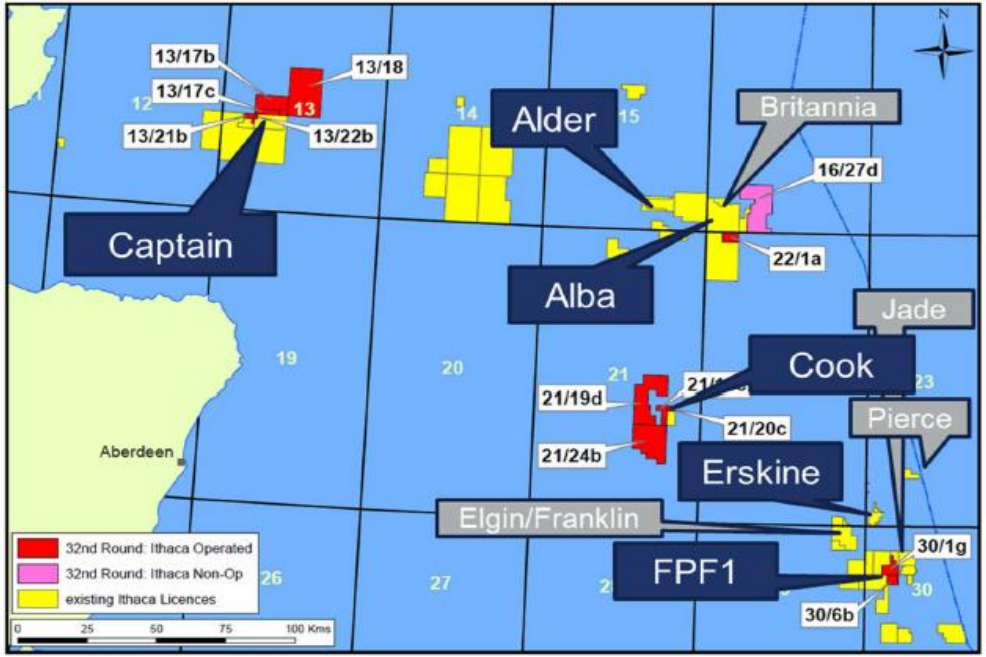
Day 1 – Monday 7th June 2021

A Novel Sampling and Testing Procedure to Confirm Polymerflood Viscosity Retention at the Captain Field

[1]Johnson, G. and [2]Hesampour, M., [1]Van Zeil, W.E., [2]Toivonen, S., [1]Carnicero, P., [2]Pin, E., [1]Hall, D., [2]Sihvonen S., [2]Hanski, S.

[1]Ithaca Energy UK LTD, [2]Kemira Oyj

Captain Asset Overview



Ithaca-operated	Offshore UK North Sea	Sea depth 350ft	3 - 11 Darcy sandstones	PWRI
1 billion barrels STOOIP	Discovered 1977	Oil 40 - 140 cP	T = 31˚C, P_{res} = 1,270psi	94% watercut

