EVALUATING THE PERFORMANCE OF MALAYSIA HEMATITE AND IT'S MIXTURES WITH BARITE AS WEIGHTING MATERIAL IN WATER-BASED MUD

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Abstract

This paper discusses the prospect of using Malaysia hematite as weighting material in water-based mud. The discussion is based on laboratory experiments.

Currently, in the petroleum industry, barite (commercial name for barium sulphate) is the standard weighting material used to elevate mud weight to a predetermined value. The supply of quality barite may fall short in the forseeable future due to the increase in drilling activities and depleting reserves of quality barite. Thus there is a need to look for an alternative weighting material.

In this study, the performance of Malaysia hematite and it's mixtures with barite were compared to barite, the standard weighting material used in the petroleum industry, in water-based mud. The experimental results revealed that for a given mud density, mud sample with higher percentage of hematite produced higher yield point and gel strength. Nevertheless, it produced little differences in plastic viscosity. The siginificant advantage realised in utilising hematite was it gave a lower solid content.

The experimental study also revealed that hematite was found to be more abrasive than barite. The abrasiveness rate was found to increase proportionally with the well angles (from horizontal).

Based on this preliminary study, it is concluded that Malaysia hematite has the potential to be used as weighting material in drilling mud.

Introduction

In the petroleum industry, a production well has to be drilled and developed prior to producing oil from a producing zone. The success of drilling a production well does not depend entirely on the utilisation of the state-of-art drilling equipments, but is also influenced by the type of drilling mud used (Gray and Darley, 1981). Fresh water mud is the most commonly used drilling mud in making a production well. The fresh water mud is used to carry cuttings to surface, to cool drill bit, to prevent excessive fluid loss into formation, and the most important of all, is to control well pressure.

In order to control well pressure effectively, drilling mud should impose sufficient hydrostatic pressure, which is normally in the range of 250 psi (1724 kPa) to 450 psi (3103 kPa) higher than the pressure in the producing zones. Barite, a commercial name for barium sulphate, is the standard weighting material used in the petroleum industry to increase mud weight to the required level. Influx of formation fluids into wellbore, a phenomenon known as kick, will only occur if the pressure in the producing zones is greater than the hydrostatic pressure. If the influx could not be controlled effectively in a relatively short period, it may cause blowout - a disaster which will cause massive damage to properties, loss of lives and severe pollution problems.

Malaysia petroleum industry consumes about 20,000 tonnes of barite annually and is being sourced locally. As Petronas has geared up it's exploration activities in order to increase hydrocarbon reserves, coupled with the incentives given by the Government of Malaysia to oil companies that venturing into deep sea drilling activities, it is anticipated that the supply of quality barite may fall short in the forseeable future (Walker, 1982). Thus, the Drilling mud research group has initiated an effort to look for an alternative local weighting material. One of the minerals that being studied currently by the group is hematite.

Hematite, an iron-based mineral, could be found abundantly at many locations in Malaysia, especially in the northen region, namely Gunung Panjang Estate, Gunung Rapat etc. Generally, hematite has higher relative density of 4.9-5.3 as compared to barite (4.2-4.5). Hematite and barite hardness are in the range of 5.5-6.5 and 2.5-3.5 (Mohs scale) respectively.

The hematite used in this study was sourced from a company located in Ipoh, Perak. In order to evaluate the potential of Malaysia hematite as weighting material in water-based mud, a laboratory experiment was conducted on the mud sample, namely rheological properties test, fluid loss test, solid content analysis and abrasiveness test. The experimental results derived from the hematite muds were then compared to barite.

Materials and Methods

This study involved with a laboratory experiment (Saipol, 1996). The water-based mud samples were prepared by utilising the following formulations used in the field. It comprised of fresh water, potassium chloride, caustic soda, soda ash, PAC R, PAC UL, Foralys, Resinex, Glycol, Polypus and weighting material. The weighting material used was either barite, hematite or mixtures of both, and were added separately in proportion into mud samples to form the required mud weight. Five different compositions of weighting material were used in this experiment:

Sample 1 comprised of 100% barite (100%B).
Sample 2 comprised of 75% barite and 25% hematite (75%B-25%H).
Sample 3 comprised of 50% barite and 50% hematite (50%B-50%H).
Sample 4 comprised of 25% barite and 75% hematite (25%B-75%H).
Sample 5 comprised of 100% hematite (100%H).

