DRILSMOOTH FLUID SYSTEM

Features and Applications

Features

- Highly shear thinning
- Exceptional hole cleaning and suspension
- Improved solids removal efficiency vs. competitive systems
- Zero flow at wellbore face
- Low reservoir damage and easy cleanup
- System stable to ~400°F
- Viscosity easily destroyed (*e.g.*, for displacement procedures)
- Cost effective vs. polymer muds
- High LC_{50} numbers

Applications

- Unconsolidated formations
- Loss zones (porous and fractured)
- Milling
- Horizontal open hole completions
- Stabilizing surface holds against collapse
- Coiled tubing drilling
- Deepwater
- High ROPs

WHAT THE DRILSMOOTH SYSTEM IS:

The **DrilSmooth** system is a unique, water-based drilling fluid developed for fractured and stabilizing mechanically weak or poorly consolidated formations and drilling high-angle or horizontal wells

Basic makeup

- Non-treated bentonite
- MMO mixed metal oxide
- Water
- Soda ash
- Caustic soda

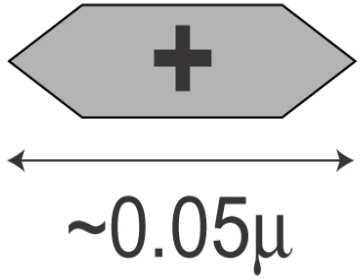
Complementary Additives

- ID-MMH FL fluid loss control additive
- Temperature stabilizers (ID-PTS)
- AS-Y Shale inhibitor
- Selected ancillary products
- Weight material

System Description

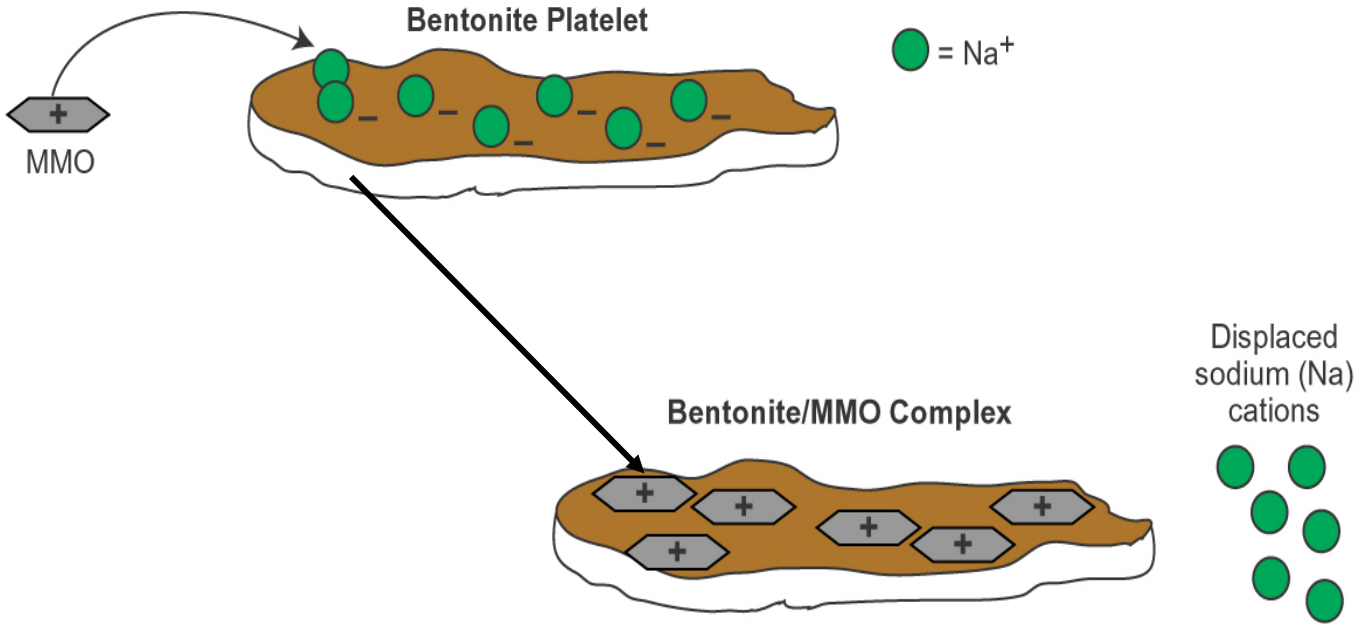
What is MMO?

A small cationic crystal . . .



- **A dimension smaller than a bentonite platelet (face dimension ~0.05 m)**
- **Flat with high specific surface area (narrow edge of ~0.0008 m)**
- **Charge density 6 to 7 times that of a bentonite platelet**
- **Acid soluble**
- **“Synthesized Structure”**

System Description



New Adduct Formed by Chemical Reaction

- Attachment of the **MMO** crystal to the bentonite platelet produces an *entirely new chemical structure*
  - ✓ PV is very low
  - ✓ YP, Fann 6 and 3, and gels are abnormally high
- The gels are formed by electrostatic attraction - which is why they are instant, but fragile

WHAT DOES DRILSMOOTH OFFER?

- Instantaneous and very effective suspension
- Excellent hole cleaning
- Resistance to movement along fractures
- Totally external filter cake if properly treated
- Minimal washout due to dead zone at wellbore wall
- Environmental peace of mind
- Temperature stability

KURDISTAN CASE HISTORY

KURDISTAN CASE HISTORY-1: GULF KEYSTONE WELL (2014-15)

- Witnessing very significant success of DRILSMOOTH (MMO) system in drilling 26'' and 17 ½'' sections of the well, 12 ¼" hole was also drilled through, Sarmond, Garagu, Chia Gara and Barsarin up to the 9 5/8" casing point 1965m / 1610m TVD with 56º inclination.

- There was significant control of formation losses (as depicted in following slides) and absolutely no hole cleaning issues.

- Several runs of well Logging over a long time, enhanced the well exposure time and the casing running faced obstructions in Garagu shales which needed higher inhibition levels.

- In MMO system the inhibition level could be attained with 2-3% KCl (< 20,000 chloride limit to use it) and with up to 3% ID-FURY.

- Seeing the inhibition limitations of the MMO system, the whole system was easily broken down to KCl-Polymer system and re-conditioned the well for successful running of the casing.

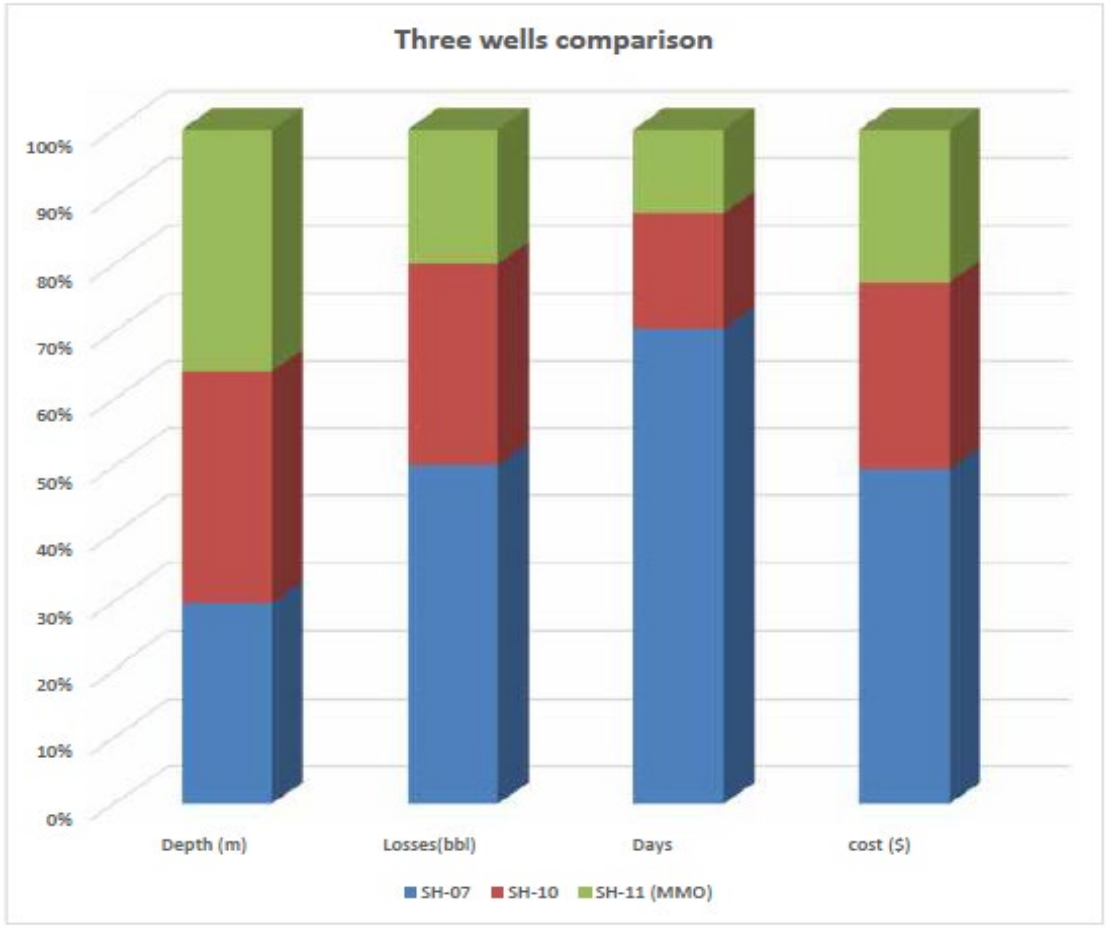
KURDISTAN CASE HISTORY-1: GULF KEYSTONE WELL (2014-15)