Captain Subsurface Development

5,000 ft wells

Mobility Ratio ~40

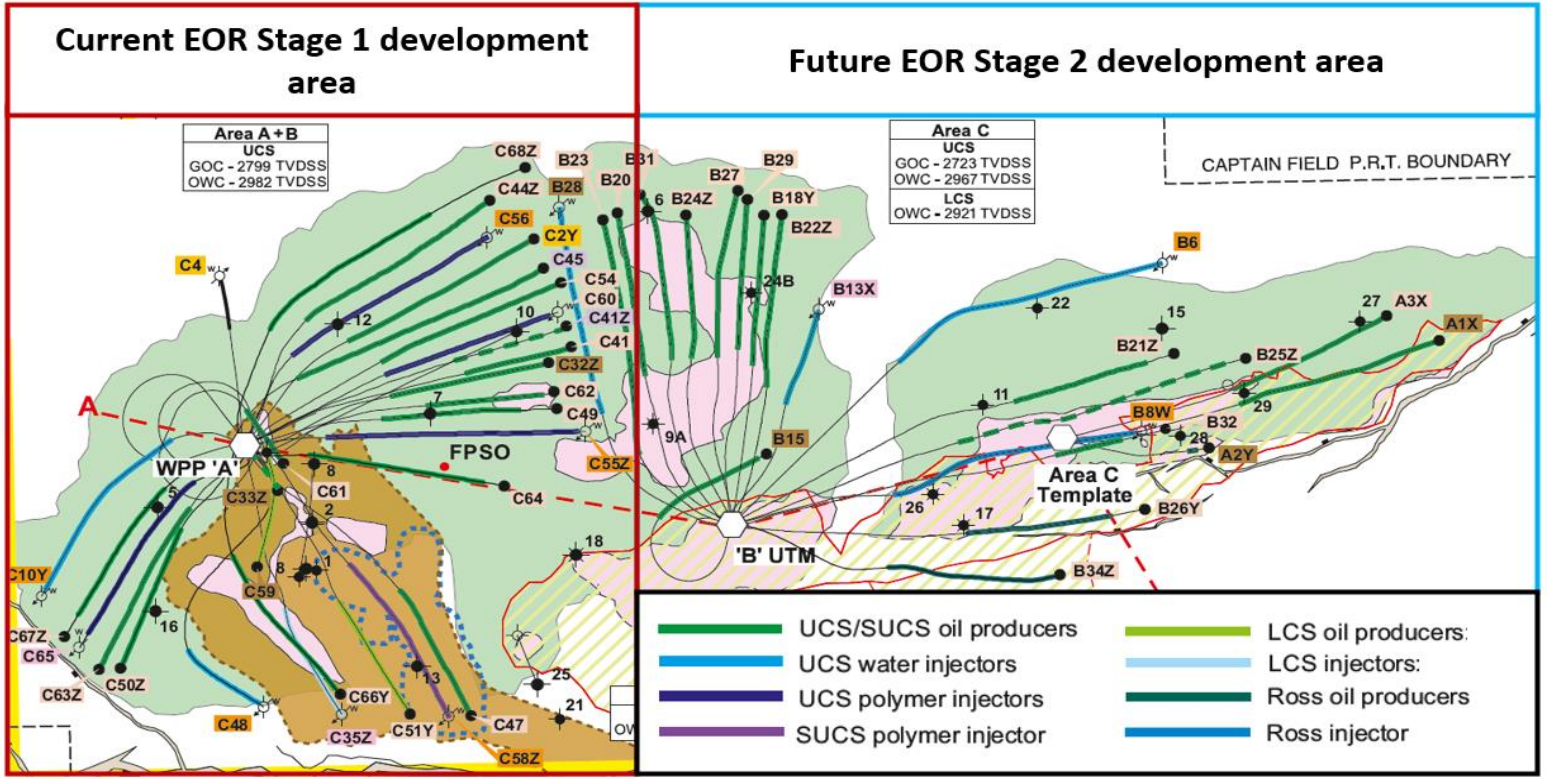
>100 horizontal wells

100m spacing

Developments:

1. Area A
2. Area B
3. Area C
4. Polymer Pilot
5. EOR Stage 1

Oil recovery mechanisms



Polymer solution yield and degradation

Displacing fluid viscosity = improved oil recovery

Emulsion based Anionic Hydrolysed Polyacrylamide polymer (HPAM)

