Mature Based for New Solutions Conference

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Field Treatment to Stimulate a Deep, Sour, Tight Gas Well Using a New, Low Corrosive and Environmentally Friendly Fluid

AkzoNobel

Dissolvine® StimWell™

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Background

- HCl is used in carbonate reservoirs to dissolve the rock
- This generates high perm channels, known as wormholes
- As a result, well productivity increases

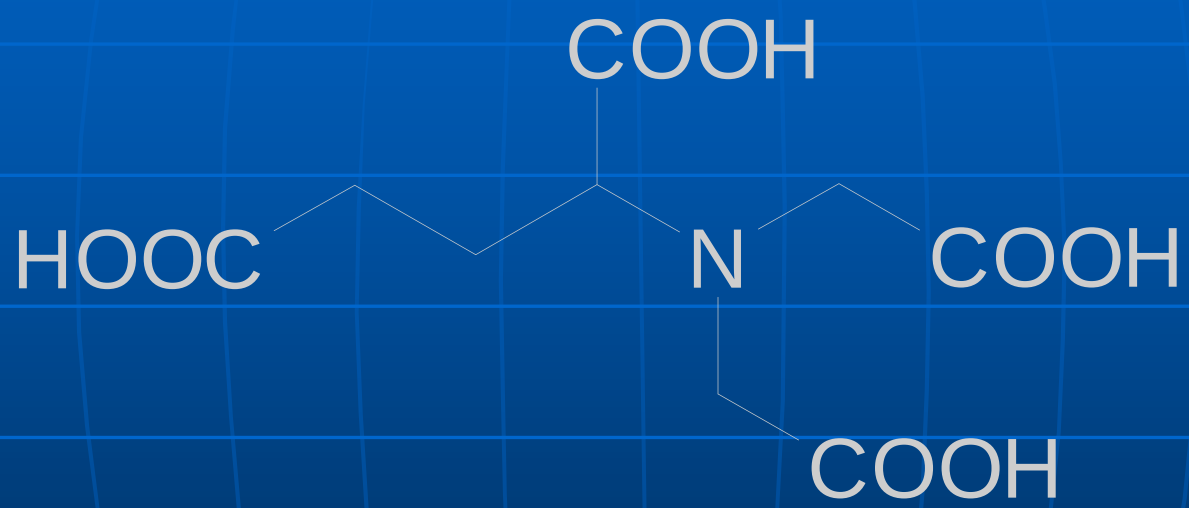
New Challenges

- High temperatures
  - Face dissolution, short wormholes, corrosion, sludges, and too many expensive additives
- H_2S as high as 40%
- CRA: Cr-based and Ni-based
- ESP
- Smart completions

Options

- Use of HCl is a big NO
- Use organic acids
- Use chelating agents
    - Fredd and Fogler, 1998
    - Frenier et al. 2001
    - LePage et al. 2011
    - Mahmoud et al. 2012

Structure of GLDA



glutamic acid, N, N-diacetic acid (GLDA)

Objectives

- Apply this new standalone fluid in the field
- Enhance well productivity
- Assess the treatment based on field data

Field Trial

- A sour gas well (20 mol% H_2S)
- Deep carbonate reservoir, 10,000 ft
- Temperature 300°F (150°C)
- Perforated well at 4 SPF at 0 phasing
- Average porosity = 11.5 %
- Average perm = 0.4 mD
- Mainly calcite, some dolomite
- Skin = + 2

The Challenges

- Sour well
- Deep at 300°F (150°C)
- CO_2 at 9%
- Contains CRA
- Two previous treatments – results were below expectations
- Strict environmental regulations
- Tight formation

Lab and Field Studies

- Corrosion tests
- Core flood experiments
- Thermal stability tests for GLDA
- Compatibility tests with various fluids
- Designed and attended the treatment
- Collected samples from well flow back
- Assess the treatment

Lab Tests

Analysis of Well Produced Water

Ion	Concentration, ppm
Na	39,000
K	875
Ca	23,000
Mg	1,800
Sr	1,420
Ba	49
Mn	8
Cl	129,010
Br	1,300
SO_4	450

Composition of Main Alloys Present in the Treated Well

	C	Mn	P	S	Si	Cu	Ni	Cr	Mo	Al	Ti
L-80	0.22	1.34	0.014	0.02	0.21	0.11	0.1	0.48	0.15	0.055	-
Alloy 28 (N08028)	0.008	1.5	0.016	0.005	0.3	1.21	30.65	26.75	3.46	-	-
Incoloy 925 (N09925)	0.02	0.63	-	0.001	0.3	1.76	40.76	22.35	2.76	0.29	1.97

Weight Loss and Corrosion Rates for 6-Hour Test at 300ºF

Material	Weight loss (g)	Corrosion rate (lb/ft^2)
L-80	0.0309	0.0107
Alloy 28 (N08028)	0.0005	0.0002
Incoloy 925 (N09925)	0.0003	0.0001