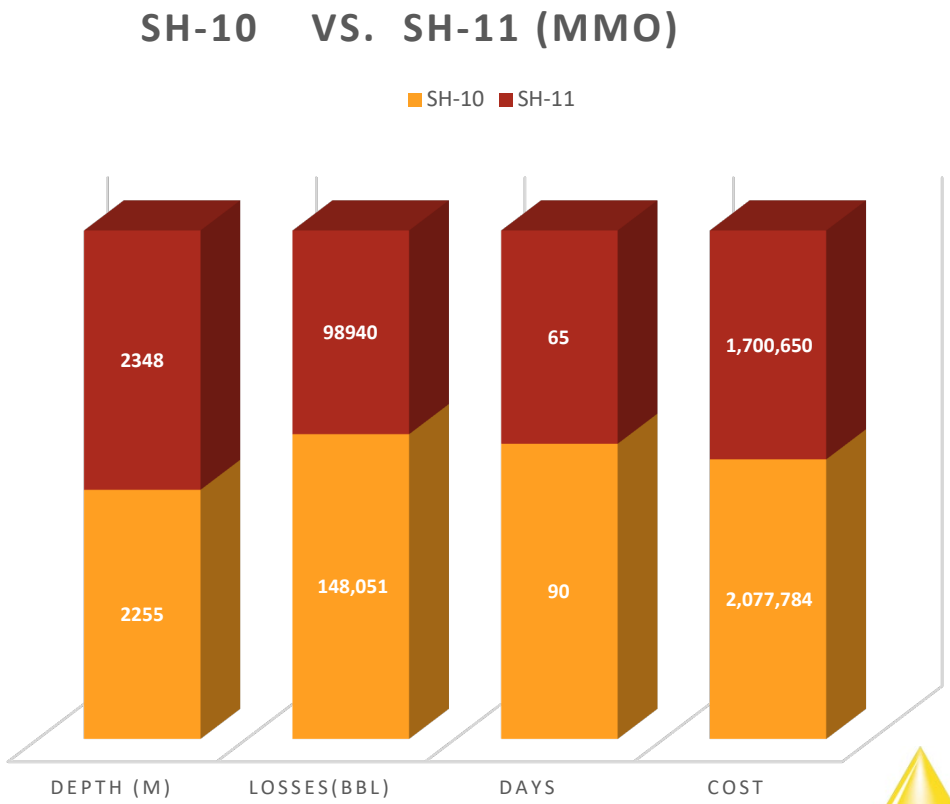
Advantages recorded using MMO mud in SH-11 vis-à-vis SH-10 drilled from the same pad

- **Overall losses were 33% less using MMO mud in 26'', 17 ½'' and 12 ¼'' holes.**
- **Total well mud cost was 18% less vis-à-vis previous well drilled.**
- **For SH-11, planned well depth was 2157 with 43.41º inclination, actual was 2348m with 62.9º, an 8 % longer well bore with higher inclination.**
- **Planned drilling-cum-completion days were 75 whereas the well was completed in 65 days, saving 13% rig time and money.**
- **Incurred 18% less mud and Engineering cost.**

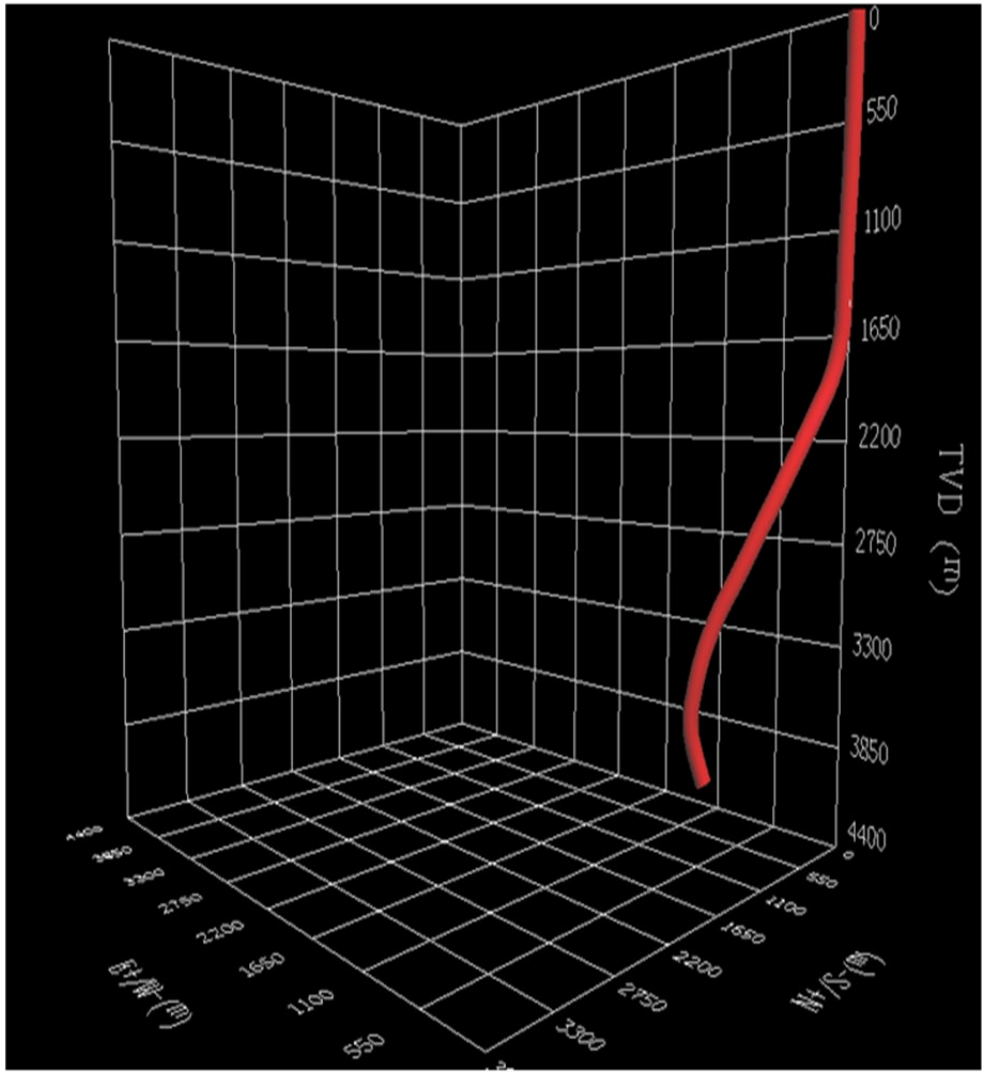
KURDISTAN CASE HISTORY-1: GULF KEYSTONE WELL (2014-15)