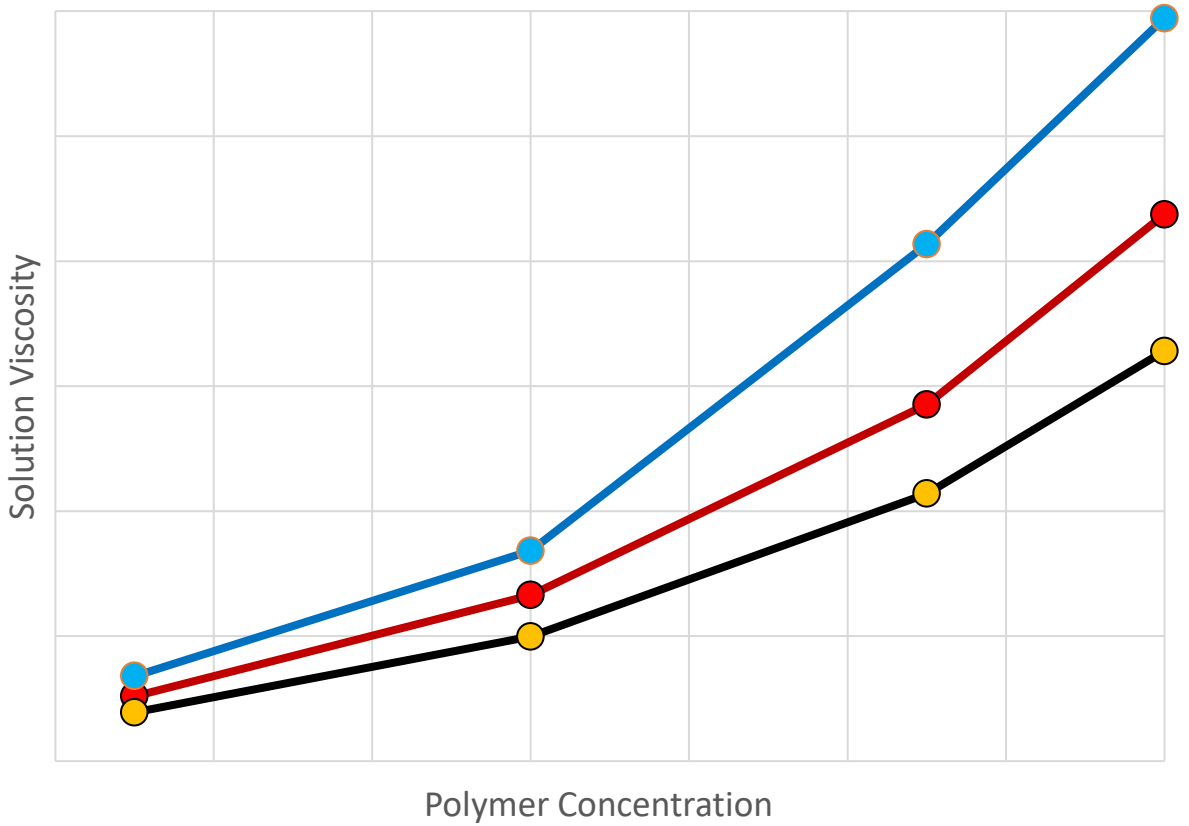
Polymer solution yield

Polymer degradation:

- Thermal
- Mechanical
- Chemical

Perceived risk of degradation at Captain

Financial impact



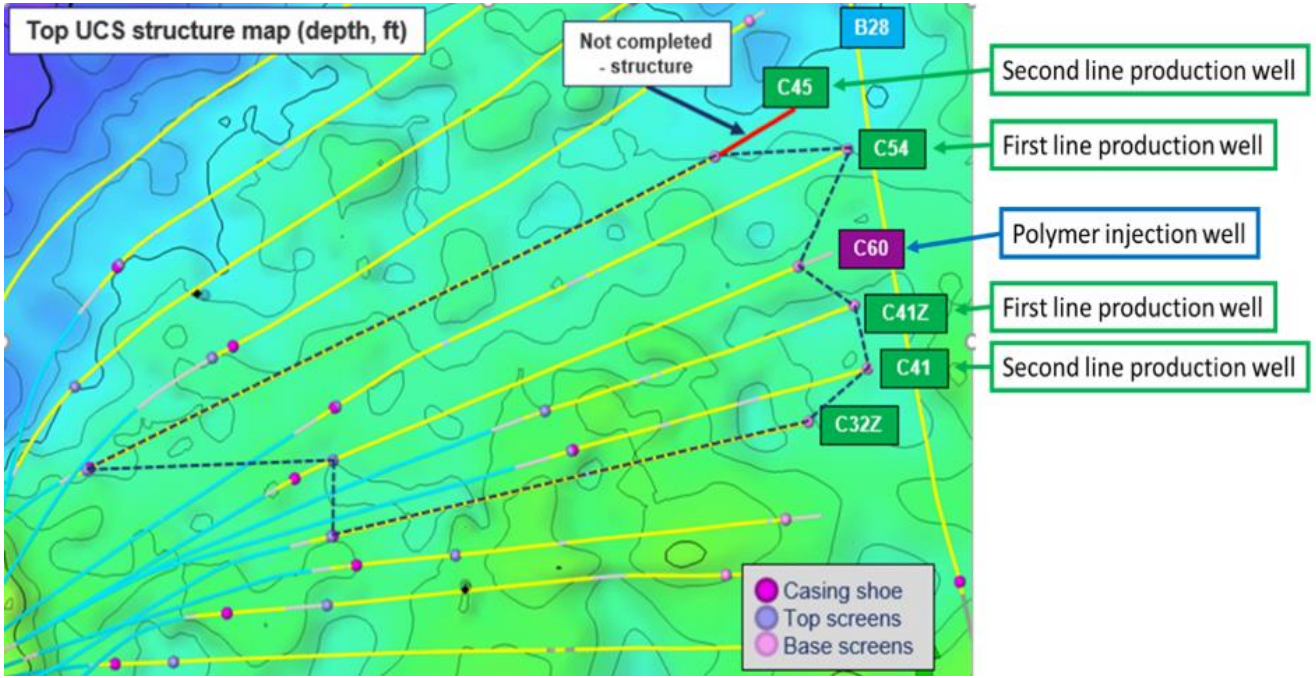
Opportunity identification

Believing vs. verifying

Field data:
- Opportunity
- Polymerflood status
- Well identified
- Sandface considerations

De-risking investment

Sampling challenges
- Subsurface
- Well intervention
- Offshore environment and climate
- Contamination

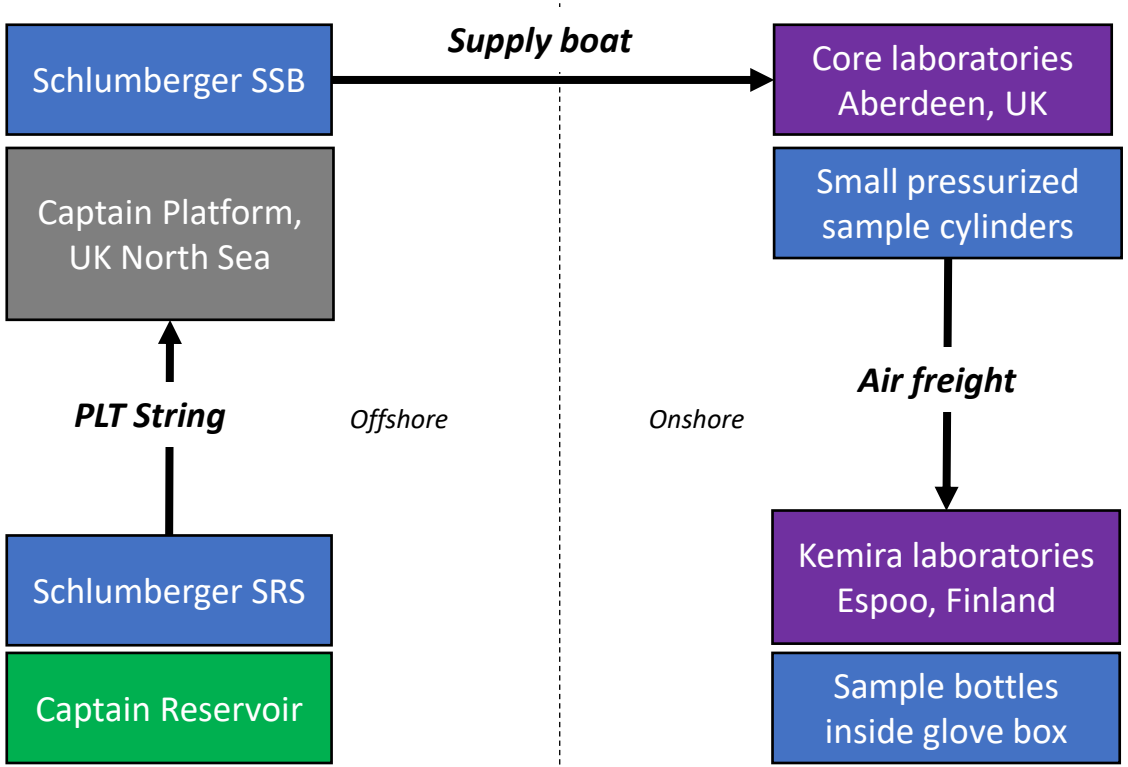


$$Degree\ of\ HPAM\ degradation, \% = 1 - \left(\frac{Viscosity\ of\ produced\ sample, cP}{Viscosity\ of\ fresh\ HPAM\ sample, cP} \right) x\ 100\%$$

Sampling and transport considerations

Sampling considerations

- Reservoir sandface
- Schlumberger SRS
- Platform considerations
- Schlumberger SSB
- Transfer onshore
- Transfer to sample cylinders
- Air freight
- Arrival at Espoo, Finland