Each of the weighting materials and their mixtures was added into water-based mud to form mud weight ranging from 9 ppg to 12 ppg.

Barite, the principle weighting material used in the petroleum industry, was given by Kota Minerals (M) Sdn Bhd of Kemaman Supply Base. Whilst the raw hematite sample was obtained from a company located in Ipoh, Perak. The hematite sample was ground prior to analysing chemically and physically to ensure that it followed the API specifications as set forth for hematite.

In this study, the weight of the mud samples were determined via the conventional mud balance. The Baroid rheometer was then used to measure the rheological properties of the mud samples, namely viscosity, yield point and gel strength. Whilst the solid content analysis was performed via the retort apparatus.

The HPHT filter press was used to evaluate the fluid loss properties of the mud samples, where data taken from this experiment were volume of filtrate collected against time and filter cake thickness. Darcy equation was used to compute the permeability of the filter cake formed. This laboratory experiment was conducted according to the API standard procedures.

To evaluate the abrasiveness characteristic of hematite, an abrasiveness test rig was used (Figure 1). This test rig comprised of a mud tank (which could accomodate 40 liters of mud), a mud pump, s stirrer, two test pipes (namely steel and aluminium), pressure gauges, valves, PVC pipes and two ultrasonic flowmeter (Andrew, 1997). In the abrasiveness test, each of the mud samples was circulated through the test pipes separately at a velocity ranging from 1.5 m/s to 10 m/s. Both test pipes were weighed initially prior to installing in the system. Each of the mud sample was then circulated continuously through the test pipes for a period of 3 hours, before the abrasiveness test was halted. Both test pipes were diconnected from the system and were weighed again. Thus by utilising the experimental data, the abrasiveness rate of each sample could be computed, the net weight loss experienced by each of the test pipes divided by circulation time.

Results and Discussion

The experimental results of sand content analysis was shown in Figure 2. It was found that 100%H mud gave lower solid content as compared to 100%B mud. For the mixtures, even though the 75%H-25%B mud produced higher solid content than 100%H, but less than other mixtures. This phenomenon was due to the speficic gravity of hematite which was higher than barite. Generally, the significant advantage of using hematite as weighting material especially when high density mud is required is it could increase the penetration rate due to less particles presence in the vicinity of drill bit, thus reducing rig time.

The relationship between mud density (or mud weight) and plastic viscosity was depicted in Figure 3. The experimental results revealed that 100%H mud gave higher readings of plastic viscosity than 100%B, but the trend was found to reverse as mud weight increased higher than 10.4 ppg. Whilst the 75%H-25%B mud curve lied closely to the 100%H mud.

This was due to the larger amount of barite particles presence in the mud than hematite, which would increase friction between particles, thus increasing the plastic viscosity. The effect was found to be significant when mud weight was increased to more than 10.4 ppg. High viscosity mud may yield several problems such as penetration rate decreasing etc.

For a given mud weight, it was found that 100%H mud produced higher yield strength than 100%B mud, as shown in Figure 4. The experimental results also revealed that eventhough the 75%H-25%B mud gave higher yield strength than other mixtures, but lower than 100%H. This was due to ferromagnetic characteristics that possessed by hematite, thus producing greater attractive forces amongst the particles. Generally, drilling mud with optimal yield strength could carry cuttings to surface in a more effective manner.

In Figure 5, for a given mud density, 100%H mud gave higher gel strength than 100%B. This phenomenon showed that hematite particles have stronger tendency to attract to each other than barite. Mud with moderate gel strength could suspend mud particles including the drill cuttings when mud circulation was halted temporarily. Nevertheless, mud with high gel strength might cause several problems such as a high power pump is required to initiate mud circulation, increase torque on drill string etc.

Figure 6 revealed the experimental results of fluid loss test, by using the HPHT filter press. This test was conducted at a pressure differential of 500 psi and temperature of 200^{o}F. It was found that 100%H mud experienced lower fluid loss than 100%B. Whilst the 75%H-25%B mud gave better performance than other mixtures, but produced higher fluid loss than 100%H. This was due to less particles presence in the 100%H mud, thus enable the differential pressure to produce a thin low permeability mud cake. This phenomenon could reduce well productivity (Chesser, Clark and Wise, 1994).

