1409-G

REGIONAL PRODUCTION LABORATORY

RECENT DEVELOPMENT IN THE USE OF CALCIUM Q - BROXIN MUDS

MARACAIBO - VENEZUELA

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CONTENTS

APPENDIX

SUMMARY

These notes have been written to bring up to date information contained in the report "Evaluation and Application of Gypsum Q-Broxin Muds" published in December, 1958.

During the past year calcium Q-Broxin muds have been used in eight wells which had total depths varying from 13,200 feet to 15,500 feet. In seven of the eight wells no drilling trouble of any kind was experienced, and in the eighth where stuck pipe resulted, this has been ascribed to differential pressure effects due to the use of excessively heavy mud. In all wells maintenance of excellent rheological and filtration properties of the muds has been easily attained at relatively low cost.

Flattening of the profile of the self potential curve when using this type of mud led to difficulties in quantitative evaluation of the fluid content of formations and in subsurface correlation studies. Investigation revealed that this was due to the low resistivity of the muds and modifications in mud treatment have resolved this problem.

Since this type of mud has been used in wells with very high bottom hole temperatures, an examination of the filtration characteristics at a series of temperatures and pressures has been commenced.

A very simple relationship has been established between the rheological properties of a mud at any two given temperatures. This has permitted the comparison of results obtained in the laboratory with those measured at flowline temperatures at the well site.

Discussion of Field Results with Gypsum Q-Broxin Muds

In five of the seven wells in which gypsum Q-Broxin muds have been used in 1959, emulsion muds containing 10 to 15% gas oil and weighing 77 to 85 lb/cu ft. have been employed to drill sandstone and shale formations at depth intervals of 11,700 to 14,400 feet. No drilling troubles of any kind have been encountered in any of these wells. The A.P.I. fluid losses of the muds have been between 3 and 5 cc. and the flowline viscosity has been maintained at 50 to 55 seconds (1000 cc), while the calcium content of the filtrates has been maintained between 500 and 800 ppm. In certain wells the calcium content of the filtrate has been run as high as 1500 ppm without any apparent deleterious effect on the rheological properties of the muds. By maintaining the pH of the muds at ca. 9.5 foaming problems have been eliminated. It is planned in future to maintain the flowline viscosity at 45 seconds and to achieve this the oil content of the emulsion muds will be limited to a maximum of 10%, so that the ratio water/solids will be increased for a given weight of mud. Table No. 1 shows typical properties of the mud from one of these wells, all measurements being made at a temperature of approximately 75°F. Drilling performance, chemical consumption and cost data for six wells are given in Table No. 2.

In a seventh well a gypsum Q-Broxin mud was used to drill from a depth of 4000 to 15,500 feet and excellent hole conditions were maintained throughout. In this well an outstanding performance was achieved when drilling an 8-1/2" hole through a gassy shale interval from 11,275 to 13,221 feet with a mud of weight 135 lb/cu.ft. The other mud properties were flowline viscosity 63-70 sec. A.P.I, water loss 3.0 - 3.4 cc A.P.I., calcium content of filtrate 440 - 660 ppm, 10 min. gel strength 10 - 15 lb/100 sq.ft., oil content 8 - 10%. In spite of the heavy mud weight, the penetration rate throughout the above shale interval of approximately 2000 feet averaged 22 feet per hour, which appears unusually high for the depth and mud weight concerned. This drilling performance can probably be explained by the fact that the differential between mud column and formation pressure was relatively small[1].

In the eighth well a troublesome squeezing shale condition was encountered when drilling 8-1/2" hole at a depth of 12,977 feet with 80 lb/cu.ft. mud causing logy hole. Increase of the mud weight by 5 lb/cu.ft. improved conditions considerably, but the trouble recurred somewhat deeper after a few days. Successive increases of mud weight were made up to 98 lb/cu.ft. although it was always appreciated that chances of sticking in sandstone bodies due to differential pressure effects[2] were being greatly magnified by increasing the mud weight. Finally pipe was stuck at a depth of 14,309 feet with some 680 feet of unstabilised 6-1/4" drill dollars buried in sandstone. The rheological and filtration properties of the mud were at all times satisfactory.