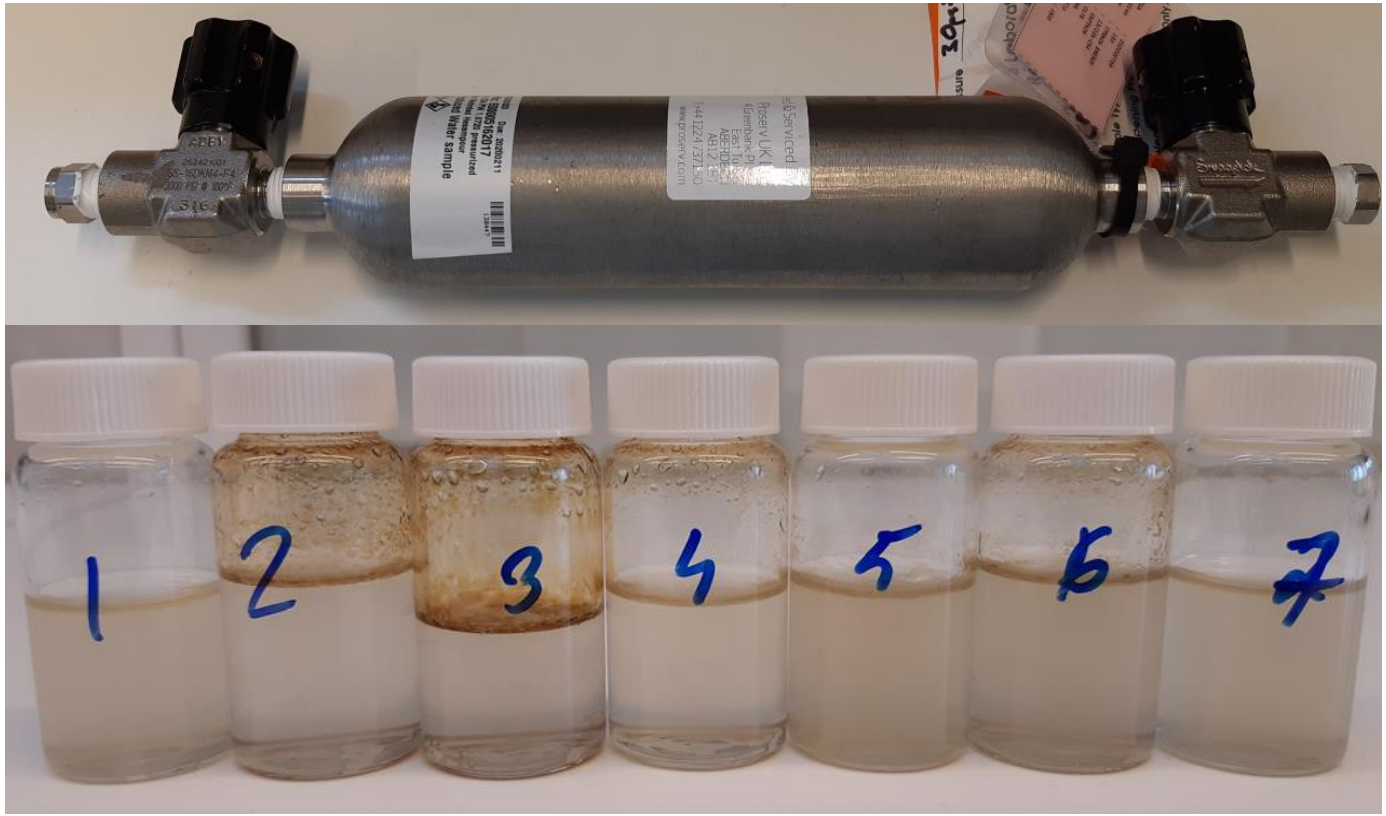
Sample bottle and solutions at laboratory

Samples received at lab in anaerobic conditions in pressurised cylinders

Cylinder at 30psi, transferred to sample bottles for viscosity measurement in glove box

