



00653507

20-19S-47W  
NWSE

**SPECIAL CORE ANALYSIS STUDY**

for

**The Anschutz Corporation**

**GEO. FILE**

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COLO. OIL & GAS CONS. COMM.

Colorado State No. 1-20 Well  
Morrow Formation  
Wildcat  
Kiowa County, Colorado  
File Number: 203-86059

Special Core Analysis



**CORE LABORATORIES, INC.**



December 5, 1986

Reply To:  
10703 E. BETHANY DRIVE  
AURORA, COLORADO 80014

The Anschutz Corporation  
555 17th Avenue, Suite 2400  
Denver, CO 80202

Attention: Mr. Kevin Wallace

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COLO. OIL & GAS CONS. COMM.

Subject:

Special Core Analysis Study  
Colorado State No. 1-20 Well  
Morrow Formation  
Wildcat  
Kiowa County, Colorado  
File Number: 203-86059

Gentlemen:

On October 17, in a meeting with a representative of Core Laboratories, Inc., Mr. Kevin Wallace of The Anschutz Corporation, requested that Formation Resistivity Factor Measurements (at atmospheric and at overburden conditions) and Formation Resistivity Index Measurements be determined on core samples obtained from the subject well. Presented herein are final results of this investigation. Mr. Wallace received preliminary data on November 11, any revisions in the preliminary data have been made to provide more accurate interpretation of the test results.

**Sample Preparation:**

Four one and one-half inch diameter samples were drilled from the full diameter core material utilizing tap water as a bit coolant and lubricant. The samples were trimmed to right cylinders, then placed into a centrifuge solvent reflux apparatus, extracted of hydrocarbons and leached of salts using, respectively, cool toluene and cool methyl alcohol. Each sample was dried in a controlled-humidity oven at 140°F and 40 to 45 percent relative humidity until individual sample weights stabilized. A lithological description of each sample, as well as the depth interval from which it was obtained, is provided on Page 1. Permeability to air and Boyle's Law porosity values (using helium as the gaseous phase) were measured for each sample, with data presented in tabular format on Page 2, and in graphic format on Page 3.

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#### Formation Resistivity Factor Measurements at Ambient and Overburden Conditions:

Samples selected for formation resistivity factor testing were testing were evacuated then pressure-saturated, as instructed by Mr. Wallace, using a sodium chloride brine having 100,000 ppm total dissolved solids. Resistance of the fully-saturated core samples was measured on successive days until the calculated resistivity of each individual sample stabilized, indicating that ionic equilibrium had been attained. Resistance was then measured at effective overburden pressures of 400 and 3680 psi. The calculated formation resistivity factors were plotted as a function of porosity from which a cementation exponent "m" was derived for each overburden pressure. All samples, with the exception of sample 33, exhibited normal trends of increasing formation resistivity factors and cementation exponents ("m") with increasing overburden pressures.

At 400 psi overburden pressure, sample 33 demonstrated a decrease in formation resistivity factor value compared to the value calculated at 0.0 psi overburden pressure. This phenomena is attributed to the coarse grains predominate in the sample causing, at atmospheric conditions, poor contacts with the source of electrical current and the sample. This poor contact, in turn, results in an erroneously high  $R_o$  measurement. Contact with the grains and source of electrical current is enhanced at 400 psi overburden pressure, resulting in an improved formation resistivity factor calculation.

Also noted in the evaluation of the cementation exponent ("m") data is sample 11. The lithological difference evident in sample 11 results in a higher "m" value than that calculated for the remaining samples of this study.

Resultant data is presented in tabular form on Page 4 and graphically on Pages 5 through 7.

#### Formation Resistivity Index Measurements:

Following the described formation resistivity factor testing, samples 20, 31, and 33 were partially desaturated in a capillary pressure cell with humidified air at pressures ranging from 0.5 to 35 psi. Once a significant amount of desaturation had been achieved, the resistivity was calculated for the individual samples. Due to permeability limitations, sample 20 completed the desaturation process in a high speed centrifuge with sample 11 which was desaturated using, exclusively, a high speed centrifuge at rates of rotation equivalent to pressures ranging from 300 psi to 1200 psi. After each rotation, the samples were wrapped individually in Saran<sup>™</sup> wrap and aluminum foil and the pore fluids were allowed to redistribute for a minimum of 48 hours; the samples were then weighed and the resistance measured. The formation resistivity index calculations were plotted as a function of water saturation from which a saturation exponent "n" was determined for each The

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December 5, 1986  
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sample. Resultant data is presented in tabular format on Page 8, and graphically on Pages 9 through 12. A composite graph is presented on Page 13.

The table below summarizes the resistivity results:

Cementation Exponent

<u>Pressure, psi</u>	<u>"a"</u>	<u>"m"</u>
0	1.00	1.84
200	1.00	1.85
3680	1.00	1.87

Saturation Exponent

<u>Sample number</u>	<u>"n"</u>
11	1.75
20	1.90
31	1.64
33	1.82
Composite	1.82

Thank you for the opportunity to perform this study for The Anschutz Corporation. Should you have any questions regarding the test results, or if we may be of further assistance, please call us at (303)751-9334.

