



## -RESEARCH ARTICLE-

### Usage of Vermiculite as Additive Material in Water-Based Drilling Muds

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#### Abstract

Drilling mud is used in drilling operations to ensure well stability and to transport the cut-offs to the surface and is generally classified as; Spud, Lignosulfonate and Polymer types. Spud Mud is the simple mud and mostly used at the beginning of drilling operations. It is mainly composed of bentonite and water. With increasing depth, It is hard to keep well stability and to carry cuttings from the bottom of hole to the surface with the basic drilling fluid. Thus, some materials are used to maintain the rheological and filtration properties of the mud. One of them is vermiculite that is a general name of the hydrated ferromagnesian aluminium silicate group. It has expanded properties when heated. Like all clay minerals, the cation exchange capacity is very high and very similar to the montmorillonites in terms of high cation exchange capacity. In this study, the usage of vermiculite as an additive material in drilling muds was investigated. Spud muds containing vermiculite in different amounts were prepared. Then rheological and filtration analysis of the muds were done according to American Petroleum Institute (API) RP-13B-1 Standard. When evaluated the results, AV reached 41cP, PV 27cP, YP 28lb/100ft<sup>2</sup>, 10 sec. gel strength 17lb/100ft<sup>2</sup>, 10 min. gel strength 26 lb/100ft<sup>2</sup> and filtration 9cc. The results showed that the vermiculite can might be used as a viscosifier and fluid loss reducing additive material in the drilling mud.

#### Keywords:

Drilling mud, Bentonite, Vermiculite, Viscosity, Rheology

#### Article history:

Received 18 April 2018, Accepted 08 May 2018, Available online 14 May 2018

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## Introduction

Water-based Spud mud is among the mainly drilling fluids. Thus, it's mostly important for drilling operations. It provides some specific properties for drilling operation such as prevent kick fluids, carry cuttings from beneath the bit to surface, suspend solids, form low-permeability filter cake, maintain the stability of the borehole, reduce friction between the drilling string and the sides of the hole, cool and clean the bit, assist in the collection and interpretation of information available from cuttings (Caenn & Chillingar, 1996; Lyens & Plisga, 2004; Hemphill & Larsen, 1997; Knox & Jiany, 2005).

Rheological and filtration properties of the mud varies during circulation in the well and loses flow features. In order to improve rheological properties of drilling mud, different additive, chemicals and polymers are used. These are generally CMC, PAC, XCD, Modified Starch and also clay minerals as viscosifier and fluid loss reducer additive material (Dyke, 2000).

Vermiculite is a general name of the hydrated ferromagnesian aluminium silicate group. It shows similar properties with mica group minerals. Like all clay minerals, the cation exchange capacity is very high and very similar to the montmorillonites in terms of high cation exchange capacity. The layer structure is 2:1 and there are four type. These are soil vermiculite, authigenic vermiculite, metamorphic vermiculite and macroscopic vermiculite. Generally expanded vermiculite is preferred in the industry applications, because of its specific chemical and physical properties. Nowadays, there are many application area such as building, agriculture, foundry and steel factories, oil refineries, cement companies, filler material in plants and drilling mud additive material in drilling operations (Bassett, 1959; Bassett, 1963; Berker, 1992; Erseçen, 1992; Hattaway, 1955; Kuşcu, 2001; Harben, 1995; Eaton, 1997; MRE, 1989).

In this study, a usage of vermiculite as additive material in muds was evaluated. Samples containing vermiculite in different concentrations (0.5, 1, 2, 4, 6 % w/v) were prepared. Then rheological properties such as apparent viscosity (AV), plastic viscosity (PV), yield point (YP), 10 sec. gel strength, 10 min. gel strength and filtrations analyses were done according to American Petroleum Institute (API) RP-13B-1 Standard (API, 2003).

## Materials and Methods

### *Bentonite*

Bentonite was supplied from Eldivan-Çankırı region in Turkey. It is a sodium type vermiculite and the particle size is lower than  $75\mu$  (Fig. 1). It is also suitable in terms of the API Specification 13A standard (API, 1990). Its elemental composition is given in Table 1.



Fig. 1. Bentonite used in Experiments

Table 1. Chemical analysis of bentonite (Kök, 2017).

