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Formation: Chance
Area: Yukon
Location: G-08/J-19/M-08

CORE ANALYSIS

NORTHERN CROSS

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NOTICE: THE INTENT OF THIS REPORT IS TO PROVIDE INFORMATION ON THE SAMPLES TESTED. WHILE THE RECOMMENDATIONS ARE MADE IN GOOD FAITH AND REASONABLE EFFORTS HAVE BEEN MADE TO ENSURE THEIR RELIABILITY, NOWSCO WELL SERVICE LTD. ACCEPTS NO LIABILITY FOR DAMAGE ARISING FROM THE USE OF THIS REPORT.

SUMMARY

A core sample from the Chance formation was submitted to characterize the rock matrix, determine permeability and identify the soluble rock species present. Coreflow testing using 15% hydrochloric acid was performed on the submitted sample to determine fluid compatibility with respect to the core.

CONCLUSION

- A Scanning Electron Microscope (S.E.M.) analysis was performed on the samples. See S.E.M. for rock matrix description and attached photomicrographs.
- The solubility in 15% hydrochloric acid (HCl) of the sample was 0.41% after 30 minutes at 22 °C.
- The solubility in 12% hydrochloric and 3% hydrofluoric acid (12/3) of the submitted sample was 7.8% after 30 minutes at 22 °C.
- Coreflow testing performed on the sample indicates that using 15% hydrochloric acid as a stimulation fluid may damage the permeability.

Lab Sample No.
P-5179a

Sample Description
Core plug, J-19, 4456 ft.

SCANNING ELECTRON MICROSCOPE ANALYSIS

A freshly fractured surface from the submitted core sample was examined using a scanning electron microscope (S.E.M.) equipped with an energy dispersive x-ray probe.

The sample consisted of moderately well sorted sandstone with visually poor porosity. Framework grains consist of quartz and chert. An intergranular mineral comprised of microcrystalline quartz and a calcium alumina-silicate of unknown structure, but does have a similar morphology to margarite. The cementation is accomplished through pressure contact solution and silica sutures. No clays were visually determined. The sample had an abundance of pyrobitumens throughout the matrix.

HCl Acid Solubility Analysis

The solubility of a two-gram portion of core was determined gravimetrically using 200 ml of 15% hydrochloric acid. Testing was conducted over a 30 minute time period at room temperature (22° C).

The acid filtrate from the 15% hydrochloric acid solubility was analyzed to determine the soluble species present. Results are summarized in Table #1 along with the molar carbonate ratio (Mg/Ca). The ratio gives a measure of the degree of dolomitization of the carbonate. Pure limestone (CaCO_3) = 0.0, pure dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) = 1.0, and the presence of magnesite (Mg_3CO_3) = > 1.0.

Table #1

Sample #	Analyzed Element (wt%)				Calculated Composition (wt%)				Molar Ratio (Mg/Ca)	Soluble (wt%)
	Ca	Mg	Fe	SO ₄	CaCO ₃	MgCO ₃	FeCO ₃	CaSO ₄		
P-5179a	0.12	<0.01	0.06	<0.01	0.29	<0.01	0.12	<0.01	<0.01	0.41

HCl/HF Acid Solubility Analysis

The solubility of two-gram portions from the submitted core was determined gravimetrically using 200 ml of 12/3 HCl/HF acid. Testing was conducted over a 30 minute time period at room temperature (22° C).

Table #2

Sample #	Solubility (%)
P-5179a	7.8

CORE FLOW ANALYSIS

Core flow testing on the sample was performed using a Newsco CFA-4 Core Flow Apparatus Newsco equipped with a Hassler sleeve-type core holder. The regained permeability of the core was established after treating the core with the 15% hydrochloric acid blend described below. Results are presented in Table #3.

- Coreflow testing was performed at a simulated bottom hole temperature of 69 °C and an overburden pressure of 4,500 psi.
- Comparing the permeability values for the reference fluid (Soltrol) before and after the 15% HCl treatment fluid stage indicates the extent of improvement or damage that is created by the treatment.
- The 15% HCl acid blend used in the coreflow test contains the following additives; Nowferr 1W at 10 L/m³ + Nowferr 14P at 0.8 kg/m³ + AH-1 at 23 L/m³ + AI-2 at 2 L/m³ + AI-275 at 3 L/m³. The acid stage had a backpressure applied to the core of 1000 psi.
- Soltrol is an iso-paraffinic C₁₃ solvent.