Samples maintained in anaerobic conditions for viscosity testing

Brine composition and polymer concentration measured separately



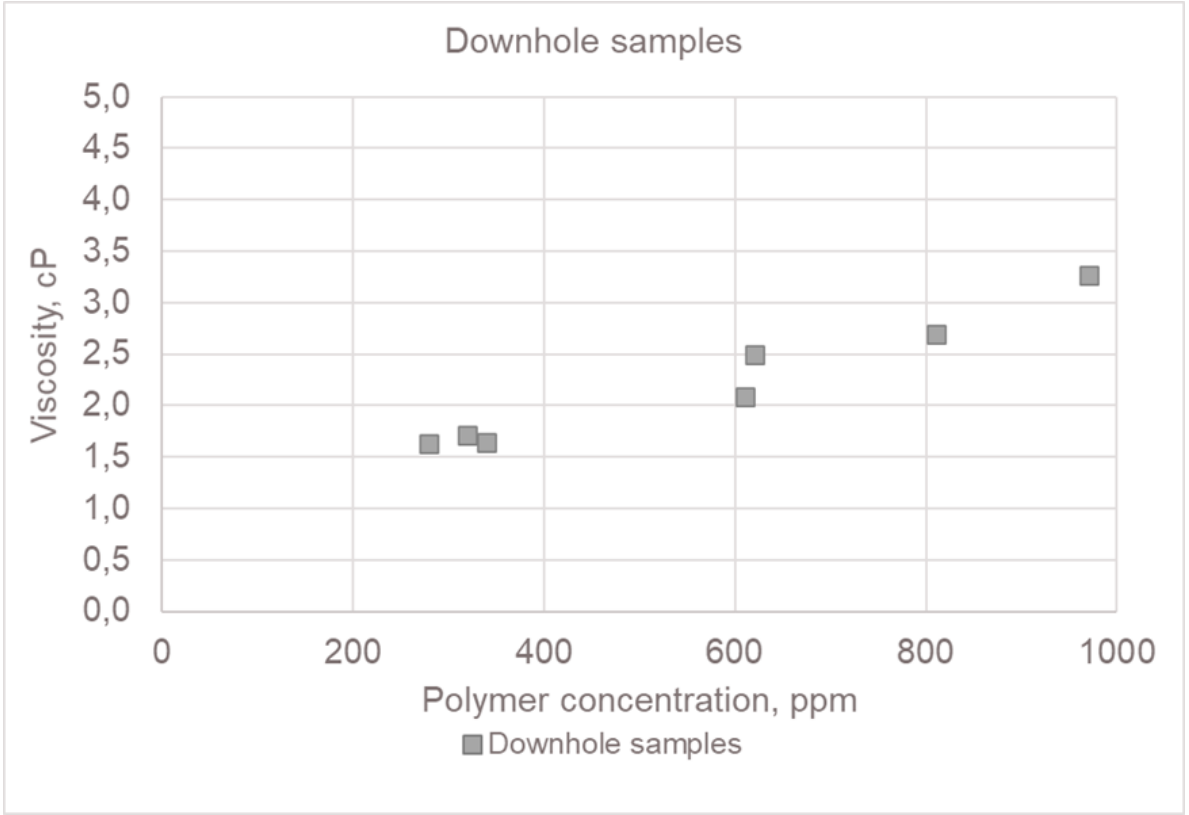
Viscosity retention from collected samples

Retained efficacy confirmed through viscosity measurement inside glove box

Brookfield viscometer used at 60rpm and 25°C

Graph shows the results of viscosity measurement from downhole samples as a function of concentration