Sincerely yours,

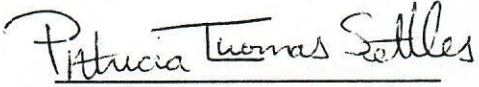

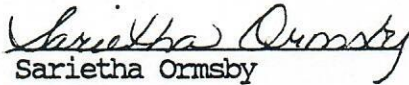
CORE LABORATORIES, INC.



Stephen H. Leeds  
Special Core Analysis Supervisor

SHL/sso  
4 cc addressee

PROGRAM PARTICIPANTS

<u>Task Performed</u>	<u>Personnel</u>
1) Sample Preparation	 Patricia Thomas Settles Senior SCAL Technician
2) Formation Resistivity Measurements and Data Evaluation	 Patricia Thomas Settles Senior SCAL Technician
3) Final Report Preparation	 Sarietha Ormsby Word Processor

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IDENTIFICATION AND LITHOLOGICAL DESCRIPTION OF SAMPLES

Company: The Anschutz Corporation  
Formation: Morrow  
County, State: Kiowa, Colorado

Well: Colorado State No. 1-20  
Field: Wildcat

<u>Sample Identification</u>	<u>Depth, feet</u>	<u>Lithological Description</u>
11	4731-32	Sst: lt gry, wl ind, vf-f gr, mod srt, lam
20	4746-47	Sst: lt gry, mod ind, f-crs gr, prly srt
31	4757-58	Sst: lt gry, mod ind, m-crs gr, mod srt
33	4759-60	Sst: lt gry, mod ind, crs gr, wl srt

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PERMEABILITY TO AIR, POROSITY, AND GRAIN DENSITY

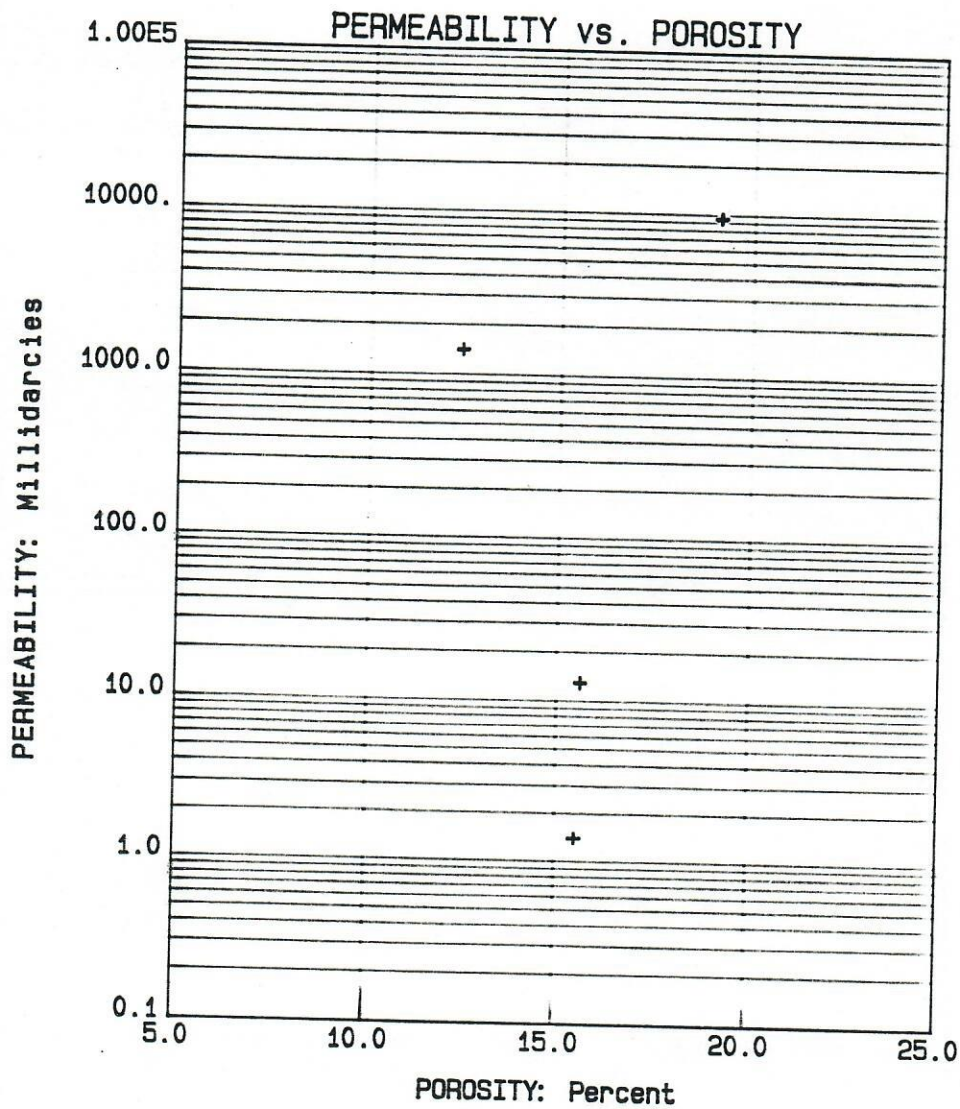
Company: The Anschutz Corporation  
Formation: Morrow  
County, State: Kiowa, Colorado