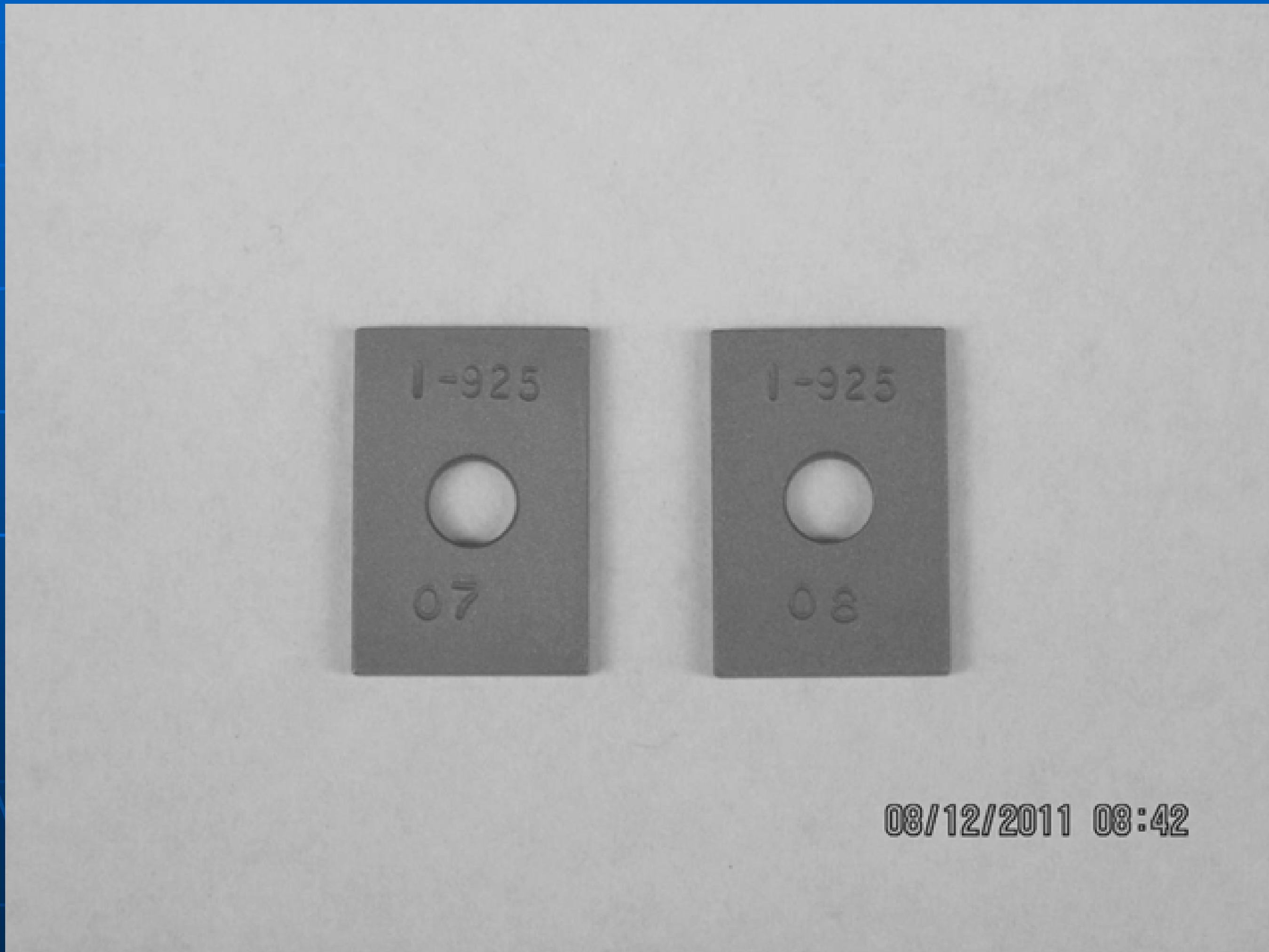
With 19 mol% H_2S and 9 mol% CO_2

Concentrations of Key Ions before and after Corrosion Tests

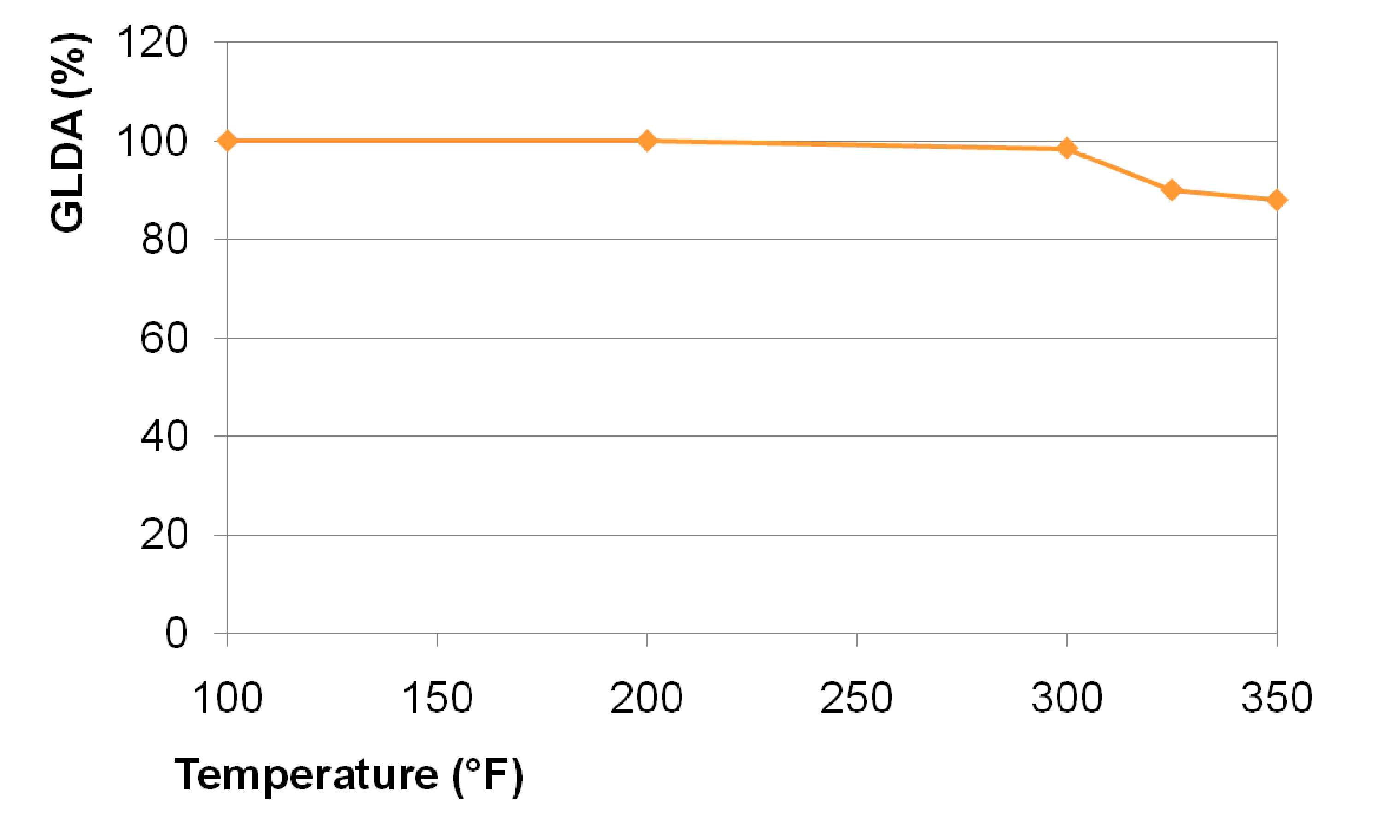
Metallurgy	Corrosion test	Cr ppm	Fe ppm	Mn ppm	Mo ppm	Ni ppm
L-80	Before	2.6	-	3.9	-	-
	After	3.5	84.0	6.1	-	-
Incoloy 925	Before	-	-	1.7	-	-
	After	-	-	1.8	-	-