Pictorial presentation of the comparison of three wells drilled by the same client in the same block:





KURDISTAN CASE HISTORY-2: TOTAL E&P WELL (2014-15)



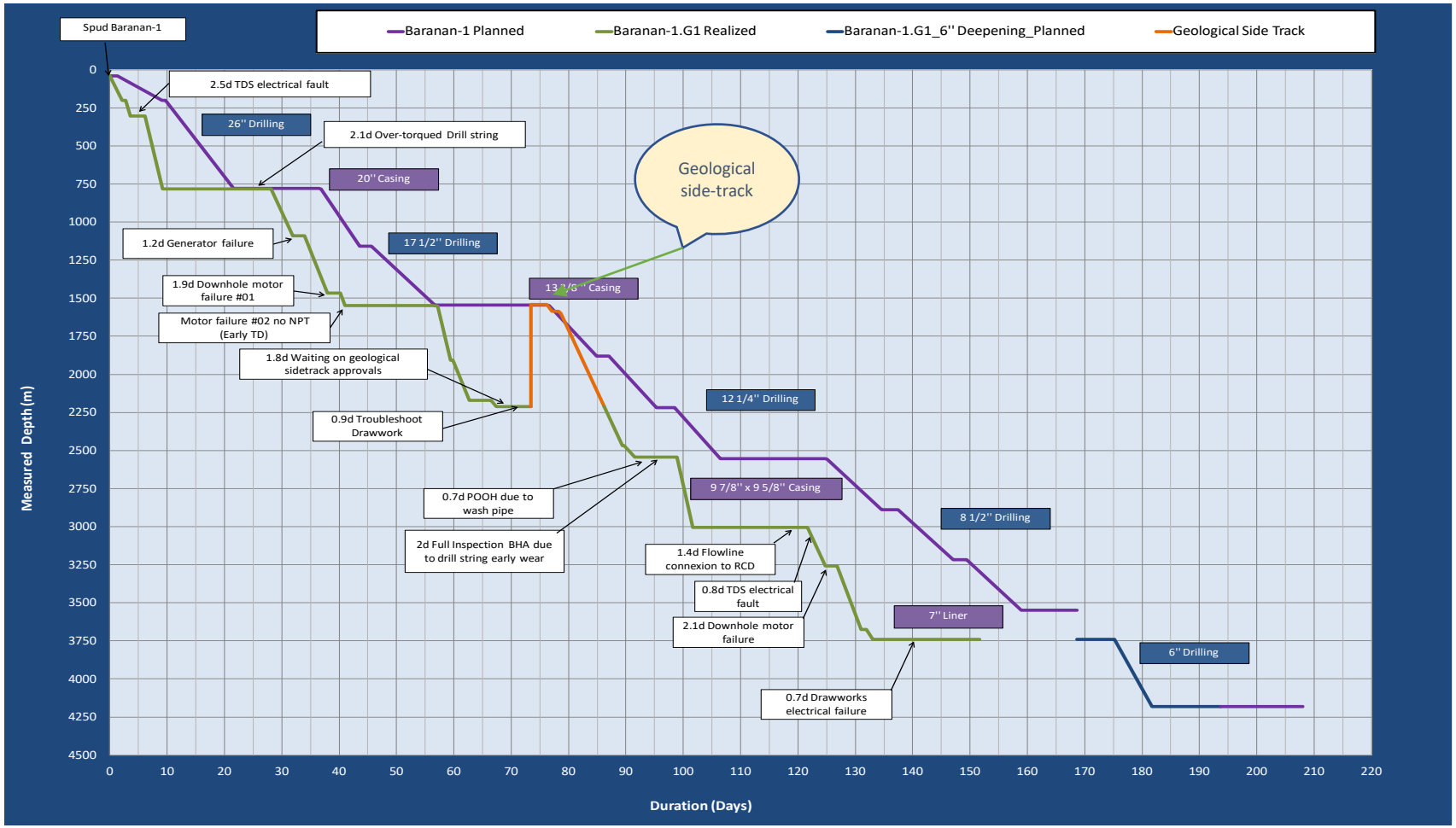
- TOTAL planned to use the MMO system for first two intervals (26” and 17 ½”) only, then due to its excellent performance and trouble-free operations, decided to use it on the 12 ¼” and 8 ½” hole sections as well.
- The 7” liner was just set and drilling resumed with KCl/Polymer mud just for one reason, to reduce the ECD due to low fracture gradient.
- Inhibition to the MMO system was provided by using 0.5% v/v AS-Y and 2% v/v ID-FURY.
- Lubricity provided by using Graphite powder, ID-FURY and ID-LUBE XL.

KURDISTAN CASE HISTORY-2: TOTAL E&P WELL (2014-15)

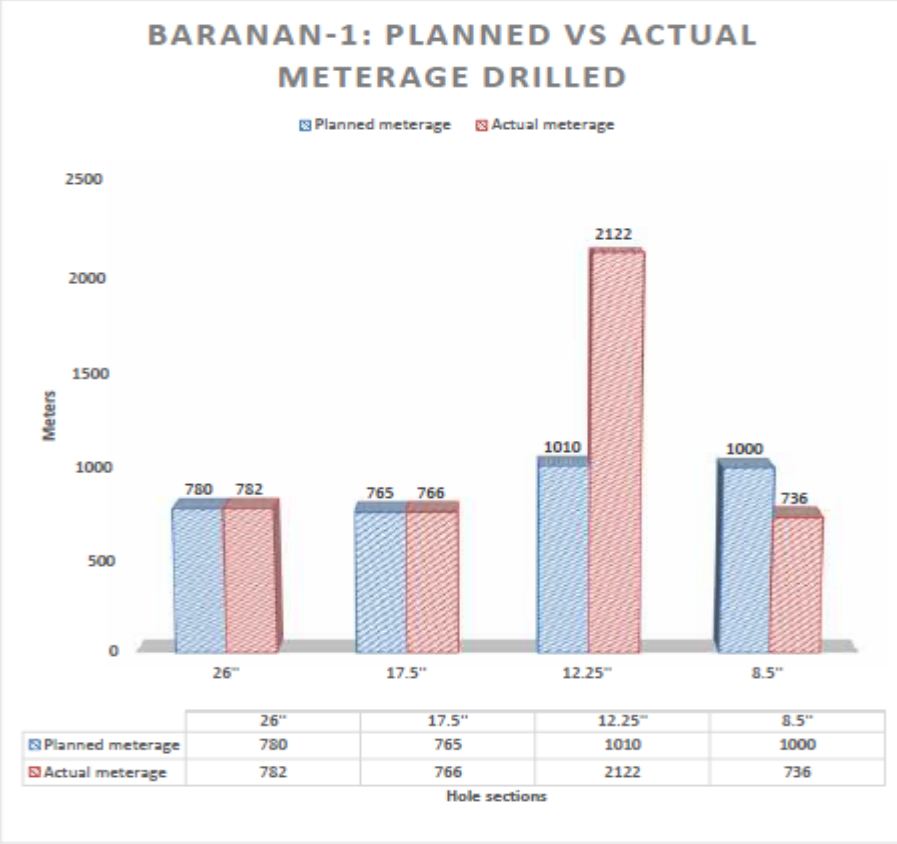
	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 5
Bit Size (inches)	26”	17.5”	12.25”	12.25” S.T.	8.5”	6”
Mud Type	MMO Mud	MMO Mud	MMO Mud	MMO Mud	MMO Mud	KCl/Glycol/Polymer mud
Top of Interval (m)	30 m	777 m	1548 m	1548 m	3000 m	3740 m
Bottom of Interval (m)	782 m	1548 m	2214 m	3000 m	3740 m	4435 m
Maximum Mud Weight (SG)	1.08	1.21	1.50	1.55	1.79	1.74
Drilling Days	8	14	9	19	12	13
Vol. Mud Built (m3)	1285.10	219.2	520.8	839.7	946.2	527.7
Formation Losses (m^3)	0	6	11.2	9	65	396.6

