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Performance of Prehydrated Local and Imported Bentonite Clay Mineral in Saline Water

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Abstract— **Drilling fluid performance is a major step in well control. Therefore, it should be designed to meet the required specification for successful drilling operations. During drilling, the drill cuttings are transported through the drilling fluid to the surface, but if not properly designed to give the right rheological and filtration properties, the borehole would not be effectively cleaned thereby leaving the cuttings downhole. This could lead to problems such as; Low penetration rate, hole deviation and stuck pipe problems. Bentonite is a clay mineral that is composed principally of three-layer clay and is widely used as mud additive for rheology and filtration control. This study is on the comparative performance of local and imported bentonite in saline water. Three samples of bentonite from different sources (1 imported and 2 local) were prehydrated, analysed and compared. Different concentrations of salt (NaCl) ranging from 2gms to 10gms were used for the prehydration to ascertain the bentonite performance for different ranges of salinity. The following properties of the bentonite mud from the different bentonite samples were obtained; mud weight, filtration, pH and the rheological properties. The three Bentonite samples prehydrated in fresh water were used for control analysis. From the results, it was observed that the mud density and fluid volume increased as the salinity increased. The pH reduced as the salinity increased and the plastic viscosity was fluctuating with an increase in salinity. The experimental analysis showed that bentonite is best suited for fresh water as saline water tends to destroy and inhibit the prehydration.**

Index Terms—**bentonite performance, saline water, fresh water, mud weight, filtration, pH, rheological properties.**

I. INTRODUCTION

Bentonite (Montmorillonite) is widely accepted and used as mud additive for viscosity and filtration control. It is the main component of water base mud. Although its use is limited by the effects of contaminants, it is nevertheless a valuable mud additive that can be used from spud to TD in almost all petroleum and gas wells. In drilling, a thorough understanding of clays can be the mud engineer's most valuable tool. Clay may be added intentionally, or may enter the mud as a major contaminant through dispersion of drill solids. In either case, it becomes an active part of the system. It is therefore necessary to understand basic clay chemistry in order to properly control water based muds. Clay is a broad term commonly used to describe sediments, soils or rocks consisting of extremely fine-grained mineral particles and organic matter. A good example is the clay found along river banks. These clays are often soft and plastic when wet but becomes hard when dry. The "soft when wet, hard when dry" physical property can be related to certain clay minerals. Clay minerals are fine-grained aluminium silicate minerals having well defined microstructures. In the drilling fluids industry, certain clay minerals such as smectite, a major component of bentonite are used to provide viscosity, gel structure and fluid-loss control. Most clay minerals are hydrous aluminium silicates usually containing alkalis, alkaline earth and iron in appreciable quantities. Clay minerals are typically formed over long periods of time by the gradual chemical weathering of rocks, usually silicate-bearing, by low concentrations of carbonic acid and other diluted solvents. The term "clay mineral" refers to phyllosilicate minerals and to minerals which impart plasticity to clay and which harden upon drying and firing. Currently, most minerals known to produce this property of plasticity are phyllosilicates, because minerals are not defined based on their crystallite size, appropriate phyllosilicates of any grain size may be considered "clay minerals". Likewise, clay minerals are not restricted by definition to phyllosilicates as had been previously defined. Bentonite is a clay material which contains 75% or more of the crystalline minerals montmorillonite. The uses of bentonite at the present time depend on its physical properties rather than its chemical composition. Bentonite in the ground is usually damp, it is a green, soft, wax-like material with a high lustre and on drying, the lustre becomes dull, and the material becomes harder and lighter in colour.

Clay in its dry state has platelets stacked in face-to-face association like a deck of cards, this is aggregation. When the dry clay is placed into fresh water with no agitation, the packets adsorb water, hydrate and swell. Upon agitation, the swollen packets disintegrate into individual plates or smaller packets of plates, this is dispersion. As long as agitation continues, dispersion will be retained and further dispersion can occur. When agitation is stopped, clay platelets will be mutually attracted in edge-to-edge or edge-to-face association. This forces a structure similar to a house of cards termed flocculation. If an anionic chemical thinner (deflocculant) is added, such as polyphosphate, lignosulfonate, or lignite, etc. It neutralizes the positive edge charges on clay platelets and the flocculated state is now deflocculated. When the deflocculated clay slurry encounters strong ionic contamination, (NaCl, CaSO4, Ca(OH)2) the deflocculant chemical is often overpowered leading again to flocculation and even to a sort of aggregation where water is lost from the clay surfaces.

