ORKUSTOFNUN
Jarðhitadeild

TESTING OF DRILLING MUDS

PATRICK BASCOU

OS-85082/JHD-41 B October 1985

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CONTENTS

PRESENTATION

The object of this report is to give the results of the rheological measurements made on some samples of drilling muds. These results can be used on the drill rig for reference, and also to compare the muds for price versus performance.

Each sample has been tested with a Fann meter and a Marsh funnel.

The measurements with the Fann meter, which is a rotating viscosi meter, give the plastic viscosity and the yield point value.

The measurements with the Marsh funnel give the Marsh viscosity, which is used in the field to measure mud viscosities because of its simplicity.

1 MUD BLENDING

For each kind of mud the concentration of bentonite of 20,40,60,80 and 100 kg/m3 has been tested. For example a blend of 20 kg/m3 is constituted by 20g of bentonite clay and 1 liter of water.

In each case the density of the mud has been measured, and it is reported along with the viscosities obtained.

2 FANN METER MEASUREMENT

The Fann meter has two speeds of rotation: 600rpm and 300 rpm. The following procedures apply. Place a container of recently agitated sample on work table and adjust surface of mud to scribe line on the rotor sleeve.

Start the motor on the high speed, wait for a steady indicator dial value and record the 600 rpm reading.
Change speed to low rpm, wait for steady value and record the 300 rpm reading.

1) Calculation of Plastic Viscosity:

The plastic viscosity value in centipoises is the 600 rpm reading minus the 300 rpm reading.

2) Calculation of Yield Point:

The yield point value in lb/100 sq ft is the 300 rpm reading minus the plastic viscosity value.

3 MARSH FUNNEL MEASUREMENT

The Marsh funnel is 6 inches in diameter at the top and 12 inches long. At the bottom, a smooth-bore tube 2 inches long having inside diameter of 3/16-inch is attached in such a way that there is no constriction at the joint. A wire screen having 1/16-inch openings, covering one-half of the funnel, is fixed at a level of 3/4 inches below the top of the funnel.

Marsh Funnel Viscosity:

With the funnel in an upright position, cover the orifice with a finger and pour the freshly collected mud sample through the screen into the funnel until the fluid level reaches the bottom of the screen (1500ml). Then remove the finger from the outlet and measure the time required for the mud to fill the receiving vessel to the 1-quart (946ml) level.

This time measured in seconds is the Marsh funnel viscosity of the sample.

4 RESULTS

4.1 API Bentonite

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	2	1	1.001	29
40	3	13	1.021	37
60	5	40	1.034	81
80	13	79	1.042	347
100	20	165	1.056	

4.2 OCMA Bentonite

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	2	0	1.008	28
40	3	2	1.021	32
60	5	10	1.033	35
80	11	33	1.042	40
100	17	62	1.056	

4.3 Gel IR 25/23

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	2	1	1.010	28
40	3	2	1.022	30
60	6	4	1.034	32
80	8	6	1.046	37
100	12	21	1.059	

4.4 Delta ij delta v G.K.

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	2	6	1.012	27
40	7	10	1.020	29
60	11	22	1.022	30
80	12	43	1.047	35
100	16	50	1.058	

4.5 Cebo gel

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	3	4	1.012	30
40	8	20	1.024	44
60	12	62	1.036	88
80	18	76	1.048	354
100	54	186	1.060	

4.6 Steetley

Blend kg/m3	Plastic viscosity centipoise	Yield point lb/ft2	Density g/cm3	Marsh viscosity s
20	2	1	1.010	28
40	4	2	1.021	34
60	12	12	1.035	58
80	26	48	1.046	195
100	52	144	1.058	