L-80 Coupons after Testing in 20 wt% GLDA Solution

Incoloy 925 Coupons after Testing in 20 wt% GLDA Solution



Thermal stability of 20 wt% GLDA (pH 3.8) 6 hr at T



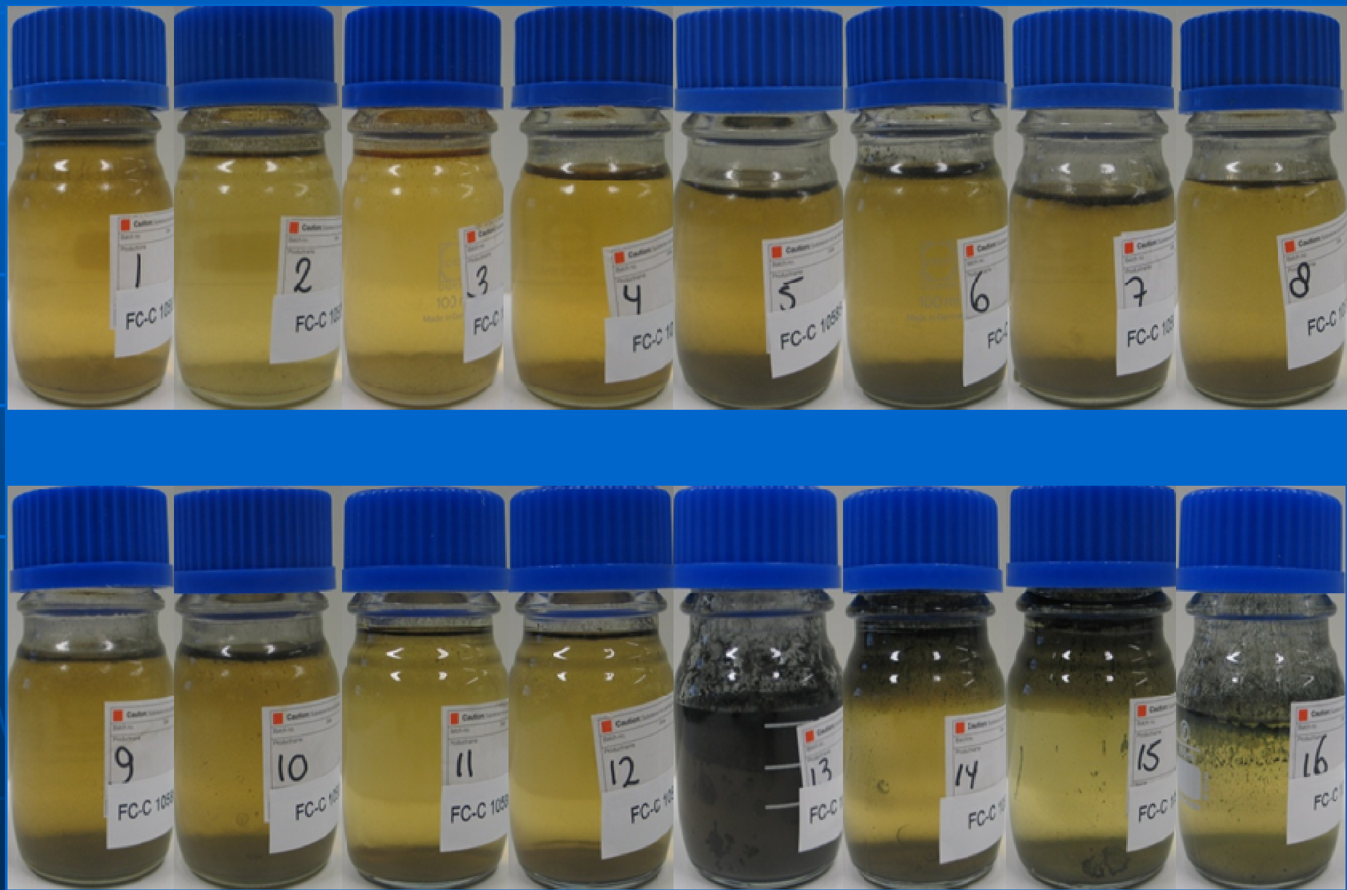
Field Application

Attended Field Treatment

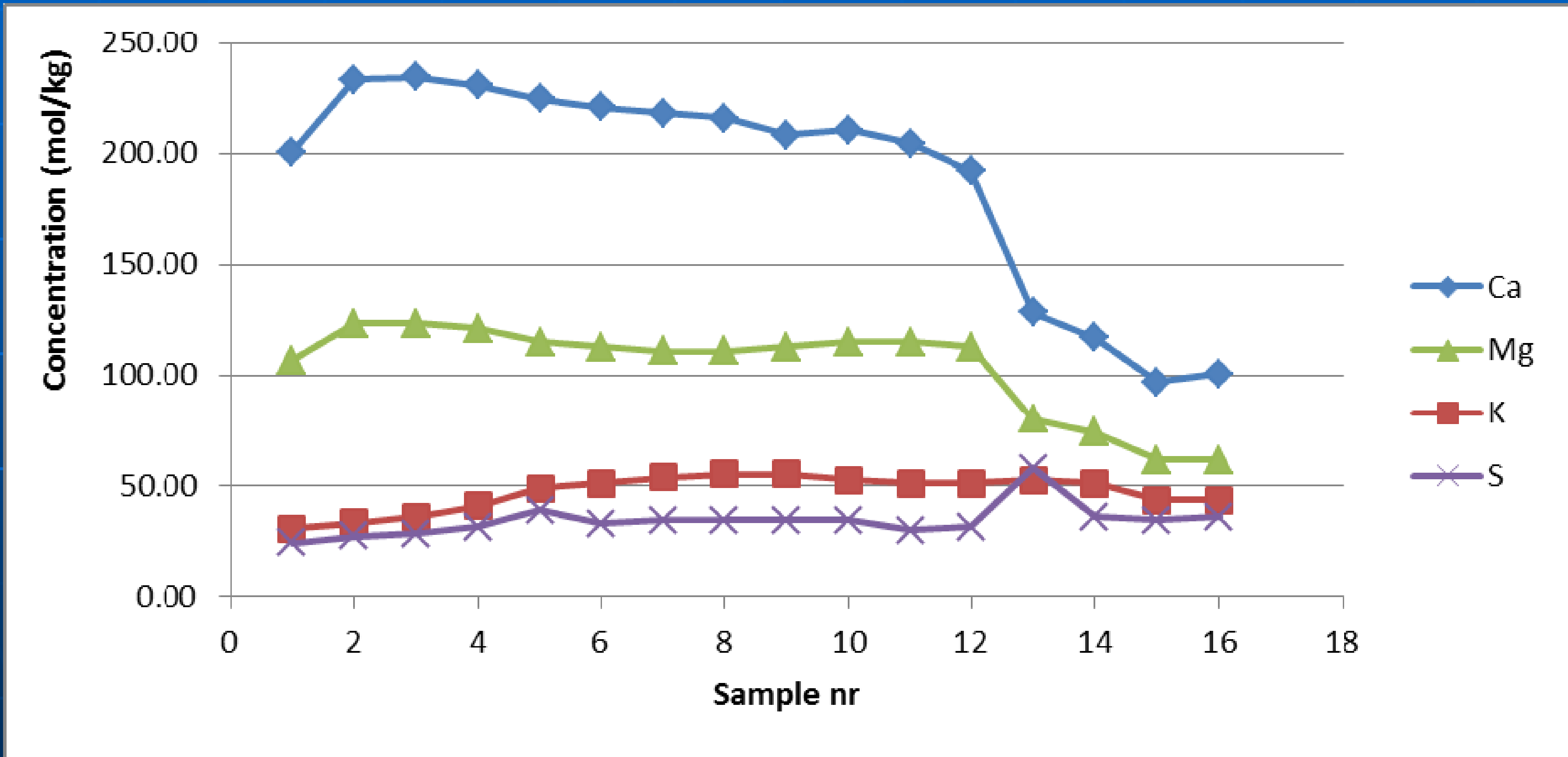
Treatment design

First treatment:	Cleaning the tubular
Second treatment:	
Pre-flush:	10 wt% mutual solvent + 0.2wt% non-ionic
Main treatment:	19wt% GLDA + 0.2wt% non-ionic + 0.85wt% corrosion inhibitor
Post-flush:	10 wt% mutual solvent + 0.2wt% non-ionic