Well: Colorado State No. 1-20  
Field: Wildcat

<u>Sample Identification</u>	<u>Depth, feet</u>	<u>Permeability to Air, millidarcys</u>	<u>Porosity, percent</u>	<u>Grain Density, gm/cc</u>
11	4731-32	1.4	15.5	2.75
20	4746-47	13	15.6	2.65
31	4757-58	1410	12.4	2.71
33	4759-60	9500	19.1	2.64

The Anschutz Corporation  
Morrow Formation  
Kiowa County, Colorado

Colorado State No. 1-20  
Wildcat



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FORMATION RESISTIVITY FACTOR AS A FUNCTION OF OVERBURDEN PRESSURE

Company: The Anschutz Corporation  
Formation: Morrow  
County, State: Kiowa, Colorado

Well: Colorado State No. 1-20  
Field: Wildcat

Saturant: 100,000 ppm NaCl

Resistivity of Saturant: 0.072 ohm-meters at 77.0°F.

Sample I.D.	Depth, feet	Permeability to Air, <u>millidarcys</u>	Porosity, <u>percent</u>	<u>Overburden Pressure, psi</u>		
				0.0	400	3680
<u>Formation Resistivity Factor</u>						
11	4731-32	1.4	15.5 14.8*	48.4	56.0	74.0
20	4746-47	13	15.6 14.9*	28.9	31.3	34.4
31	4757-58	1410	12.4 10.9*	50.8	54.0	56.5
33	4759-60	9500	19.1 17.5*	19.4	18.8**	20.2

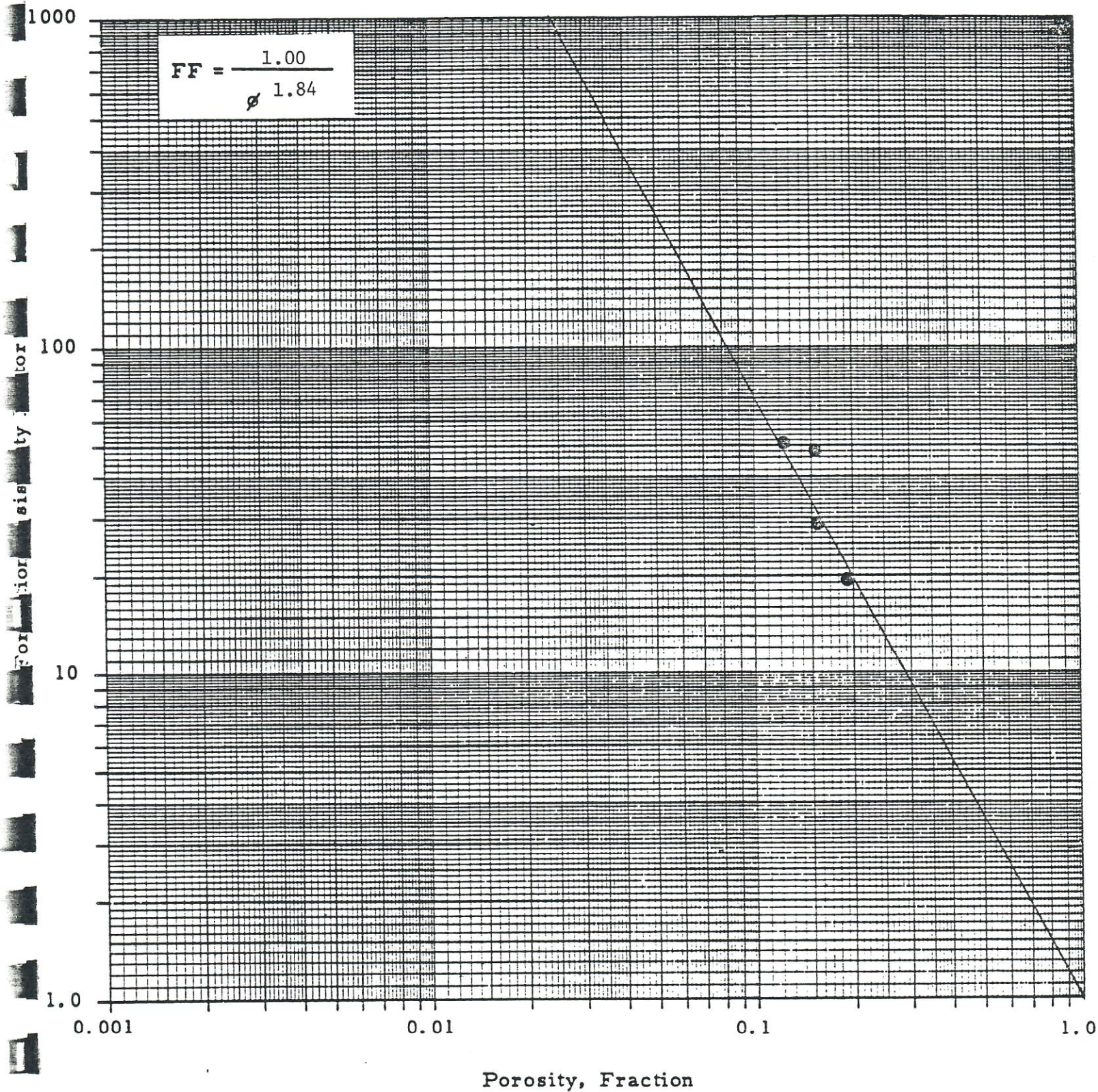
\* Reduced porosity due to overburden stress