Figures 7 and 8 are shewing the abrasiveness test results. It was found that 100%H mud produced higher abrasiveness rate than 100%B. Whilst the 75%H-25%B mud gave higher abrasiveness rate than other mixtures. Generally, hematite is more abrasive because it has higher hardness of 5.5-6.5 compared to barite which is around 2.5-3.5 (Mohs scale). The experimental results also revealed that the abrasiveness rates produced by all the mud samples increased as well angle was elevated from 30^{o} to 90^{o} from horizontal due to the better contact presence between particles and the inner surface of pipe.

Conclusion

1. Malaysia hematite has the potential to be used as weighting material in drilling mud, especially when higher mud weight is required.

2. The rheological properties produced by 100% hematite mud was found to be comparable with performance produced by 100% barite mud. The 75%H-25%B mud gave better performance than other mixtures.

3. Mud samples which comprised of larger hematite particles gave lower solid content. This phenomenon could increase rate of penetration.

4. The presence of hematite particles in drilling mud could reduce fluid loss.

5. Hematite is found to be more abrasive than barite. The experimental results also revealed that the abrasiveness rate is proportional to the increase in well angle from horizontal.

Acknowledgement

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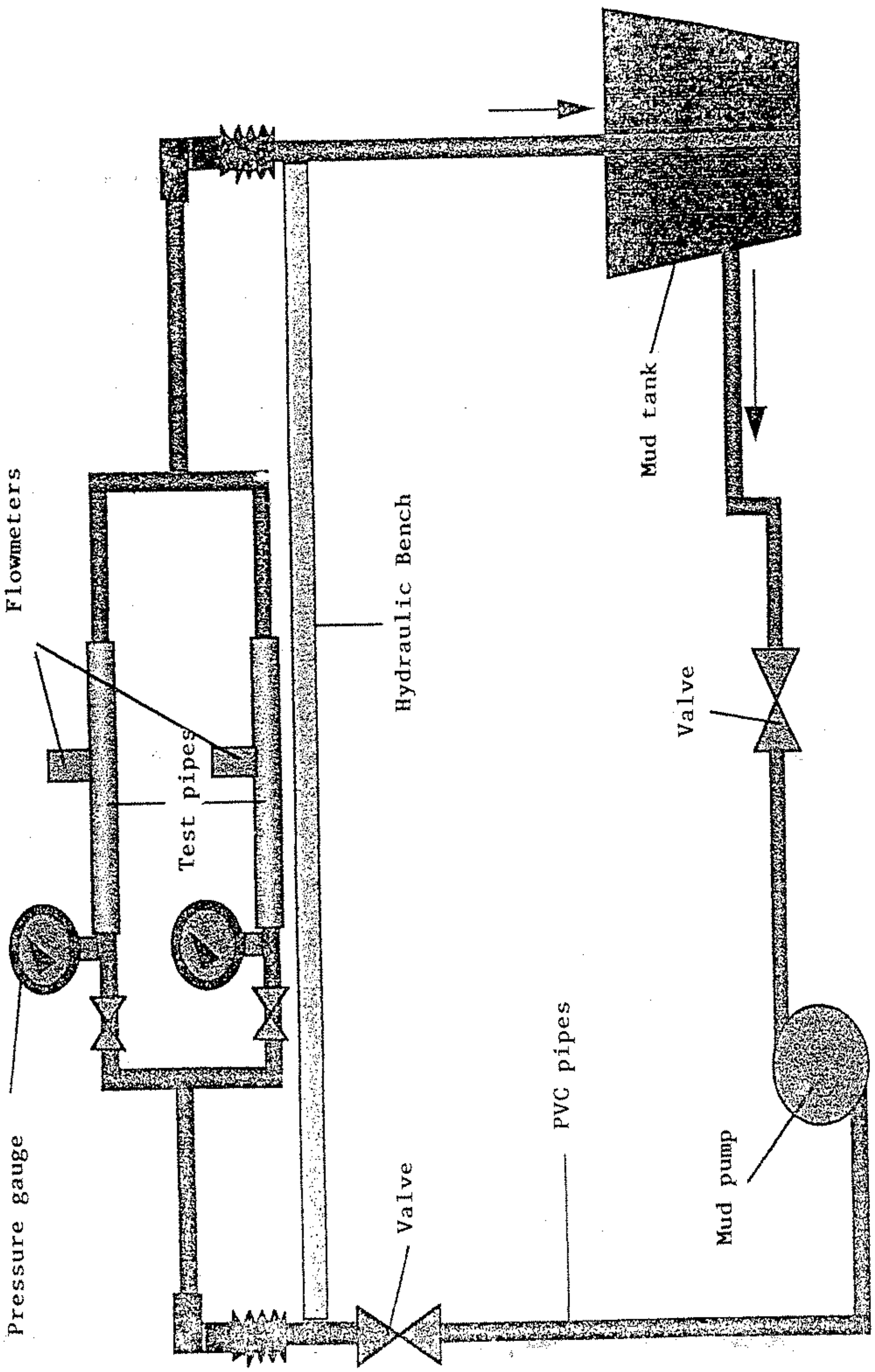