Bentonite occurs in Wyoming in seams interbedded in shales and sandstones. The seams range from a fraction of an inch up to twelve feet in thickness. The bottom contact of a bentonite seam is in most cases sharp while the upper contact is in most cases gradational, especially in shale.

Most of the seams are in the lower part of the upper cretaceous series. They are especially abundant in the Mowry shale, decreasing the number above and below it. The most persistent seam is at the top of the Mowry

The bentonite crystal consists of three layers: an alumina layer

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with a silica layer above and below it. The clay platelet is negatively charged and has a cloud of cations associated with it. If a significant amount of these cations are sodium, the clay is often called sodium montmorillonite. If they are primarily calcium, then the clay is called calcium montmorillonite. When dry clay contacts freshwater, the interlayer spacing expands, and the clay adsorbs a large “envelope” of water. These phenomena allow clays to generate viscosity. The thickness of the adsorbed water film is controlled by the type and amount of cations associated with the clay. Water adsorbed to the large, flat, planar surfaces comprises the major part of the total water retained by hydratable clays. Divalent cations such as Ca^{2+} and Mg^{2-} increase the attractive force between platelets, thus decreasing the amount of water that can be adsorbed. Monovalent cations such as Na+ give rise to a lesser attractive force and allow more water to penetrate between the platelets.

II. MATERIALS AND METHODs

Bentonite (2 local and 1 imported), sodium chloride(NaCl), distilled water, mud balance, viscometer, pH meter, API filter press assembly, beakers, Hamilton beach mixer/blender, Hamilton beach cup/mud cup, measuring cylinder, stop watch, weighing balance. The Bentonite samples are; Imported Bentonite, local Bentonite A and local Bentonite B.

Step 1: with fresh water

350ml of distilled water was measured into the Hamilton beach cup, 22.5gms of bentonite was added and stirred for about 10 minutes and then analysis were carried out for both imported and local bentonite clay respectively.

The fluids were then prehydrated for 16 hours, after which they were stired for 10 minutes, then tests and analysis carried out

Step 2: with saline water

350ml of distilled water was measured into the Hamilton beach cup; 2gms of salt (Nacl) was added into it and stirred. Bentonite of 22.5gms was added to it and various tests were conducted on it. The procedure was carried out for 4gms, 6gms, 8gms and 10gms of salt respectively for both imported and local bentonite.

The fluids were then prehydrated for 16 hours, then the various tests and analysis carried out.

III. RESULTS AND DISCUSSION

Density is weight per unit volume of mud and has a buoyant effect upon the particles. Increasing mud density increases its carrying capacity both by buoyancy and particles due to additional solids in interference from high salinity.

The results are presented in tables 1 to 8 of the Appendix. From the experiment conducted, it was observed that the mud weight increased with increase in salt concentration as shown in fig 2, that is, the more the salt, the heavier the bentonite. Viscosity is significant in affecting cuttings transportation and depends upon the concentration, quality, and dispersal of the suspended solids. It was also observed that salinity has a great effect on the viscosity of bentonite. The viscosity fluctuated with increasing salinity as shown in fig. 4 and fig. 5. Again, it was observed that the higher the salt content in the bentonite, the higher the filtrate volume as shown in fig. 3 and fig. 7. This is so because it does not allow the bentonite to withstand the pressure exerted by the filter press assembly, and this led to increase in filtration. Also, it was also observed that the higher the salt content, the lower the pH of bentonite mud (fig. 6) and pH greater than 7 is acidic and could cause corrosion to the drilling bits, mud pumps and drill strings.

IV. CONCLUSION

Increasing the viscosity of a drilling mud may best be accomplished with the least amount of solids by adding clay which has the highest yield. Lower fluid-loss values can be obtained with bentonite since coarse and medium-sized particles are normally produced from the formation. The quality of the mud will be improved by utilizing high-quality Wyoming bentonite. Hydration and dispersion of dry clay is greatly affected if the makeup water contains salt or various metallic ions. In general the experimental analysis showed that bentonite is more suitable in fresh water formation than in saline water formation.

