Attenuation characteristics of soils in the prospecting program infiltration site for Exxon Minerals Company.

ATTENUATION CHARACTERISTICS OF SOILS IN THE PROSPECTING PROGRAM INFILTRATION SITE FOR EXXON MINERALS COMPANY

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SOIL ATTENUATION STUDY OVERVIEW

The raw waste water, generated from mine dewatering and runoff from the rock storage piles, is anticipated to have the chemical characteristics listed in Table 1 (CH2M Hill, 1980). The concentrations cited are predicted to be the worst-case situation. Once the waste water is treated, these characteristic concentrations will be significantly reduced.

Of the two major soil types found in the proposed waste water infiltration field area and in the environmental study area in general, one is noncalcareous and the other is calcareous. The noncalcareous soils (Langlade drift) are found near the surface, while the calcareous soils (Green Bay drift) are found at greater depths and underlie the noncalcareous soils throughout the area (Dames & Moore, 1981).

To aid in establishing soil attenuation characteristics and to predict the mobility of waste water constituents through the soils, the batch or shaker test is recommended (Federal Register, 1975). This test consists of combining a known volume of waste water of a predetermined composition with a given mass of dried soil. The mixture is shaken until equilibrium is attained. If the constituents of interest are attenuated (removed), their concentrations in the solution phase of the mixture will decrease. Conversely, if the constituents of interest are augmented through leaching from the soil, their concentrations in the solution phase of the mixture will increase. The equilibrated solution is generally separated from the solid phase by centrifugation or filtering. The resulting relative distribution of the constituents between adsorbed-desorbed and soil-water

phases depends on factors such as soil properties, temperature, and constituent concentration of the original waste water and soil (Weston, 1978).

Attenuation and leaching are generally used as general terms to signify a decrease of constituent concentration and an increase of constituent concentration, respectively, in the solution phase of the waste water-soil mixture. In reality, these terms encompass several physicochemical processes. Attenuation can be attributed to the physical processes of adsorption and absorption in addition to the chemical process of precipitation. Leaching can be attributed to the physical process of desorption, which is the name given to the reverse processes associated with adsorption and absorption. The chemical process associated with leaching is solubilization, which is the reverse of precipitation.

LABORATORY ANALYSIS

The predicted waste water characteristics were simulated in the laboratory for the purpose of running batch tests on noncalcareous and calcareous soil samples. Methods employed are based upon accepted standard procedures (Weston, 1978; Federal Register, 1975) and are presented in detail in Appendix A. All the laboratory work was conducted by Aqualab, Inc., of Streamwood, Illinois. A literature search was conducted for the 16 chemical constituents predicted to be characteristic of the waste water generated during the prospecting project. Characteristics of compounds containing the ions listed in Table 1 were reviewed to determine their compatibility with each other in solution, their solubility, and their ability to remain compatible under various pH conditions.

etc. They were then dried at 105°C to a constant weight. Upon completion of drying, they were sieved through a No. 10 U.S. Standard Sieve. Sufficient soil (approximately 20 pounds of each) was prepared for all testing. All subsampling after this point was done using the standard quartering technique (Appendix A).

Once the above preparations were completed, 90 grams of soil were weighed and placed into each of six 960-ml bottles for each soil type. The bottles were labeled B through G and 810 grams of the corresponding solutions were added. After all soil-solution mixtures were prepared, each was shaken vigorously every 5 minutes for 1 hour. The pH of each bottle was then measured, and they were allowed to equilibrate for 23 hours. The pH was again recorded. The supernatant from each bottle was filtered through 0.45-micron membrane filters and was again analyzed for the parameters listed in Table 1. The pH values were also measured after filtering.

DATA ANALYSIS

Data generated in the laboratory are used in conjunction with adsorption relationships. The underlying theory and the development of adsorption relationships are discussed by Weber (1972). The adsorption relationship generally used to describe soil attenuating characteristics is the empirical Freundlich equation. Other relationships that may be tried with the same data are the linear, the Langmuir, and the Brunauer, Emmett, Teller (BET) relationships. The various relationships are presented in a graphical format on Figure 1.

Missing Page 6

Unit Analysis:

$$qe = \frac{(mg/l)(l)}{g} + \frac{mg}{g} = \frac{mg\ constituent}{g\ soil}$$

Leaching = -qe

$$-qe = \frac{-\ mg\ Attached}{g\ Soil} = -\left[\frac{mg\ Adsorbed + mg\ Initially\ Attached}{g\ soil}\right]$$

-mg Adsorbed = mg released, then

$$-qe = \frac{mg\ released - mg\ Initially\ Attached}{g\ soil}$$

$$-\ qe = \frac{C_d V}{M} - \frac{C_I}{M}$$

Unit Analysis:

$$-qe = \frac{(mg/l)(l)}{g} - \frac{mg}{g} = \frac{mg\ constituent}{g\ soil}$$

Once the values for the variables qe and C_{eqc} were known, they were integrated into the relationship of interest (Figure 1). These values were plotted and used in a linear regression analysis. This was done for each relationship except BET. The BET relationship was not used because the initial solution concentrations were not high enough to establish a saturated concentration (C_s). The choice of the relationship to be used in the model, for each constituent of the waste water was based on the correlation coefficient of the linear regression (r^2) and the graphical representation of the relationship. To establish a relationship, a correlation coefficient greater than 0.900 was required along with a definite linear trend in the graphical representation.

Table 2

DATA FOR ZINC ATTENUATION RELATIONSHIPS IN NONCALCAREOUS SOIL*

Parameter: Zinc Soil Type: Noncalcareous

Test A = C_D = 0.002

Test B = Leach Test: 0.031, 0.182, 0.032, 0.035, 0.047, and 0.054 Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	6.18	30.9	61.8	123.6	618
C_{eq}	0.924	16.5	43.6	101	558

	LINEAR RELATIONSHIP		LANGMUIR RELATIONSHIP		FREUNDLICH RELATIONSHIP	
	C_{eqc}	qe	$\frac{1}{C_{eqc}}$	$\frac{1}{qe}$	log C_{eqc}	log qe
C	0.922	0.047	1.08	21.1	-0.035	-1.325
D	16.5	0.130	0.061	7.72	1.217	-0.887
E	43.6	0.164	0.023	6.10	1.639	-0.786
F	101	0.203	0.010	4.92	2.004	-0.692
G	558	0.540	0.002	1.85	2.747	-0.268
Intercept	0.102		4.75		-1.342	
Slope	7.96×10^{-4}		15.2		0.364	
r^2	0.969		0.938		0.975	
r	0.984		0.969		0.987	
n	5		5		5	
Equation:	$qe = 7.96 \times 10^{-4} C_{eqc} + 0.102$		$\frac{1}{qe} = 15.2 \frac{1}{C_{eqc}} + 4.75$		$\log qe = 0.364 \log C_{eqc} - 1.342$	

*Appendix A

REFERENCES

CH_2M Hill, 1980, Prospecting project water management study: Exxon Minerals Company, U.S.A., Crandon Project (unpublished).

Dames & Moore, 1981, Crandon project draft environmental impact report: Exxon Minerals Company, U.S.A. (unpublished).

Federal Register, 1975, Protocol for adsorption tests: U.S. GPO, Washington, D.C., vol. 40, no. 123, p. 26881-26895.

Weber, W.J., Jr., 1972, Physicochemical processes for water quality control: Wiley-Interscience, New York, N.Y., p. 199-219.

Weston, R.F., Inc., 1978, Pollution prediction techniques for waste disposal siting; a state-of-the-art assessment: U.S. EPA Office of Solid Waste, Washington, D.C., p. 165-168.

FIGURE 2

FLOW DIAGRAM FOR LINEAR RELATIONSHIP CALCULATION

General Linear Relationship

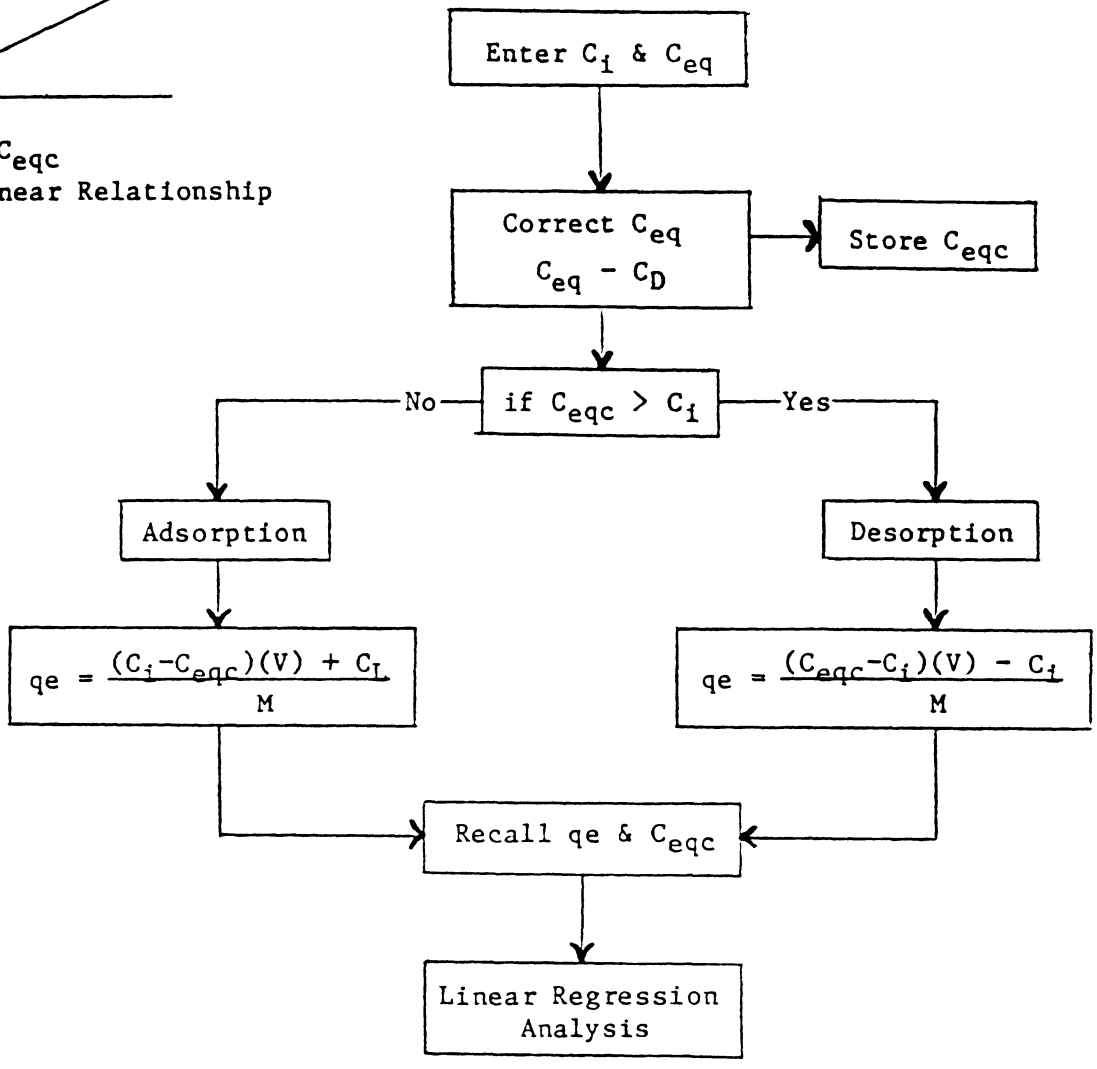
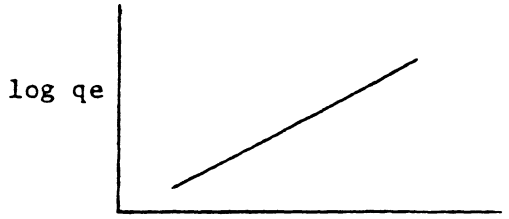
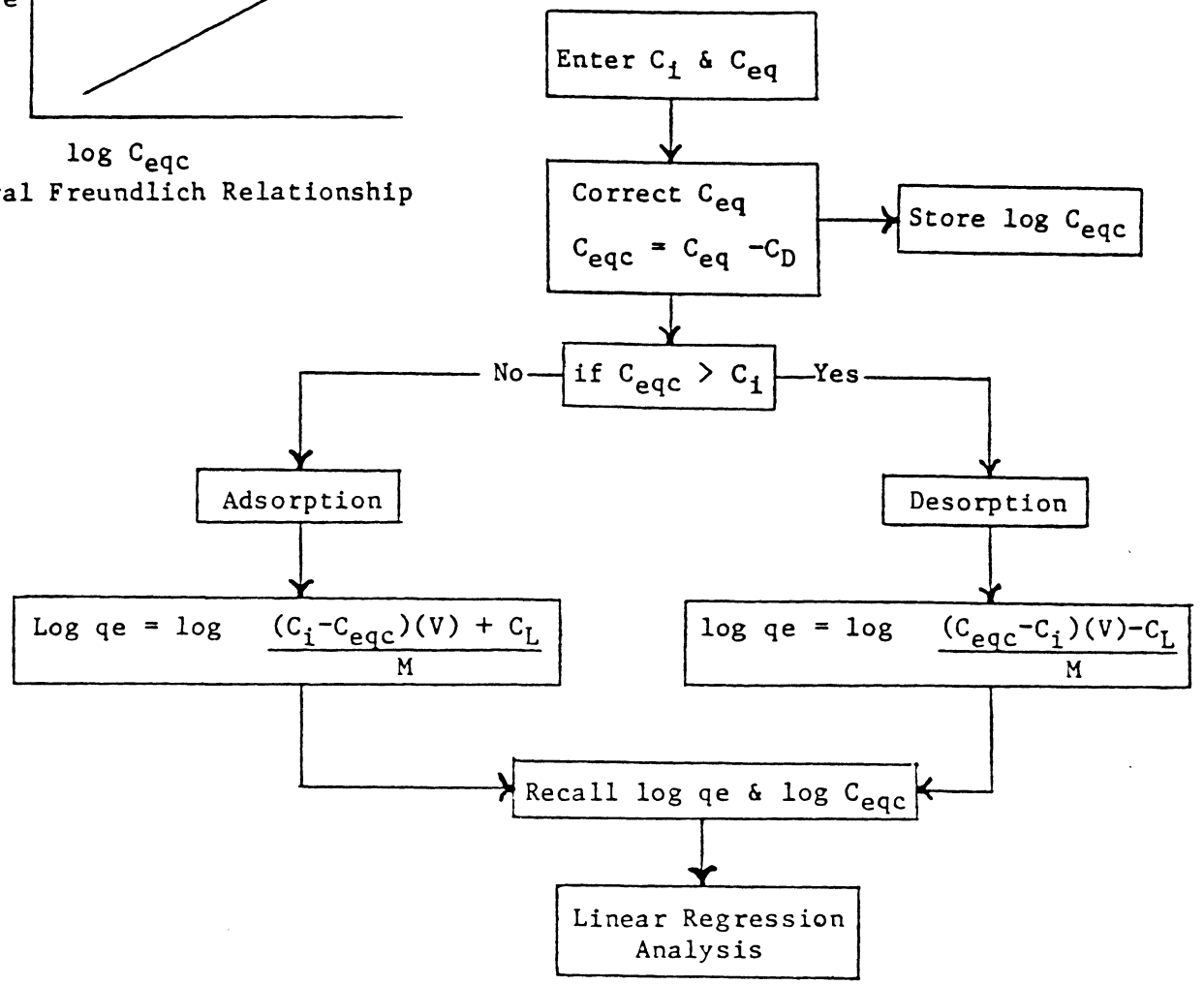