Figure:1: Abrasiveness test rig

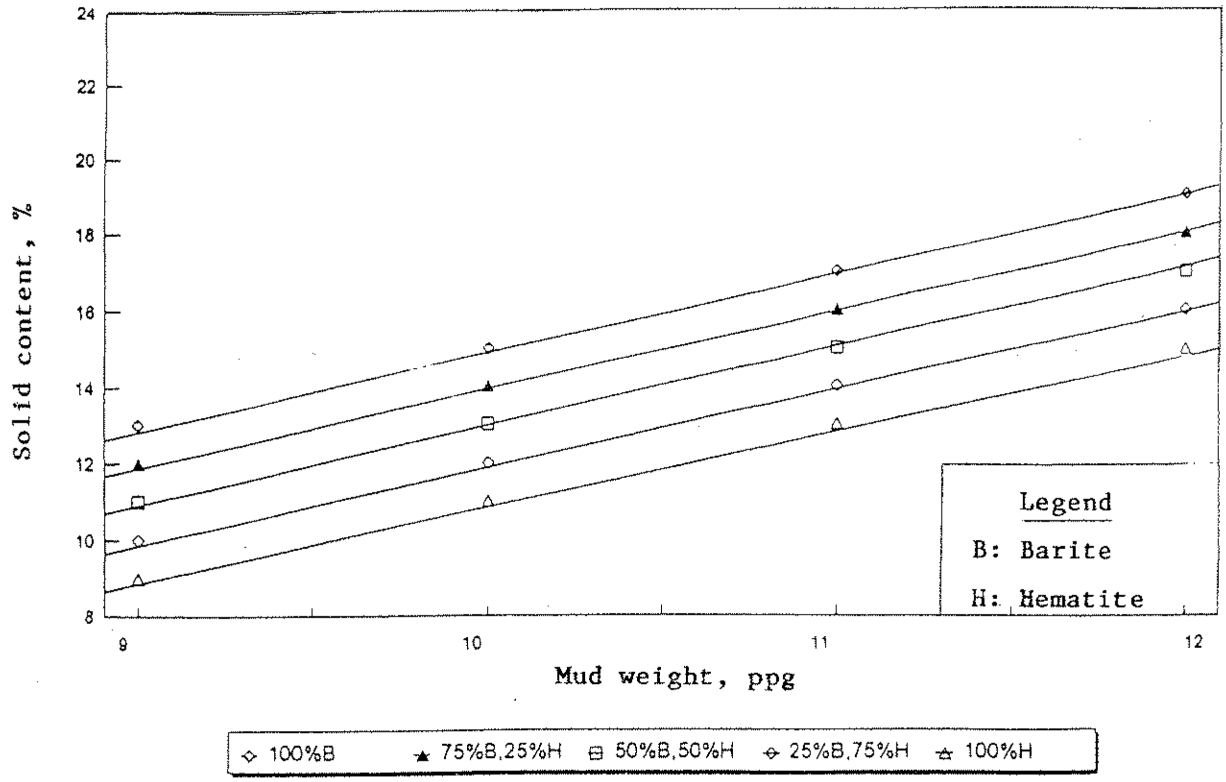

Figure 2: Solid content vs mud weight