APPENDIX

Results before prehydration

Table 1 - local and imported bentonite with fresh water

Bentonite Sample	Mud Weight(ppg)	PH	θ600	θ300	PV	YP	Fluid Volume(ml)
IMPORTED	8.60	7	43	35	8	27	13.80
LOCAL A	8.50	7	41	34	7	27	13.90
LOCAL B	8.40	7	34	25	9	16	14.00

Table 2 - imported bentonite with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.60	9.15	42	35	7	28	15.70
4	8.70	8.98	38	33	5	28	18.30
6	8.75	8.85	37	30	7	23	21.00
8	8.90	8.69	35	29	6	23	23.90
10	9.10	8.49	32	27	5	22	24.60

Table 3 - local bentonite A with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.55	8.73	41	31	10	21	17.00
4	8.60	8.40	40	30	10	20	18.50
6	8.70	8.19	38	29	9	20	20.30
8	8.80	7.82	34	27	7	20	24.00
10	8.90	7.70	33	24	9	15	24.80

Table 4 - local bentonite B with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.50	8.30	32	23	9	14	21.00
4	8.60	7.91	30	21	9	12	23.80
6	8.70	7.75	27	17	10	7	24.50
8	8.80	7.31	24	15	9	6	26.00
10	8.90	6.98	21	12	9	3	29.30

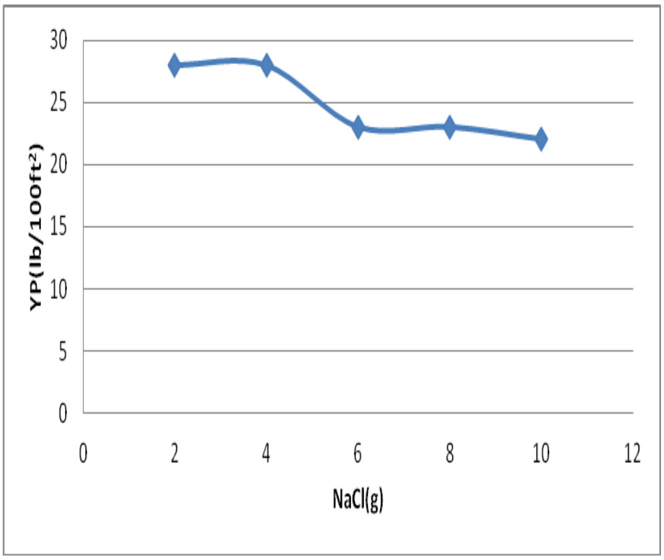

Figure 1 - graphical representation of YP vs NaCl (imported bentonite)

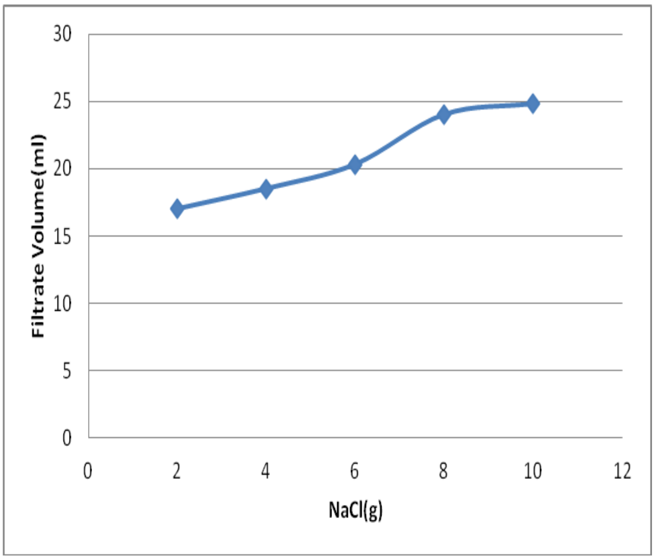

Figure 3 - graphical representation of filtrate volume vs NaCl (local bentonite A)

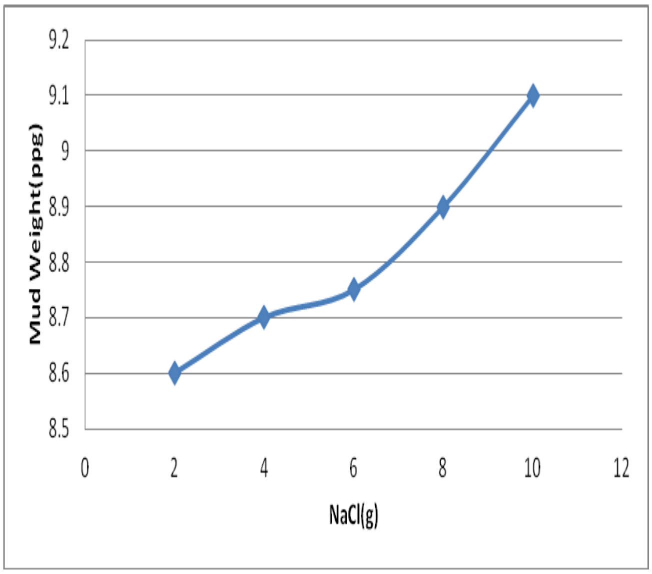

Figure 2 - graphical representation of mud weight vs NaCl (imported bentonite)