Oxides	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	MgO	CaO	K <sub>2</sub> O	TiO <sub>2</sub>
Concentration (wt %)	65.3	20.3	5.75	2.38	2.24	1.3	0.66	0.23

### *Vermiculite*

Vermiculite was brought from Yıldızeli, Sivas region in Turkey. Particle size of the vermiculite was found between 0.35mm and 1mm, so it was named as super fine vermiculite (Fig. 2). The chemical composition of the vermiculite is given in Table 2.



Fig. 2. Vermiculite (Super Fine) used in Experiments

Table 2. Chemical analysis of vermiculite (Uysal, 2012).

Oxides	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	K <sub>2</sub> O
Concentration (wt%)	36.9	12.0	10.0	28.8	1.8	7

### *Experiments*

First, Spud mud containing 6% w/v bentonite was prepared according to API standards. Then, vermiculite was added at different amounts (0.5, 1, 2, 4, 6 % w/v) and 6 mud samples were prepared for the investigation of the rheological and filtration properties.

The samples were aged 16 hours. Rheological and filtration analyses such as AV, PV, YP, 10 sec. gel strength and 10 min. gel strength analyses were done according to API RP-13B-1 Standard. The filtration test was measured using a filtration device (API Filter press) according to the same standard. Each experiment was repeated three times and the average values were taken to decrease experimental errors.

### **Results**

The data obtained from rheological and filtration analysis are given in Table 3 and the graphs are represented in Fig. 3-4-5-6-7 and 8 respectively.

Table 3. All results of experiments

Samples (% w/v)	AV (cP)	PV (cP)	YP (lb/100ft <sup>2</sup> )	10 sec. gel strength (lb/100ft <sup>2</sup> )	10 min. Gel strength (lb/100ft <sup>2</sup> )	Filtration (cc)
Based	4.5	3	3	1	2	20
0.5	5	3	4	2	4	19
1	8	6	4	4	6	18
2	12	9	6	6	10	16
4	25	15	20	10	14	12
6	41	27	28	17	26	9

Evaluation of the all results showed that the vermiculite enhanced the rheological and filtration properties of the water-based mud. The values of AV, PV, YP, 10 sec. gel strength and 10 min. gel strength specifications increased while fluid loss was decreased with increasing the vermiculite concentration in the mud.

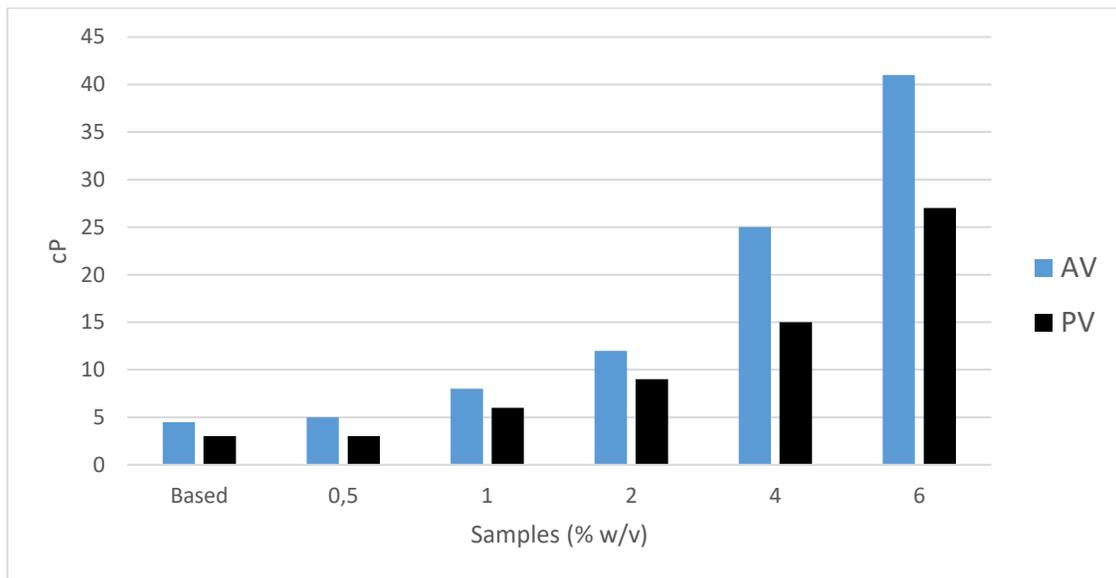


Fig. 3. Analysis results of AV and PV

Fig. 3 indicated that cP values of AV increased with increasing of the vermiculite ratio. The cP values of the Based solution and the drilling mud mixing 6% w/v vermiculite were found as 4.5 cP and 41 cP, respectively. The 41 cP value is enough for nearly all of water-based drilling muds.