Table #3

Sample #: P-5179a				
Plug Diameter: 2.5 cm		Plug Length: 6.35 cm		
<i>Fluid</i>	<i>Direction</i>	<i>Pressure</i> (psi)	<i>Volume</i> (mls)	<i>Permeability</i> (mD)
Nitrogen	Forward	35	---	11.64
API Brine	Forward	100	50	9.51
Soltrol	Forward	317	50	3.40
15% HCl	Reverse	556	100	0.93
Soltrol	Forward	923	50	0.74

SUMMARY

Core samples from the Chance formation were submitted to characterize the rock matrix, determine permeability and identify the soluble rock species present. Coreflow testing using various fluids was performed on the submitted samples to determine fluid compatibility with respect to the core.

CONCLUSION

- A Scanning Electron Microscope (S.E.M.) analysis was performed on the samples. See S.E.M. for rock matrix description and attached photomicrographs.
- The high concentrations of calcium feldspars reduce the chances of a successful hydrofluoric (HF) treatment. If HF acid is to be used it is recommended not to exceed an HF concentration of 1.5%.
- The solubility in 15% hydrochloric acid (HCl) of the submitted samples ranged from 4.8 to 12.3% after 30 minutes at 22 °C.
- The solubility in 12% hydrochloric and 3% hydrofluoric acid (12/3) of the submitted samples P-4975a through P-4975d ranged from 3.1 to 23.2% after 30 minutes at 22 °C.
- Permeability of the core plugs tested ranged from 0.14 to 149.95 millidarcies (mD).
- Coreflow testing performed on sample P-4975a indicates that a 91.3% decrease in permeability would occur. Testing performed on sample P-4975d however, indicates that permeability would increase. Coreflow testing using HF acid on these samples is inconclusive.
- Coreflow testing performed on sample P-4975e indicates that using 15% hydrochloric acid as a stimulation fluid should significantly increase the permeability.

Sample Identification

<u>Lab Sample No.</u>	<u>Sample Description</u>
P-4975a	Core plug, J-19, 4458.5 ft.
P-4975b	Core plug, G-08, 4400 ft.
P-4975c	Core plug, M-08, 4372 ft.
P-4975d	Core plug, M-08, 4365 ft.
P-4975e	Core plug, G-08, 4399.2 ft.
P-4975f	Core plug, G-08, 4401.0 ft.
P-4975g	Core plug, M-08, 4364.0 ft.
P-4975h	Core plug, M-08, 4363.0 ft.

SCANNING ELECTRON MICROSCOPE ANALYSIS

A freshly fractured surface from core samples P-4975a and P-4975d were examined using a scanning electron microscope (S.E.M.) equipped with an x-ray dispersive probe.

Sample P-4975a was examined after being treated with acid, outlined in the coreflow testing procedure. The sample was friable but not unconsolidated. It consisted of a moderately well sorted sandstone with good visual porosity. The matrix grains were predominately quartz and feldspars, and exhibited a rough surface texture, most likely from exposure to acid. Cementation was difficult to determine, the sample appeared to have poor cementation and visually it looks as if this was accomplished through pressure contact and minor amounts of silica sutures. No accessory minerals were determined other than the presence of an abundant amount of Silica fines throughout the pore system. The sample was extremely abundant with pyrobitumens.

Sample P-4975h was also examined and was not exposed to acid. The sample consisted of a moderately well sorted sandstone with some areas exhibiting good porosity and other areas with poor to no porosity. The good porosity areas will be referred to as "open" and the poor areas as "infill". The matrix grains were composed of quartz, calcium-rich feldspar and minor amounts of chert. There was also an abundance of pyrobitumens present. Cementation in the "open" areas consisted primarily of pressure contact and silica sutures. In the "infill" areas the cementation consisted of calcite infill. Accessory minerals consisted of fine silica particles and very fine calcium-rich feldspars. No clays were visually determined. The calcium-rich feldspars had the appearance of becoming or were in the process becoming clays.

It is recommended due to the presence of calcite and calcium-rich feldspars that an XRD analysis be performed to determine the amount of these minerals present so a better decision on the type of stimulation fluid can be made.

See attached photomicrographs.

HCl Acid Solubility Analysis

The solubility of two gram portions of core from each of the intervals were determined gravimetrically using 200 ml of 15% hydrochloric acid. Testing was conducted over a 30 minute time period at room temperature (22° C).

The acid filtrate from the 15% hydrochloric acid solubility was analyzed to determine the soluble species present. Results are summarized in Table #1 along with the molar carbonate ratio (Mg/Ca). The ratio gives a measure of the degree of dolomitization of the carbonate. Pure limestone (CaCO_3) = 0.0, pure dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) = 1.0, and the presence of magnesite (MgCO_3) = > 1.0.