\*\* Decrease in FF value -- see text for explanation

Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

0.0 psi Effective Overburden

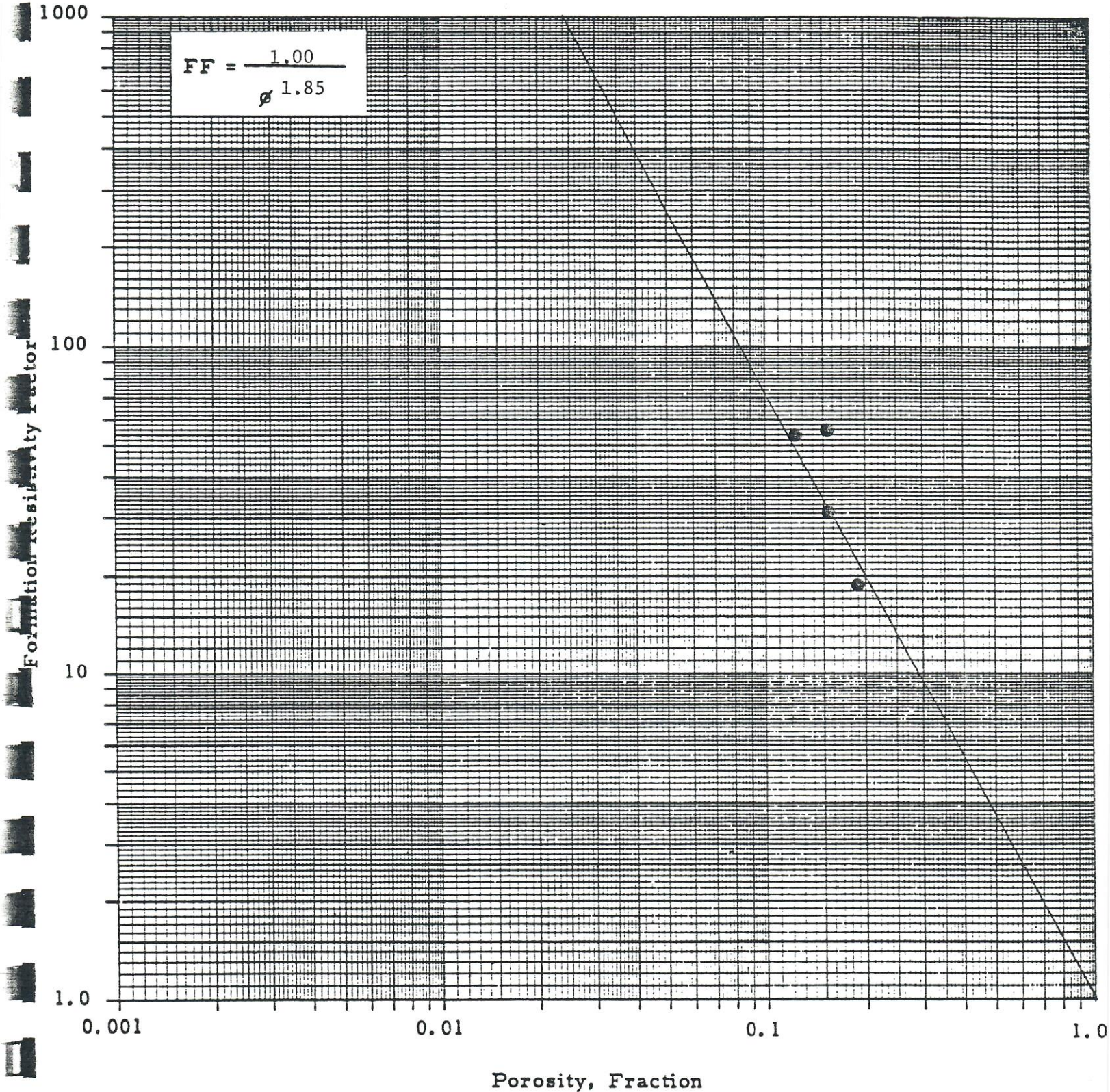
$$FF = \frac{1.00}{\phi^{1.84}}$$



Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

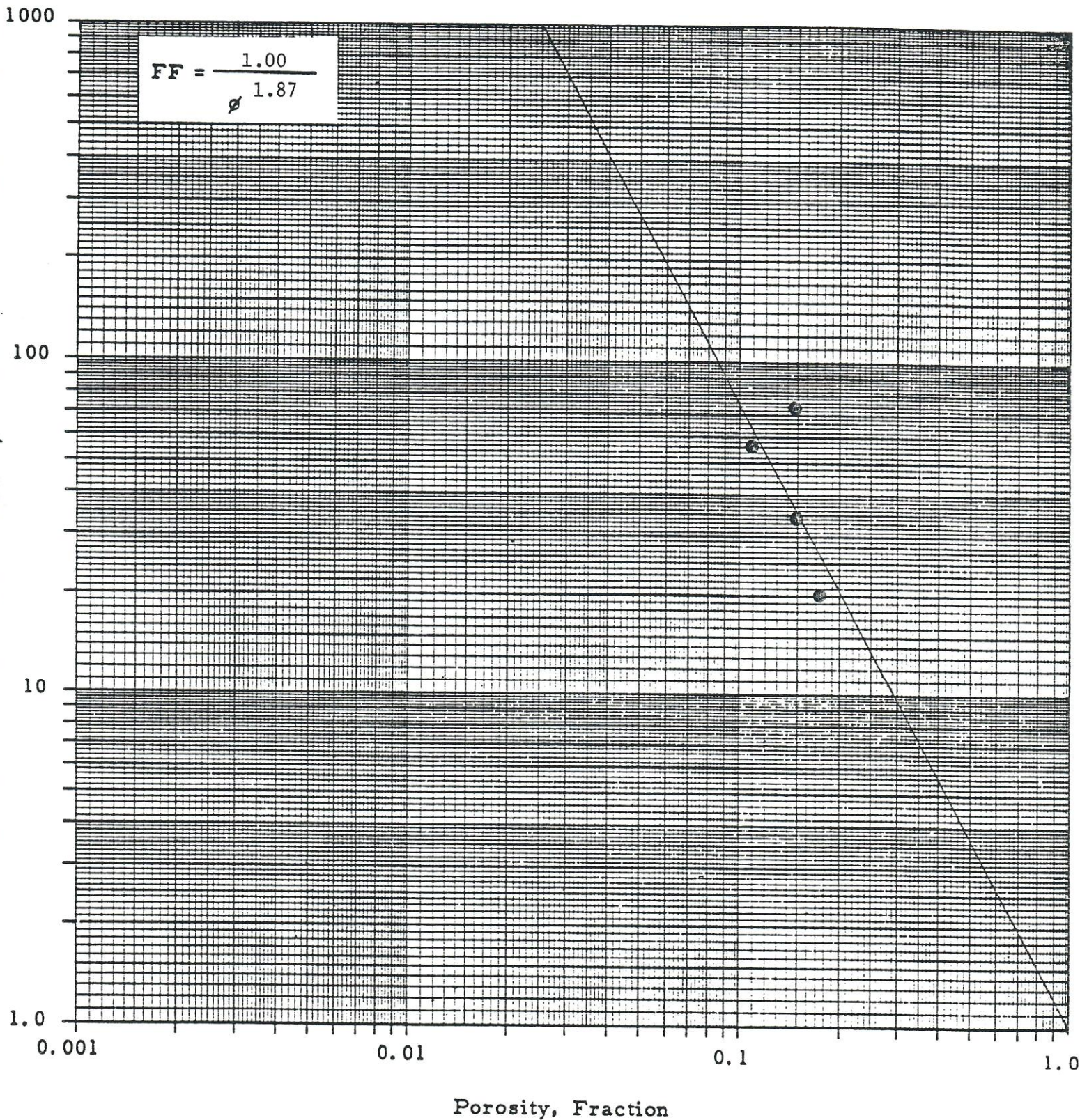
400 psi Effective Overburden

$$FF = \frac{1.00}{\phi^{1.85}}$$



Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

3680 psi Effective Overburden



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FORMATION RESISTIVITY INDEX

Company: The Anschutz Corporation  
Formation: Morrow  
County, State: Kiowa, Colorado