Same trend was observed for the plastic viscosity, The value of cP increases with the increase in the amount of vermiculite in the water based drilling mud. The maximum value was

recorded for 6% w/v vermiculite addition. However, the optimum value was obtained with the 4% concentration. This result is enough for nearly all of water-based drilling muds.

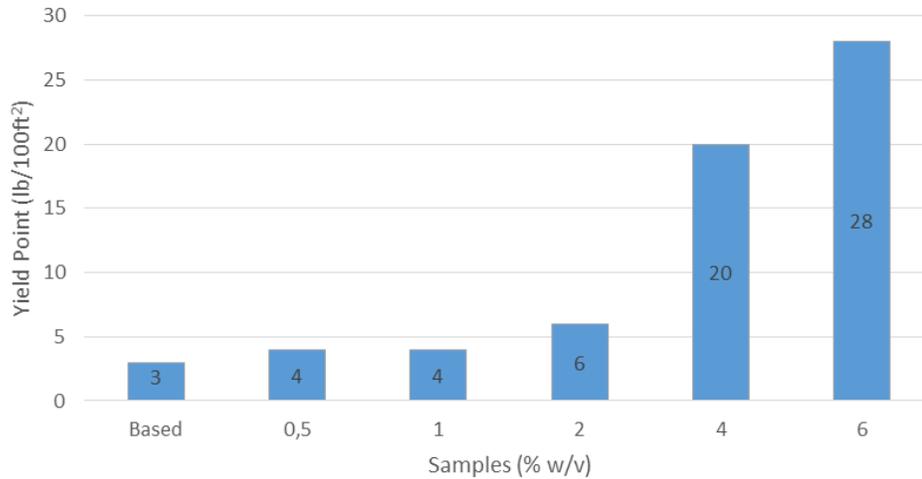


Fig. 4. Analysis results of YP

As known that yield point is another important factor for a pump selection and the pressure arrangement. Fig. 4 indicates that the optimum value was reached at the 4% w/v vermiculite concentration and enough for nearly all of water-based drilling muds.

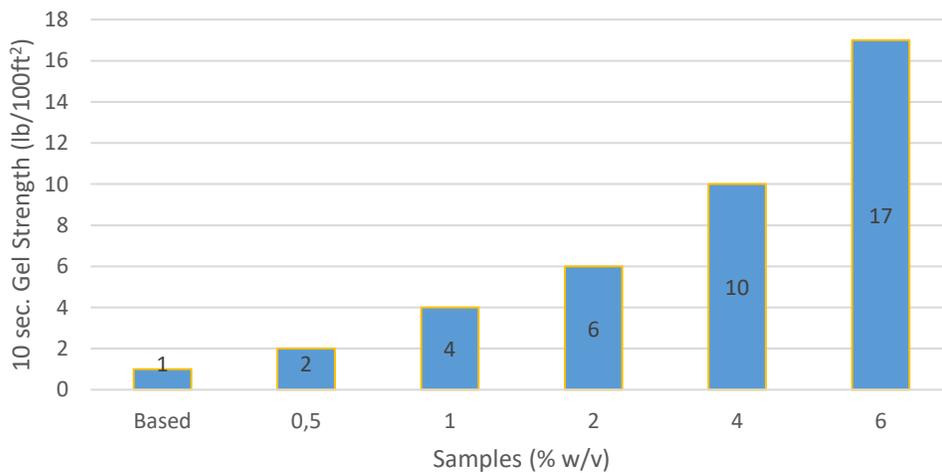


Fig. 5. Analysis results of 10 sec. gel strength

According to results of 10 sec. gel strength (Fig 5) and 10 min. gel strength (Fig. 6), the addition of vermiculite increased the gelation for both. Based solution value was 1 lb/100ft<sup>2</sup> and 2 lb/100ft<sup>2</sup>, respectively and these values were not enough. But as a result of this increase with 6% concentration of vermiculite, 10 sec. gel strength reached 17 lb/100ft<sup>2</sup>. However, the optimum

value for the 10 sec. gel strength and 10 min. gel strength were determined at 2% w/v and 4% w/v vermiculite concentration. The obtained values were enough for nearly all of water-based drilling muds.