Character of S.P. Logs

After drilling four of the above wells complaints were received from subsurface geologists that they were having difficulty in making satisfactory correlations of the various formations due to a general flattening of the self potential curve. Examination of SP logs taken in the same formations in wells A and B which were drilled with caustic soda/quebracho muds indicated that the logs in these wells were infinitely superior to those obtained in subsequent wells when using gypsum Q-Broxin muds, and further that the resistivities of the former were very considerably higher than those of the gypsum muds. The maximum deviation of the SP curve from the shale base line in sandstone sections was collected for all wells, together with mud resistivity data and general observations as to the quality of the log.

In graph No. 1 the mud resistivities are plotted against the corresponding maximum SP deviation in mV. From this graph and from the data given in Table No. 3 it can clearly be seen that all poor logs are connected with low mud resistivities. Adequate to good logs were obtained in all wells with mud resistivities greater than about 0.9 to 1.0 ohm m. at 77°F. Logs run in wells with muds of resistivity less than 0.8 ohm m. at 77°F were uniformly poor.

It was believed that one of the main reasons for the low resistivities of the muds might well have been the presence in the aqueous phase of the mud of sodium sulphate formed by reaction of caustic soda and gypsum. The sulphate and chloride content of the mud filtrate in well G were determined, and in addition the resistivities of both mud and filtrate were measured with the following results:

Cl ppm	SO_4 ppm	R_m (at 75°F in ohm m.)	R_{mf} (at 75°F in ohm m.)
2,750	12,500	0.9	0.54

Since these results confirmed our views, it was planned in well H to limit the addition of caustic soda to 1.5 lb/ft, and if the pH of the mud remained lower than the desired value of 9.5, to control this by using lime, in an attempt to limit the amount of soluble sulphate. It was found, however, as noted in Table No. 4, that with this treatment the sulphate content of the filtrate was still high and the resistivity of mud and filtrate remained low. Below a depth of 13,300 feet additions of gypsum were discontinued entirely, and treatment of the mud was continued with only lime, Q-Broxin and C.M.C. The mud weight was rather higher than usual for this area of operations due to a suspected inflow of formation water, and very considerable quantities of Q-Broxin were used to maintain the rheological properties at the desired level. As can be seen the sulphate content of the filtrate tended to decrease after a short period of time but the resistivity of both mud and filtrate showed no change in spite of additions of fairly large quantities of make up water daily: the calcium content of the mud filtrate showed a slight increase during the same period. The ratio R_{mf}/R_m of $0.5 \neq 0.6$: 1 appeared to be considerably less than with other types of mud.

This led to an examination of the resistivities of solutions of Q-Broxin in water. It is clear, from the results given in Table No. 5, that addition of Q-Broxin to water results in a very marked decrease in the resistivity. A conductometric titration of an aqueous solution of Q-Broxin with caustic soda has indicated that Q-Broxin acts as a very weak acid[3] and the resistivity of the solution decreases steadily as caustic soda is added. In terms of mud treatment this would imply that some upper limit should be set on the amount of caustic soda and Q-Broxin which should be added to a mud to maintain given values of resistivity.

In well J it was decided to try to obtain a mud with the required resistivity values by drilling the entire section without addition of gypsum and caustic soda and replacing these with lime. It was further planned to keep Q-Broxin additions below 3lb/foot drilled. From the analytical data given in Table No. 6 it can be seen that a certain amount of sulphate was found in the filtrate presumably due to accidental additions of gypsum in the early stages of the change over to lime. As expected this change in treatment resulted also in much lower calcium contents of the mud filtrate than were present in the gypsum muds. However, hole conditions remained excellent throughout the drilling of the well and there appeared to be no increase in the wash out of shale sections drilled. The rheological and filtration properties of the mud were excellent and the consumption of chemicals and maintenance cost (Table No. 2), were markedly lower than with the gypsum muds. It should be noted that the pH of this lime Q-Broxin mud was in the later stages maintained at ca.9.5. As can be seen from Table No. 6 the resistivity of the mud increased during treatment from 1.17 to 1.55 ohm m. at 74°F while that of the mud filtrate showed only a slight tendency to increase from 0.75 to ca. 0.85 ohm m. at almost the same temperature of measurement. An excellent and clearly detailed SP curve was obtained with the maximum reading in sandstone sections being ca. 70 mV.