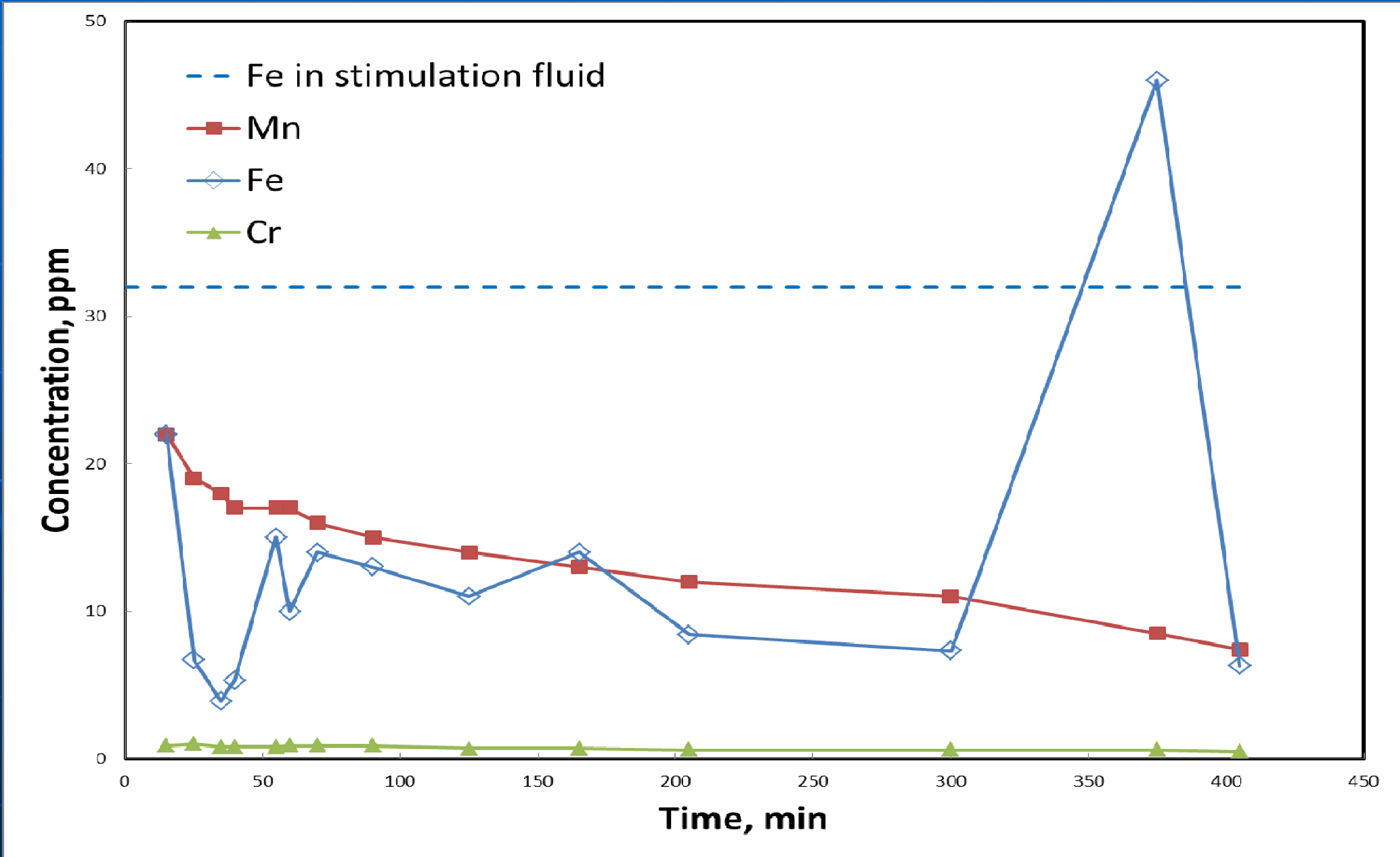
Picture of the Flowback Samples 10 Days after the Field Treatment



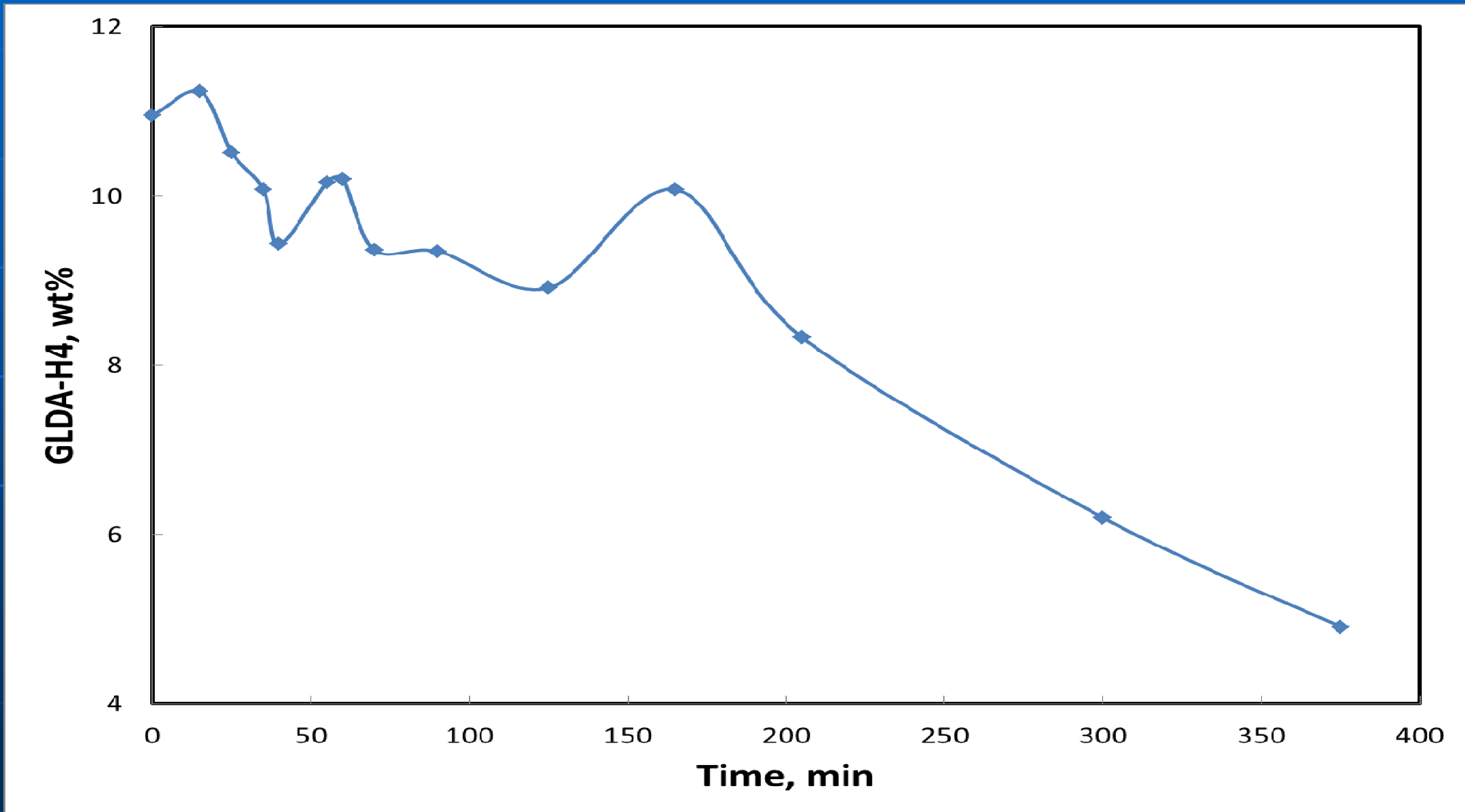
Main Ions Present in the Flowback Samples