FIGURE 4

FLOW DIAGRAM FOR FREUNDLICH RELATIONSHIP CALCULATIONS



General Freundlich Relationship



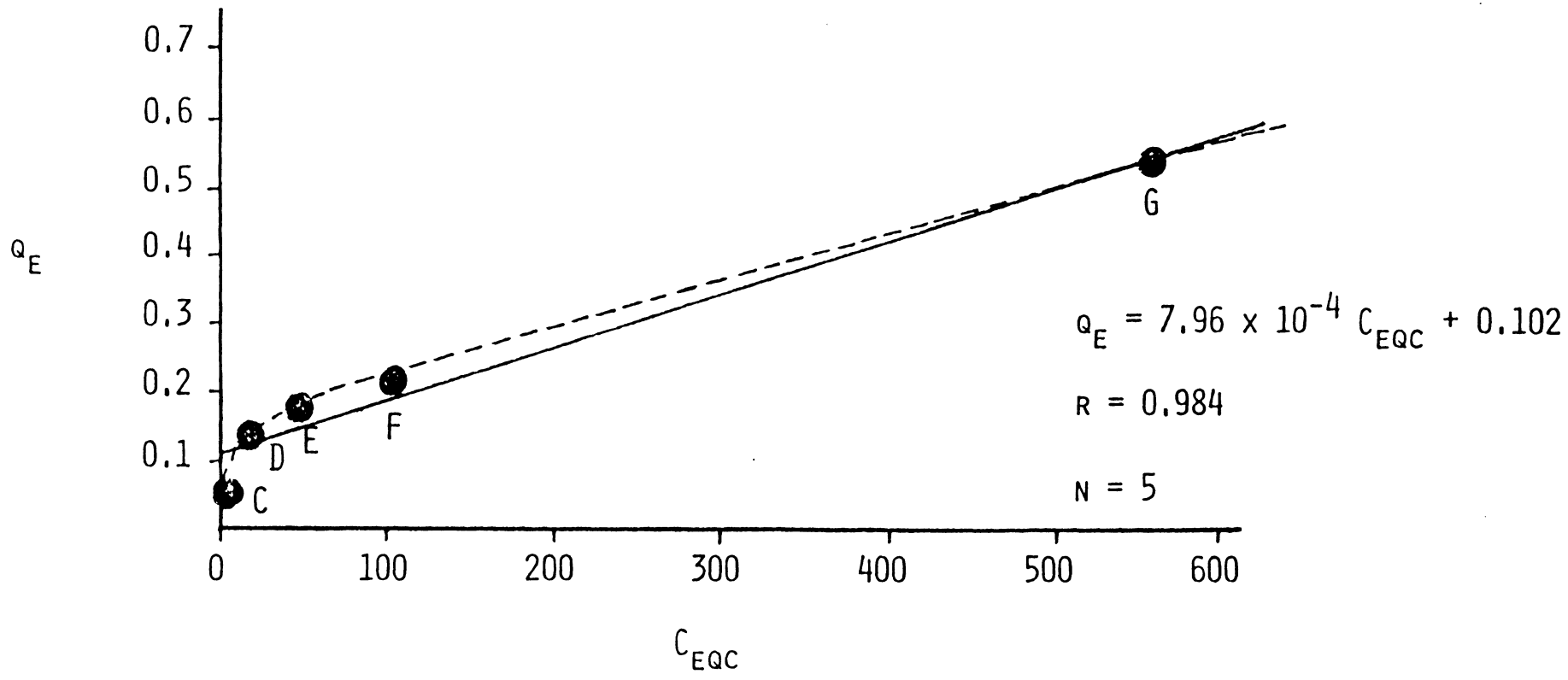


FIGURE 6

LINEAR RELATIONSHIP FOR ZINC IN NONCALCAREOUS SOIL

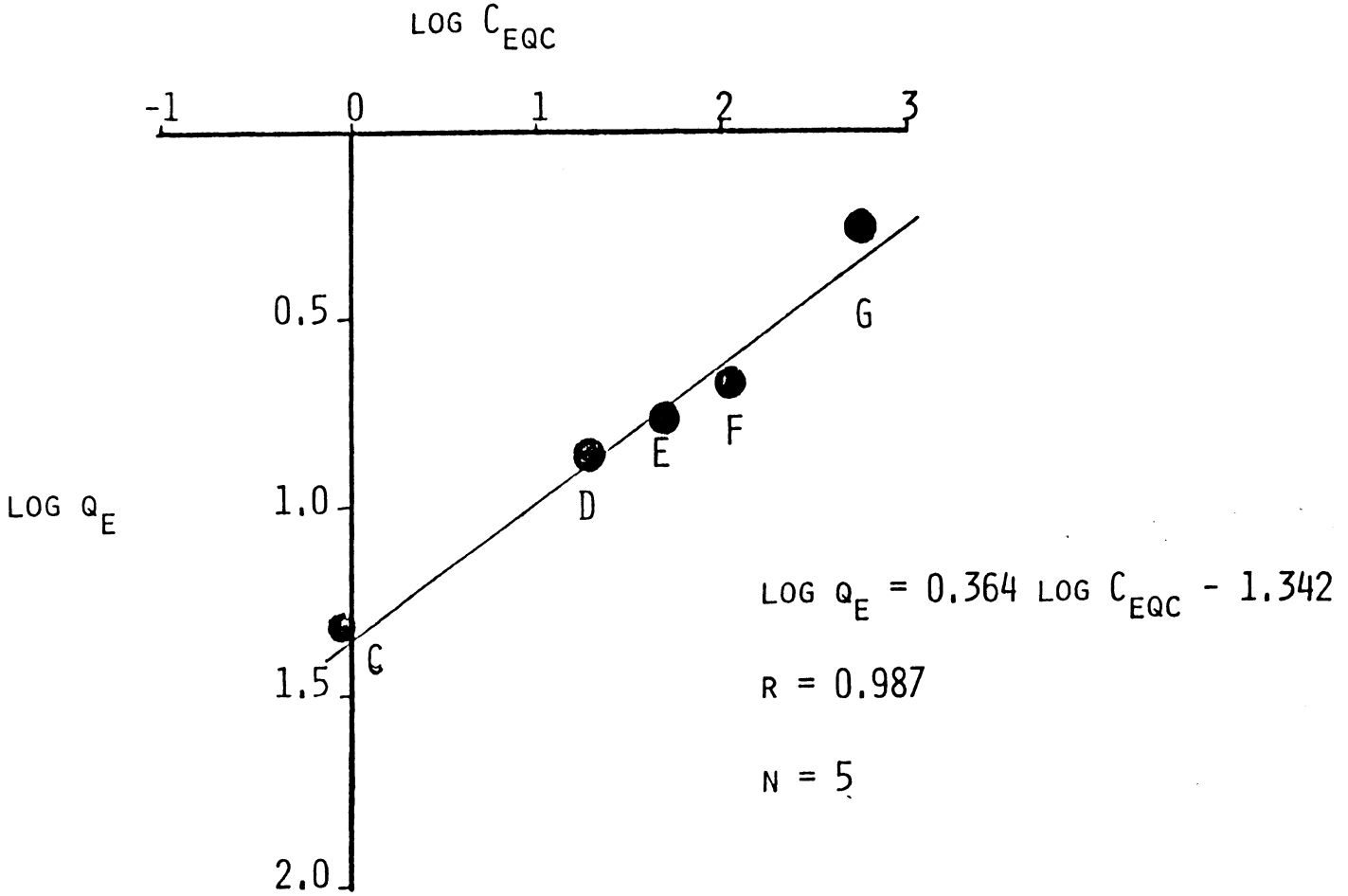


FIGURE 8

FREUNDLICH RELATIONSHIP FOR ZINC IN NONCALCAREOUS SOIL

APPENDIX A

BATCH ATTENUATION STUDIES RESULTS

aqualab inc.
rt 20 at valley lane
streamwood, illinois 60103
312/289-3100

25 April 1980

Mr. Kurt Thomsen
DAMES & MOORE
1550 Northwest Highway
Park Ridge, IL 60068

Dear Mr. Thomsen:

Enclosed please find the data for the Batch Attenuation Studies. Because of the experimental nature of this study and the volume of data generated, a detailed discussion of our procedures and data follows.

We received from Dames & Moore two different types of soil--Calcareous (#68032) and Non-calcareous (#68033). The Calcareous soil was a composite of your designations DM1-1, #8; DM1-3, #7; DM1-3, #8; DM1-3, #9; DM1-4, #10; DM1-7 #5; DM1-7, #10, DM1-7, ?; DM1-7, ?; DM1-8, #9; DM1-8, #10; and BHA, #6. The Non-calcareous soil was a composite of your designations S-4 and S-5. Equal weights of each designation were used to make the composites.

After compositing, the soils were force sieved through a No. 8 U.S. Standard Sieve to remove sticks, stones, etc. They were then placed on aluminum sheets and dried at 105°C to a constant weight. Upon completion of drying, they were sieved through a No. 10 U.S. Standard Sieve. Sufficient soil (approximately 20 pounds of each) was prepared for all testing. All sub-sampling after this point was done using the standard quartering technique.

An element literature study was done for the 16 ions requested for your stock solution. Compounds were looked at closely for their solubility, their compatibility with each other in solution, and their pH function. Table I lists the final compounds used. Also listed are the names and formulas of the compounds, their molecular weights, the percentage of each ion per compound, the target concentrations, and the weights in milligrams per liter needed to make the desired concentrations.

Continued.....

After a thorough examination of the data, we were requested to rerun the batch solutions for each soil. A new stock solution was made and the original study rerun for selected parameters. It should be noted that solutions A and B were adjusted to a pH of 4.70 with phosphoric acid for the rerun. We then analyzed for selected parameters per Dames & Moore. The data for the Calcareous soil is found in Table VI and the Non-calcareous in Table VII. The new values for each solution are also listed in these tables.

Individual element attenuation studies were requested for barium, arsenic, iron, mercury, and selenium. These were performed using the same procedure as described except that individual solutions were used which contained only the element of interest. This data can be found in Tables VIII and IX. Also included are the concentrations of each solution.

Our final study consisted of four series of D.I. water leaches. Both Calcareous and Non-calcareous soil were leached with six successive liters of pH adjusted D.I. water. Each liter was allowed to equilibrate for 24 hours as previously described. The data obtained is listed in Table X. Also listed are the values for the pH adjusted D.I. water blank.

We wish to thank Dames & Moore for this opportunity to be of service. If there are any questions or if we can be of assistance in interpreting the data, don't hesitate to call.

Yours very truly,

AQUALAB, INC.

Stan S. Zawarski

Stan S. Zawarski
General Manager

SSZ:i

Encls.

BATCH ATTENUATION STUDY

Solution B - Manganese Rerun

Solution B with both types of soil was re-run adjusting pH with nitric acid to the approximate pH levels of Solution G (see Table IV).

	pH		
Sample No.	1 hr.	24 hrs.	Manganese (mg/l)
68032B-1	6.14	6.25	0.053
68033B-1	5.03	5.15	0.032

BATCH ATTENUATION STUDY

Selected Parameter Re-runs - Non-Calcareous Soil

NUMBER	DESCRIPTION	Cadmium	Fluoride	Sulfate	Nitrate
68033A-A	D.I. Water Blank	<0.001	<0.12	<1.	<0.05
	D.I. Water	<0.001	<0.12	<1.	<0.05
68033B-A	D.I. Water + Soil	<0.001	<0.12	<1.	0.15
	D.I. Water	<0.001	<0.12	<1.	<0.05
68033C-A	Soln C + Soil	0.005	<0.12	---	0.98
	Soln C	0.027	0.10	---	0.78
68033D-A	Soln D + Soil	0.067	---	---	---
	Soln D	0.133	---	---	---
68033E-A	Soln E + Soil	0.172	---	---	---
	Soln E	0.266	---	---	---
68033F-A	Soln F + Soil	0.409	---	609.	---
	Soln F	0.532	---	806.	---
68033G-A	Soln G + Soil	2.51	---	4306.	---
	Soln G	2.66	---	4032.	---

Note: A designates second batch of concentrate

BATCH ATTENUATION STUDY

Individual Element Attenuation Data - Non-Calcareous Soil

Solution Number	Description	Barium	Iron	Mercury	Selenium
8033A-B	D.I. Water Blank	<0.01	<0.01	<0.0001	<0.001
	D.I. Water	<0.01	<0.01	<0.0001	<0.001
8033B-B	D.I. Water + Soil	<0.01	<0.01	<0.0001	<0.001
	D.I. Water	<0.01	<0.01	<0.0001	<0.001
68033C-B	Soln C + Soil	0.05	<0.01	<0.0001	0.004
	Soln C	0.48	0.10	0.0001	0.108
8033D-B	Soln D + Soil	0.05	<0.01	<0.0001	0.068
	Soln D	2.41	0.48	0.0004	0.540
8033E-B	Soln E + Soil	0.18	<0.01	<0.0001	0.510
	Soln E	4.83	0.97	0.0008	1.08
68033F-B	Soln F	0.29	<0.01	<0.0001	0.500
	Soln F + Soil	9.66	1.94	0.0017	2.16
8033G-B	Soln G	7.23	<0.01	<0.0001	3.22
	Soln G + Soil	48.3	9.70	0.0084	10.8
8033E-B-QA	Soln E + Soil	---	---	---	0.510
	Soln E	---	---	---	1.08

Note: -B designates individual concentrate solutions for each parameter

APPENDIX B

SUMMARY OF SOIL ATTENUATION MODELING DATA

CALCAREOUS SOIL

Summary of Soil Attenuation Modeling Data

Calcareous Soil

Parameter	Relationship	Intercept	Slope	r^2	n
Arsenic	Freundlich	-1.820	0.877	0.978	5
Barium	"	-1.16	0.54	0.90	5
Cadmium	"	-2.650	0.310	0.995	5
Calcium*	"	-1.4	0.4	0.9	5
Copper	"	-1.230	0.441	0.921	5
Lead	Langmuir	3.06	1.84	1.00	3
Lead	Freundlich	-0.56	0.82	1.00	3
Selenium	"	3.540	3.010	0.780	5
Zinc	"	-1.030	0.176	0.942	5

* Calcium is a desorption relationship – all others are adsorption

Exxon Attenuation Study

QC [illegible] 5/15

Parameter Arsenic Soil Type Calcareous Test A = C_0 = 0

Test B = Leach Test: < 0.001 Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	[illegible]	0.0001	0.01101	0.0202	0.101
C_{eq}	0.001	.007	0.010	0.017	0.148

QA 0.008

Linear Relationship

	C_{eqc}	q_e
C	0.001	[illegible]
D	[illegible]	[illegible]
E	0.010	[illegible]
F	0.017	[illegible]
G	0.148	[illegible]

Intercept [illegible]

Slope [illegible]

r^2 [illegible]

r [illegible]

n —

Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	1000	3.691×10^4
D	250	6.901×10^3
E	100	3.691×10^3
F	58.82	1.758×10^3
G	6.757	4.392×10^2

Intercept 5.593×10^2

Slope [illegible]

r^2 0.995 (9.954 × 10⁻¹)

r 0.998

n 5

Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-3.000	-4.567
D	-2.398	-3.839
E	-2.000	-3.567
F	-1.770	-3.245
G	-0.830	-2.643

Intercept −1.818

Slope 0.877

r^2 0.978

r 0.989

n 5

Equation:

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s —

Intercept —

Slope —

r^2 —

r —

n —

Equation:

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Langmuir Relationship

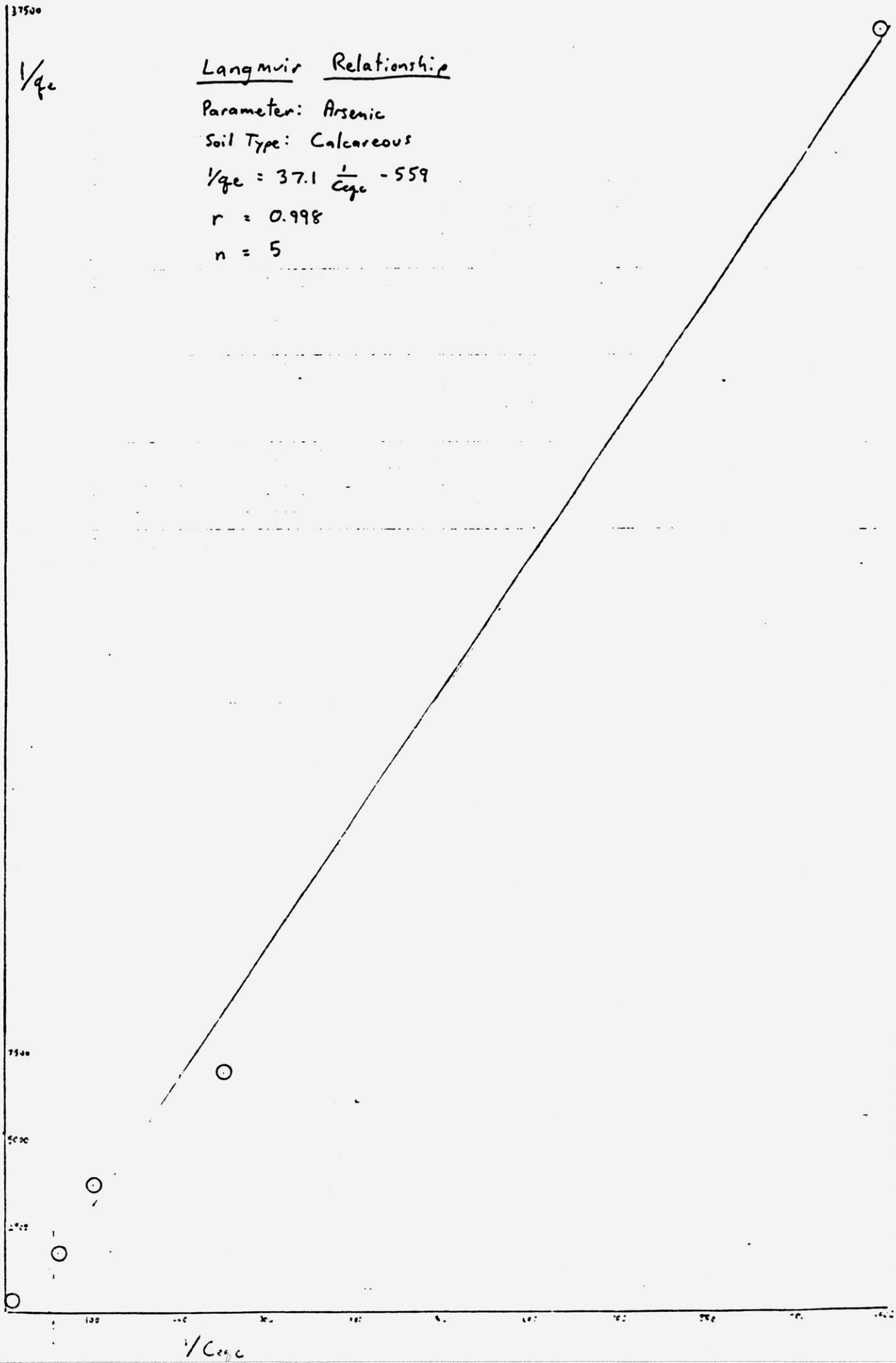
Parameter: Arsenic

Soil Type: Calcareous

$1/q_e = 37.1 \frac{1}{C_{eq}} - 559$

$r = 0.998$

$n = 5$



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Exxon Attenuation Study

Parameter Barium Soil Type Calcareous Test A = C_0 = < 0.01

Test B = Leach Test: < 0.01 Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	0.483	2.4115	4.83	9.66	48.3
C_{eq}	0.02	0.03	0.38	1.08	16.0

QA 0.39

Adsorption

Linear Relationship

	C_{eqc}	q_e
C	.020	4.167×10^{-3}
D	.030	.021
E	0.380	.040
F	1.080	0.077
G	16.000	0.291

Intercept 0.013
Slope 0.061
r^2 0.775
r 0.772
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	50.000	237.981
D	33.333	46.587
E	2.632	24.969
F	0.926	12.950
G	0.063	3.440

Intercept 0.149
Slope 2.763
r^2 0.167
r 0.374
n 5
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-1.691	-2.386
D	-1.523	-1.668
E	-0.420	-1.371
F	0.033	-1.112
G	1.204	-0.537

Intercept -1.159
Slope
r^2 0.917
r 0.777
n 5
Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation:

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Langmuir Relationship

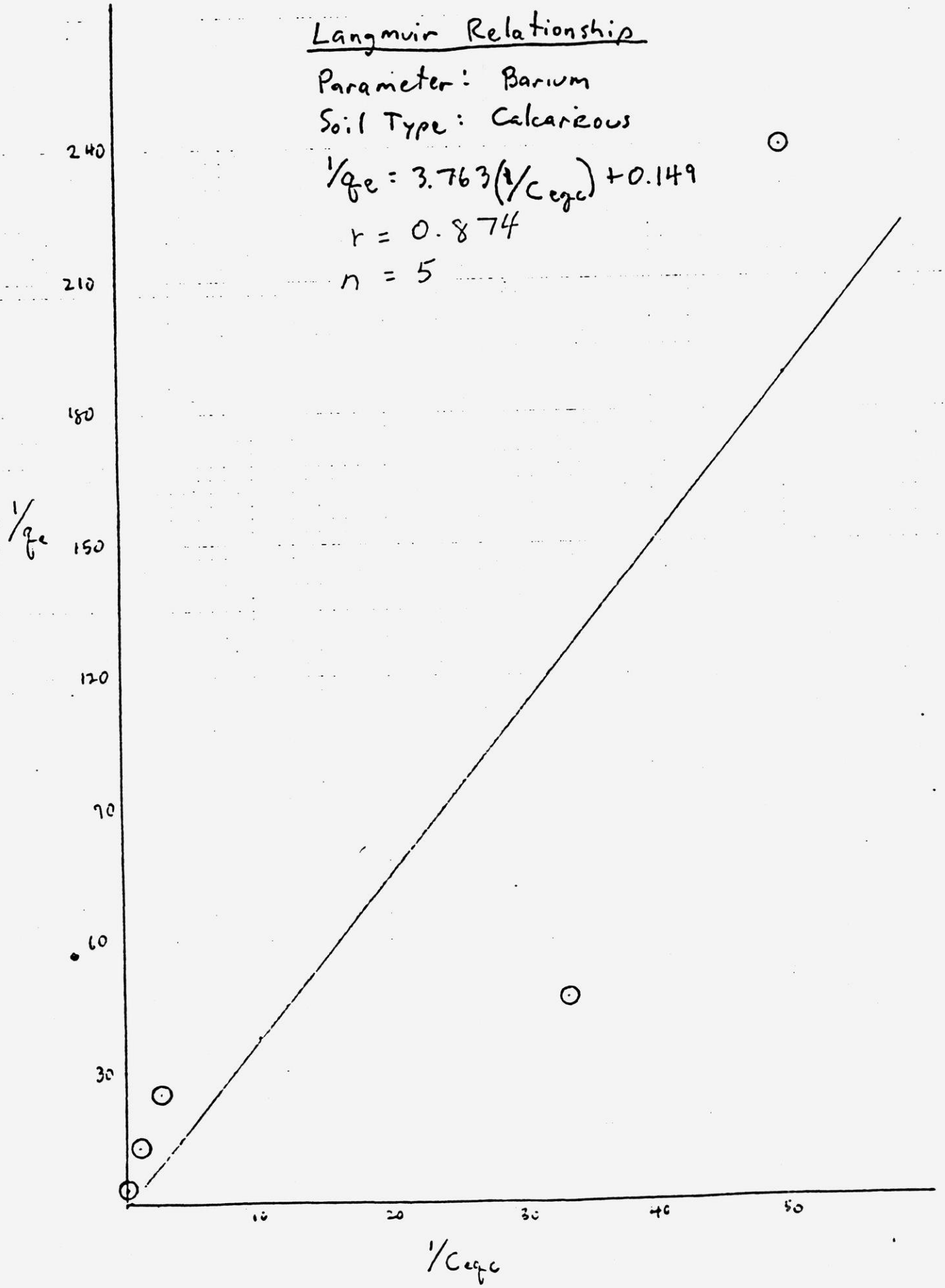
Parameter: Barium

Soil Type: Calcareous

$1/q_e = 3.763(1/C_{eqc}) + 0.149$

$r = 0.874$

$n = 5$



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Exxon Attenuation Study — INDIVIDUAL TEST

Parameter Cadmium Soil Type Calcareous Test A = C_0 = <0.001

Test B = Leach Test: 0.002, < 0.001 & <0.001 Total Leached = C_L = 0.002 mg/l

Adsorption

	Test C	Test D	Test E	Test F	Test G
C_i	0.0266	0.133	0.266	0.532	2.66
C_{eq}	0.001	0.039	0.129	0.347	2.36

QA 0.126

Linear Relationship

	C_{eqc}	q_e
C	0.001	2.526×10^{-4}
D	0.039	8.682×10^{-4}
E	0.129	1.255×10^{-3}
F	0.347	1.687×10^{-3}
G	2.36	2.722×10^{-3}

Intercept 8.885×10^{-4}
Slope 8.148×10^{-4}
r^2 0.782
r 0.884
n 5

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	1000.00	3958.48
D	25.64	1151.78
E	7.752	796.67
F	2.882	592.69
G	0.424	367.35

Intercept 694.66
Slope 3.274
r^2 0.969
r 0.985
n 5

Freundlich Relationship

	log C_{eqc}	log q_e
C	-3.000	-3.598
D	-1.409	-3.061
E	-0.889	-2.901
F	-0.460	-2.773
G	0.373	-2.565

Intercept -2.646
Slope 0.310
r^2 0.995
r 0.998
n 5

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s ____
Intercept ____
Slope ____
r^2 ____
r ____
n ____
Equation: ____

Langmuir ... ation

SUBJECT

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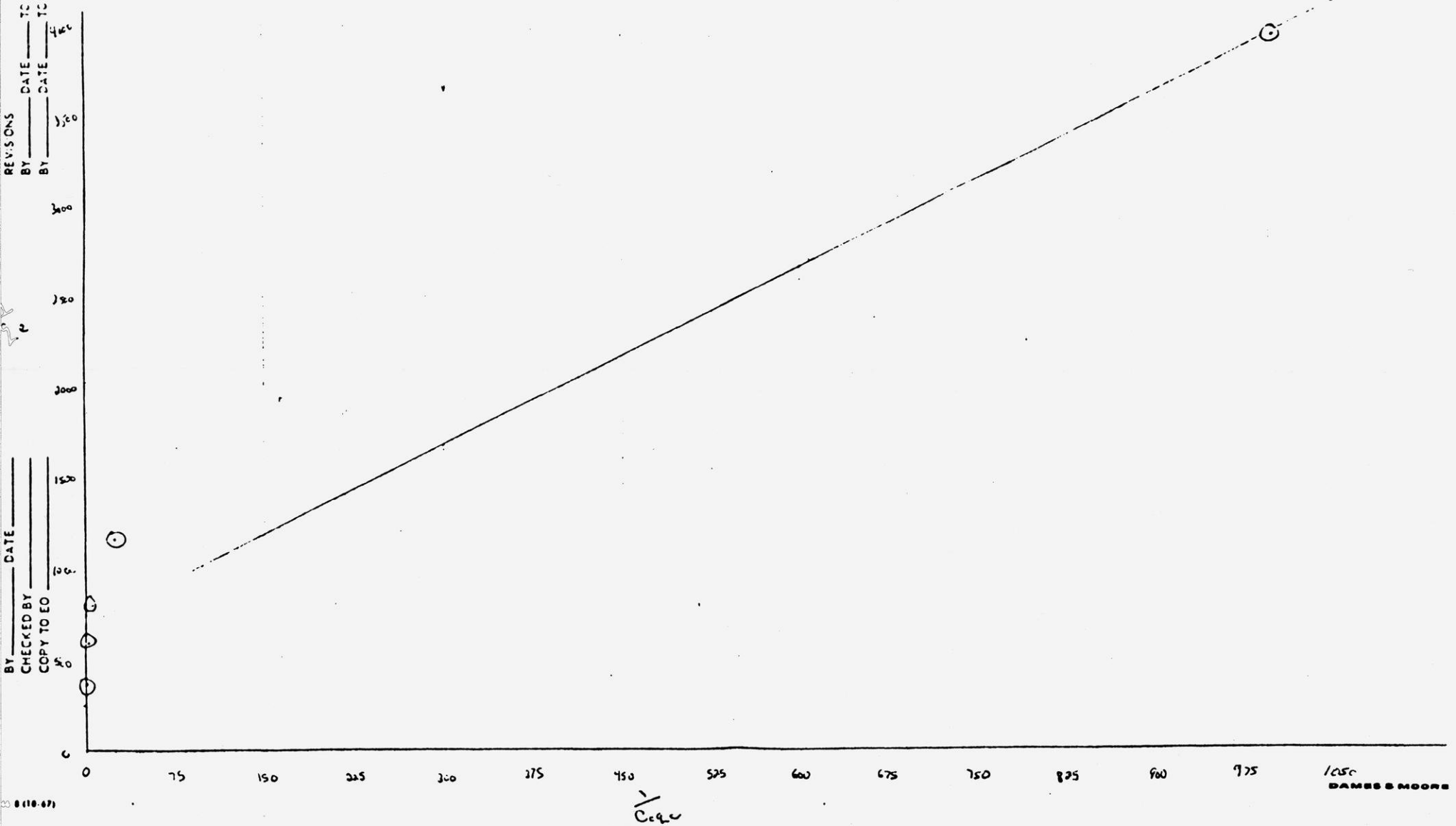
parameter: cadmium

soil type: calcareous

$\frac{1}{q_e} = 3.274 \frac{1}{C_{eqc}} + 69.66$

$r = 0.985$

$n = 5$



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DAMES & MOORE

Lesson 10

Exxon Attenuation Study

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Parameter Calcium Soil Type Calcareous Test A = C_0 = 0.052

Test B = Leach Test: 3.65, 3.00, 4.36, 4.22, 1.77, & 3.67 Total Leached = C_L = ____

	Test C	Test D	Test E	Test F	Test G
C_i	4.07	20.35	40.7	81.4	407
C_{eq}	13.3	37.8	59.2	104	440

✓ QA ____

Linear Relationship

	C_{eqc}	q_e
C	13.218	0.083
D	37.748	0.157
E	57.148	0.166
F	103.948	0.203
G	439.948	0.297

Intercept 0.128
Slope 4.039×10^{-4}
r^2 0.931
r 0.911
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	0.075	12.106
D	0.026	6.386
E	0.017	6.023
F	0.010	4.928
G	0.002	3.372