KURDISTAN CASE HISTORY-2: TOTAL E&P WELL (2014-15)

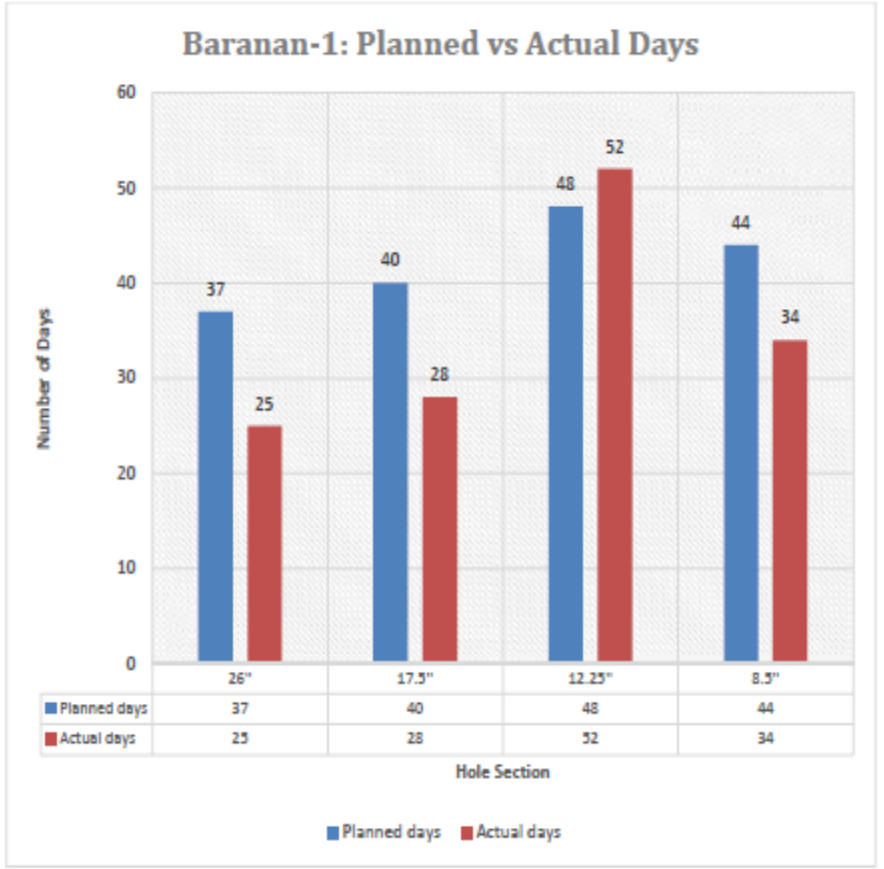
Drilling curve is ahead of planned, and if not for the many rig equipment failure and geological side-track, more time could have been saved:



KURDISTAN CASE HISTORY-2: TOTAL E&P WELL (2014-15)



	26"	17.5"	12.25"	8.5"
Planned meterage	780	765	1010	1000
Actual meterage	782	766	2122	736



	26"	17.5"	12.25"	8.5"
Planned days	37	40	48	44
Actual days	25	28	52	34

Hole Size	26''	17.5''	12.25''	8.5''	Total
Planned meterage	780	765	1010	1000	3555
Actual meterage	782	766	2122	736	4406
	Actual meterage drilled: 24% more than planned (includes geological side track in 12 ¼'' section)				

Hole Size	26"	17.5"	12.25"	8.5"	Total days
Planned days	37	40	48	44	169
Actual days	25	28	52	34	139
	Total 30 days saved i.e. 18% of TIME SAVED				

MMO System Inhibition Improvement Project

BACKGROUND

Challenge:

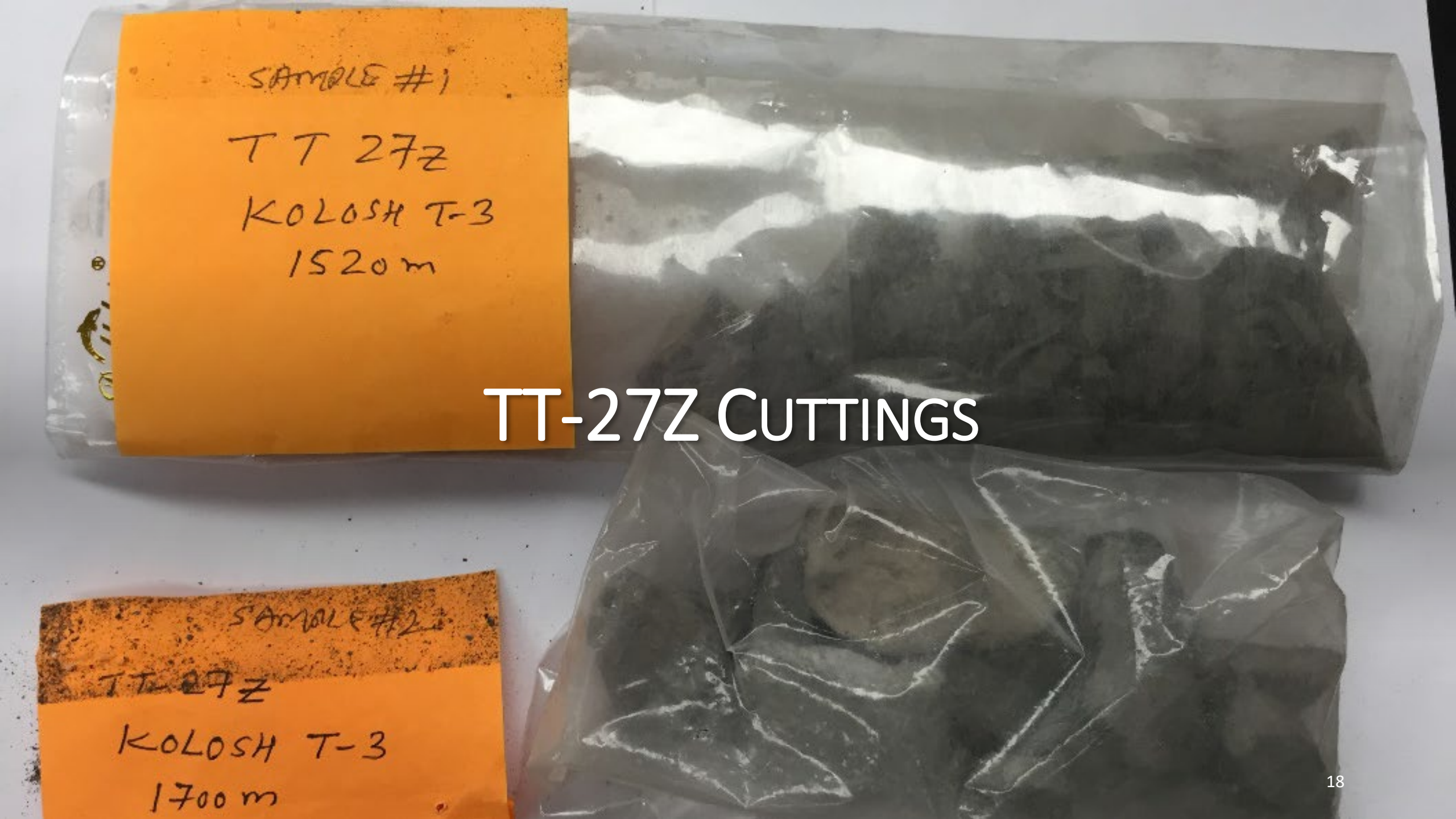
- To improve MMO system's inhibition and expand its applications

Solution:

- QMax received cuttings from different troublesome formations in North Iraq region and sent to our R&D Center in Houston for testing
- Several tests were done comparing different inhibitors and their impact on system's rheology and inhibition performance
- Lab test matrix was set for the project