Fluid Loss at Elevated Temperatures and Pressures

With the advent of ever deeper drilling for oil the filtration behaviour of muds under conditions of high temperature and pressure has become increasingly important.

An investigation was therefore commenced to determine the fluid loss characteristics of typical drilling fluids used in the Western Division at elevated temperatures and pressures, using the Baroid model 387 high-pressure, high-temperature filter press with the model 387-20 back pressure receiver. The apparatus was modified only to the extent that compressed air rather than carbon dioxide cartridges was used as the pressure source. Tests were made at four temperatures 75, 150, 225 and 300°F and five differential pressures 100, 200, 400, 600 and 800 psi. A constant back pressure of 100 psig was used throughout.

The fluid loss of three such muds weighing 77 to 84 lb/cuft.are presented in Table No.7.The actual fluid losses measured with the high pressure, high temperature apparatus were multiplied by a factor of 2 to correct them to the values that would have been obtained with the filtering area of the standard API test apparatus.

For filtration of compressible homogeneous suspensions such as drilling fluids, at constant applied pressure and any given temperature, it can be shown that the total volume of filtrate passing through the filter medium for any given time can be expressed by a relationship of the form:

$$t = af_1(P)\,\mu\,V^2 + bf_2(P)\,\mu\,V$$

where a and b are constants

V = volume of filtrate produced in time t

μ = viscosity of filtrate

and f_1 (P), f_2 (P) express the variation of the specific resistance, i.e. permeability, of the filter cake and the filter medium as a function of pressure[4].

In cases where the second term is small compared with the first, the relationship approximates to that usually presented in discussions of drilling fluid filtration, in which the volume of filtrate produced is proportional to the square root of the time. It is also evident that if the constant "a" and the function f_1 (P) are independent of temperature, i.e. if the state of flocculation of the clays is not affected, then it could be expected that the filter loss would be inversely proportional to the square root of the filtrate viscosity.

The experimental results given in Table No. 7 indicate that the ratio of the fluid loss with any given pressure differential at temperature T°F to that at 75°F is almost without exception greater than the ratio of the square root of the filtrate fluidities at the two temperatures, but less than that of the ratio of their fluidities.

Further it can be said that in the case of two of the three muds the filter loss at any given temperature is virtually independent of applied pressure, which would imply the presence of a very compressible filter cake. With the third mud there would appear to be a marked effect of pressure on the filter loss at any fixed temperature.

Finally it can be said that all three muds showed satisfactory filtration properties at temperatures up to 300°F and do not exhibit any signs of flocculation of clays due to the high temperatures concerned.

Rheological Properties of Water-Base Drilling Fluids at Elevated Temperatures

In a recent publication, Srini-Vasan and Gatlin[5] have reported the results of an investigation into the variation of the rheological properties of a variety of laboratory-prepared water base drilling fluids with temperature. With the exception of one sample, a 75 lb/cu. ft. drilling emulsion containing 10% diesel oil, the relationship between plastic viscosity and temperature could be expressed by the relationship.

$$\ln \mu_P/\mu_W = a + bT$$

where μ_P and μ_W are the plastic viscosity of the mud, and the viscosity of water at the temperature T. This equation may be rewritten:

$$\frac{\mu_{P_1}}{\mu_{P_2}} = \frac{\mu_{W_1}}{\mu_{W_2}} \exp.\{b(T_1 - T_2)\}$$

where μ_{P_1}, μ_{P_2}, μ_{W_1} and μ_{W_2} are the respective values for two temperatures T1 and T2. The constant "b" was found to be positive for all muds, with the exception of a 3% bentonite mud, where it was essentially zero, i.e., the ratio of the plastic viscosities of the mud at two temperatures was, in this one case, essentially equal to the ratio of the viscosities of water at the corresponding temperatures.

Similar data had been accumulated by C.S.V. primarily to discover whether or not the variation in viscosity of drilling fluids with temperature was determined solely, or largely by the variation in viscosity of the water with temperature. It was argued that notwithstanding the results of Srini-Vasan and Gatlin, the plastic viscosity of a clay suspension at any given temperature should depend firstly on the volume and physicochemical state of the clay contained in the mud, and secondly on the viscosity of the suspension medium at that temperature. This is explicit in the equation of Einstein and others. If the volume and state of peptisation of the clay fraction present in the mud remains the same at two different temperatures, then the ratio of the plastic viscosity of the mud at two temperatures should be equal to the ratio of the corresponding viscosities of water.