Intercept 3.595
Slope 113.185 (1.135) $\times 10^2$
r^2 0.986
r 0.993
n 5
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	1.122	-1.083
D	1.577	-0.805
E	1.772	-0.780
F	2.017	-0.693
G	[illegible]	[illegible]

Intercept -1.116
Slope [illegible]
r^2 [illegible]
r [illegible]
n ____
Equation:

B.E.T Relationship

C_{eqc}/C_s $q_e\left[\frac{C_{eqc}}{C_s - C_{eq}}\right]$

C
D
E
F
G

C_s ____
Intercept ____
Slope ____
r^2 ____
r ____
n ____
Equation: C_{eqc}

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Langmuir Relationship

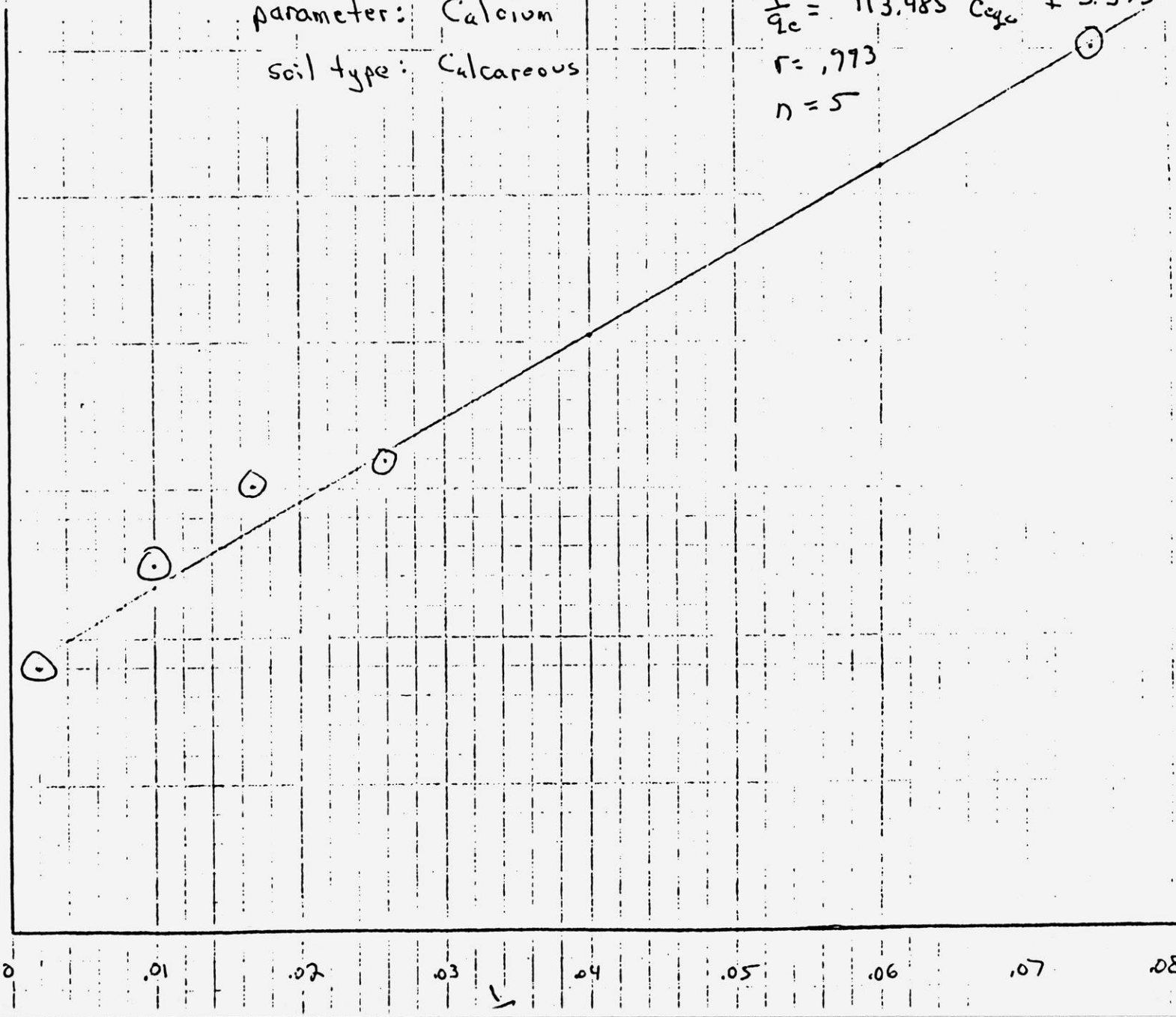
parameter: Calcium

soil type: Calcareous

$\frac{1}{q_e} = 113.485 \frac{1}{C_{eq}} + 3.595$

$r = .993$

$n = 5$



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DAMES & MOORE

Exxon Attenuation Study

QC BKF 5-15

Parameter Copper Soil Type Calcareous Test A = C_0 = 0.002

Test B = Leach Test: Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	0.304	1.52	3.04	6.08	30.4
C_{eq}	0.005	0.027	0.074	0.348	15.4

QA ✓

Linear Relationship

	C_{eqc}	q_e
C	0.003	0.71×10^{-3}
D	0.025	1.35×10^{-2}
E	0.072	2.67×10^{-2}
F	0.346	5.16×10^{-2}
G	15.398	0.135

Intercept 0.023
Slope 0.007
r^2 0.991
r 0.995
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	3.33×10^2	3.69×10^2
D	40.000	7.43×10^1
E	13.887	37.436
F	2.890	19.378
G	0.065	7.4106

Intercept 19.229
Slope 1.055
r^2 0.996
r 0.998
n 5
Equation:

Freundlich Relationship

	log C_{eqc}	log q_e
C	-2.523	-2.567
D	-1.602	-1.871
E	-1.143	-1.573
F	-0.461	-1.287
G	1.187	-0.870

Intercept -1.233
Slope 0.4141
r^2 0.921
r 0.960
n 5
Equation:

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation: C_{eqc}

FILE
SUBJECT
SHEET OF

Langmuir Relationship

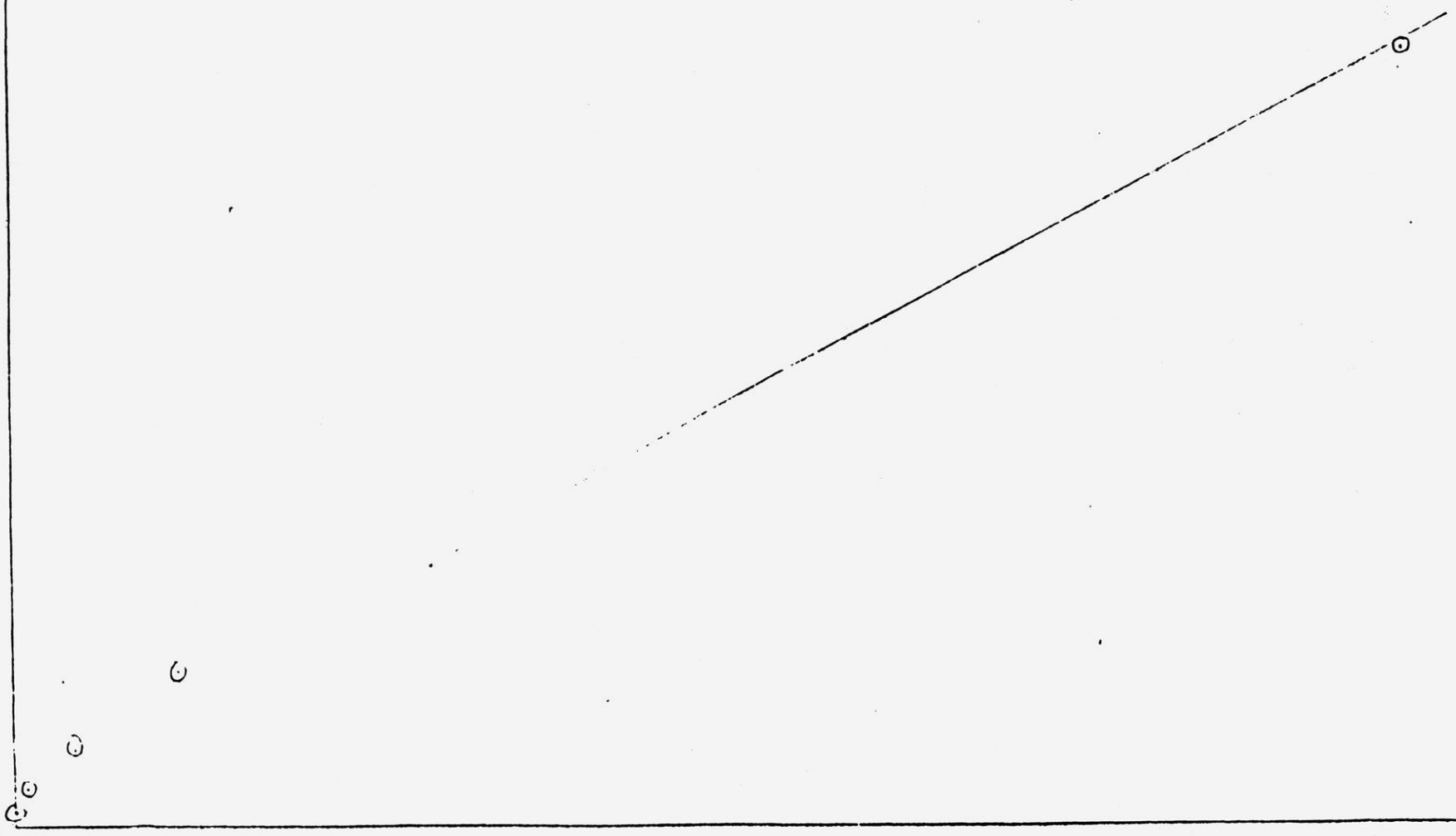
parameter: Copper

Soil type: Calcareous

$\frac{1}{q_e} = 1.055 \frac{1}{C_{eq}} + 19.229$

$r = .998$

$n = 5$



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Exxon Attenuation Study

BKF 5-7-89 QC DKF 5-15

Parameter Lead Soil Type Calcareous Test A = C_0 = < 0.01

Test B = Leach Test: < 0.01 Total Leached = C_L = 0 mg/l

	Test C	Test D	Test E	Test F	Test G
Adsorption C_i			1.18	2.36	11.80
C_{eq}			0.02	0.04	0.31

QA

Linear Relationship

	C_{eqc}	q_e
E	0.020	0.010
F	0.040	0.021
G	0.310	0.103

Intercept 0.006
Slope 0.314
r^2 0.998
r 0.999
n 3
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	—	—
D	—	—
E	50.00	95.78
F	25.00	47.89
G	3.226	9.67

Intercept 3.062
Slope 1.843
r^2 0.999
r 1.000
n 3
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	—	—
D	—	—
E	-1.699	-1.981
F	-1.398	-1.680
G	-0.509	-0.985

Intercept -0.559
Slope 0.824
r^2 0.997
r 0.999
n 3
Equation:

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C	—	—
D	—	—
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation:

FILE

SUBJECT

SHEET ___ OF

Langmuir Relationship

parameter: Lead

Soil type: Calcareous

$\frac{1}{q_e} = 1.843 \frac{1}{C_{eq_e}} + 3.062$

r = 1.0

n = 3

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$\frac{1}{q_e}$

90

80

70

60

50

40

30

20

10

0

0 10 20 30 40 50

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Exxon Attenuation Study

15KF 5-7-80
QC BKF 5-15

Parameter Selenium Soil Type Calcareous Test A = C_0 = <0.001

Test B = Leach Test: <0.001 Total Leached = C_L = 0 mg/l

		Test C	Test D	Test E	Test F	Test G
adsorption	C_i	0.0826	0.413	0.826	1.652	8.26
	C_{eq}	0.007	0.008	0.016	0.020	0.020

QA ____

Linear Relationship

	C_{eqc}	q_e
C	0.007	0.001
D	0.008	0.004
E	0.016	0.007
F	0.020	0.015
G	0.020	0.074

Intercept -0.024
Slope 3.115
r^2 0.415
r 0.644
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	142.86	1469.7
D	125.000	274.35
E	62.5	137.17
F	50.0	68.08
G	50.0	13.48

Intercept -566.06
Slope 11.138
r^2 0.658
r 0.811
n 5
Equation:

Freundlich Relationship

	log C_{eqc}	log q_e
C	-2.155	-3.167
D	-2.097	-2.438
E	-1.796	-2.137
F	-1.699	-1.833
G	-1.699	-1.130

Intercept 3.538
Slope 3.006
r^2 0.780
r 0.883
n 5
Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s ____
Intercept ____
Slope ____
r^2 ____
r ____
n ____
Equation:

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Langmuir Relationship

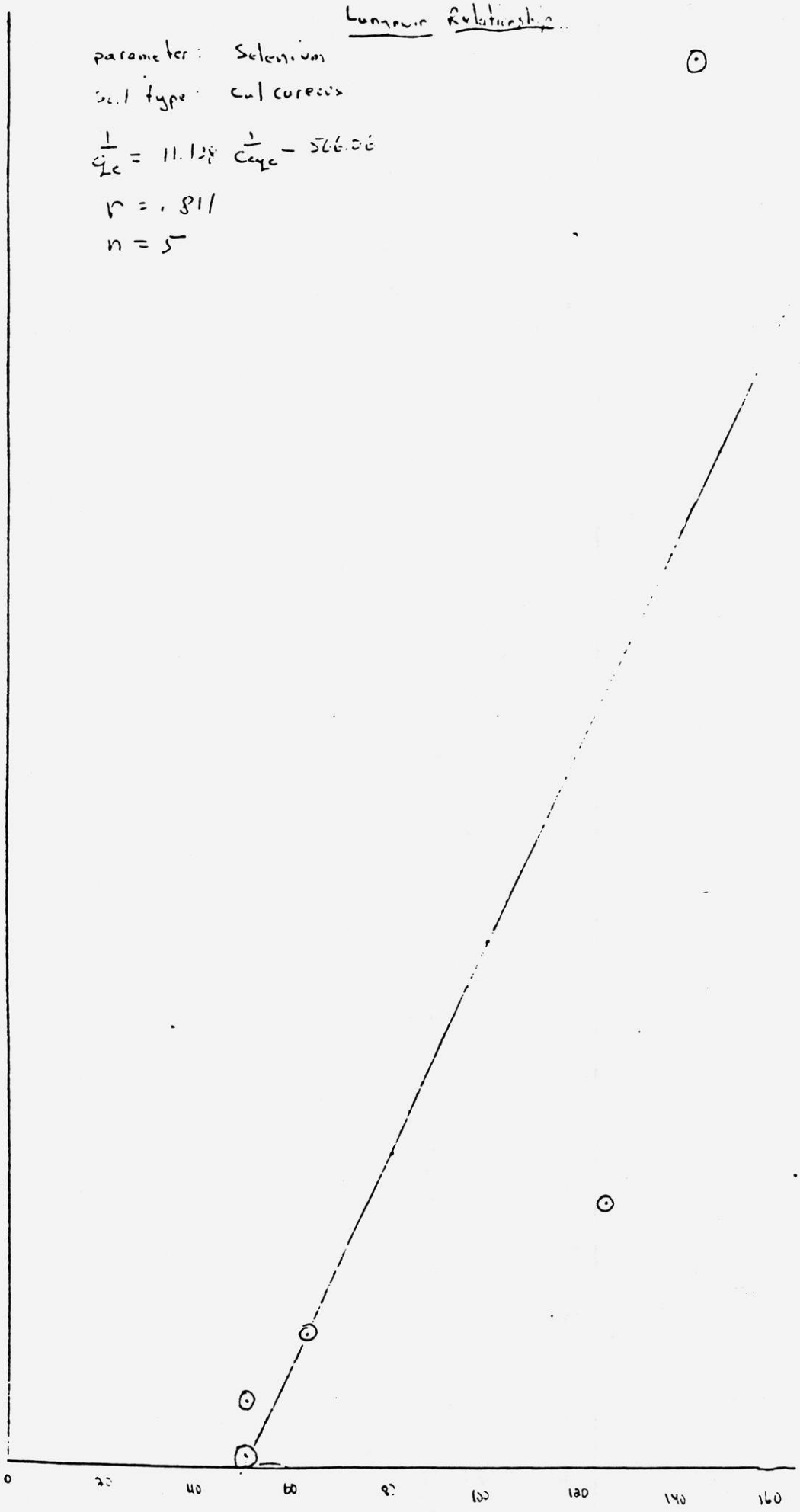
parameter: Selenium

Soil type: Cal coreco2

$\frac{1}{C_{Le}} = 11.13 \frac{1}{C_{eqe}} - 566.06$

$r = .811$

$n = 5$



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Exxon Attenuation Study

BKF 5-6-00 QC BKF 5-15

Parameter Zinc Soil Type Calcareous Test A = C_0 = 0.002

Test B = Leach Test: 0.006, 0.029, 0.637, 0.460, 0.757 + 1.09 Total Leached = C_L = ~~0.497 mg/l~~