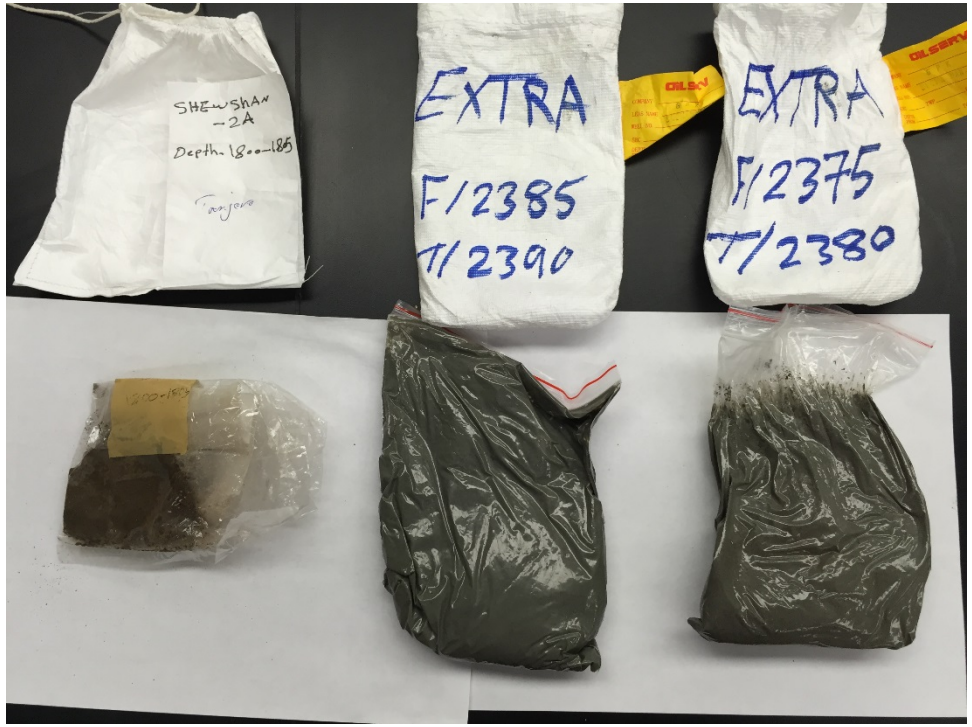
BACKGROUND

Project #	HOU-0092	HOU-0103	HOU-0109	HOU-0107
Lab Tests	TT-27Z Cuttings	Shale Control Additives for MMO	Gasplus Cuttings	Shale Inhibition Using Silicate Fluids
XRD-Minerology	✓		✓	
CST			✓	On-going
Linear Swelling		✓	✓	✓
Clay Recovery		✓		✓
Bulk Hardness	✓	✓		