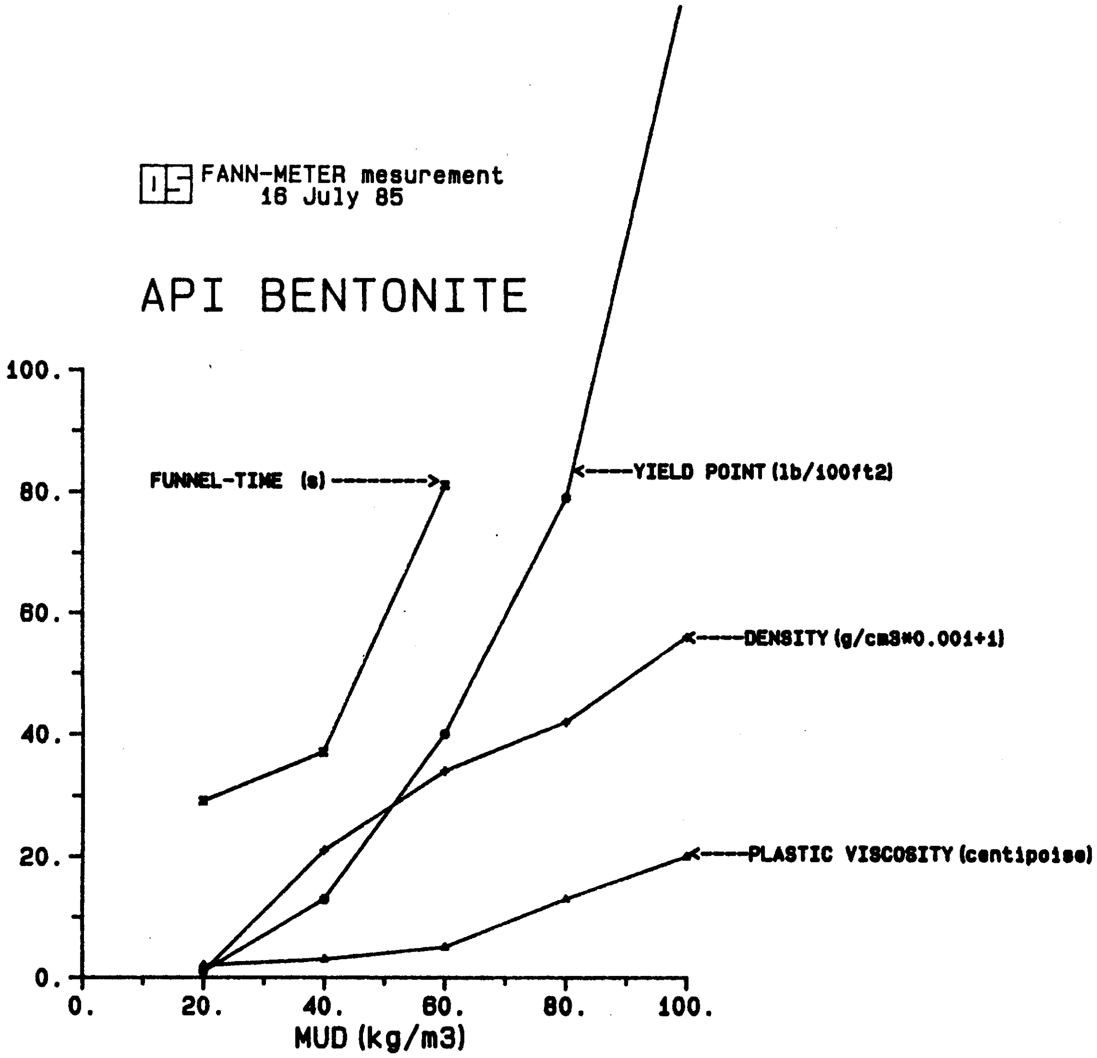
4.7 BW gel

blend kg/m3	plastic viscosity centipoise	yield point lb/ft2	density g/cm3	Marsh viscosity s
20	2	0	1.009	28
40	3	2	1.021	30
60	5	6	1.034	38
80	12	14	1.046	45
100	24	46	1.058	