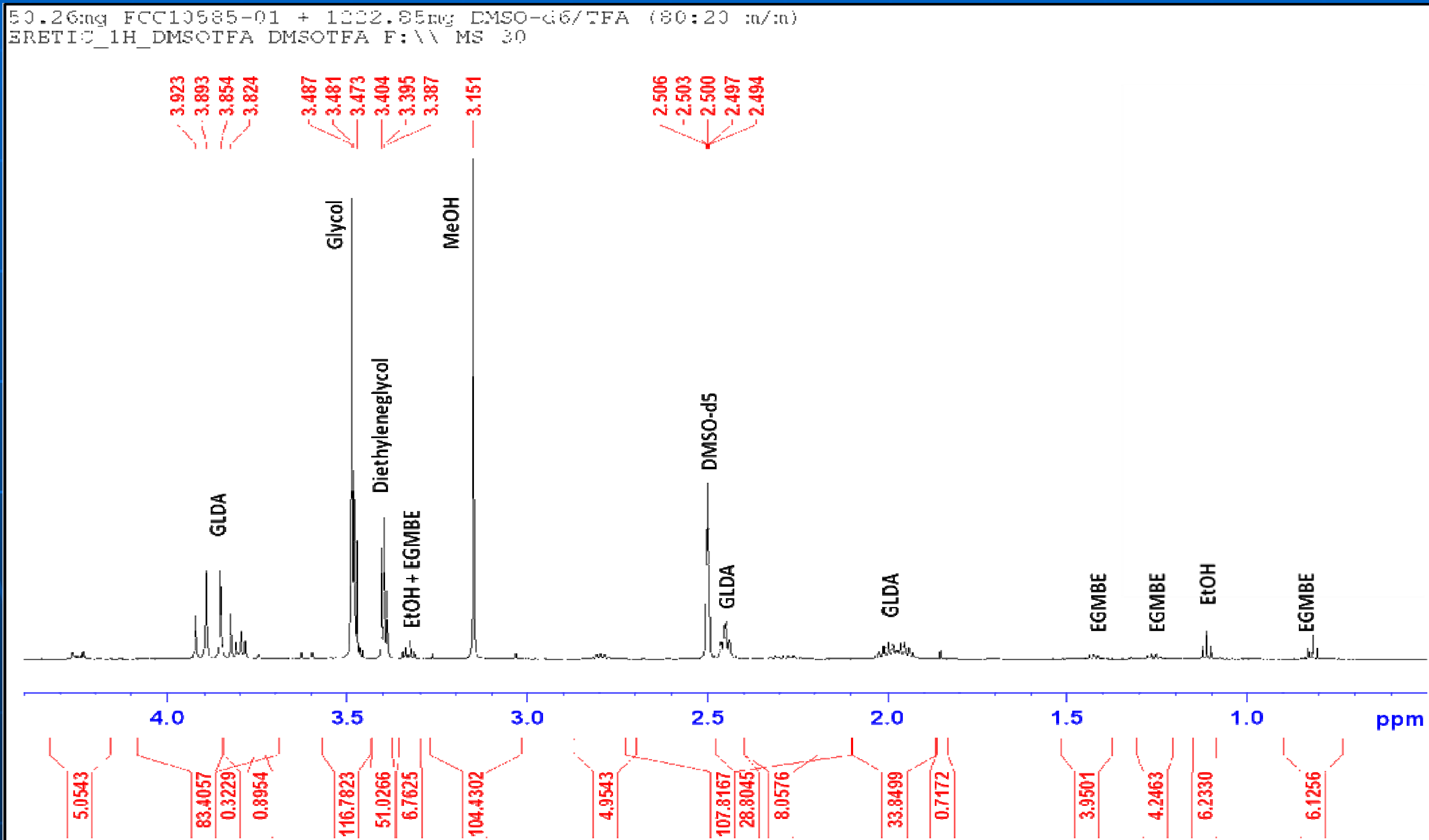
Cations Relevant to Corrosion in Flowback Samples