Well: Colorado State No. 1-20  
Field: Wildcat

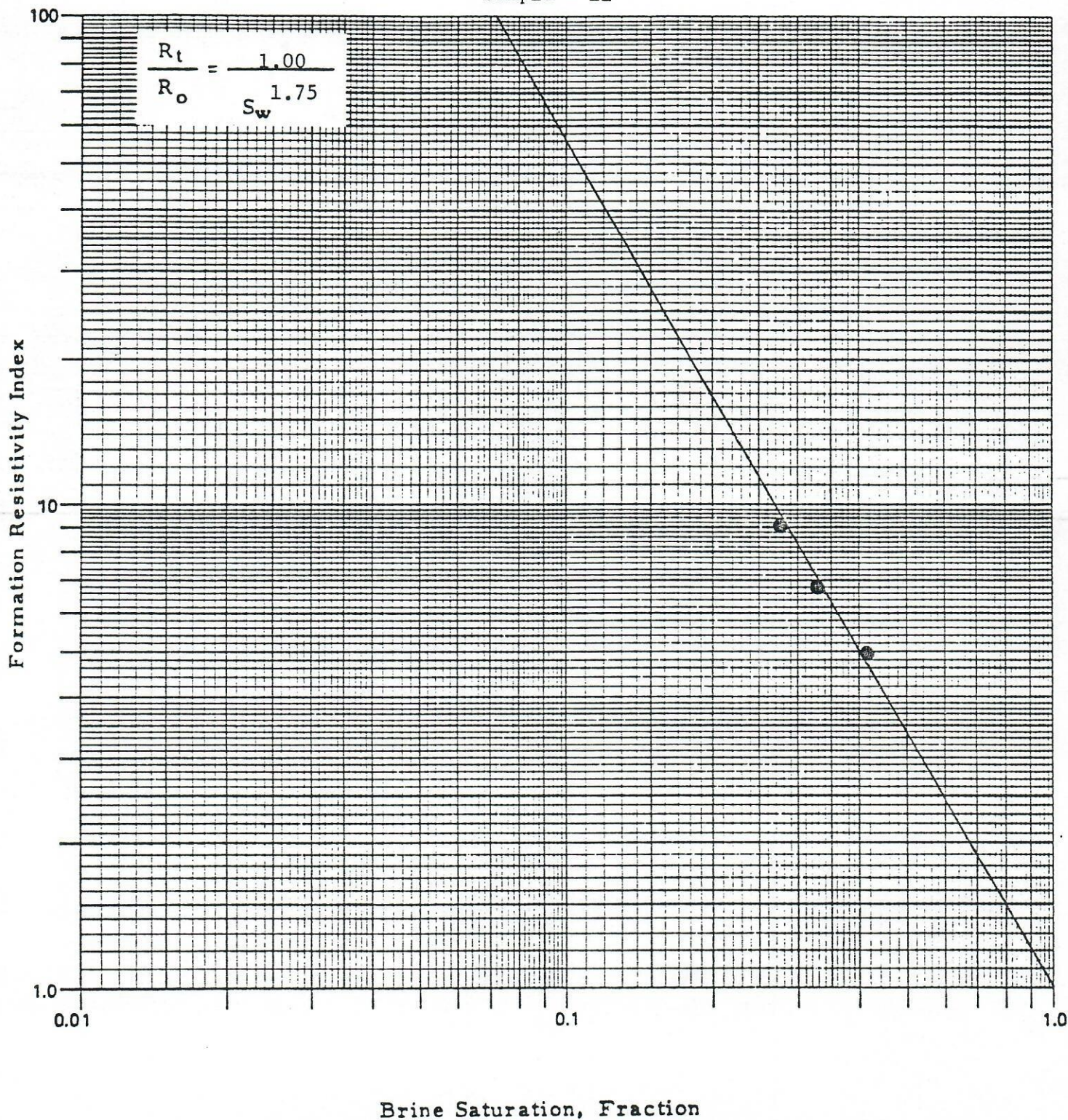
Saturant: 100,000 ppm NaCl  
Resistivity of Saturant: 0.072 ohm-meters at 77.0°F.

<u>Sample I.D.</u>	<u>Depth, feet</u>	<u>Permeability to Air millidarcys</u>	<u>Porosity percent</u>	<u>Brine Saturation percent pore space</u>	<u>Resistivity Index</u>
11	4731-32	1.4	15.5	41.6 33.0 27.5	4.95 6.81 9.03
20	4746-47	13	15.6	80.5 25.1 15.9	1.71 14.5 28.4
31	4757-58	1410	12.4	51.0 45.2 30.8	2.96 4.15 6.99
33	4759-60	9500	19.1	38.5 32.5 22.0	5.60 8.44 15.3

These analyses, opinions or interpretations are based on observations and material supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgement of Core Laboratories, Inc. (all errors and omissions excepted), but Core Laboratories, Inc. and its officers and employees, assume no responsibility and make no warranty or representations as to the productivity, proper operation, or profitability of any oil, gas or other mineral or sand in connection with such report is used or relied upon.