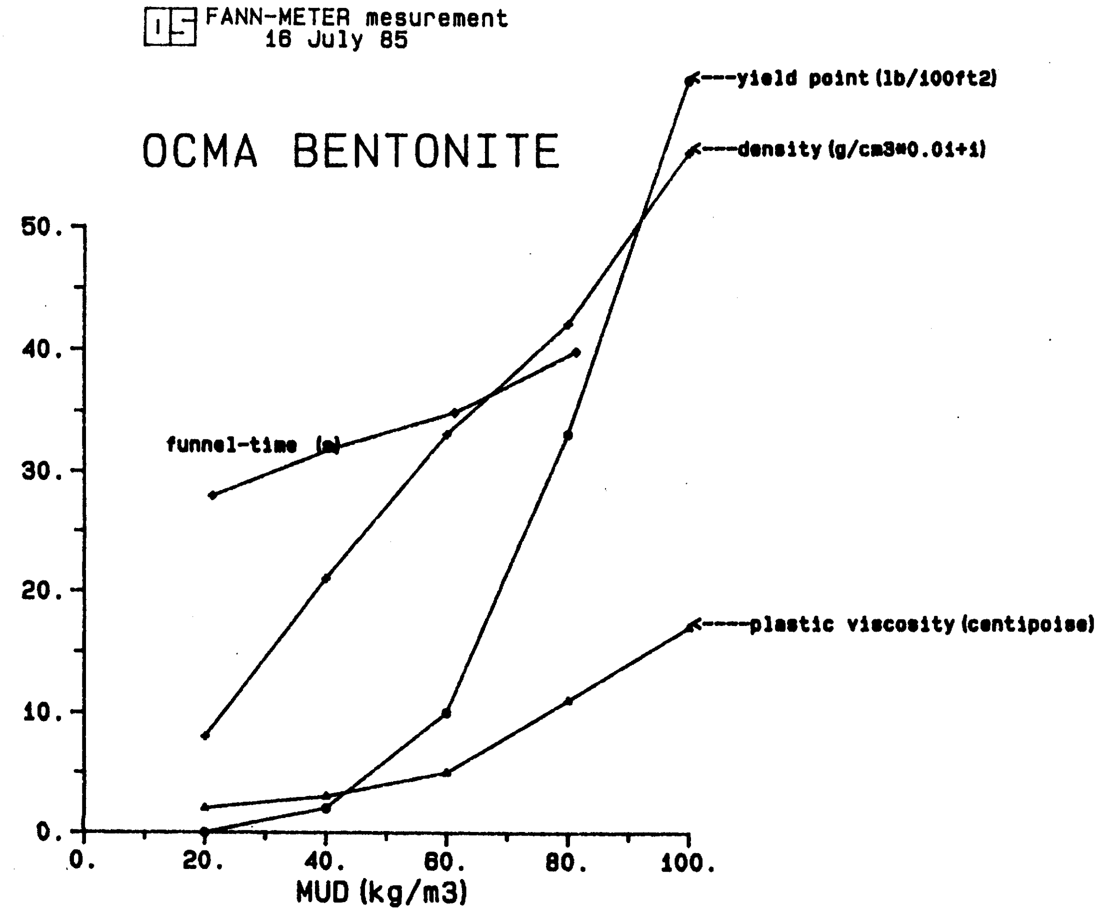
5 GRAPHS

In the following pages, there is, for each kind of mud, a graph showing the plastic viscosity, density, yield point and Marsh viscosity (Funnel time) as function of mud blend.

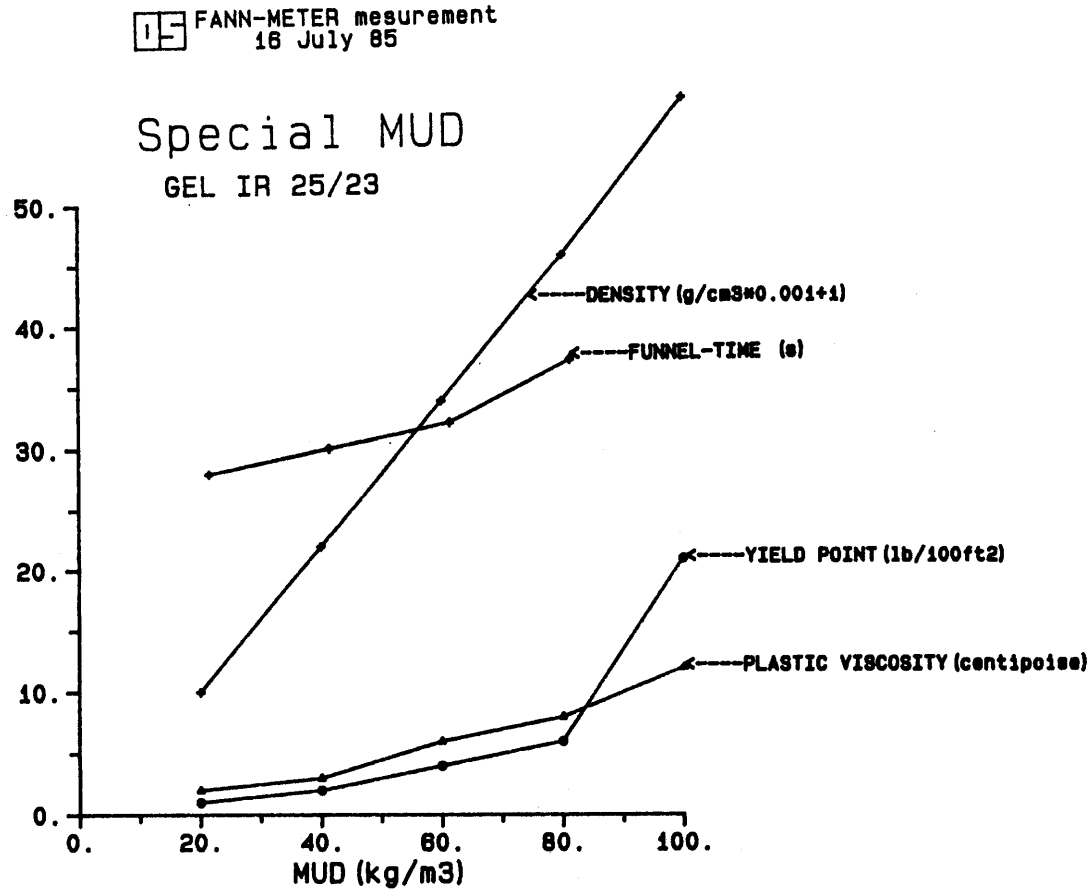
There is also a graph showing all the plastic viscosity charts of the different muds, and a graph with all the Marsh viscosity charts (Funnel time).