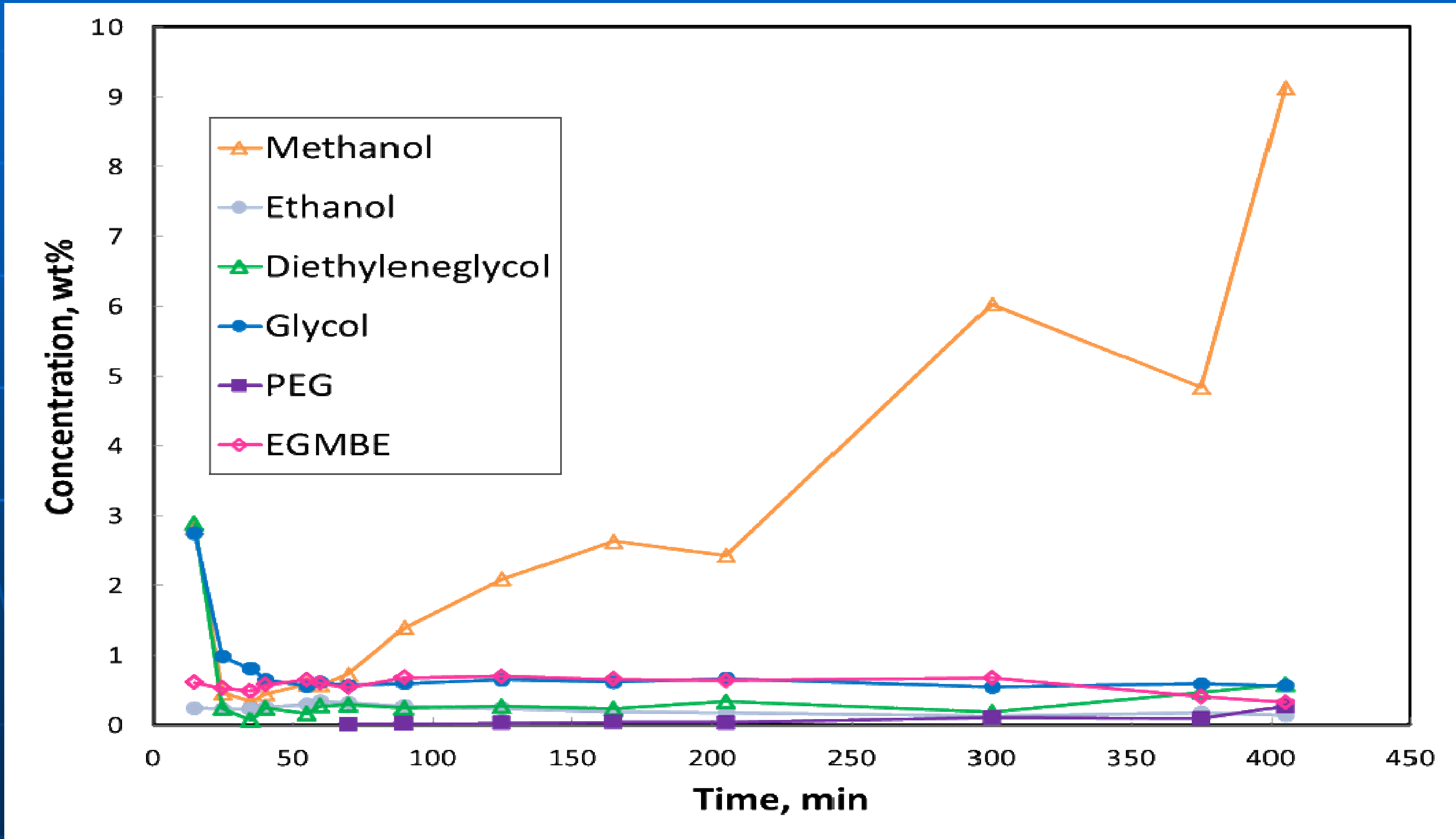
GLDA Concentration in Flowback Samples



^{1}H Proton NMR for Aqueous Phase Collected from Sample 1



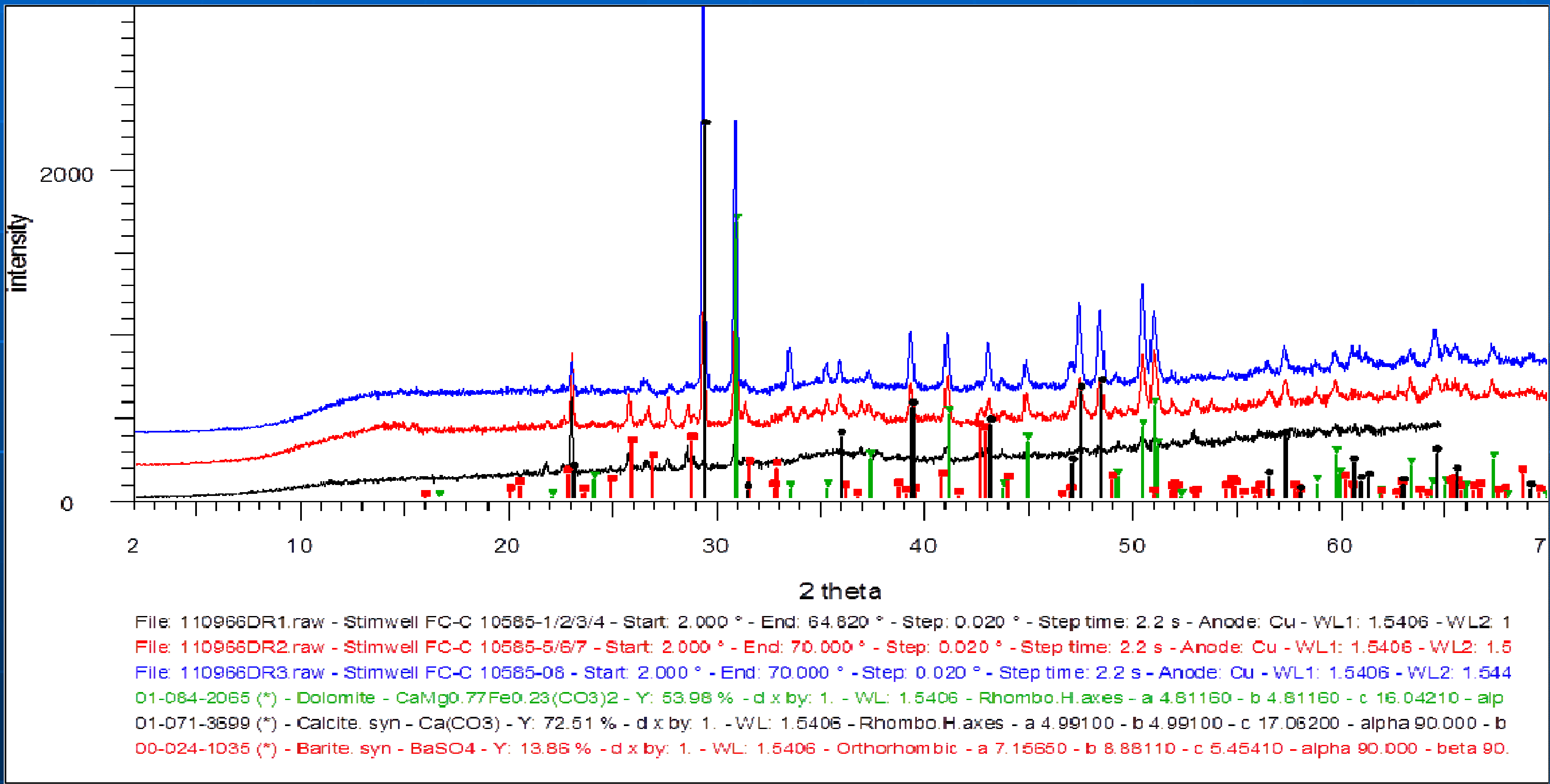
Concentrations of Various Organic Compounds in the Flowback Samples