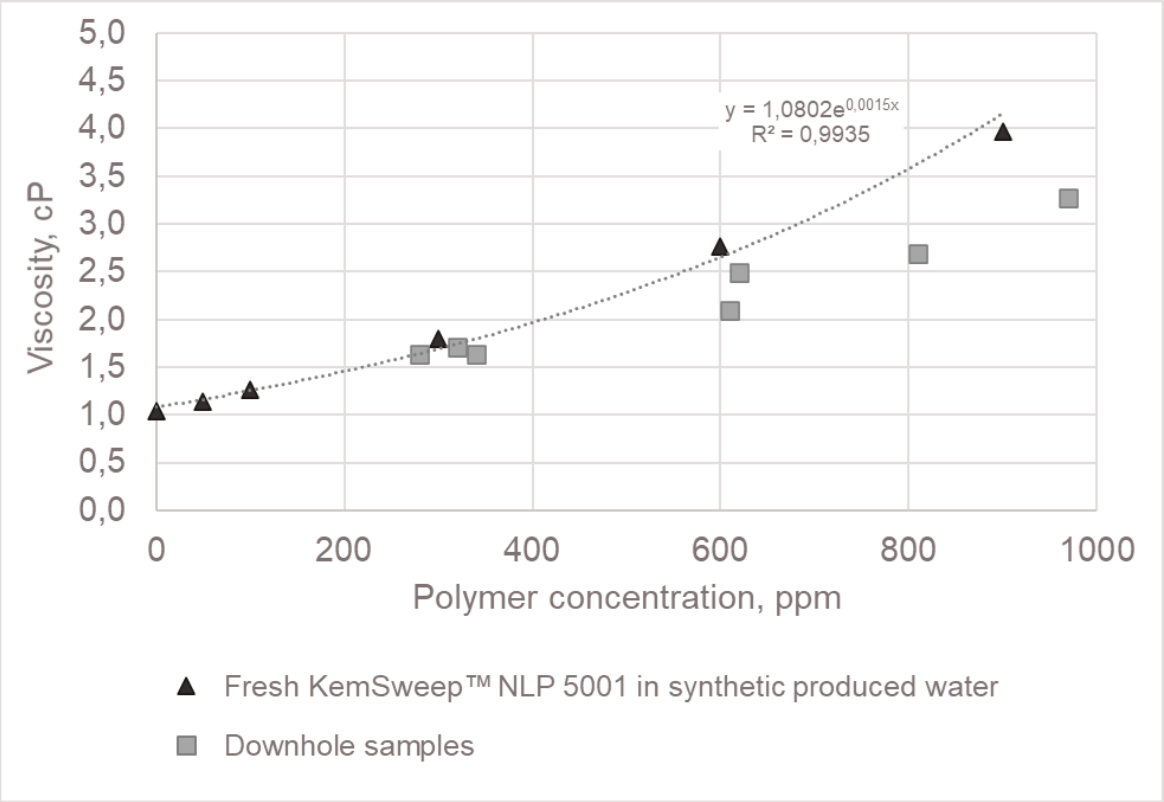
Viscosity increases with increasing concentration



Viscosity comparison to reference curve

Concentration - viscosity curve of fresh polymer solution prepared in a synthetic brine with equal salt composition

Graph shows the comparison of viscosity measurement from downhole samples with the expected viscosity of fresh polymer



Full table of results from samples

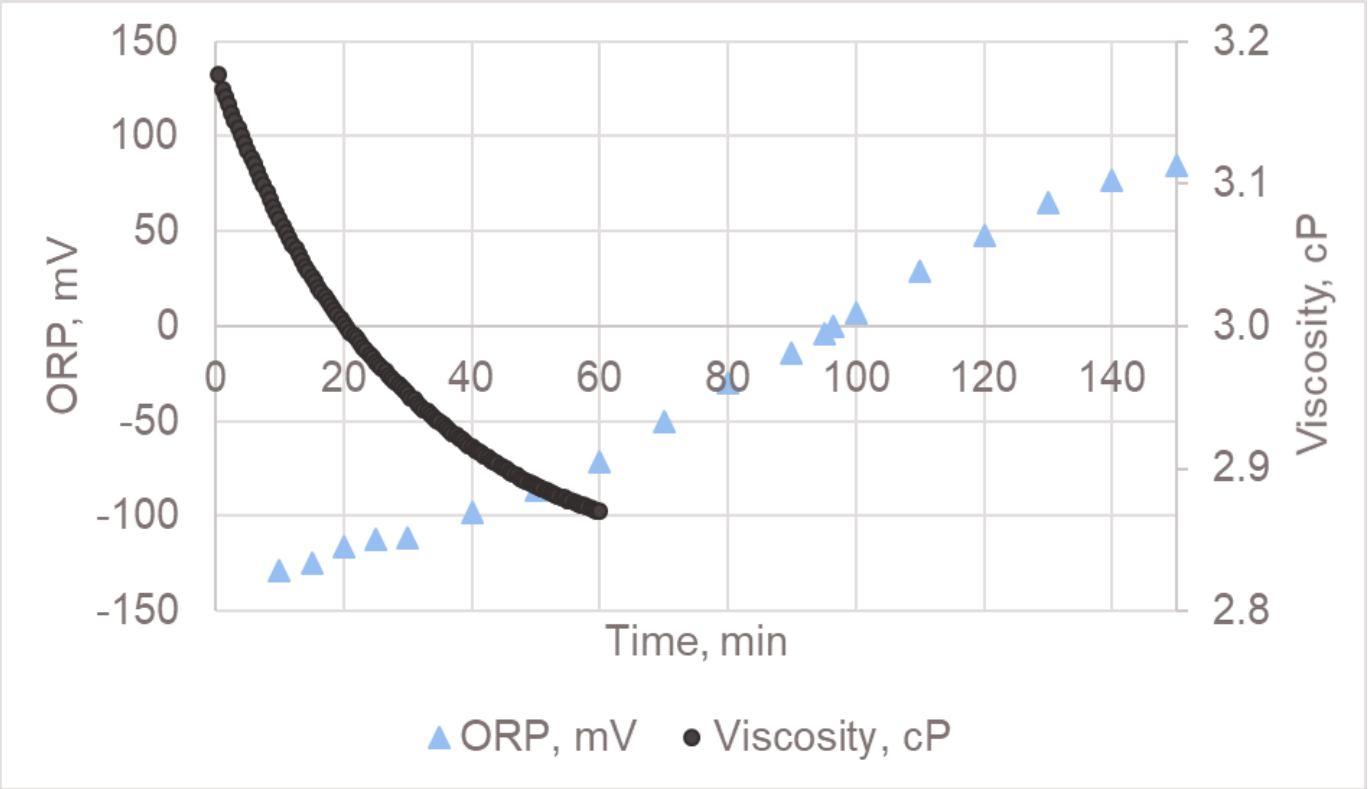
Sample number	Depth, Feet	Polymer concentration, ppm *(measured with SEC)*	Expected viscosity, cP *(based on fresh polymer in synthetic C54 brine)*	Viscosity measured with Brookfield, cP	Degree of polymer degradation, %	ORP, mV
1.0120	10,700	320	1.75	1.71±0.02	2 %	-317
1.0220	10,700	280	1.64	1.63±0.02	1 %	-312
1.0420	9,500	340	1.80	1.64±0.02	9 %	-302
1.0320	8,900	620	2.74	2.49±0.02	9 %	-306
1.0520	8,300	610	2.70	2.09±0.02	23 %	-377
1.0620	7,700	810	3.64	2.69+0.02	26 %	-379
1.0720	6,200	970	4.63	3.27±0.02	29 %	-318