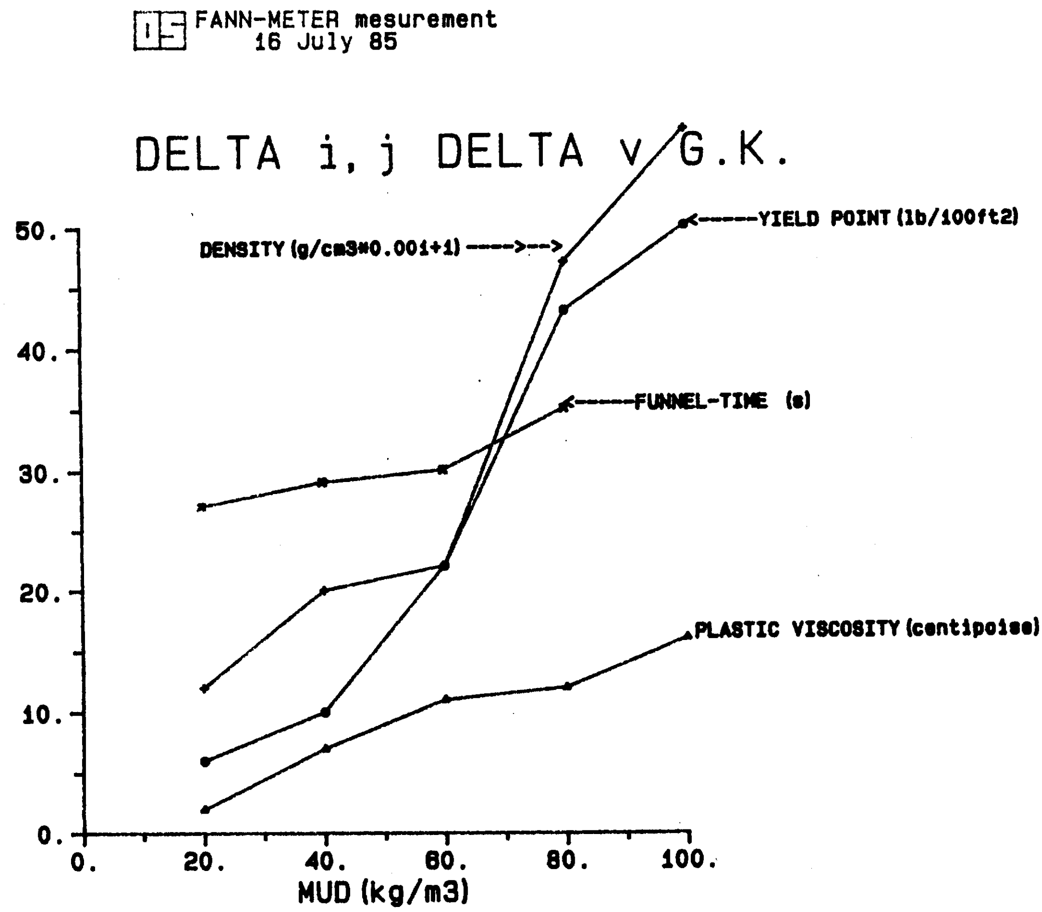


FANN-METER mesurement
16 July 85
API BENTONITE
FUNNEL-TIME (s)
YIELD POINT (lb/100ft2)
DENSITY (g/cm3*0.001+1)
PLASTIC VISCOSITY (centipoise)
MUD (kg/m3)



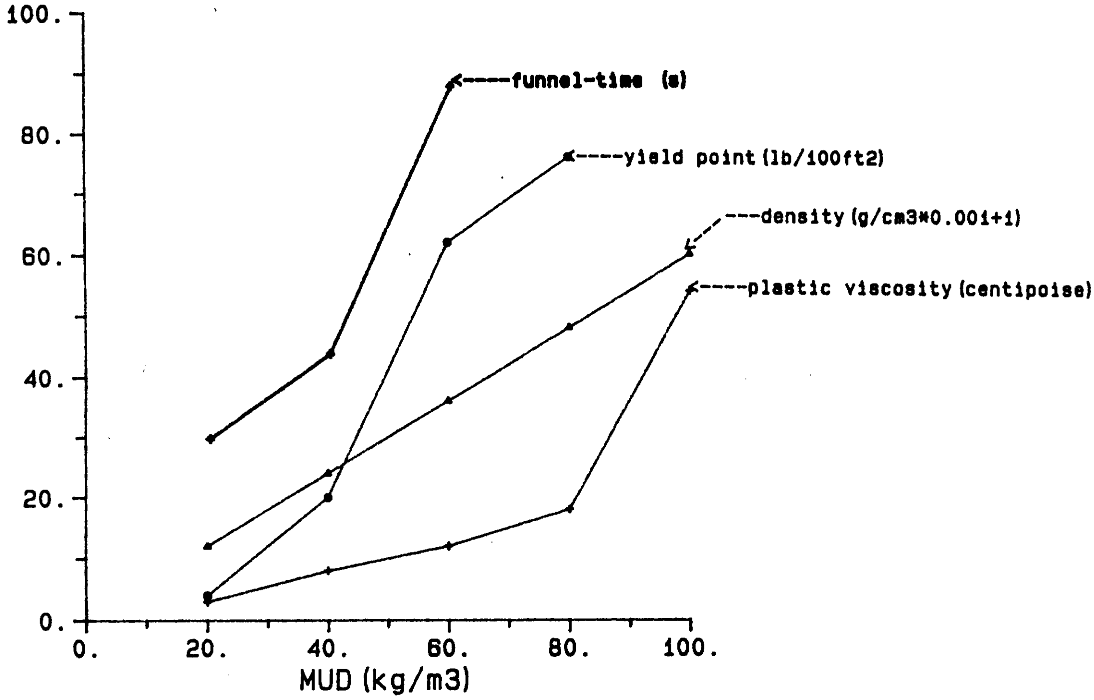
FANN-METER mesurement
16 July 85
OCMA BENTONITE
yield point (lb/100ft2)
density (g/cm3*0.01+1)
funnel-time (s)
plastic viscosity (centipoise)
MUD (kg/m3)