Data for sixty gas-oil emulsion muds used in the Lake Concessions were examined, and their general nature and range of properties were as follows:

a) Quebracho, caustic soda gas-oil emulsion muds,	44 samples
b) Gypsum/Q-Broxin gas-oil emulsion muds	16 "
c) Range of plastic viscosities (25°C)	29-85 cp.
d) Range of mud weights	77-95 lb/cu.ft.
e) Range of oil content	5-22 % by vol.

For each sample the ratio of plastic viscosity, apparent viscosity and Bingham Yield as measured at 50°C and 70°C, to the corresponding values at 25°C were determined, and the mean and standard deviation for each ratio calculated. The following results were obtained:

Property	Ratio 50°C/25°C Mean	Std. Dev.	Ratio 70°C/25°C Mean	Std. Dev.
Plastic viscosity	0.61	0.06	0.47	0.04
Apparent viscosity	0.60	0.07	0.46	0.05
Bingham Yield	0.58	0.10	0.45	0.10

It is apparent that not only does the ratio of the plastic viscosities for the two temperatures equal the ratio of the corresponding viscosities of water μ (50°C)/μ (25°C) = 0.61 and μ 70°C/μ (25°C) = 0.45 with a relatively low standard deviation, considering the limited preciseness with which temperature control is possible, but that the ratios are essentially the same for the apparent viscosity and the Bingham Yield.

This latter result is somewhat difficult to accept intuitively. In practice, however, the fact that all three calculated properties show ratios, for two given temperatures, equal to the ratio of the corresponding viscosities of water, indicates that the ratio of the measured torques at two temperatures, for both the 300 and 600 RPM speeds, must be equal and also equal to the ratio of the viscosities of water. This can be confirmed by graphical construction of the rate of shear, shearing stress diagrams.

The difference between the results for these Lake Concessions field muds, and Srini-Vasan and Gatlin's laboratory muds cannot be explained. Unfortunately these authors give no information as to whether their muds were treated with thinners, and it is possible that the degree of dispersion and aggregation of their clays may have been such that marked changes occurred over the temperature range investigated. The results obtained for the field muds confirm, however, that their temperature viscosity characteristics are entirely in line with those that would be anticipated from the various published equations for the viscosities of suspensions.

This therefore implies that it is entirely possible to calculate from laboratory measured values, the rheological properties of any mud at either flowline or bottom hole circulating conditions, always assuming that the state of peptisation of the suspended clays does not alter. It should perhaps be mentioned that the mud properties given in Tables Nos. 1 and 6 were measured at approximately 75°F whereas the flowline temperatures in the wells varied from 115 to 130°F, so that viscosity data at flowline conditions can be obtained by multiplying by a factor of 0.63 to 0.56.

CONCLUSIONS

1. Gypsum Q-Broxin muds have proved in practice to be excellent muds for the drilling of deep holes to depths of 15,500 feet.
2. Maintenance of satisfactory rheological properties of the muds has been easily attained at moderate cost.
3. As evidenced by trouble-free drilling through considerable sandstone sections and confirmed by laboratory tests, Gypsum Q-Broxin muds retain satisfactory filtration characteristics to temperatures of 300°F.
4. The rather low resistivity of Gypsum Q-Broxin muds may result in a flattening of the self potential curve and thus lead to difficulties in subsurface correlation work.
5. Such logging difficulties can be overcome by use of lime Q-Broxin muds of pH 9.5. With hard shales such as are normally encountered

at considerable depths, the reduction in calcium content caused by this change in treatment should not lead to excessive washing out of shales.

6. Preliminary costs from one well suggest that maintenance costs of the lime Q-Broxin muds will be less than those of the Gypsum Q-Broxin muds.

7. A simple correlation has been established by means of which the rheological properties of a mud can be calculated at any given temperature from measurements taken under different temperature conditions.