TT-27Z Cuttings

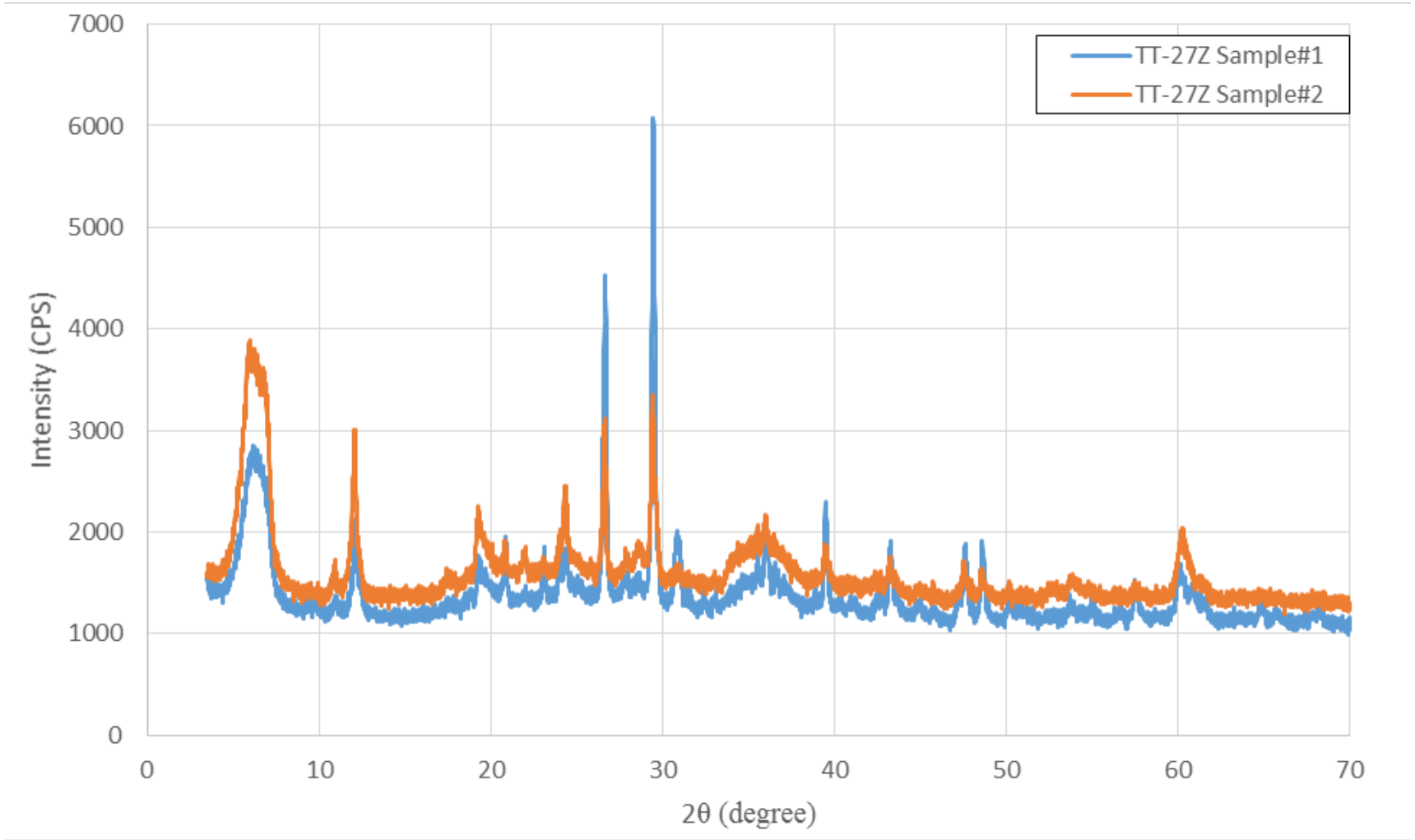
GASPLUS CUTTINGS



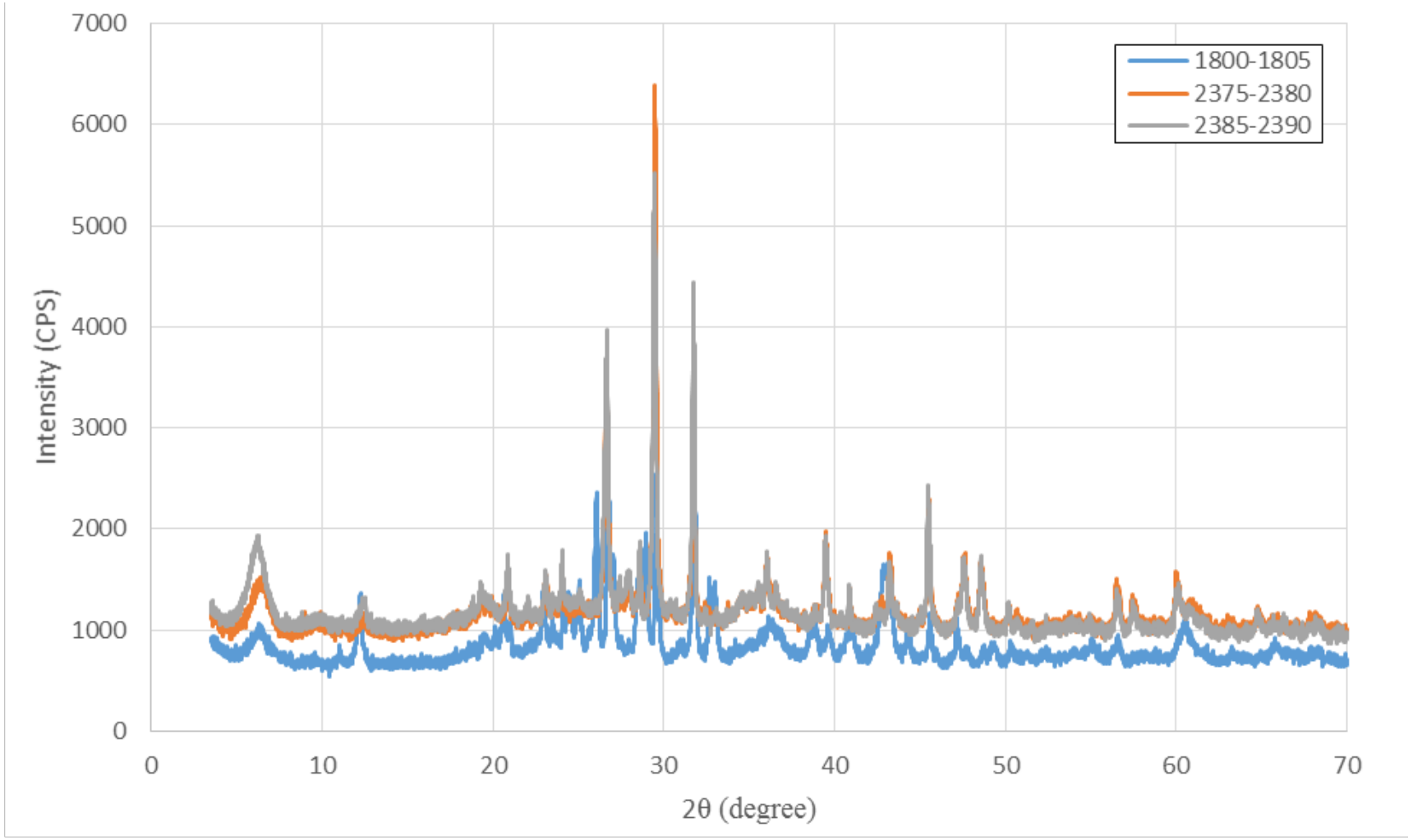
SHEWSHAW-2A well in Tanjero

SH-2A well in Kolosh

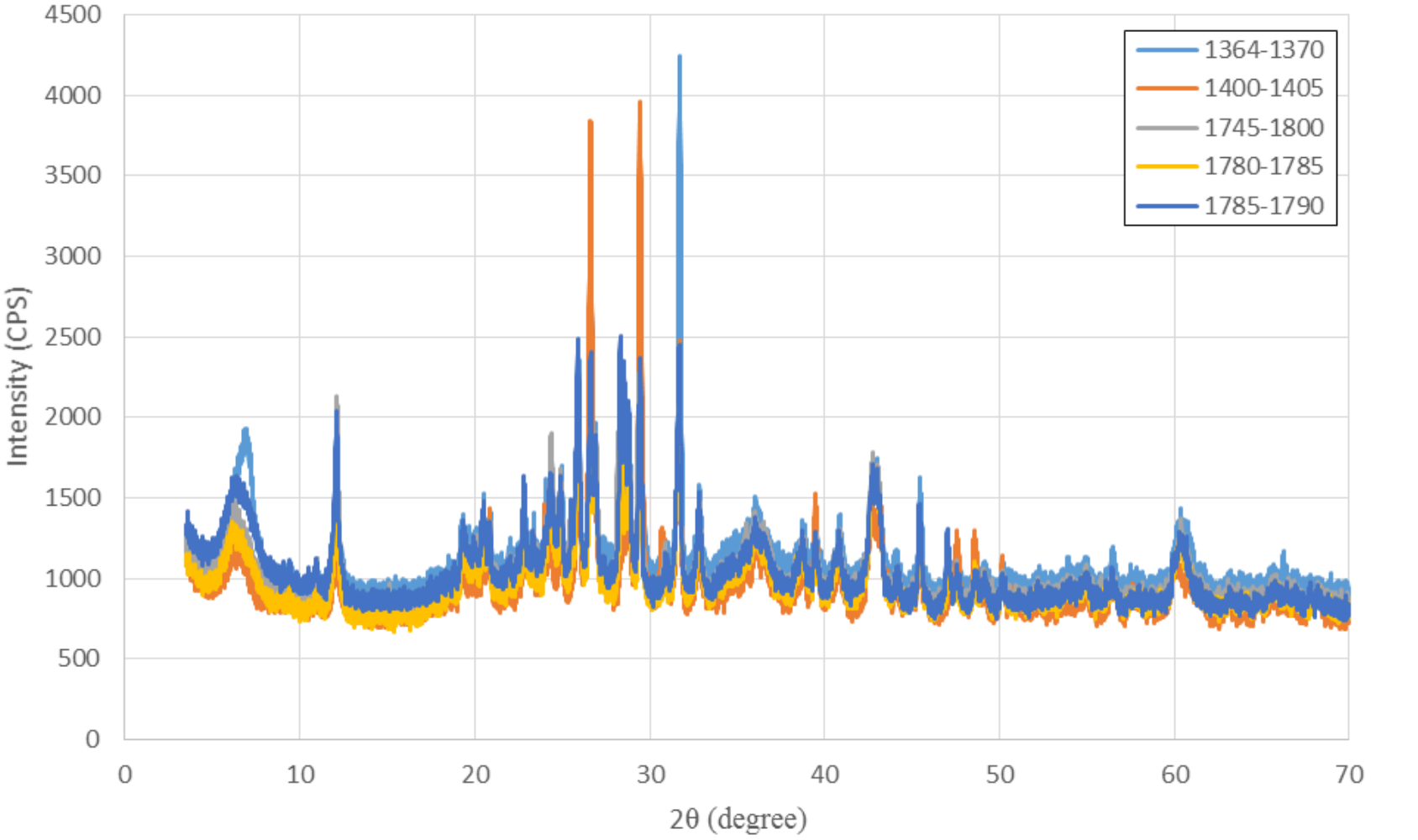
MINERALOGY: TT-27Z WELL IN KOLOSH T3



MINERALOGY: SHEWSHAW-2A WELL IN TANJERO



MINERALOGY: SH-2A WELL IN KOLOSH



MINERALOGY

Formation0	Kolosh T3		Tanjero			Kolosh				
Well	TT-27Z		SHEWSHAW-2A			SH-2A				
Depth (m)	Sample #1	Sample #2	1800-1805	2375-2380	2385-2390	1364-1370	1400-1405	1745-1800	1780-1785	1785-1790
NON-CLAYS										
Quartz	2.2	0.1	0.8	2.6	2.8	1.6	4.2	0.9	1.6	1.3
Feldspar	7.3	6.8	12.3	7.3	8.2	8.1	7.7	6.9	6.4	8.1
Plagioclase	5.9	7.5	8.5	9.6	11.0	10.2	11.6	15.7	10.5	14.2
Calcite	9.3	5.5	5.8	9.9	9.3	3.8	6.9	3.3	3.2	3.0
Dolomite	4.4	2.6	2.9	3.1	3.1	3.1	3.6	2.7	2.7	2.2
Siderite	1.9	2.2	2.8	2.2	1.7	2.2	1.7	1.8	2.2	1.7
Halite	0.1	0.0	1.4	1.9	2.2	2.1	0.9	0.9	1.0	0.9
Pyrite	0.9	1.1	1.5	1.3	1.3	1.4	1.5	1.2	1.3	1.4
Total non-clays	32.1	25.8	35.9	37.8	39.7	32.6	38.1	33.4	28.9	32.9
CLAYS										
Kaolinite	3.2	5.6	4.9	3.5	3.2	4.0	3.9	4.8	5.0	4.8
Smectite	15.5	17.1	20.1	13.5	13.6	19.5	14.0	16.3	20.4	20.1
Illite	7.0	11.0	3.5	1.3	1.8	3.8	2.0	3.9	2.8	3.0
Chlorite	40.5	40.6	35.6	40.6	40.8	40.1	42.0	41.7	42.9	39.3
Muscovite	1.6	0.0	0.0	3.2	0.9	0.0	0.0	0.0	0.0	0.0
Total clays	67.9	74.2	64.1	62.2	60.3	67.4	61.9	66.6	71.1	67.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