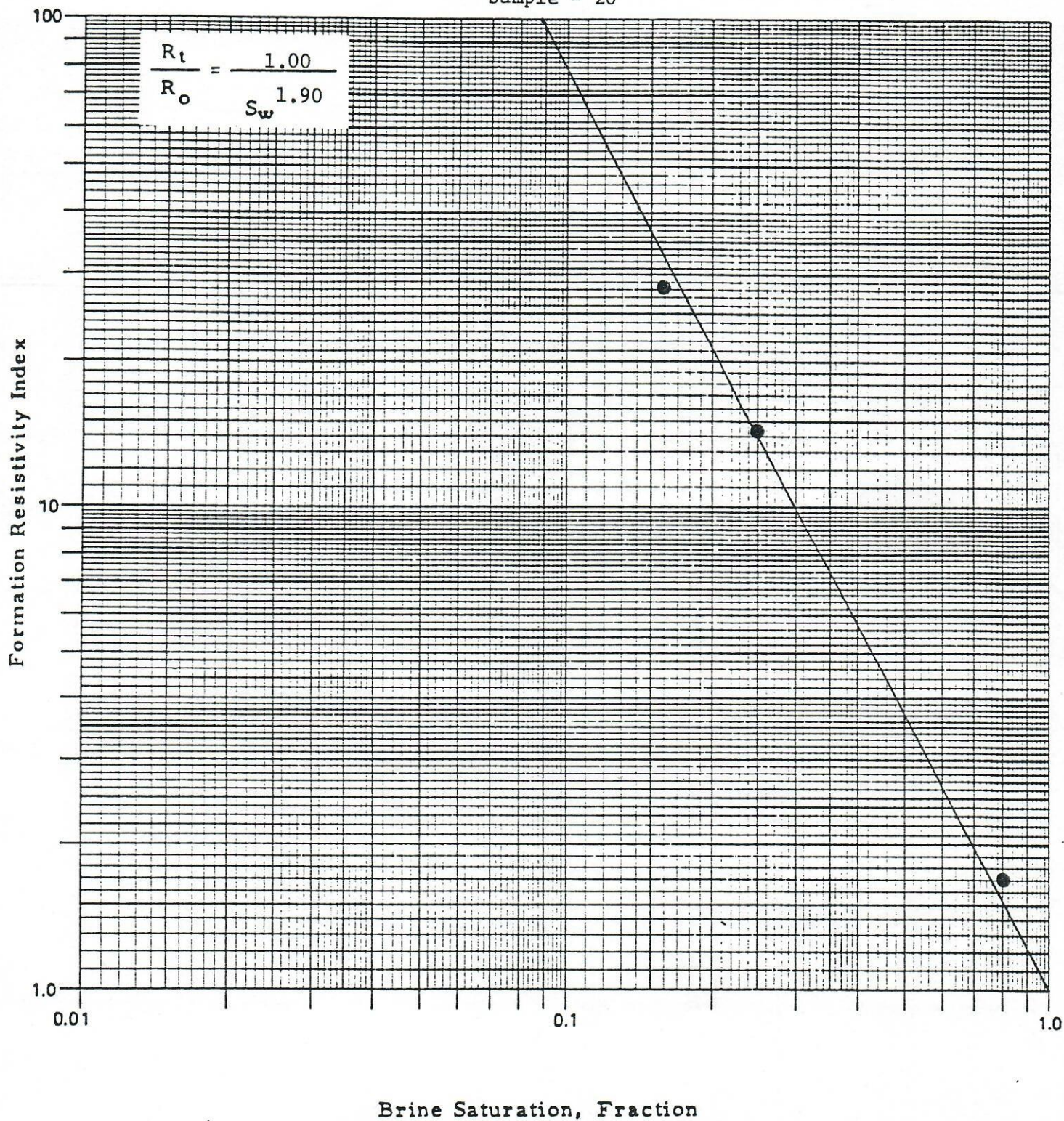
Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

Sample - 11



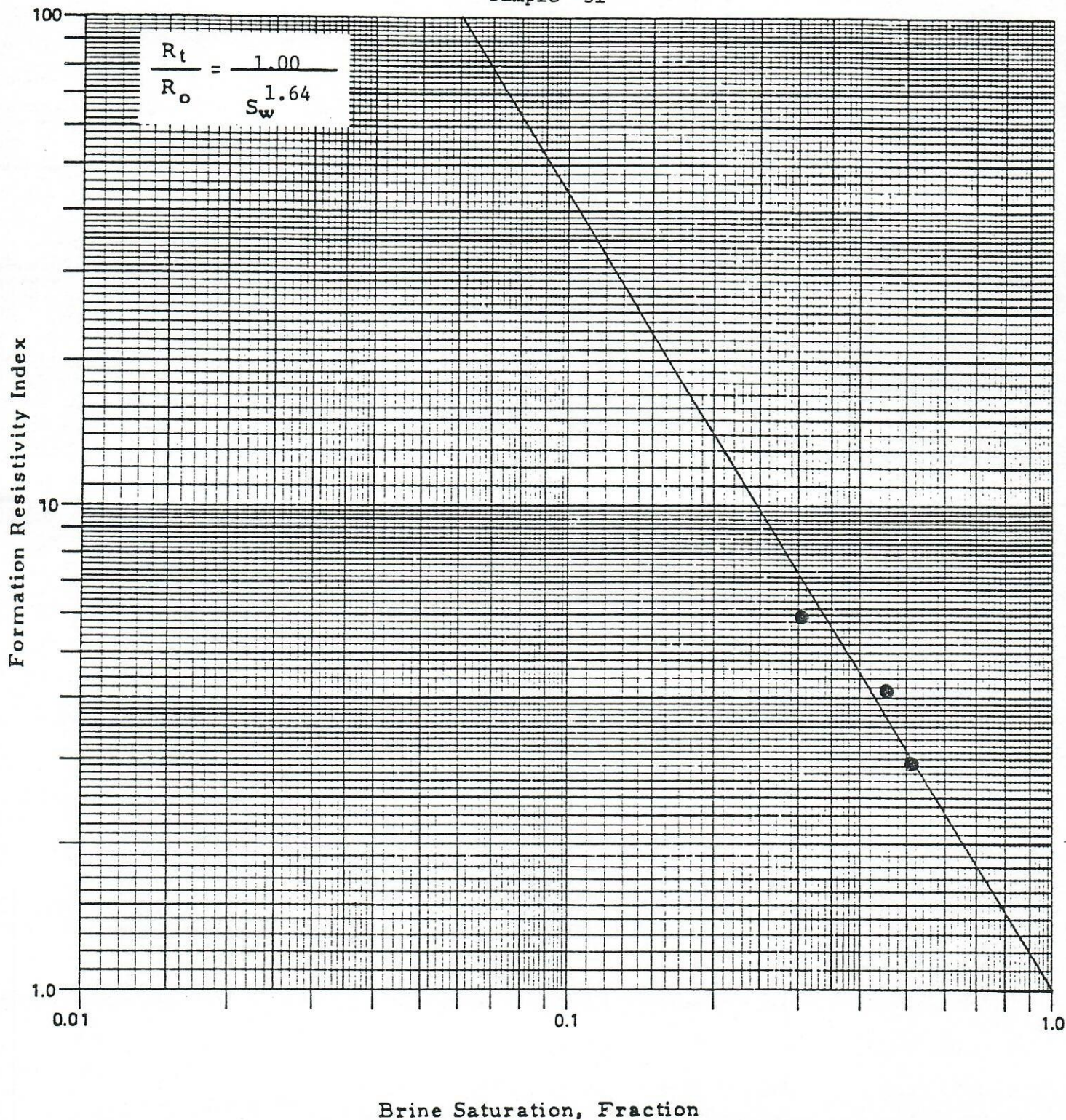
Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