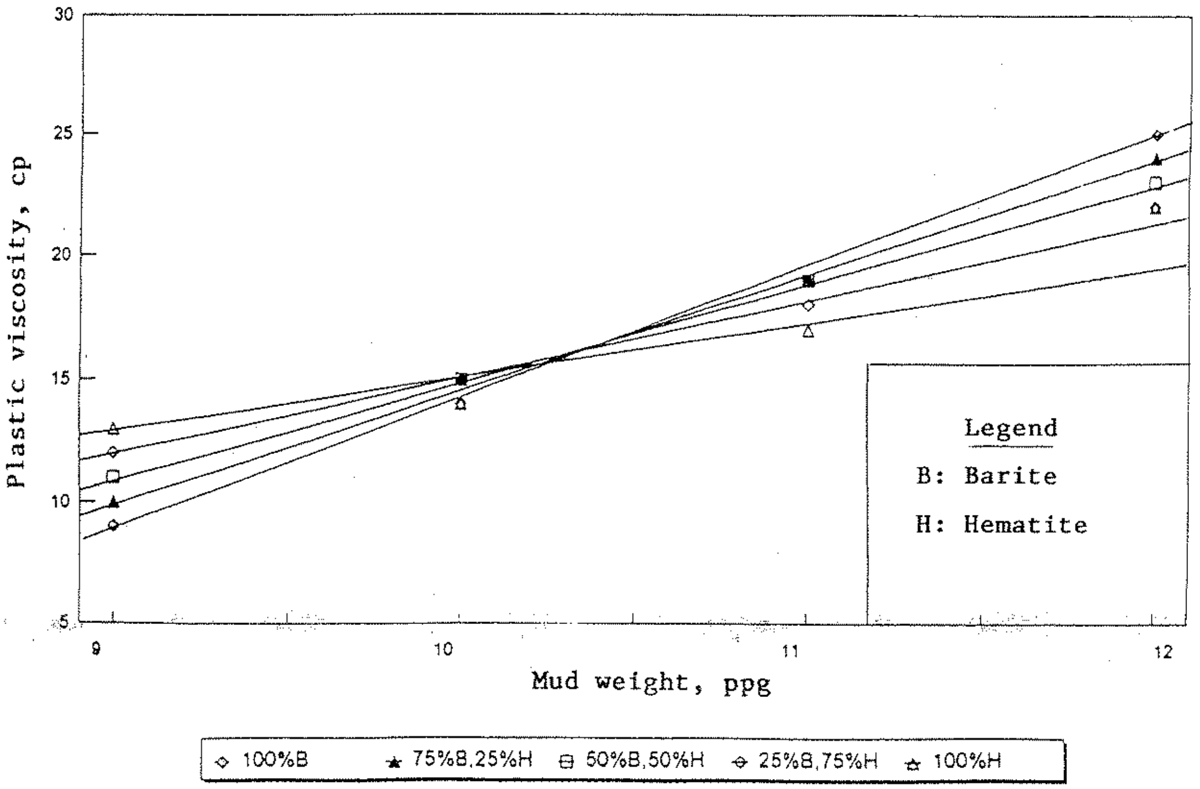

Figure 3: Plastic viscosity vs mud weight

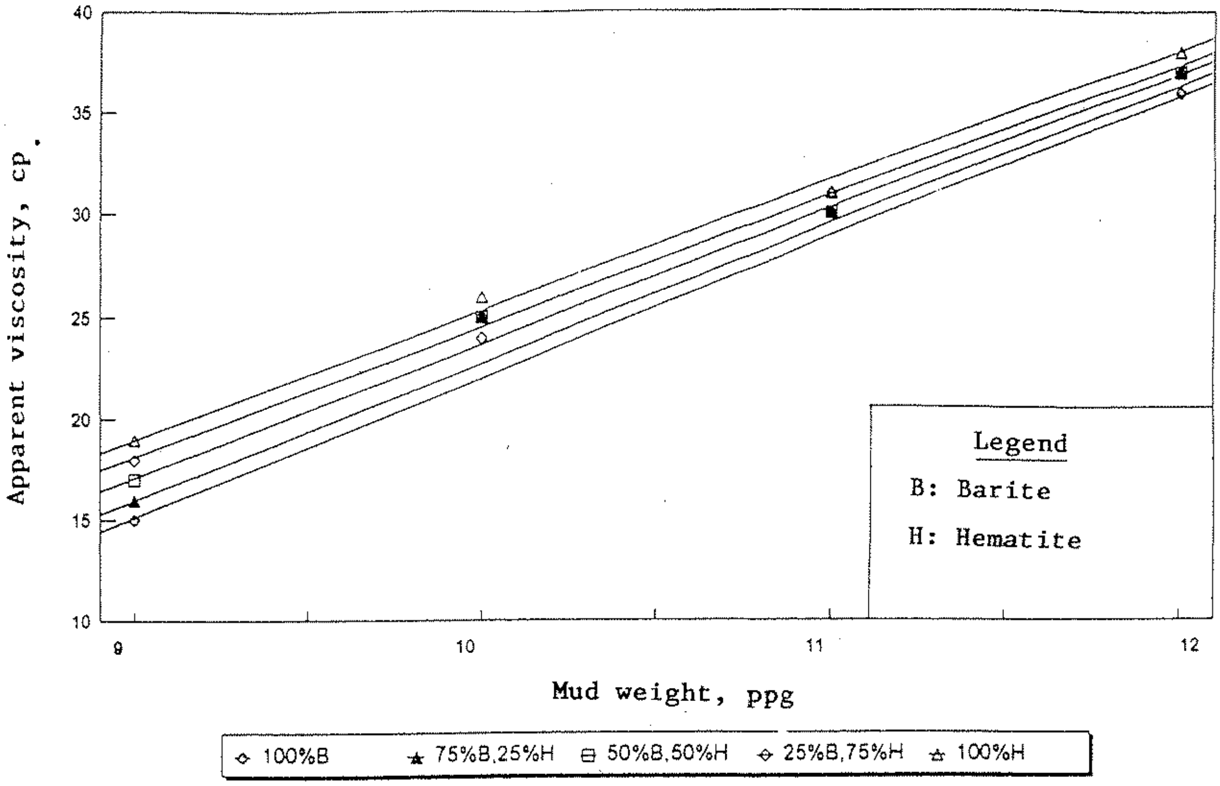