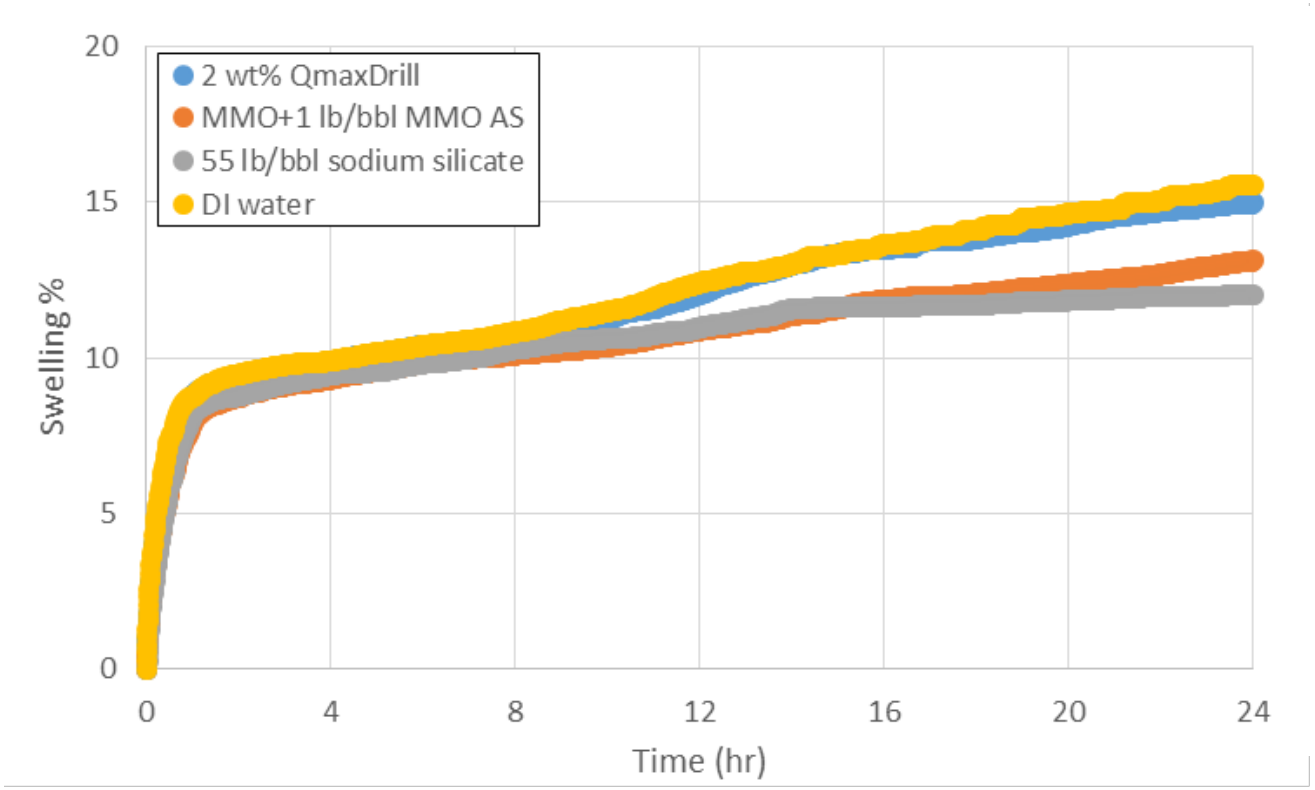
BULK HARDNESS: TT-27Z

Fluid	Unexposed	DI Water	MMO	3% MMO-AS	3% Glymax
Bulk hardness, in-lb	4	1	1	1	2

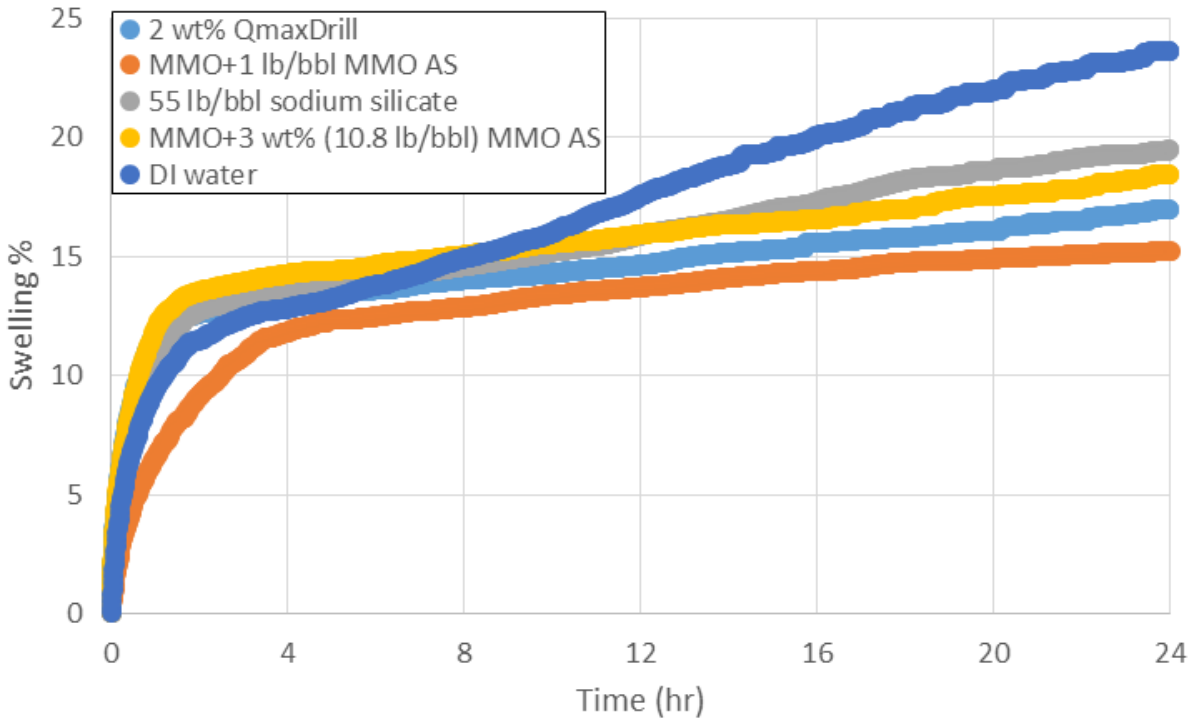
CST: GASPLUS CUTTINGS

Sample	Fluid	CST #1 (s)	CST #2 (s)	CST #3 (s)	Avg. CST (s)
Tanjero	DI water	73.9	57.0	84.1	71.7
	MMO + 1 lb/bbl MMO-AS	2734.7	2973.3	>3000	>3000
	1 lb/bbl MMO-AS in DI water	21.6	21.3	21.1	21.3
	2 wt% QmaxDrill	17.8	18.2	18.8	18.3
	55 lb/bbl sodium silicate	127	153.8	134.2	138.3
Kolosh	DI water	32.8	35.4	37.2	35.1
	MMO + 1 lb/bbl MMO-AS	3187.3	3146.5	>3000	>3000
	1 lb/bbl MMO-AS in DI water	15.0	16.1	15.8	15.6
	2 wt% QmaxDrill	15.7	15.8	13.4	15.0
	55 lb/bbl sodium silicate	54.7	64.9	49.2	56.3