	Test C	Test D	Test E	Test F	Test G
C_i	6.18	30.9	61.8	123.6	618
C_{eq}	0.047	13.1	43.0	105	580

✓

QA ____

Linear Relationship

	C_{eqc}	q_e
C	0.045	0.055
D	13.1	0.160
E	43.0	0.169
F	105	0.167
G	520	0.342

Intercept 0.121 ~~3.87 x 10^-4~~

Slope ____

r^2 0.846

r 0.920

n 5

Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	22.2	18.1
D	0.076	6.24
E	0.023	5.91
F	0.010	5.97
G	0.002	2.92

Intercept 5.24

Slope 0.579

r^2 0.948

r 0.974

n 5

Equation:

Freundlich Relationship

	log C_{eqc}	log q_e
C	-1.347	-1.258
D	1.117	-0.795
E	1.633	-0.772
F	2.021	-0.776
G	2.763	-0.466

Intercept -1.031

Slope 0.176

r^2 0.942

r 0.970

n 5

Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s ____

Intercept ____

Slope ____

r^2 ____

r ____

n ____

Equation:

FILE
SUBJECT
SHEET ___ OF ___

Langmuir Relationship

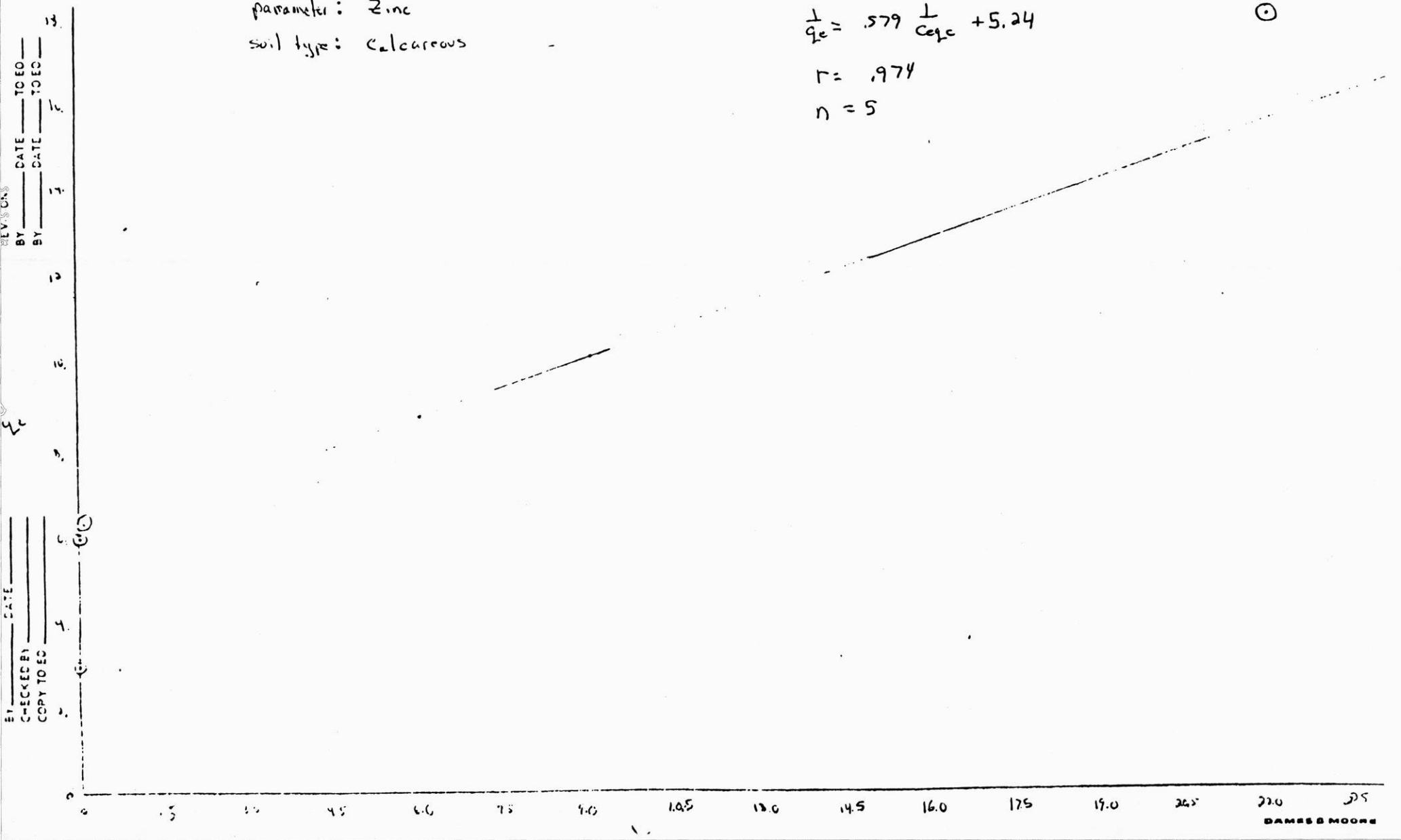
parameter: Zinc

soil type: Calcareous

$\frac{1}{q_e} = .579 \frac{1}{C_{eq}} + 5.24$

$r = .974$

$n = 5$



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APPENDIX C

SUMMARY OF SOIL ATTENUATION MODELING DATA

NONCALCAREOUS SOIL

Summary of Soil Attenuation Modeling Data

Non Calcareous Soil

Parameter	Relationship	Intercept	Slope	r^2	n
Arsenic	Liricar	-3.9×10^{-4}	0.380	1.000	3
Arsenic	Freundlich	0.200	1.300	1.000	3
Cadmium	"	− 2.900	0.322	0.938	5
Calcium*	Langmuir	3.1	138.0	1.0	5
Copper	Freundlich	−1.690	0.445	0.973	5
Fluoride	"	− 1.90	1.00	0.96	5
Lead	Linear	0.01	0.17	1.00	3
Lead	Freundlich	− 0.83	0.69	0.99	3
Magnesium	"	− 2.8	0.8	1.0.	5
Manganese*	"	− 2.590	0.793	1.000	5
Nitrate*	"	− 2.58	0.97	0.98	4
Selenium	"	− 1.710	0.586	0.875	5
Zinc	"	− 1.340	0.364	0.975	5

* Calcium, Manganese & Nitrate are desorption relationships – all others are adsorption

Exxon Attenuation Study

Parameter Zinc Soil Type Non Calcareous Test A = C_0 = 0.002

Test B = Leach Test: 0.031, 0.183, 0.032, 0.035, 0.047 & 0.054 Total Leached = C_L = —

	Test C	Test D	Test E	Test F	Test G
C_i	6.18	30.9	61.8	123.6	618
C_{eq}	0.924	16.5	43.6	101	558

QA 44.5

Linear Relationship

	C_{eqc}	q_e
C	0.922	0.047
D	16.5	0.130
E	43.6	0.164
F	101	0.203
G	558	0.540

Intercept 0.102
Slope 7.96×10^{-4}
r^2 0.969
r 0.984
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	1.08	21.1
D	0.061	7.72
E	0.023	6.10
F	0.010	4.92
G	0.002	1.85

Intercept 4.75
Slope 15.2
r^2 0.938
r 0.969
n 5
Equation:

Freundlich Relationship

	log C_{eqc}	log q_e
C	−0.035	−1.325
D	1.217	−0.887
E	1.639	−0.786
F	2.004	−0.692
G	2.747	−0.268

Intercept −1.342
Slope 0.364
r^2 0.975
r 0.987
n 5
$r = 1 \cdot n$

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C	9.55×10^{-7}	4.52×10^{-8}
D	1.71×10^{-5}	2.22×10^{-6}
E	4.52×10^{-5}	7.40×10^{-6}
F	1.05×10^{-4}	2.13×10^{-5}
G	5.78×10^{-4}	3.12×10^{-4}

C_s 9.65×10^{5} mg/l
Intercept -1.47×10^{-5}
Slope 0.559
r^2 0.989
r 0.995
n 5

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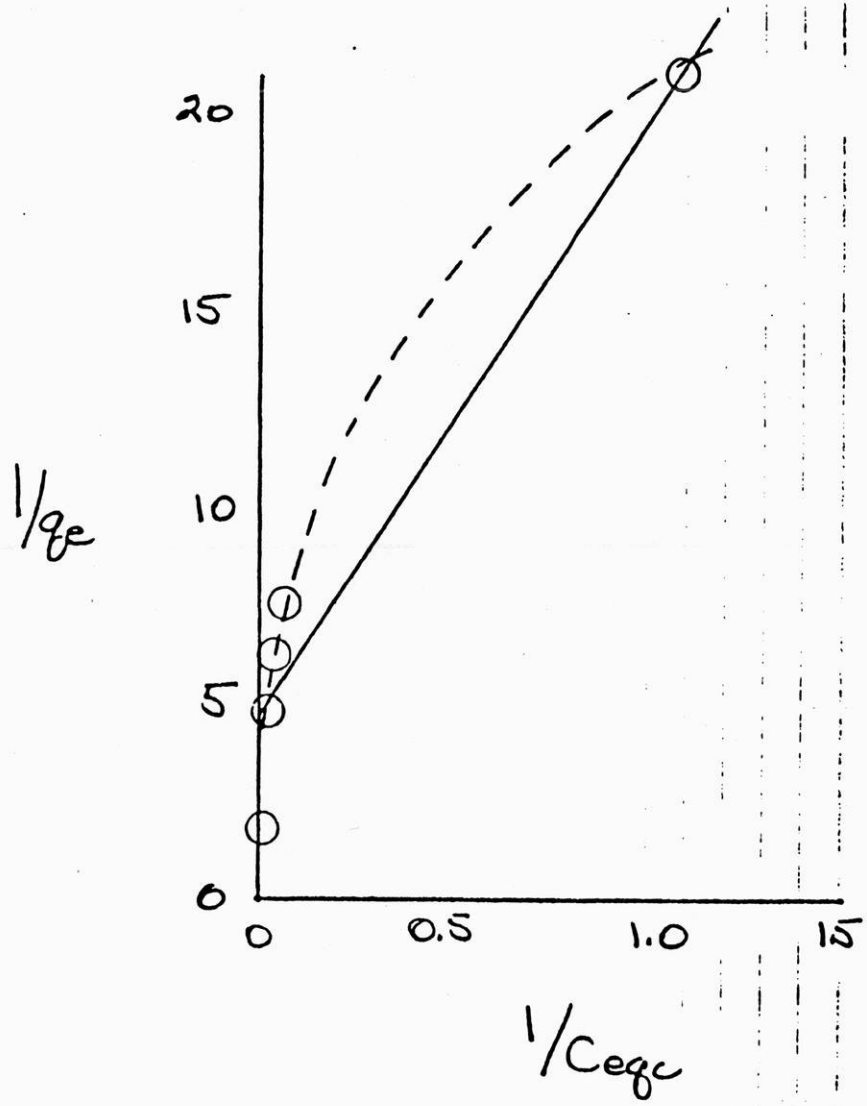

Langmuir Relationship

$1/q_e = 15.2/C_{eqc} + 4.75$

$r = 0.969$

$n = 5$

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Exxon Attenuation Study

Parameter Arsenic Soil Type Non Calcareous Test A = C_0 = 0

Test B = Leach Test: < 0.001 Total Leached = C_L = ____

	Test C	Test D	Test E	Test F	Test G
C_i	–	–	0.043	0.086	0.43
C_{eq}	–	–	0.002	0.003	0.011

QA ____

Linear Relationship

	C_{eqc}	q_e
C		
D		
E	0.002	3.697×10^{-4}
F	0.003	7.470×10^{-4}
G	0.011	3.771×10^{-3}

Intercept -3.170×10^{-4}
Slope 0.378
r^2 1.000
r 1.000
n 3
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C		
D		
E	500.000	2710.027
F	333.333	1338.688
G	90.909	1.337×10^3

Intercept -3.687×10^{-5}
Slope 5.864
r^2 0.969
r 0.984
n 3
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C		
D		
E	-2.699	-3.433
F	-2.523	-3.127
G	-1.959	-2.424

Intercept 0.200
Slope 1.335
r^2 0.995
r 0.997
n 3
Equation:

B.E.T Relationship

$\frac{C_{eqc}}{C_s}$ $q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$

C
D
E
F
G

C_s ____
Intercept ____
Slope ____
r^2 ____
r ____
n 3
Equation:

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Langmiur Relationship

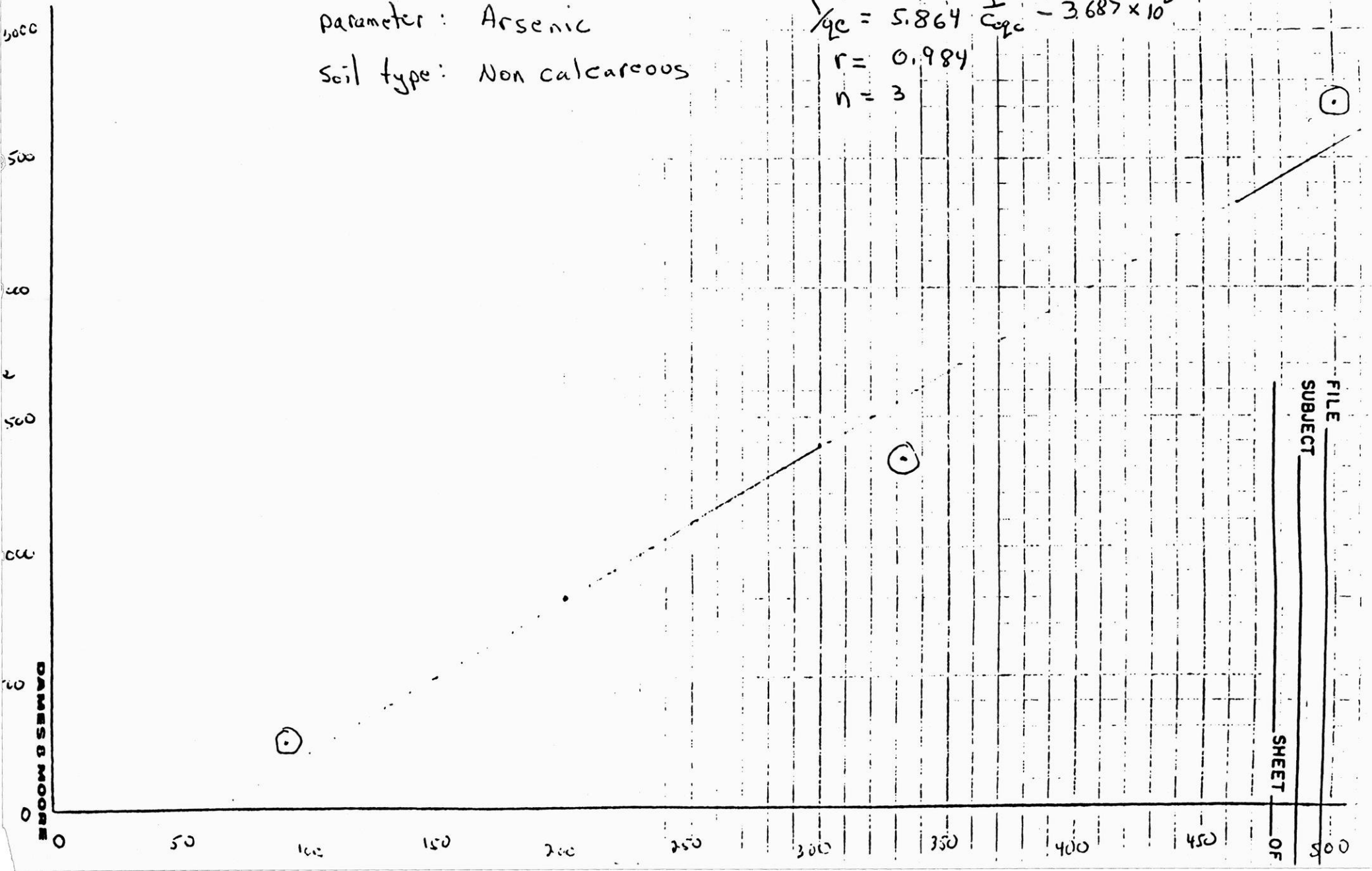
parameter: Arsenic

soil type: Non calcareous

$\frac{1}{q_e} = 5.864 \frac{1}{C_{eq}} - 3.687 \times 10^{2}$

$r = 0.984$

$n = 3$



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Exxon Attenuation Study

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QC BKF 5/15

INDIVIDUAL TEST

Parameter Cadmium Soil Type Non Calcareous Test A = C_0 = < 0.001

Test B = Leach Test: < 0.001 Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	0.0266	0.133	0.266	0.532	2.66
C_{eq}	0.005	0.067	0.172	0.409	2.51

QA ✓

Linear Relationship

	C_{eqc}	q_e
C	[illegible]	[illegible] C
D	[illegible]	[illegible] D
E	[illegible]	[illegible] E
F	[illegible]	[illegible] F
G	[illegible]	[illegible] G

Intercept 6.16×10^{-4}
Slope 3.198×10^{-4}
r^2 5.708×10^{-1}
r 0.756
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	[illegible]	[illegible]
D	[illegible]	[illegible]
E	[illegible]	[illegible]
F	[illegible]	[illegible]
G	0.398	[illegible]

Intercept [illegible]
Slope [illegible]
r^2 [illegible]
r [illegible]
n [illegible]
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-2.301	-3.711
D	-1.174	-3.226
E	-0.764	-3.073
F	-0.388	-2.956
G	0.400	-2.870

Intercept -2.895
Slope 0.322
r^2 0.938
r 0.969
n 5
Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		[illegible]
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation:

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Langmuir Relationship

parameter: Cadmium

soil type: non calcareous

$\frac{1}{q_e} = 20.870 \frac{1}{C_{Eq}} + 997.490$

$r = .991$

$n = 5$

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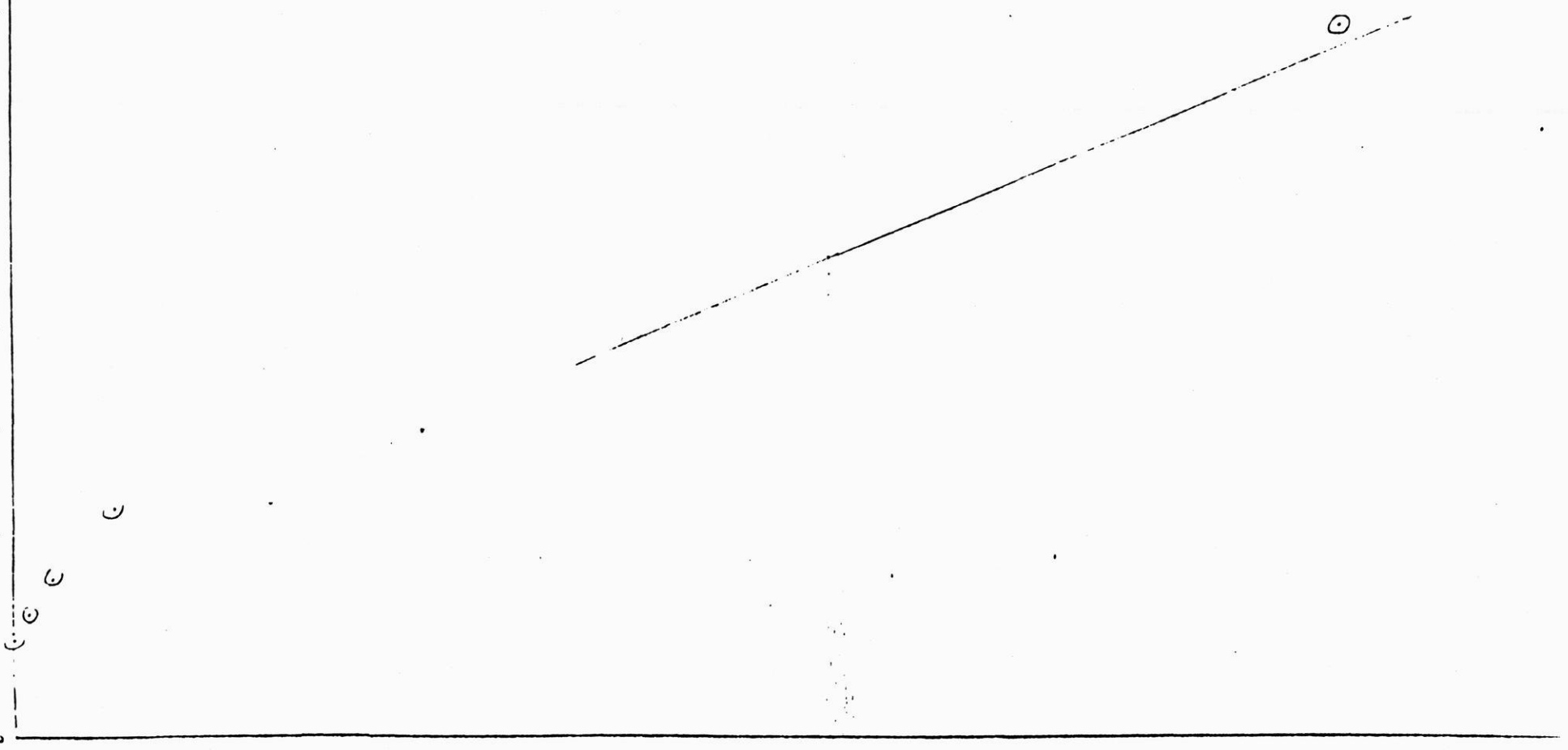

Exxon Attenuation Study

J. Wicz.
QC BKF 5-15

Parameter Calcium Soil Type Non Calcareous Test A = C_0 = 0.052

Test B = Leach Test: Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	4.07	20.35	40.7	81.4	407
C_{eq}	11.4	37.0	61.6	106	435

QA ✓

Linear Relationship

	C_{eqc}	q_e
C	11.316	0.065
D	35.148	0.149
E	61.518	0.178
F	105.776	0.231
G	434.716	0.357

Intercept 0.135
Slope 2.037×10^{-4}
r^2 0.967
r 0.983
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	0.088	~~2.154×10^{2}~~
D	0.027	6.694
E	0.016	5.330
F	0.009	4.526
G	0.002	3.976

Intercept ~~-332.115~~ 3.105
Slope 2.667×10^{4} 134.6
r^2 0.930 0.977 1.000
r 0.965 0.999
n 5
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	1.055	-1.184
D	1.568	-0.826
E	1.789	-0.727
F	2.025	-0.656
G	2.638	-0.599

Intercept -1.454
Slope 0.361
r^2 0.908
r 0.910
n 5
Equation:

B.E.T Relationship

$\frac{C_{eqc}}{C_s}$ $q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$

C
D
E
F
G

C_s
Intercept
Slope
r^2
r
n
Equation: C_{eqc}

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Langmuir Relationship

parameter: Calcium

Soil type: Non calcareous

$\frac{1}{q_e} = 26670 \frac{1}{C_{eq}} - 332.113$

$r = 0.965$

$n = 5$

pt. C' was not graphed

7.0
6.0
5.0
4.0
3.0
2.0
1.0

.003 .006 .009 .012 .015 .018 .021 .024 .027

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Exxon Attenuation Study

J. Wiers
QC BKF 5-15

Parameter Copper Soil Type Non Calcareous Test A = C_0 = 0.002

Test B = Leach Test: Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i	0.304	1.52	3.04	6.08	30.4
C_{eq}	0.018	0.180	0.756	2.43	22.8

✓ QA

Linear Relationship

	C_{eqc}	q_e
C	0.016	3.59×10^{-3}
D	0.175	1.31×10^{-2}
E	0.751	$...16 \times 10^{-2}$
F	2.423	5.29×10^{-2}
G	22.778	6.84×10^{-2}

Intercept 1.463×10^{-2}
Slope 2.422×10^{-3}
r^2 0.935
r 0.935
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	62.500	3.258×10^{2}
D	5.618	82.795
E	1.336	18.605
F	0.412	30.425
G	0.044	141.616

Intercept 33.193
Slope 5.669
r^2 0.992
r 0.996
n 5
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-1.796	-2.526
D	-0.750	-1.918
E	-0.123	-1.687
F	0.385	-1.483
G	1.358	-1.165

Intercept -1.686
Slope 0.1915
r^2 0.773
r 0.486
n 5
Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation:

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Longmuir Relationship

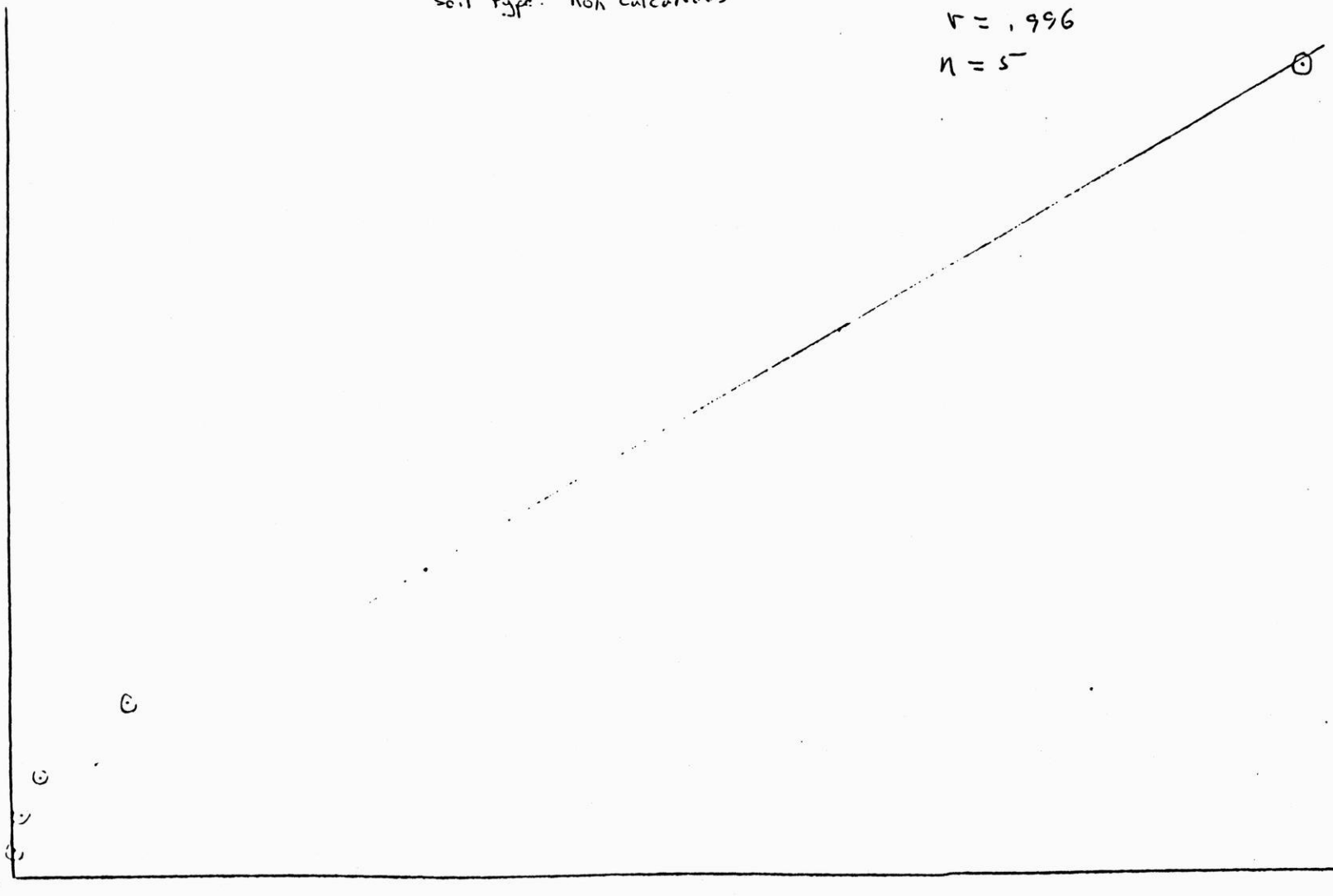
parameter: Copper

soil type: non calcareous

$\frac{1}{q_e} = 5.669 \frac{1}{C_{eq}} + 33.193$

$r = .996$

$n = 5$



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DAMES & MOORE

Exxon Attenuation Study

BKF 5-7-80
QC BKF 5-15

Parameter Fluoride Soil Type Non Calcareous Test A = C_0 = <0.12

Test B = Leach Test: <0.12 Total Leached = C_L = 0

	Test C	Test D	Test E	Test F	Test G
C_i		0.475	0.95	1.9	9.5
C_{eq}		0.23	0.32	0.82	4.0

adsorption

/ QA 0.32

Linear Relationship

	C_{eqc}	q_e
D	0.230	0.002
E	0.320	0.006
F	0.820	0.010
G	4.000	0.050

&

Intercept 2.736×10^{-4}
Slope 0.012
r^2 0.998
r 0.999
n 4

Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C		
D	4.348	453.5
E	3.125	176.4
F	1.220	102.9
G	0.250	20.20

Intercept -23.818
Slope 94.86
r^2 0.868
r 0.932
n 4

Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C		
D	-0.638	-2.657
E	-0.495	-2.246
F	-0.086	-2.012
G	0.602	-1.305

Intercept -1.901
Slope 0.999
r^2 0.962
r 0.981
n 4

Equation:

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		~~2.205×10^{-3}~~
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n

Equation:

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Langmuir Relationship

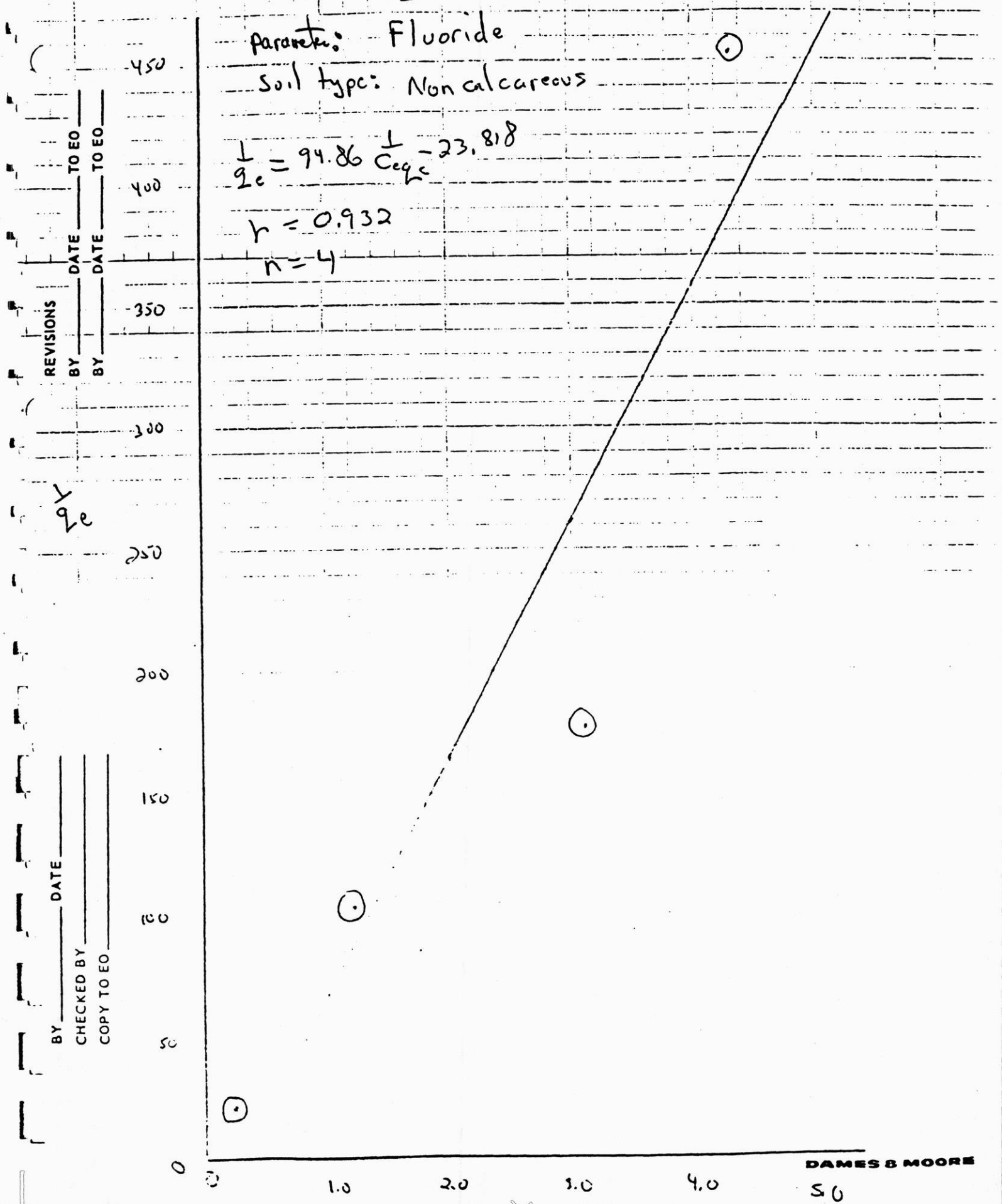
parameter: Fluoride

Soil type: Non calcareous

$\frac{1}{q_e} = 94.86 \frac{1}{C_{eq_e}} - 23.818$

$r = 0.932$

$n = 4$



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DAMES & MOORE

JKI
5-7-80
QC BKF
5-15

Exxon Attenuation Study

Parameter Lead   Soil Type Non Calcareous   Test A = C_0 = <0.01

Test B = Leach Test: <0.01   Total Leached = C_L = 0 mg/l

i) sorption

	Test C	Test D	Test E	Test F	Test G
C_i	—	—	1.18	2.36	11.80
C_{eq}	—	—	0.02	0.07	0.55

/ QA ______

Linear Relationship

	Ceqc	qe
C	~~0.020~~	~~0.010~~
D	~~0.070~~	~~0.021~~
E	0.020	0.010
F	0.070	0.021
G	0.550	0.101

Intercept 0.008
Slope 0.170
r^2 1.000
r 1.000
n 3
Equation:

Langmuir Relationship

	1/Ceqc	1/qe
C		
D		
E	50.00	95.78
F	14.29	48.52
G	1.818	9.877

Intercept 14.347
Slope 1.681
r^2 0.955
r 0.977
n 3
Equation:

Freundlich Relationship

	log Ceqc	log qe
C		
D		
E	-1.699	-1.981
F	-1.155	-1.686
G	-0.260	-0.995

Intercept -0.834
Slope 0.694
r^2 0.992
r 0.996
n 3
Equation:

B.E.T Relationship

	Ceqc/Cs	qe[Cs-Ceqc]
C		
D		
E		
F		
G		

Cs ______
Intercept ______
Slope ______
r^2 ______
r ______
n ______
Equation:

Crec

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Langmiur Relationship

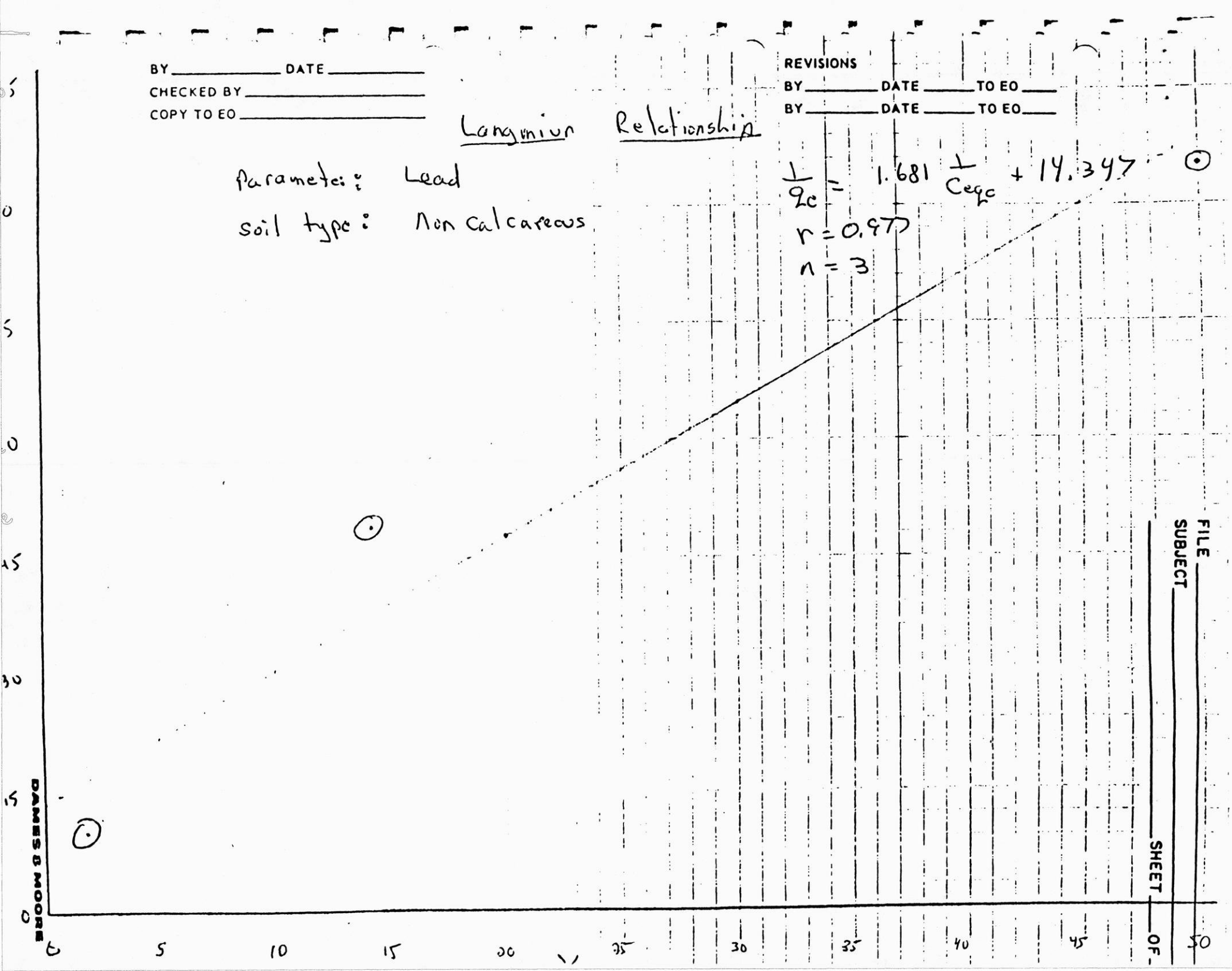
Parameter: Lead

Soil type: Non calcareous

$$\frac{1}{q_e} = 1.681 \frac{1}{C_{eq}} + 14.347$$

$r = 0.97$

$n = 3$



DAMES & MOORE

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Exxon Attenuation Study

DK 5-8-90
QC & KF 5-15.

Parameter Magnesium Soil Type Non Calcareous Test A = C_0 = 0.009

Test B = Leach Test: 0.50, 1.33, 0.53, 1.39, 0.65 & 1.01 Total Leached = C_L = 0 mg/l

		Test C	Test D	Test E	Test F	Test G
Adsorption	C_i	5.01	25.05	50.1	100.2	501
	C_{eq}	4.39	22.7	46.5	91.0	475

QA 46.9 ✓

Linear Relationship

	C_{eqc}	q_e
C	4.38	0.006
D	22.69	0.021
E	46.49	0.032
F	90.99	0.083
G	474.99	0.234

Intercept 0.015
Slope 4.691×10^{-4}
r^2 0.977
r 0.988
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	0.228	176.65
D	0.044	47.10
E	0.022	30.79
F	0.011	12.065
G	0.002	4.272

Intercept 8.598
Slope 742.46
r^2 0.993
r 0.997
n 5
Equation:

Freundlich Relationship

	log C_{eqc}	log q_e
C	0.642	-2.247
D	1.356	-1.673
E	1.667	-1.488
F	1.959	-1.082
G	2.677	-0.631

Intercept -2.767
Slope 0.809
r^2 0.989
r 0.995
n 5
Equation:

B.E.T Relationship

	$\frac{C_{eqc}}{C_s}$	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation: C_{eqc}

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Langmuir Relationship

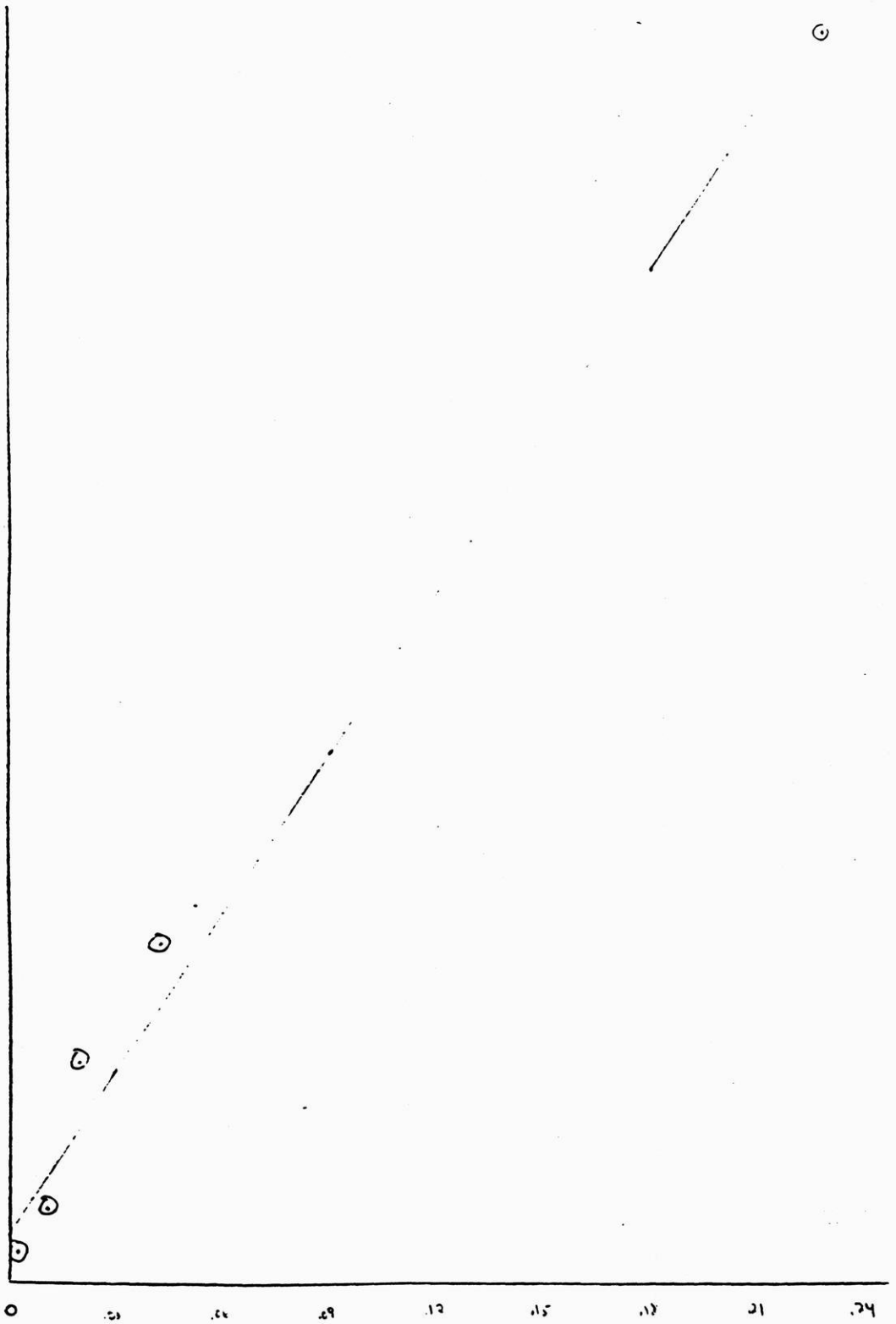
Parameter: Magnesium

Soil type: Non calcareous

$\frac{1}{Q_e} = 742.46 \frac{1}{C_{eq}} + 8.558$

$r = 0.997$

$n = 5$



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DIETZGEN MOORE

Exxon Attenuation Study

BAT 5-8-80 | JC WKF 5-15 ORIGINAL

Parameter Manganese Soil Type Non Calcareous Test A = C_0 = <0.001

Test B = Leach Test: 0.021, 0.038, 0.027, 0.056, 0.033, 0.059 Total Leached = C_L = 0 mg/l

Description	Test C	Test D	Test E	Test F	Test G
C_i	0.0915	0.458	0.915	1.83	9.15
C_{eq}	0.158	0.668	1.26	2.39	11.1