Table #1

Sample #	Analyzed Element (wt%)				Calculated Composition (wt%)				Molar Ratio (Mg/Ca)	Soluble (wt%)
	Ca	Mg	Fe	SO ₄	CaCO ₃	MgCO ₃	FeCO ₃	CaSO ₄		
P-4975a	0.10	<0.01	0.06	<0.01	0.25	<0.01	0.13	<0.01	<0.01	0.4
P-4975b	5.40	<0.01	0.06	0.25	13.22	<0.01	0.12	0.35	<0.01	13.7
P-4975c	11.38	0.01	0.07	<0.01	28.41	0.04	0.15	<0.01	<0.01	28.6
P-4975d	2.72	<0.01	0.07	<0.01	6.79	<0.01	0.14	<0.01	<0.01	6.9
P-4975e	4.27	<0.01	0.04	0.09	10.57	<0.01	0.09	0.12	<0.01	10.8
P-4975f	4.89	<0.01	0.04	0.10	12.11	<0.01	0.08	0.14	<0.01	12.3
P-4975g	1.00	<0.01	0.06	0.16	2.32	<0.01	0.13	0.22	<0.01	2.7
P-4975h	4.40	<0.01	0.04	0.11	10.87	<0.01	0.08	0.16	<0.01	11.1

HCl/HF Acid Solubility Analysis

The solubility of two gram portions from samples P-4975a to P-4975d were determined gravimetrically using 200 ml of 12/3 HCl/HF acid. Testing was conducted over a 30 minute time period at room temperature (22° C).

Table #2

Sample #	Solubility (%)
P-4975a	3.1
P-4975b	6.2
P-4975c	23.2
P-4975d	9.9

In all cases a white precipitate formed when the rock came into contact with HF acid. The precipitate was likely fluorosilicates.

Permeability to Nitrogen Determination

The permeability to nitrogen on submitted core plugs P-4975a to P-4975h was determined using a Nowsco CFA-4 Core Flow Apparatus equipped with a Hassler sleeve-type core holder. All testing was conducted at 22 °C. Results are presented on Table #3.

Table #3

Sample #	Permeability (mD)
P-4975a	2.33
P-4975b	1.53
P-4975c	0.14
P-4975d	55.17
P-4975e	18.19
P-4975f	2.23
P-4975g	1.50
P-4975h	149.95

CORE FLOW ANALYSIS

Core flow testing on samples P-4975a, P-4975d and P-4975e was performed using a Nowasco CFA-4 Core Flow Apparatus. The regained permeability of the core was established after treating the core with various treatment fluids. Results are presented in Table #4, #5 and #6.

- All core flow testing was performed at a simulated bottom hole temperature of 69 °C and an overburden pressure of 4,500 psi.
- Comparing the permeability values for the reference fluid (soltrol) before and after each treatment fluid stage indicates the extent of improvement or damage that is created by the treatment.
- The 15% HCl acid blend used in all the coreflow tests contains the following additives; Nowferr 1W at 10 L/m³ + Nowferr 14P at 0.8 kg/m³ + AH-1 at 23 L/m³ + AI-2 at 2 L/m³ + AI-275 at 3 L/m³. The 12/3 acid blend also contained 50 kg/m³ ammonium bifluoride.
- Soltrol is an iso-paraffinic C₁₃ solvent.

Table #4

Sample #: P-4975a				
Plug Diameter: 6.5 cm		Plug Length: 2.5 cm		
Fluid	Direction	Pressure (psi)	Volume (mls)	Permeability (mD)
Nitrogen	Forward	180	---	2.27
API Brine	Forward	1131	100	3.29
Soltrol	Forward	1947	100	1.50
15% HCl	Reverse	1871	100	0.74
12/3 HCl/HF	Reverse	1885	100	0.59
3% NH ₄ Cl	Reverse	1851	100	0.98
Soltrol	Forward	2210	10	0.13

Table #5

Sample #:P-4975d				
Plug Diameter: 2.52 cm		Plug Length: 4.59 cm		
<i>Fluid</i>	<i>Direction</i>	<i>Pressure</i> (psi)	<i>Volume</i> (mls)	<i>Permeability</i> (mD)
Nitrogen	Forward	8.1	---	55.2
API Brine	Forward	80	50	31.0
Soltrol	Forward	150	150	27.1
15% HCl	Reverse	20	285	251.2
12/3 HCl/HF	Reverse	8	300	523.4
3% NH ₄ Cl	Reverse	8	100	785.1
Soltrol	Forward	2.8	200	1115.0

Table #6

Sample #:P-4975e				
Plug Diameter: 2.51 cm		Plug Length: 3.17 cm		
<i>Fluid</i>	<i>Direction</i>	<i>Pressure</i> (psi)	<i>Volume</i> (mls)	<i>Permeability</i> (mD)
Nitrogen	Forward	13	---	18.2
API Brine	Forward	225	50	4.4
Soltrol	Forward	379	200	2.5
15% HCl	Reverse	16	150	67.1
Soltrol	Forward	1.7	200	1734.2