Sample - 20



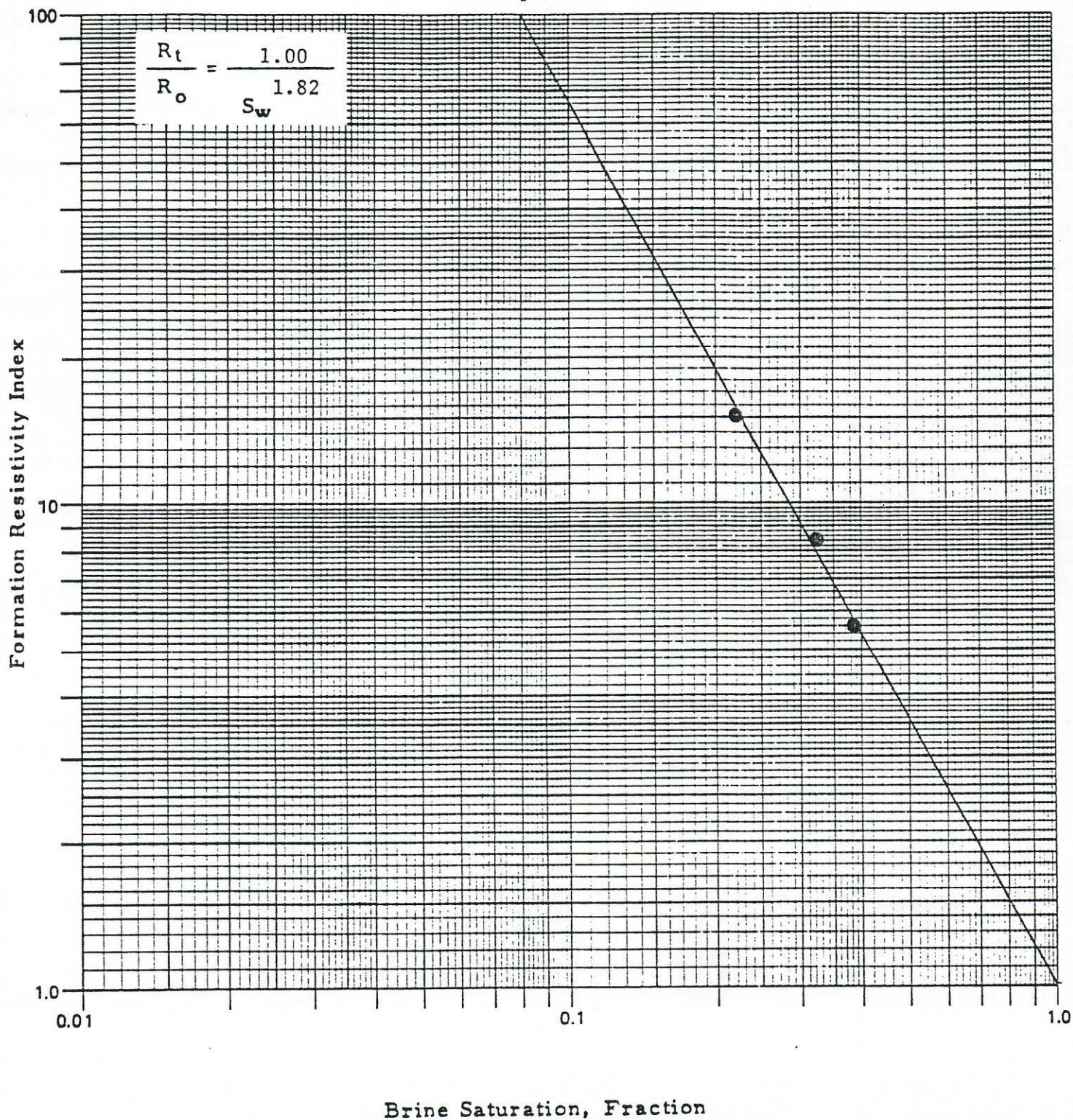
Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

Sample -31



Company The Anschutz Corporation Formation Morrow  
Well Colorado State No. 1-20 County Kiowa  
Field Wildcat State Colorado

Sample - 33



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Company The Anschutz Corporation Formation Morrow  
 Well Colorado State No. 1-20 County Kiowa  
 Field Wildcat State Colorado

Composite Plot