References:

1. Cunningham and Eenink: Journal of Petroleum Technology January 1959.
2. Helmick and Longley: Drilling and Production Practice 1957.
3. Glasstone: Textbook of Physical Chemistry 2nd. Edition, page 900.
4. Walker, Lewis, McAdams and Gilliland: Principles of Chemical Engineering, Chapter XI "Filtration".
5. Srini Vasan and Gatlin: Journal of Petroleum Technology December 1958.

TABLE No. 1

MUD PROPERTIES: WELL F

Depth ft.	Weight lb/cuft.	Viscosity M.F. sec.	Water Loss cc API	Sand %	Filter cake mm	pH	Ca ppm	Oil content %	Solids % Vol.	Fann Plastic Viscosity cp.	Fann Bingham Yield lb/100ft^2	0/10' Gel. Strength, Fann lb/100ft^2
12437	77.5	46	4.9	1.5	0.5	9.5	800	13	14	26	15	1/4
12456	78	43	5.0	1.6	1.0	9.5	800	13	14	23	12	1/3
12565	77	40	5.1	1.4	1.0	10.4	600	12	13	24	13	1/4
12722	77.5	40	5.0	0.8	1.0	10.0	650	13	13	27	18	2/5
12907	78	42	5.0	1.0	1.0	10.0	550	12	13	23	10	2/5
13062	78	50	4.8	1.5	1.0	10.3	600	11	14	31	20	3/7
13170	79	55	4.6	2.1	1.0	10.4	750	10	14	37	18	4/10
13243	78	50	4.2	1.6	1.0	10.0	700	10	13	26	16	3/7
13460	78	53	4.0	1.8	1.0	10.0	800	9	13	33	19	4/11
13661	78	58	4.0	1.9	1.0	10.2	700	9	13	35	20	4/10
13688	78	54	4.0	2.0	1.0	10.4	650	12	13	35	22	3/9
13758	78	54	4.0	1.8	1.0	10.5	800	11	13	33	19	6/13
13890	78	65	3.8	3.2	1.0	10.3	750	10	13	34	20	4/9
13914	78	53	3.8	2.0	1.0	9.9	700	10	13	36	22	4/10

TABLE No. 2

DRILLING PERFORMANCE, CHEMICAL CONSUMPTION AND COST DATA OF WELLS

Well No.	D	E	F	G	H	J
Interval (feet)	11723-13894	11329-13269	12370-13904	11641-13660	12485-13920	11985-14300
Footage	2171	1940	1534	2019	1435	2315
Hole Size (in.)	8-1/2	8-1/2	8-1/2	8-1/2	8-1/2	8-1/2
Days Drilling	33	15	17	18	17	14
Footage/day	65	129	90	112	85	165
Total rotating hours	248	118	122	182	162	148
Average penetration ft/hr.	8.8	16.4	12.6	11.2	8.9	15.0
Barytes (lb/ft)	11151	17.27	23.06	21.11	60.00	32.78
Caustic Soda "	3.53	2.47	3.15	2.26	1.25	0.09
Bentonite "	5.48	4.68	8.60	2.74	4.98	0.71
CMC "	1.83	1.13	1.73	1.74	2.49	1.23
Gypsum "	6.93	5.36	6.42	2.50	4.36	-
Q-Broxin "	8.84	6.29	6.38	5.79	11.01	2.59
Gas Oil (bbl/ft)	0.04	0.06	0.09	0.06	0.10	0.06
Lime (lb/ft)	-	-	-	-	2.36	1.42
Chemical costs per foot Bs.	13.9	10.91	13.63	11.39	21.43	8.15