FANN-METER mesurement
16 July 85
Special MUD
GEL IR 25/23
DENSITY (g/cm3*0.001+1)
FUNNEL-TIME (s)
YIELD POINT (lb/100ft2)
PLASTIC VISCOSITY (centipoise)
50.
40.
30.
20.
10.
0.
0.
20.
40.
60.
80.
100.
MUD (kg/m3)


FANN-METER mesurement
16 July 85
DELTA i, j DELTA v/G.K.
DENSITY (g/cm3*0.001+1)
YIELD POINT (lb/100ft2)
FUNNEL-TIME (s)
PLASTIC VISCOSITY (centipoise)
50.
40.
30.
20.
10.
0.
0.
20.
40.
60.
80.
100.
MUD (kg/m3)

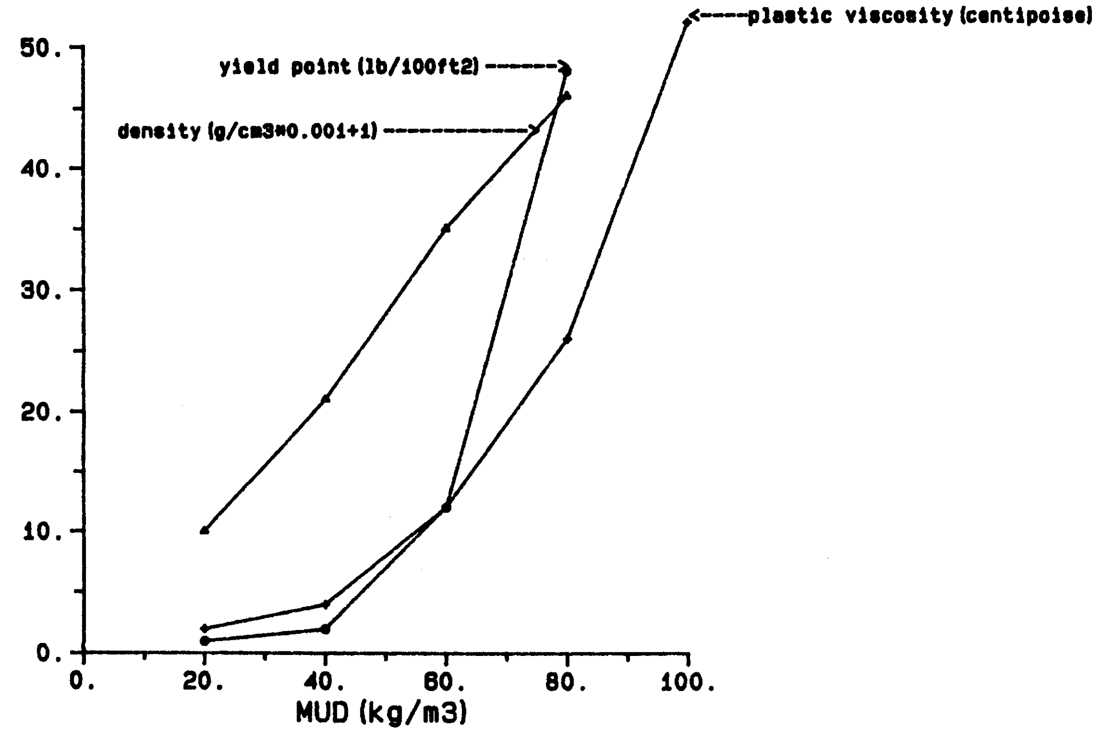
FANN-METER mesurement
16 July 85

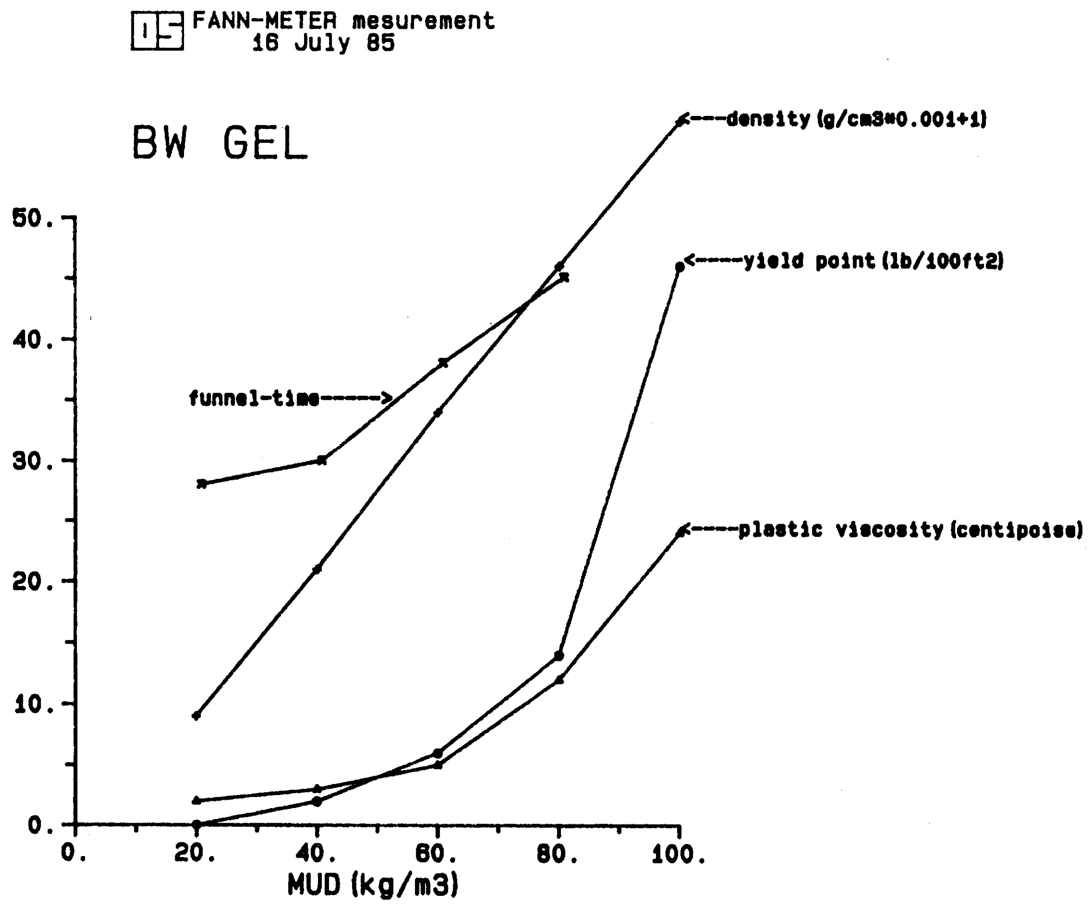
CEBO GEL

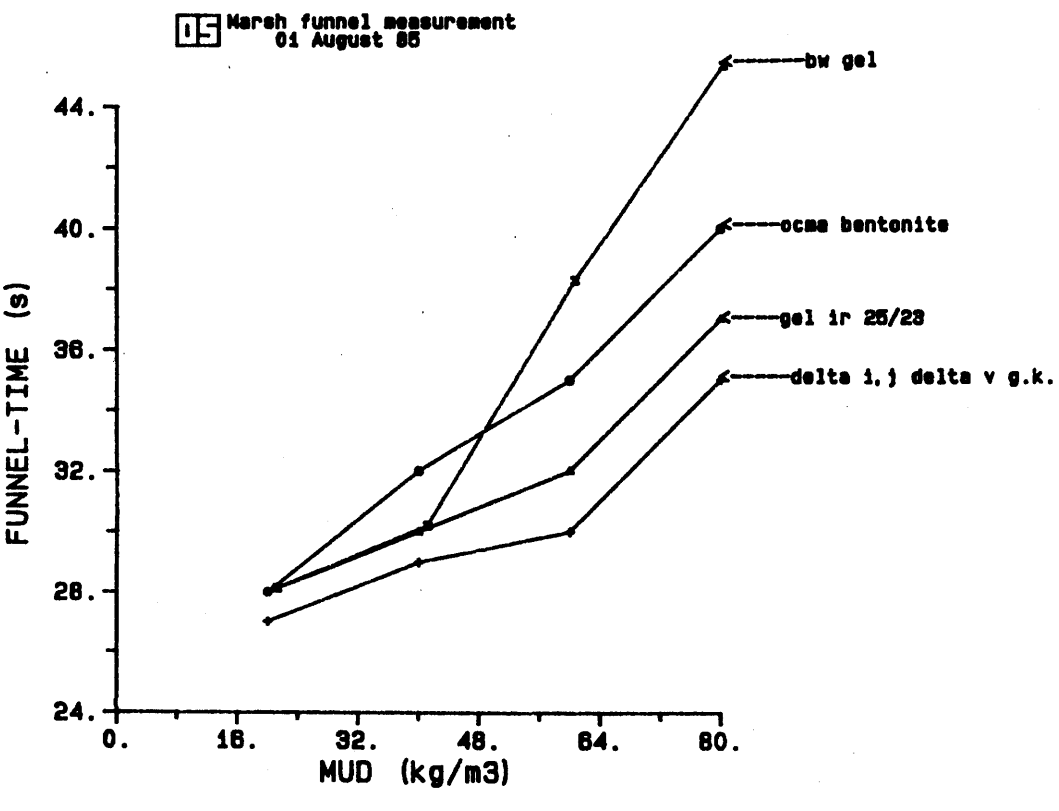


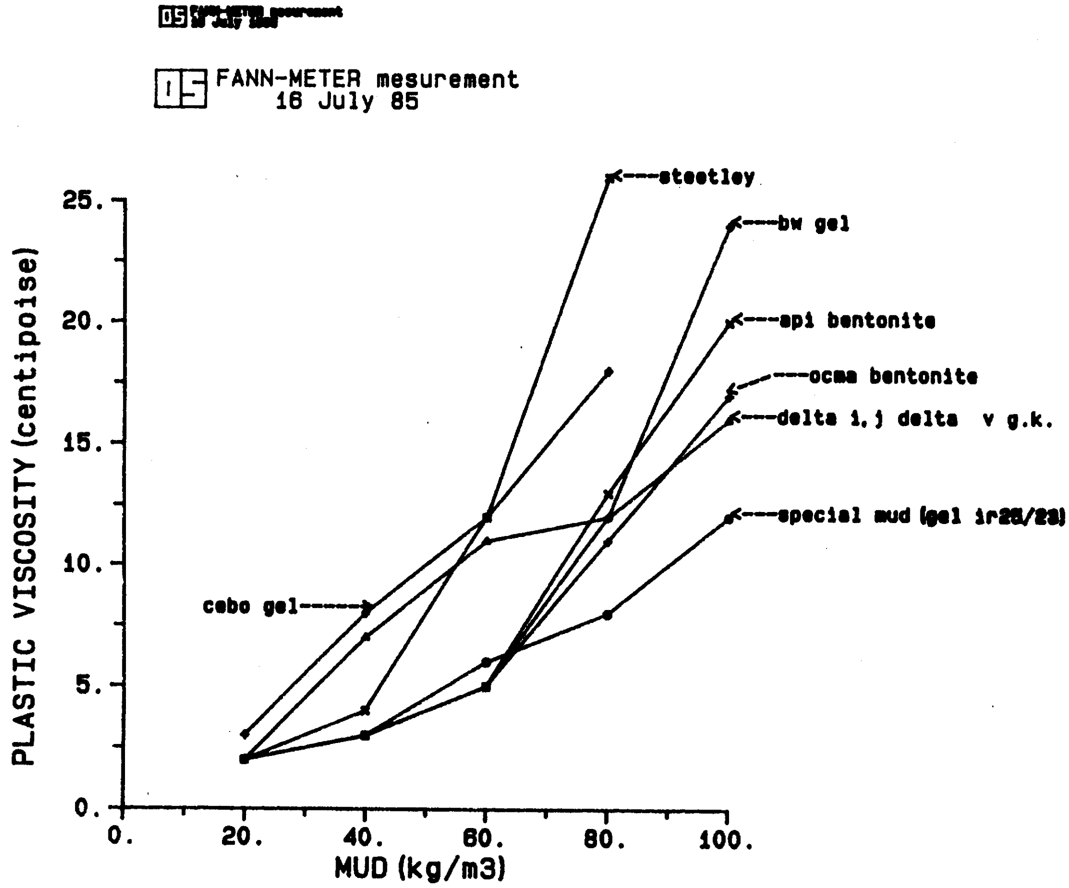
FANN-METER mesurement
16 July 85

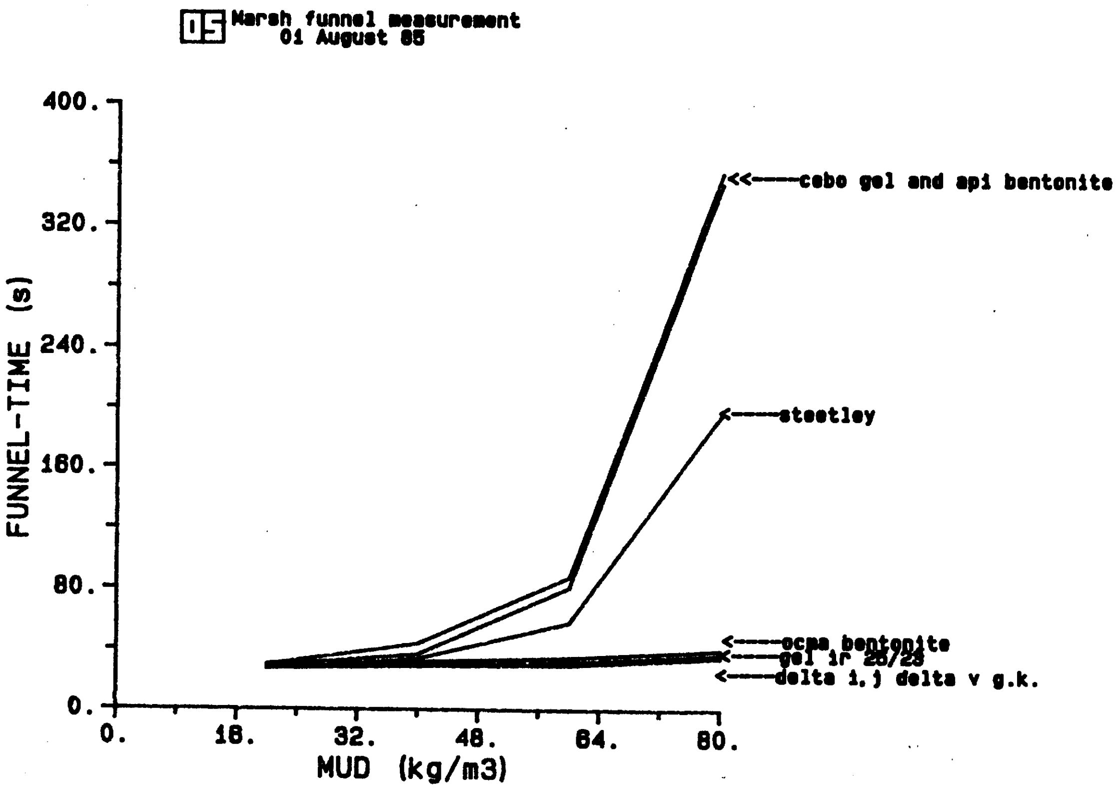
STEETLEY




FANN-METER mesurement
16 July 85
BW GEL
density (g/cm3*0.001+1)
yield point (lb/100ft2)
funnel-time
plastic viscosity (centipoise)
50.
40.
30.
20.
10.
0.
0.
20.
40.
60.
80.
100.
MUD (kg/m3)


Marsh funnel measurement
01 August 85