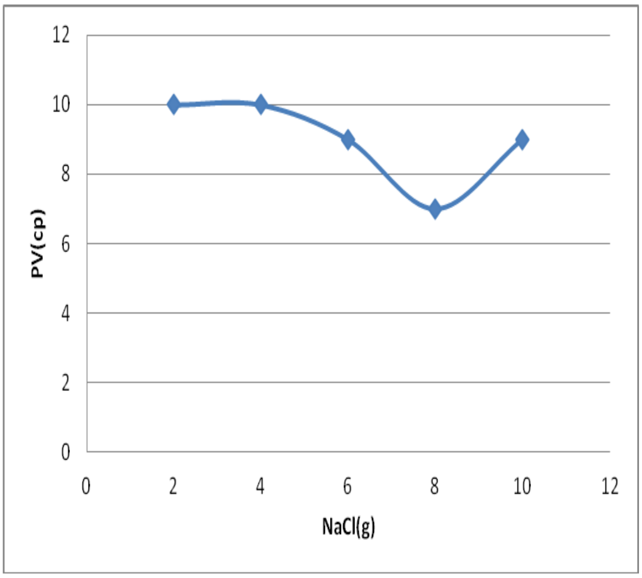

Figure 4 - graphical representation of PV vs NaCl (local bentonite A)

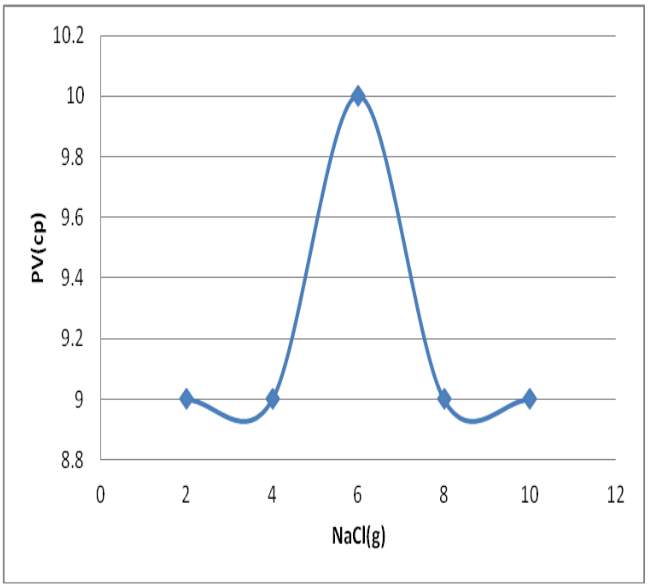

Figure 5 - Graphical representation of PV vs NaCl (local bentonite B)

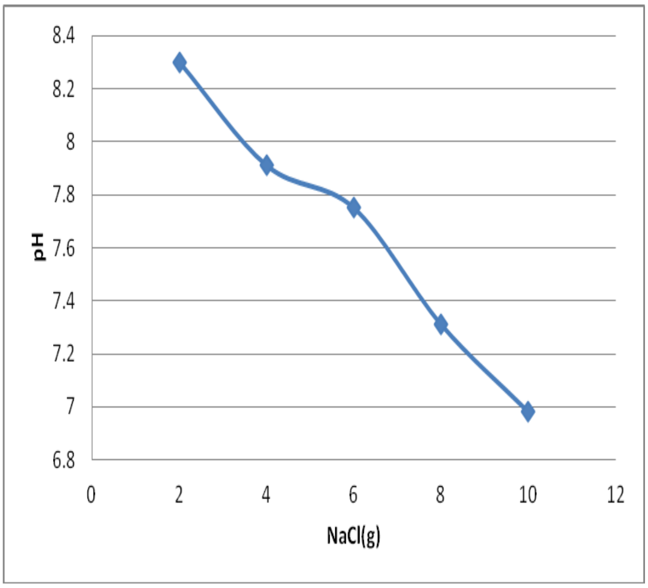

Figure 6 - graphical representation of pH vs NaCl (local bentonite B)

Analysis for bentonite test after prehydration

Table 5 - local and imported bentonite with fresh water

Bentonite Sample	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
IMPORTED	8.50	7	40	35	5	30	13.00
LOCAL A	8.50	7	40	33	7	26	13.20
LOCAL B	8.40	7	32	27	5	22	13.40