TABLE No. 3

MUD RESISTIVITY AND S.P. DATA

Well	Interval (feet)	Rm/77°F ohm. m.	S.P. Log Quality	S.P. Log Max.Dev. m.V.	Mud Type
A	11,389-12,000	2.6	Good	35	NaOH/Quebracho
"	12,000-12,762	1.5	"	30	" "
B	11,900-14,122	1.6	Good	35	NaOH/Quebracho
C	10,000-12,282	2.9	"	45	" "
"	12,282-13,411	1.45	Adequate	18	Gypsum/Q-Broxin
"	13,411-13,761	1.32	"	15	" "
"	13,761-14,080	1.0	"	20	" "
"	14,080-14,340	0.99	"	32	" "
D	10,300-11,668	1.7	Good	30	NaOH/Quebracho/Q-Broxin
"	11,668-12,650	0.9	Poor	13	Gypsum/Q-Broxin
"	12,650-13,611	0.66	"	12	" "
"	13,611-13,887	0.55	Very poor	8	" "
E	11,316-12,362	0.93	Poor	9	Gypsum/Q-Broxin
F	12,370-13,930	0.86	Adequate	15	" "
"	13,930-14,224	0.32	Very Poor	*	" "
G	11,628-13,649	0.77	Poor	12	" "
J	12,550-13,500	1.35	Good	20	Lime/Q-Broxin
"	13,500-13,800	1.46	"	35	" "
"	13,800-14,200	1.52	"	70	" "
K	12,240-13,194	1.1	"	32	Gypsum/Q-Broxin
"	13,194-13,731	1.16	"	22	" "
"	13,731-13,995	0.94	"	32	" "
"	13,995-14,160	0.95	"	32	" "
L	11,540-12,461	0.66	Very Poor	*	" "
"	12,461-12,829	0.73	"	*	" "
"	11,800-13,002	0.88**	Adequate	25	" "
N	11,800-12,676	1.32	Good	25	" "
"	12,676-13,112	1.35	"	25	" "

* Log completely featureless with S.P. showing positive and negative deviations from shale base line.

** Mud changed prior to this third log run.

TABLE No. 4

FILTRATE COMPOSITION AND RESISTIVITY OF GYPSUM Q-BROXIN MUD IN WELL H

Depth ft.	Weight lb/cu.ft.	Resistivity ohm cm at 76°F		Filtrate ppm			pH
		Mud	Filtrate	Ca'	SO_4	Cl'	
12595	81	109	69	440	5000	2400	10.2
12710	81	101	67	468	5300	2500	9.9
12812	83	98	60	616	8000	2700	10.0
12890	N.D.	98	59	792	8000	2700	10.4
13039	82.5	98	66	552	9200	2700	10.4
13124	85	100	54	792	9200	2700	10.0
13143	86	102	53	1056	10600	2900	9.3
13256	84.5	96	44	1276	13200	2800	9.0
13302	85.5	94	44	1188	11800	3000	8.5
13435	85.5	94	44	1420	14000	3000	9.0
13540	85.5	91	42	1408	9800	3000	8.7
13616	84	90	45	1408	9600	3000	9.8
13671	84	89	45	1584	8800	3200	9.3
13741	84	93	45	1540	8800	4600	9.0
13804	84.5	94	46	1540	8800	3600	9.5
13874	84	90	44	1452	9000	3800	10.0
13920	82	94	42	1672	9000	3800	10.0

TABLE No. 5

RESISTIVITY OF Q-BROXIN SOLUTIONS

Chemicals lb/bbl.		Resistivity ohm cm.	Temperature °F
Q-Broxin	NaOH		
-	-	39,000*	77
2	-	965	"
6	-	410	"
10	-	250	"
20	-	145	"
4	-	585	76
4	0.1	540	"
4	0.2	480	"
4	0.3	419	"
4	0.4	352	"
4	0.5	273	"
4	0.6	214	"
4	0.7	173	"
4	0.8	143	"
4	0.9	116	"
4	1.0	108	"
4	1.2	89	"
4	1.4	73	"
4	1.6	64	"
4	1.8	56	"
4	2.0	50	"

(*) Resistivity of water used for making up solutions.