Figure 4: Apparent viscosity vs mud weight

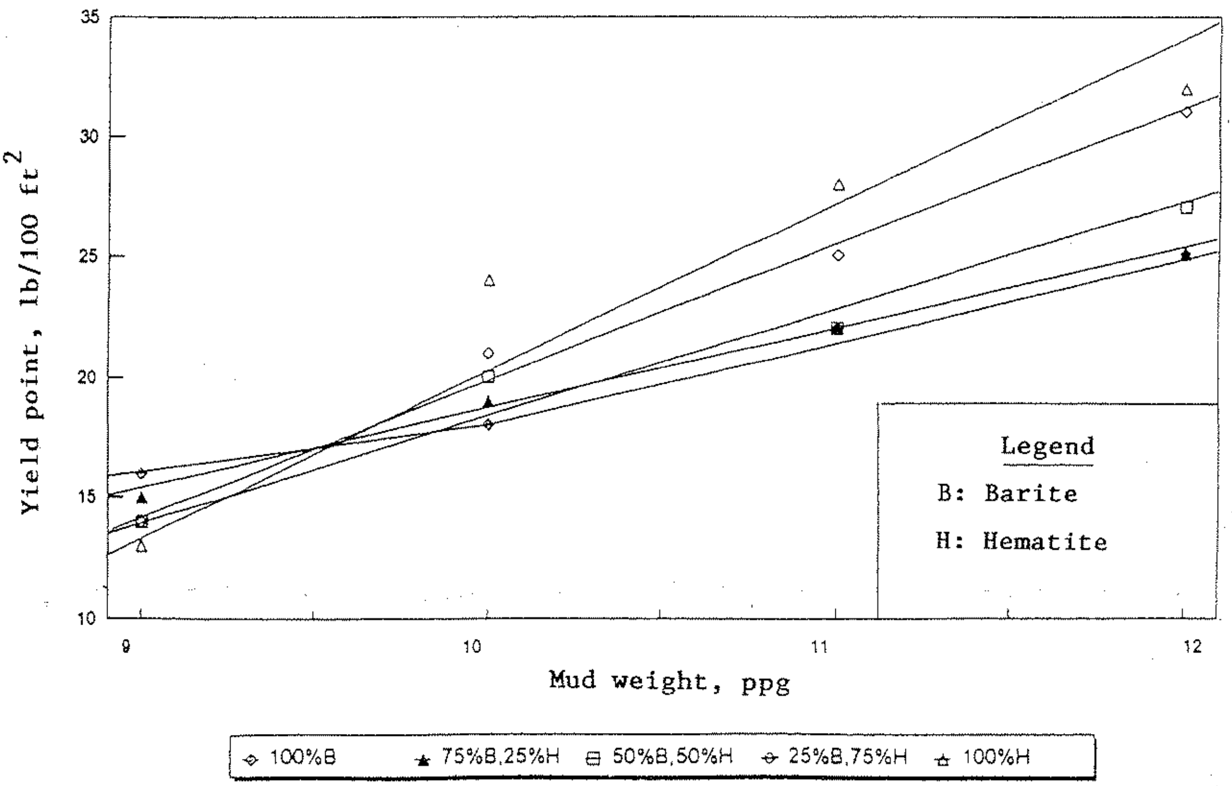