bw gel
ocma bentonite
gel ir 25/23
delta i,j delta v g.k.
FUNNEL-TIME (s)
44.
40.
36.
32.
28.
24.
0.
16.
32.
48.
64.
80.
MUD (kg/m3)


FANN-METER mesurement
16 July 85
PLASTIC VISCOSITY (centipoise)
MUD (kg/m3)
steetley
bw gel
api bentonite
ocma bentonite
delta i, j delta v g.k.
special mud (gel ir28/23)
cebo gel
0.
5.
10.
15.
20.
25.
20.
40.
60.
80.
100.


Marsh funnel measurement
01 August 85
FUNNEL-TIME (s)
MUD (kg/m3)
cebo gel and api bentonite
steetley
ocma bentonite
gel ir 28/23
delta i, j delta v g.k.
0.
80.
160.
240.
320.
400.
16.
32.
48.
64.
80.

6 CONCLUSIONS

Direct comparison of the properties of the muds tested is shown in graphs. The following ranking, from the best viscosity to the worst, was obtained.

1 Cebo gel
2 Steetley
3 API bentonite
4 BW gel
5 OCMA bentonite
6 Delta ij
7 Gel IR 25/23

For muds 1-4, acceptable viscosity is obtained by 4-6% addition of bentonite.

For muds 5-7, more than 8% is required.

APPENDIX: XRD Analysis