TABLE No. 6

MUD PROPERTIES: WELL J

Depth ft	Weight lb/cuft	Viscosity M.F. sec.	Water Loss cc API	Sand %	Filter cake mm	pH	Ca ppm	Oil content %	Solids % Vol.	Fann		0/10'	Gel.	Cl'	SO_4	Resistivities ohm m.			
										Plastic Viscosity cp	Bingham Yield lb/100 ft^2	Stormer g.	Fann lb/100 ft^2	ppm	ppm	Rm	°F	Rm	°F
12125	76.5	53	3.4	0.3	1.0	11.6	220	12	12	30	15	5/13	3/7	2500	850	1.17	(73°)	0.75	(74°)
12154	76.5	51	4.2	0.4	1.0	11.3	220	10	12	25	10	4/7	2/4	2500	1200	1.31	(72°)	0.83	(74°)
12335	75.5	50	2.8	0.3	1.0	10.9	308	16	10	29	15	5/8	3/4	2500	2000	1.28	(75°)	0.79	(73°)
12451	81.5	55	2.0	0.3	1.0	10.2	308	14	15	35	20	5/10	3/5	2600	2000	1.41	(72°)	0.79	(73°)
12597	82.0	55	1.7	0.5	1.0	9.6	440	14	16	40	25	6/19	3/10	2700	2750	1.31	(76°)	0.73	(77°)
12964	81.0	54	2.8	0.5	1.0	9.2	396	13	10	38	27	3/22	3/12	2600	3000	1.42	(73°)	0.77	(77°)
13203	79.5	53	2.6	0.5	1.0	9.6	440	14	14	34	20	8/25	3/13	2300	2500	1.39	(77°)	0.82	(77°)
13452	80.5	54	2.0	0.6	1.0	9.2	396	14	16	37	21	7/27	3/13	2700	2200	1.47	(74°)	0.79	(76°)
13690	79.5	49	2.7	0.7	1.0	9.7	396	15	15	29	17	6/19	3/10	3400	2000	1.40	(73°)	0.73	(76°)
13865	81.0	48	2.5	0.8	1.0	9.5	396	13	15	32	16	6/17	4/8	2700	2650	1.52	(74°)	0.89	(76°)
14023	80.5	52	3.2	0.9	1.0	9.1	396	14	16	31	17	-	4/9	2700	2650	1.50	(75°)	0.81	(76°)
14130	80.5	50	3.6	0.8	1.0	9.1	352	12	16	25	15	-	3/9	2500	2000	1.50	(75°)	0.85	(77°)
14260	79.0	50	3.7	0.8	1.0	9.4	352	15	15	29	14	6/24	3/14	2700	2500	1.55	(74°)	0.83	(77°)