Concentration of Elements in the Solids in Flowback Samples

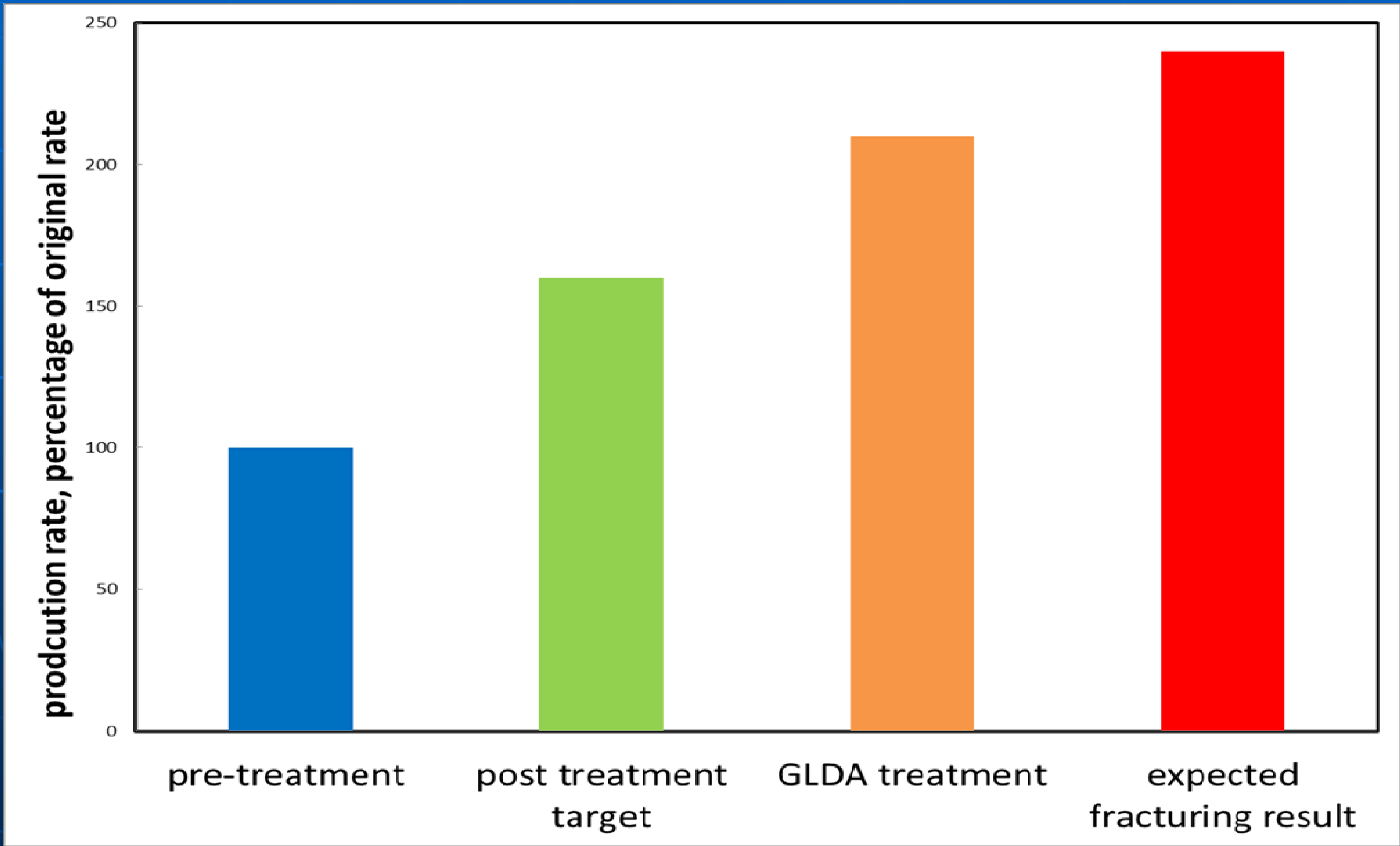
Sample	C	O	Na	Mg	S	Cl	Ca	Fe	Ba
1-4	43.2	11.7	1.5	0.5	27.4	0.9	1.9	2.9	2.6

XRD Analysis of Solids from Flowback Samples



Flare After the Treatment

Pre- and Post-Treatment Production Rates



Conclusions

- No operational problems encountered during GLDA treatment.
- The treated well experienced significant production rate increase after the treatment.
- The GLDA treatment had a long lasting positive effect on the production rate
- The treatment did not affect the integrity of well internals or tubulars.
- GLDA was stable and did not undergo any degradation reaction at bottomhole conditions and after 6 hours in the formation.
- Currently, over 40 wells have been treated with GLDA

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