Table 6 - imported bentonite with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.60	9.15	39	30	9	21	15.3
4	8.70	8.98	36	27	9	18	17.00
6	8.80	8.85	34	26	8	18	19.40
8	8.90	8.69	30	23	7	16	21.80
10	9.30	8.49	29	20	9	11	22.40

Table 7 - local bentonite A with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.50	8.73	37.00	32	5.00	27.00	16.80
4	8.60	8.40	35.00	29	6.00	23.00	18.20
6	8.65	8.19	34.80	27	7.80	19.20	19.10
8	8.80	7.82	33.00	24	9.00	15.00	22.90
10	9.00	7.70	30.00	20	10.00	10.00	25.00

Table 8 - local bentonite B with increasing salinity

NaCl (gms)	Mud Weight(ppg)	pH	θ600	θ300	PV	YP	Fluid Volume(ml)
2	8.40	8.30	31	22	9	13	20.00
4	8.70	7.91	30	21	9	12	22.40
6	8.80	7.75	26	18	8	10	24.20
8	9.00	7.31	25	15	10	5	27.00
10	9.10	6.98	22	13	9	4	29.70

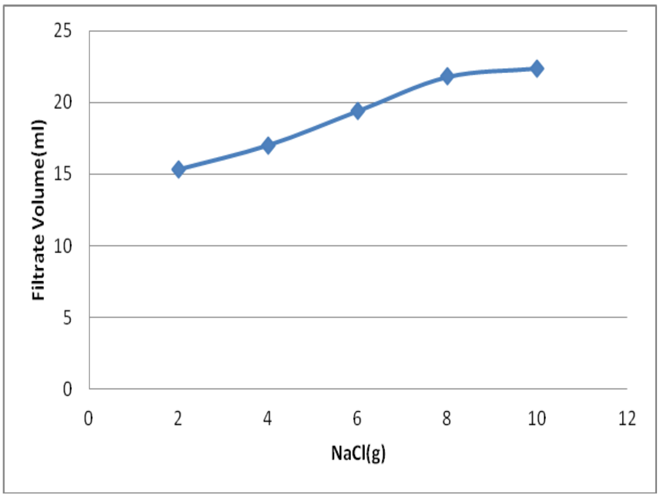

Figure 7 - graphical representation of filtrate volume vs NaCl (imported bentonite)

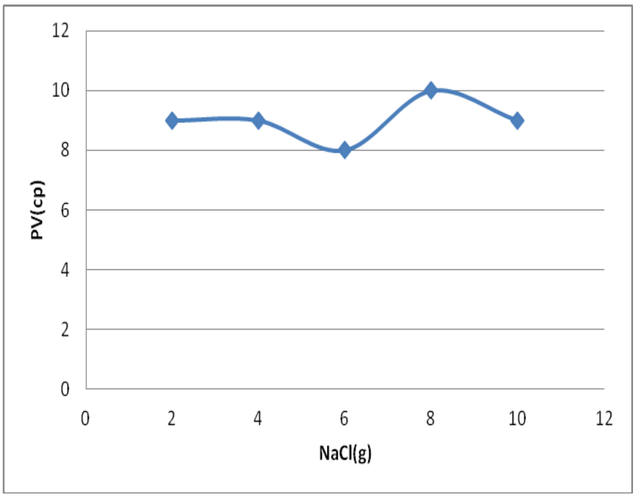

Figure 9 - graphical representation of PV vs NaCl (local bentonite B

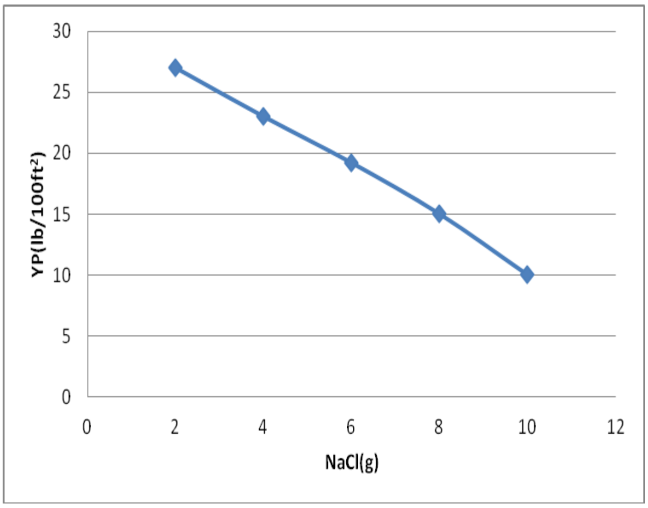

Figure 8 - graphical representation OF YP vs NaCl (local bentonite A)

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