Guðrún Sverrisdóttir

XRD determination was made on the drilling mud samples, in order to identify their interlayer cations and hence their swelling properties.

Each sample was run three times after separate preparation: 1) At 35% relative humidity, which measures the basal spacing (Å) of sheets in the layer silicates. If the clay consists of one unmixed clay mineral, it is possible to see from this spacing which cations connect the sheets in the clay structure. 2) The samples were saturated with etylenglycol and run in order to test their swelling properties. 3) The samples were run after drying at 550°C for 1 hr. From these three runs the clay minerals can be identified.

All samples represent mixed layers of Montmorillonite/Illite clay minerals. That makes it difficult to determine their type of inter-layers cations. The two samples IR 25/23 and Steetly show the best swelling properties and are the least interlayered. From the basal spacing, it seems most likely that Na is the dominant interlayer cation in the layer silicates, which gives better swelling properties in montmorillonite than if it were Ca for example.

The better the swelling ability of the bentonite, the better one would expect the drilling mud to be. Pure bentonite swells to ca. 17Å. A sodium saturated pure montmorillonite is the best possible drilling mud.

TABLE 1 Interlayer cations

Sample	35% rel.hum.		Glycol sat		Dried 550°C 1 hr	Clay minerals	Int. cations
IR 25/23	13.18		16.66		9.75	Mixed montmorillonite/Illite	Na
Steetley	13.38		16.66		9.64	Mixed montmorillonite/Illite	Na
API							
Bentonite	12.80		16.35		9.75	Mixed montmorillonite/Illite	Na
BW Gel	12.61	6.24	13.79		9.70	Mixed layer	
Ocrna							
Bentonite	13.18	6.18	16.05		9.70	Mixed montmorillonite/Illite	Na
Delta ij							
Delta vGk	12.98	9.92	16.05	9.97	9.81	Mixed montmorillonite/Illite	Na
Cebo Gel	12.80		16.35		9.64	Mixed montmorillonite/Illite	Na