Degradation test due to Oxygen ingress

After the anaerobic viscosity measurement, the remaining samples were removed from glove box.

ORP and viscosity (at constant shear rate 72 $^{s-1}$) as function of time were measured to understand the rate of changes upon exposure to oxygen.

The drop in viscosity is around 10% per hour



Summary and conclusion

Authors have demonstrated a recent assessment of polymer degradation potential within the reservoir for an offshore polymer flood

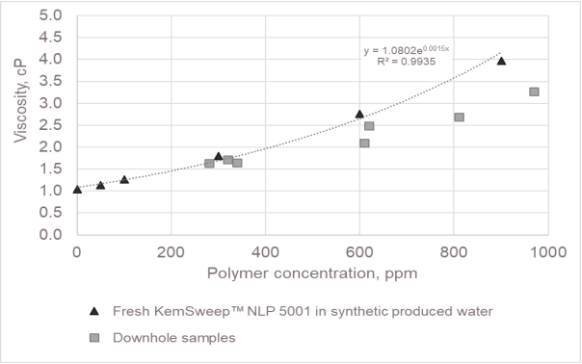
A method to quantify the overall degree of degradation in an active polymer flood through physical sampling and testing has been presented

Whilst simple in theory, this method requires the utmost care and diligence during all steps of sampling, storage, transport and testing in the lab, in particular:

- Oxygen ingress
- Sudden pressure changes

Following testing and analysis of the C54 well produced polymer samples, the team has quantified the degree of viscosity retention in the Captain reservoir.

Verification of viscosity retention, despite distances and time, adds greater certainty to future polymer flood EOR investment decisions in the Captain field



Mehrdad Hesampour
Susanna Toivonen
Sirkku Hanski
Stina Sihvonen
Erica Pin
Geoffrey Johnson
Wiens Van Zeil
Pablo Carnicero
Douglas Hall, D

The authors acknowledge the contributions of many people who made the investigation and findings possible, not least including:

- Captain Asset team personnel who made the sampling procedure a success.
- Schlumberger and Core Laboratories (U.K.) Ltd personnel who completed the sampling of the fluids, transferring of samples and transportation.
- Ithaca's Captain co-venturer Dana Petroleum (E&P) Limited for reviewing and granting their permission to publish this paper.
- Heriot-Watt University, Institute of Petroleum Engineering, Flow Assurance and Scale Team (FAST), who have provided invaluable support and coaching.