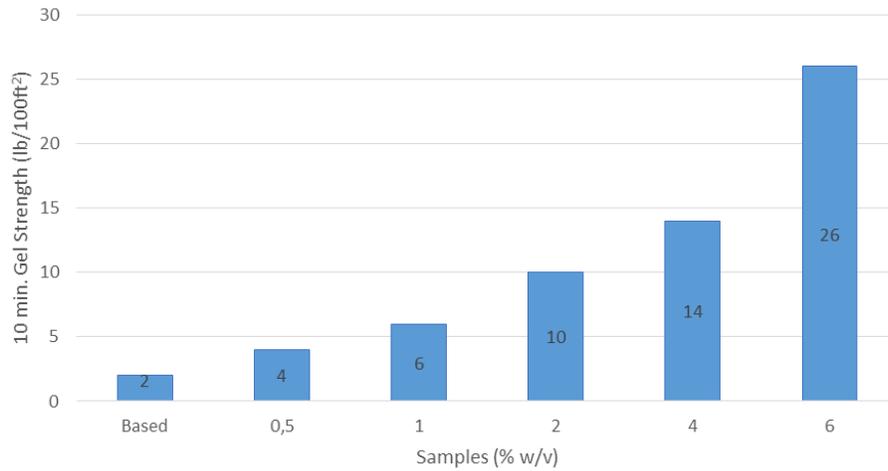


Fig. 6. Analysis results of 10 min. gel strength

According to results of 10 min. gel strength, vermiculite increased the gelation. Based solution value is 2 lb/100ft<sup>2</sup> and not enough. But as a result of this increase with 6% concentration of vermiculite, 10 min. gel strength reached 26 lb/100ft<sup>2</sup>. Reached the optimum value with the 4% concentration and enough for nearly all of water-based drilling muds.

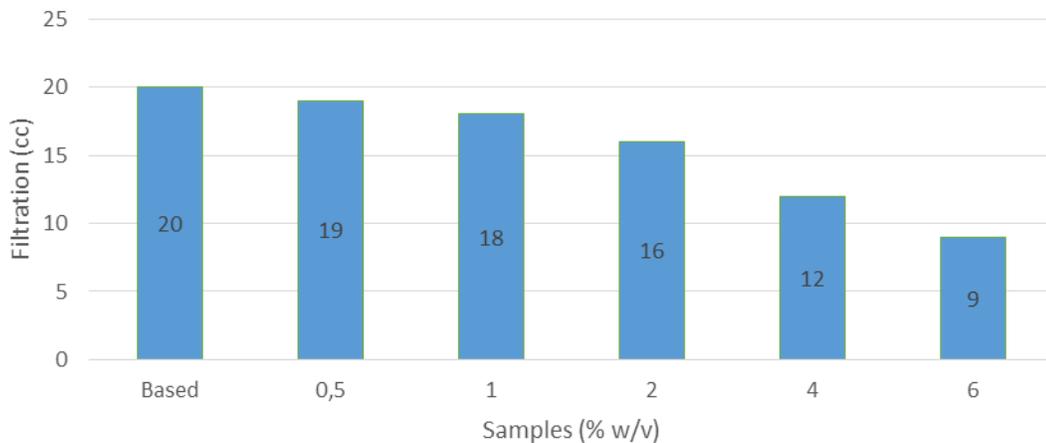


Fig. 7. Analysis results of filtration

The filtration loss of the muds decreased with increasing the vermiculite ratio into the muds. It can be explained with the super fine particle size which can penetrate into holes and decreased permeability of the mud into formations. Based solution value was 20 cc but as a result of this increase with 6% concentration of vermiculite, filtration reached 9 cc. Reached the

optimum value was with the 2% concentration. This result is enough for nearly all of water-based drilling muds.

### Discussion

In this study, usability of vermiculite in spud muds was evaluated. Samples containing vermiculite in different concentrations (0.5, 1, 2, 4, 6 % w/v) were prepared and aged 16 hours. Then, AV, PV, YP, 10 sec. gel strength, 10 min. gel strength and fluid loss analyses were done according to API.

When evaluated the experiments and results, it is determined that vermiculite has positive effects on the rheological and filtration properties. As a result, vermiculite can be used as viscosifier and fluid loss reducer additive material in water-based drilling muds.

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