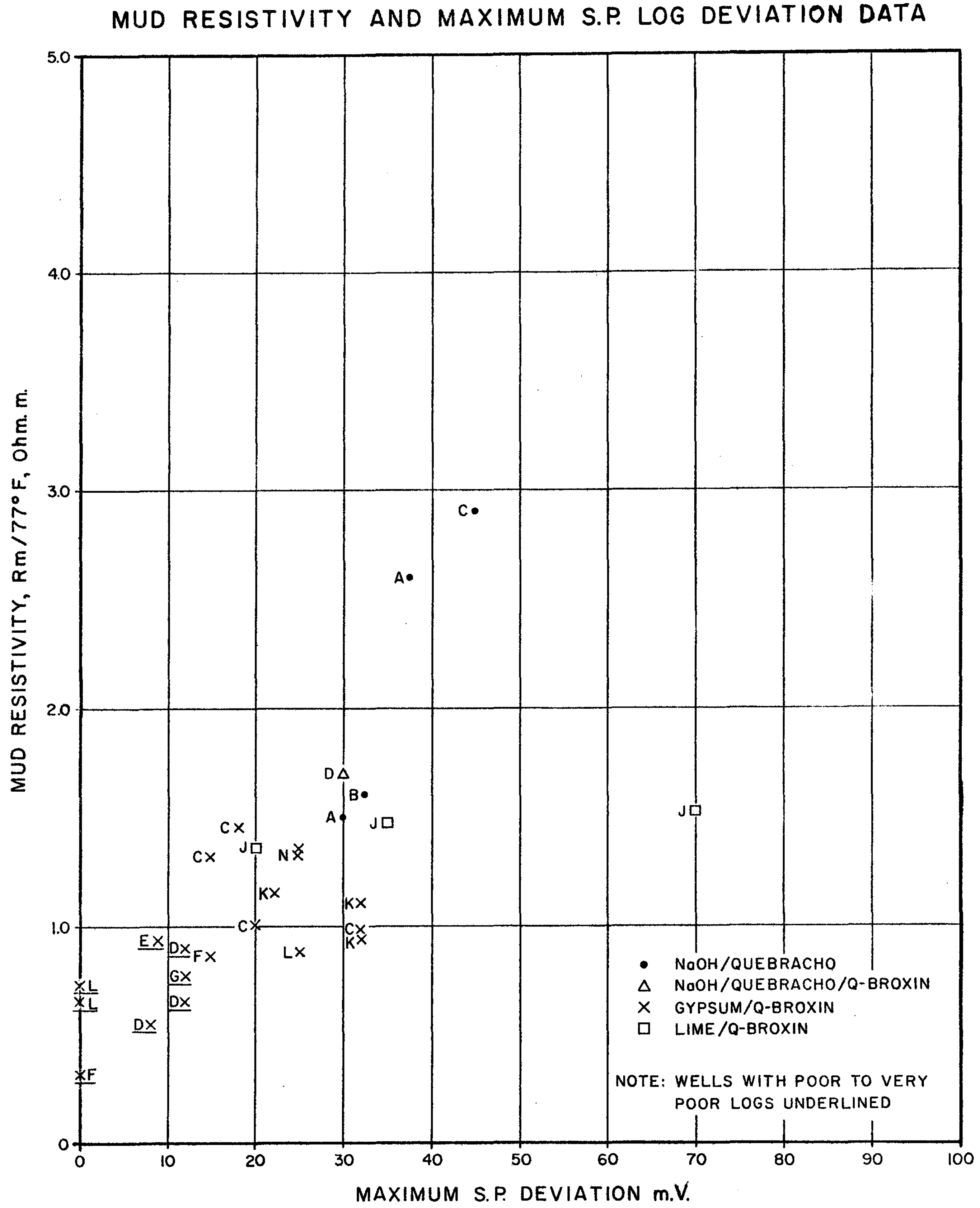
TABLE No. 7

FLUID LOSS OF MUDS AT VARIOUS TEMPERATURES AND PRESSURES

Temperature, °F	75°F	150°F	225°F	300°F
$\mu(75°F)/\mu(T°F)$	-	2.13	3.46	4.91
$\sqrt{\mu}(75°F)/\sqrt{\mu}(T°F)$	-	1.46	1.86	2.22
Gypsum/Q-Broxin				
100 psig	4.0	6.4 (1.6)	9.6 (2.4)	14.4 (3.6)
200 "	4.6	6.6 (1.4)	9.6 (2.1)	14.8 (3.2)
400 "	4.2	7.4 (1.8)	9.6 (2.3)	16.4 (3.9)
600 "	3.0	6.8 (2.3)	11.0 (3.7)	14.4 (4.8)
800 "	3.4	6.0 (1.8)	9.0 (2.6)	13.2 (3.9)
Gypsum/Q-Broxin				
100 psig	1.6	3.4 (2.1)	6.0 (3.7)	8.2 (5.1)
200 "	2.8	4.6 (1.6)	7.6 (2.7)	9.6 (3.4)
400 "	3.2	6.6 (2.1)	10.2 (3.2)	12.0 (3.7)
600 "	4.8	7.4 (1.5)	10.8 (2.3)	13.0 (2.7)
800 "	4.8	8.0 (1.7)	11.8 (2.5)	14.8 (3.1)
NaOH/Quebracho				
100 psig	1.0	3.4 (3.4)	5.2 (5.2)	11.2 (11.2)
200 "	2.4	4.6 (1.9)	7.6 (3.2)	13.0 (5.4)
400 "	2.8	5.2 (1.9)	8.0 (2.9)	13.0 (4.6)
600 "	3.6	5.4 (1.5)	8.0 (2.2)	12.6 (3.5)
800 "	3.2	5.4 (1.7)	8.2 (2.6)	12.6 (3.9)

Note: Numbers in brackets are the ratio Fluid Loss (T°F)/Fluid Loss 75°F at a given pressure differential.

FIG. I


MUD RESISTIVITY AND MAXIMUM S.P. LOG DEVIATION DATA
MUD RESISTIVITY, Rm/77° F, Ohm. m.
MAXIMUM S.P. DEVIATION m.V.
0
1.0
2.0
3.0
4.0
5.0
10
20
30
40
50
60
70
80
90
100
NaOH/QUEBRACHO
NaOH/QUEBRACHO/Q-BROXIN
GYPSUM/Q-BROXIN
LIME/Q-BROXIN
NOTE: WELLS WITH POOR TO VERY POOR LOGS UNDERLINED