QA 1.29

Linear Relationship

	C_{eqc}	q_e
C	0.158	0.001
D	0.663	0.002
E	1.26	0.003
F	2.39	0.005
G	11.1	0.018

Intercept 9.399×10^{-4}

Slope 1.505×10^{-3}

r^2 0.996

r 0.998

n 5

Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	6.329	1670.84
D	1.497	529.10
E	0.794	322.06
F	0.418	198.41
G	0.090	56.98

Intercept 97.10

Slope 251.08

r^2 0.995

r 0.998

n 5

Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-0.801	-3.223
D	-0.175	-2.724
E	0.100	-2.508
F	0.378	-2.298
G	1.045	-1.756

Intercept -2.588

Slope 0.793

r^2 1.000

r 1.000

n 5

Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s ____

Intercept ____

Slope ____

r^2 ____

r ____

n ____

Equation:

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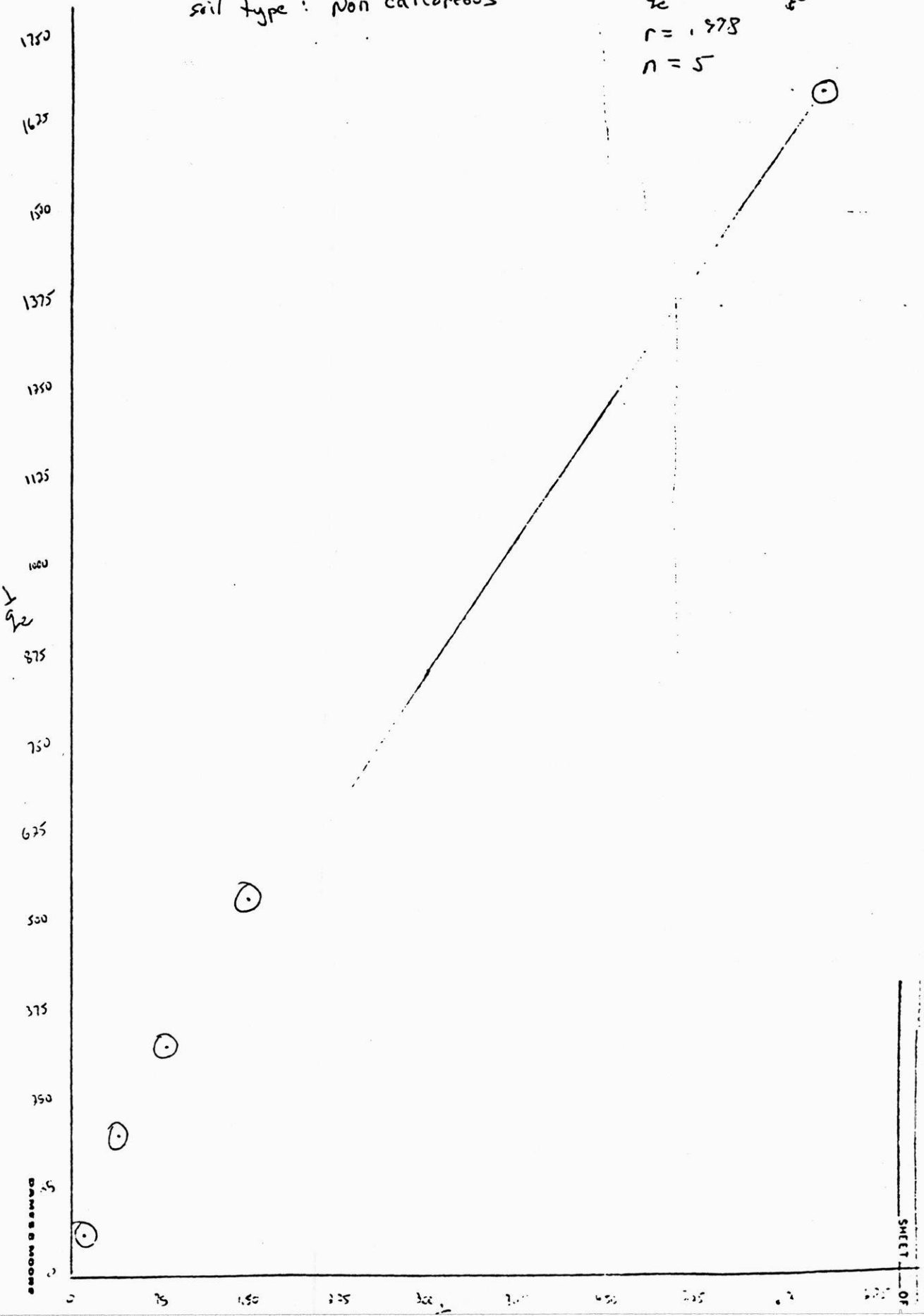
Langmuir Relationship

parameter : Manganese
soil type : Non calcareous

$\frac{1}{q_e} = 251.88 \frac{1}{C_{eq}} + 971$

$r = .878$

$n = 5$



SHEET ___ OF ___

Exxon Attenuation Study

Parameter [illegible] Soil Type Non Calcareous Test A = C_0 = < 0.01

Test B = Leach Test:

Total Leached = C_L = 0.25

Corrected Data

Desorption

	Test C	Test D	Test E	Test F	Test G
C_i	0.18	3.4	6.8	13.6	68
C_{eq}	0.98	5.37	10.0	17.6	95.1

QA ____

Linear Relationship

	C_{eqc}	q_e
C	0.926	0.001
D	5.36	0.014
E	9.918	0.026
F	17.576	0.033
G	95.096	0.241

Intercept 0.001

Slope 0.002

r^2 0.999

r 0.999

n 5

Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	1.08	1.023
D	0.186	69.6 66.9
E	0.101	39.1 38.1
F	0.057	30.1
G	0.011	4.15

Intercept 173.9

Slope −1158

r^2 0.915

r 0.957

n ____

Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	—	—
D	0.730	−1.825
E	1.000	−1.585
F	1.246	−1.479
G	1.978	−0.618

Intercept −2.58

Slope 0.972

r^2 0.981

r 0.990

n ____

Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s ____

Intercept ____

Slope ____

r^2 ____

r ____

n ____

Equation:

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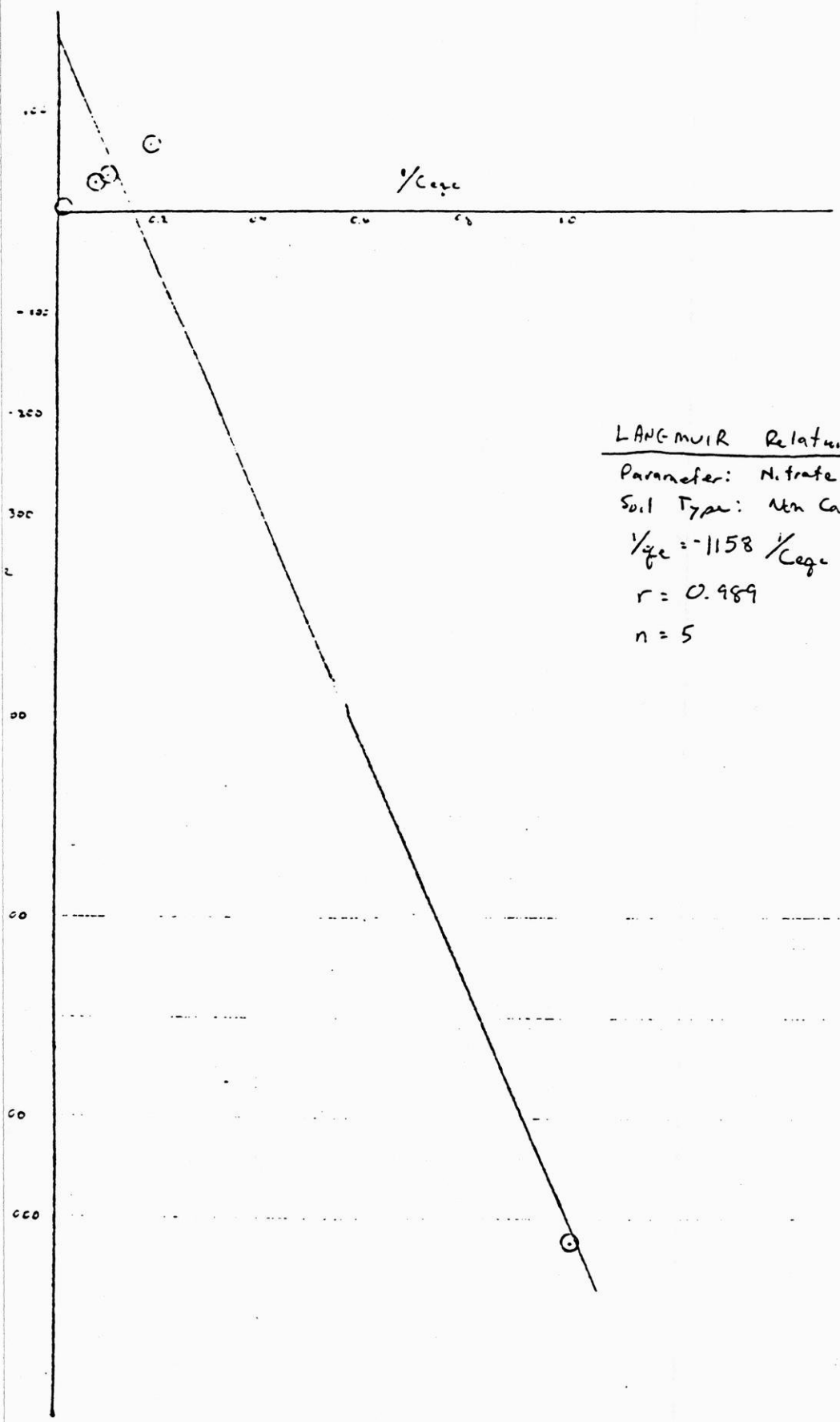

LANGMUIR Relationship

Parameter: Nitrate

Soil Type: Non Calcareous

$1/q_e = -1158\ 1/C_{eqe} + 172.9$

$r = 0.989$

$n = 5$

FILE
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Exxon Attenuation Study

KF
5-7-80
QC-BKF
5-15

Parameter Selenium Soil Type Non Calcareous Test A = C_0 = < 0.001

Test B = Leach Test: < 0.001 Total Leached = C_L = 0 mg/l

Adsorption	Test C	Test D	Test E	Test F	Test G
C_i	0.108	0.54	1.08	2.16	10.8
C_{eq}	0.004	0.068	0.510	0.500	3.22

✓ QA 0.510

Linear Relationship

	C_{eqc}	q_e
C	0.004	0.001
D	0.068	0.004
E	0.510	0.005
F	0.500	0.015
G	3.22	0.068

Intercept 7.694×10^{-4}
Slope 0.021
r^2 0.982
r 0.991
n 5
Equation:

Langmuir Relationship

	$1/C_{eqc}$	$1/q_e$
C	250.0	1068.4
D	14.71	235.4
E	1.961	194.9
F	2.000	66.93
G	0.311	14.66

Intercept 108.632
Slope 3.856
r^2 0.969
r 0.985
n 5
Equation:

Freundlich Relationship

	$\log C_{eqc}$	$\log q_e$
C	-2.398	-3.029
D	-1.167	-2.372
E	-0.292	-2.290
F	-0.301	-1.826
G	0.508	-1.166

Intercept -1.709
Slope 0.586
r^2 0.875
r 0.935
n 5
Equation:

B.E.T Relationship

	C_{eqc}/C_s	$q_e\left[\frac{C_{eqc}}{C_s - C_{eqc}}\right]$
C		
D		
E		
F		
G		

C_s
Intercept
Slope
r^2
r
n
Equation: C_{eqc}

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Langmuir Relationship

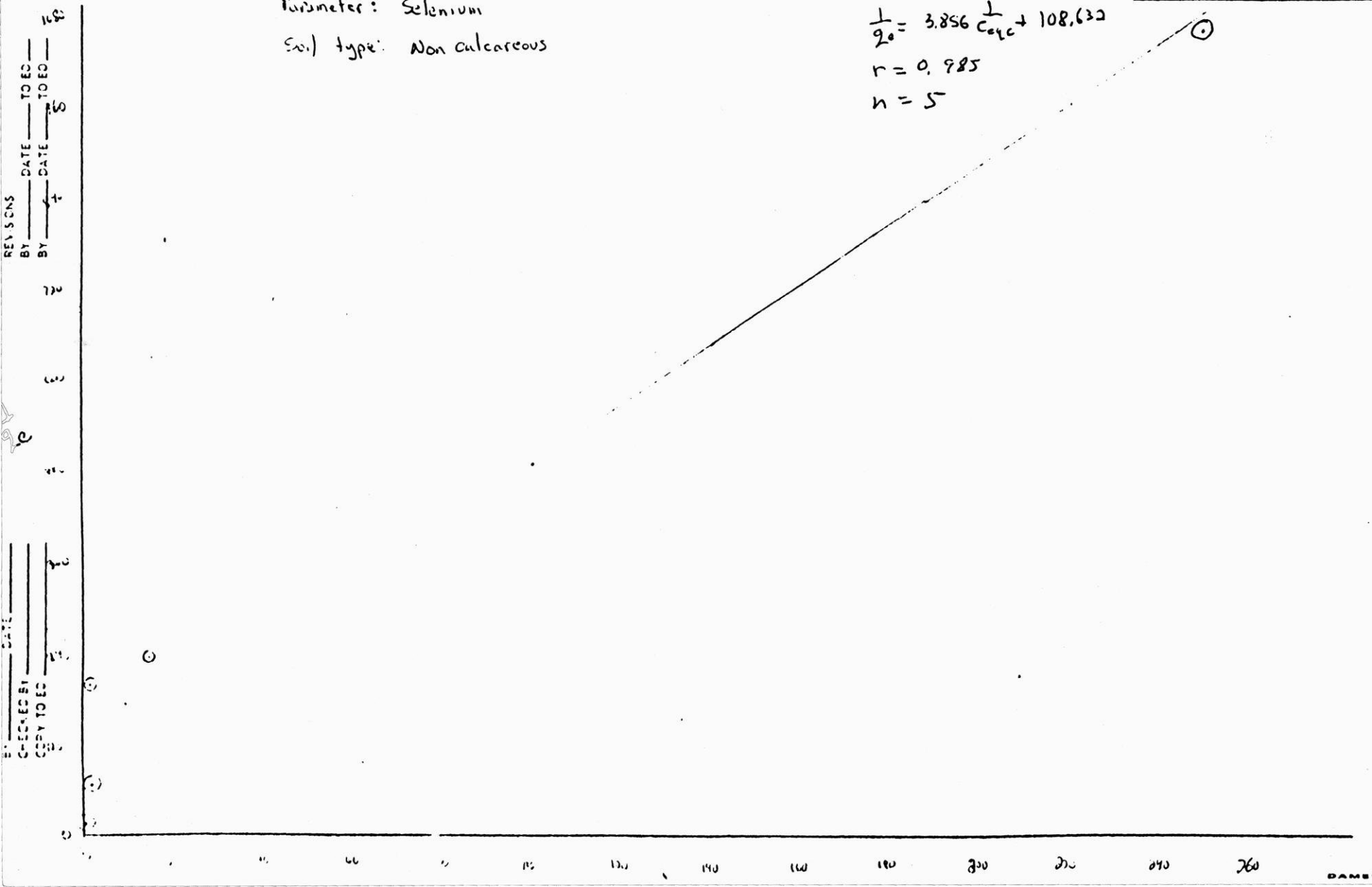
Parameter: Selenium

Soil type: Non calcareous

$\frac{1}{q_e} = 3.856 \frac{1}{C_{eqc}} + 108.632$

$r = 0.985$

$n = 5$



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