LINEAR SWELLING: GASPLUS CUTTINGS



SH-2A well in Kolosh



SHEWSHAW-2A well in Tanjero

FLUID RHEOLOGY

Fluid	MMO	MMO+3% MMO-AS	MMO+1 lb/bbl MMO-AS	MMO+3% KCl	MMO+3% Glymax	MMO+3% Liquid Gilsonite
Water, bbl	0.9899	0.9899	0.9899	0.9899	0.9899	0.9899
Bentonite, lb	5.5	5.5	5.5	5.5	5.5	5.5
Soda Ash, lb	0.5	0.5	0.5	0.5	0.5	0.5
PAL FC, lb	2	2	2	2	2	2
PRIMO MMO-D, lb	0.55	0.55	0.55	0.55	0.55	0.55
PRIMO MMO-AS, lb	-----	10.8	1	-----	-----	-----
KCl, lb	-----	-----	-----	10.8	-----	-----
Glymax, lb	-----	-----	-----	-----	10.8	-----
Liquid Gilsonite, lb	-----	-----	-----	-----	-----	10.8
Mud weight, lb/gal	8.46	8.46	8.46	8.46	8.46	8.46
Rheology						
θ 600 / θ 300 @ 120°F	31/25	62/49	23/16	22/18	35/33	20/21
θ 200 / θ 100	22/18	42/34	14/12	17/14	32/30	20/16
θ 6 / θ 3	11/11	20/20	6/6	6/3	17/16	3/2
Plastic viscosity, cP	6	13	7	4	2	-1
Yield point, lb/100 ft²	19	36	9	14	31	22
10-sec Gel, lb/100 ft²	12	20	7	3	15	2
10-min Gel, lb/100 ft²	11	21	8	3	14	1
30-min Gel, lb/100 ft²	12	20	10	4	16	1

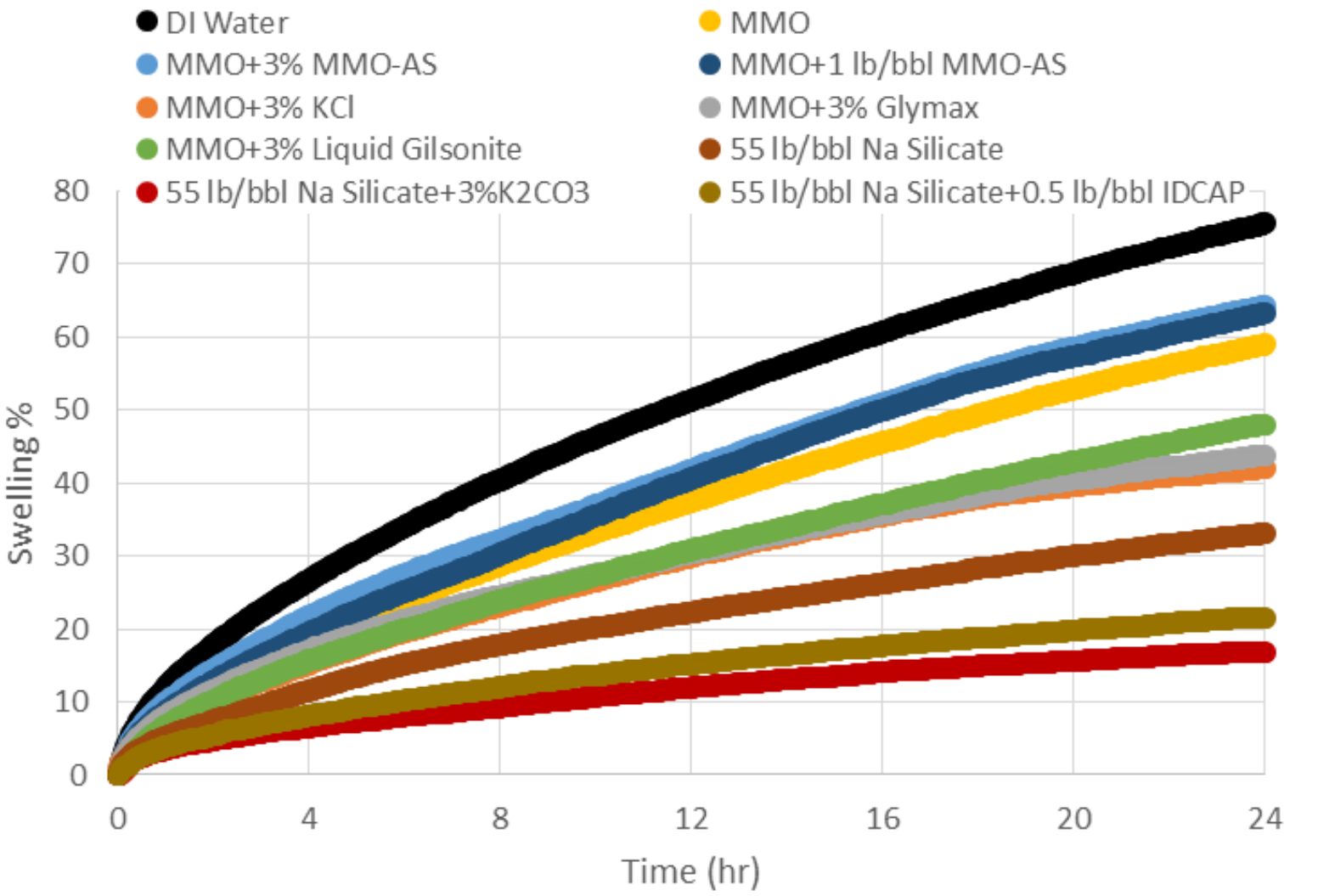
Clay Recovery Test

Fluid	Original weigh, g	Recovered weight, g	Amount recovered
DI Water	20.87	<0.01	<0.05 wt%
MMO	21.05	<0.01	<MMO+0.05 wt%
MMO+3% MMO-AS	20.55	8.45	41.1 wt%
MMO+1 lb/bbl MMO-AS	20.23	0.03	0.15 wt%
MMO+3% KCl	20.49	5.78	28.2 wt%
MMO+3% Glymax	20.64	1.01	4.9 wt%
MMO+3% Liquid Gilsonite	20.38	<0.01	<0.05 wt%
55 lb/bbl Na silicate	20.99	13.53	64.5 wt%
55 lb/bbl Na silicate+3% K2CO3	20.1	10.56	52.5 wt%
55 lb/bbl Na silicate+0.5 lb/bbl IDCAP	20.44	16.66	81.5 wt%

MMO-based

Silicate-based

LINEAR SWELLING: BENTONITE PELLETS



MMO Inhibition Improvement – Further Studies

Due to the continued success of the DrilSmooth system in other areas, further tests were performed in Houston to boost system's inhibition using a combination of regular and new inhibitors

Cuttings samples from East Africa were sent to the lab in Houston to check on the best combination of inhibitors to use in the field and stabilize these formations

XRD AND CED RESULTS

Mineralogy (wt%)	Ngamia-3: 790 – 800 ft	Etom-2: 150 – 160 ft	Etom-2: 160 – 170 ft	Etom-2: 460 – 465 ft	Amosing-5: 560 – 570 ft	Amosing-5: 570 – 580 ft
NON-CLAYS						
Quartz	2.6	0.5	1.1	4.1	8.2	5.2
Feldspar	15.6	12.2	16.5	19.3	17.9	19.8
Plagioclase	6.0	9.6	10.2	8.7	14.3	8.1
Calcite	4.9	5.6	7.5	4.7	3.0	1.9
Dolomite	4.4	3.0	3.1	3.2	2.6	2.6
Siderite	1.6	1.7	1.7	1.1	1.3	1.1
Halite	0.2	0.1	0.2	0.3	0.2	0.2
Pyrite	0.9	0.9	0.9	0.6	0.7	0.9
Total non-clays	36.0	33.7	41.4	42.0	48.1	39.8
CLAYS						
Kaolinite	5.2	4.9	5.0	4.2	3.4	6.5
Smectite	9.9	14.2	13.5	14.4	11.7	11.1
Illite	3.2	5.4	3.2	4.4	3.3	2.1
Chlorite	42.0	39.4	36.7	35.0	33.2	36.9
Muscovite	3.7	2.5	0.3	0.0	0.3	3.5
Total clays	64.0	66.3	58.6	58.0	51.9	60.2
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Sample	CEC (meq/100 g)
Ngamia-3: 790 – 800 ft	14
Etom-2: 150 – 160 ft	29
Etom-2: 160 – 170 ft	32
Etom-2: 460 – 465 ft	21
Amosing-5: 560 – 570 ft	17
Amosing-5: 570 – 580 ft	16

Thank you