Figure 5: Yield point vs mud weight

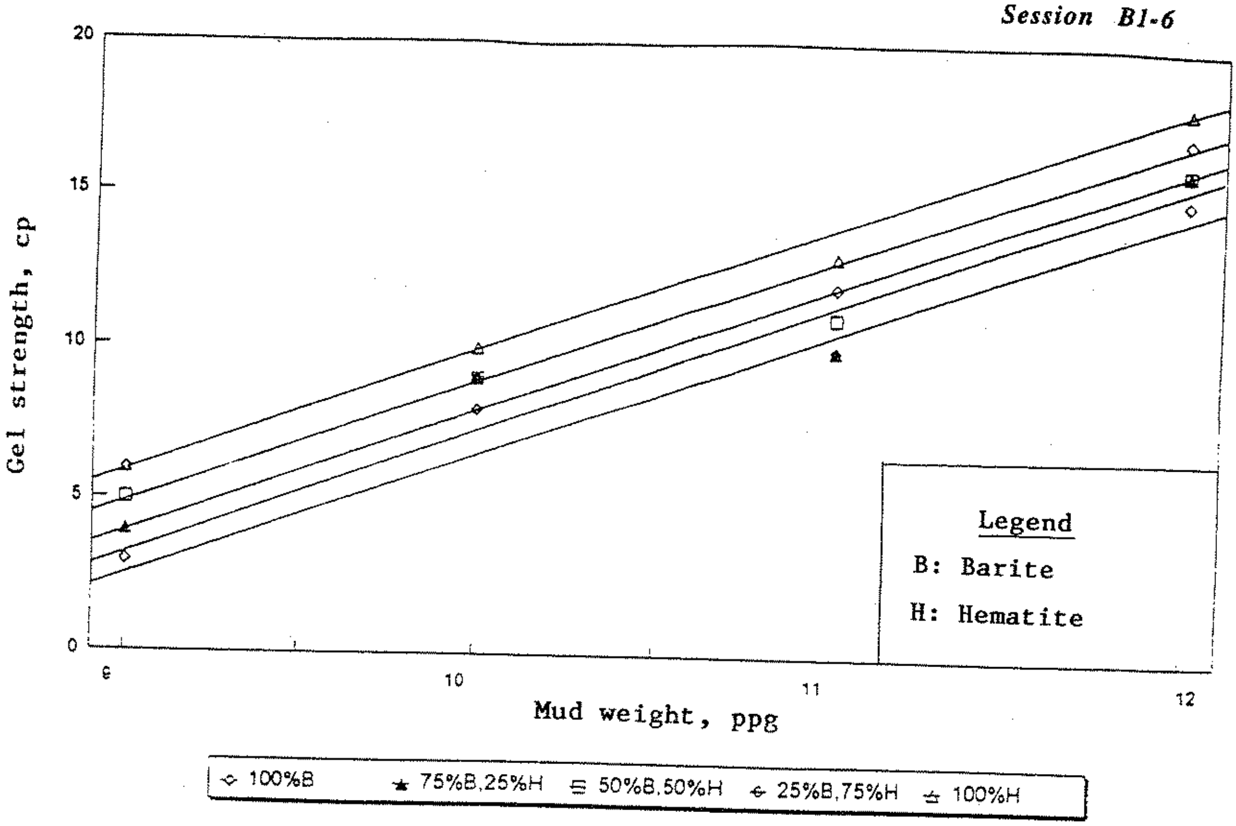

Figure 6: Gel strength vs mud weight

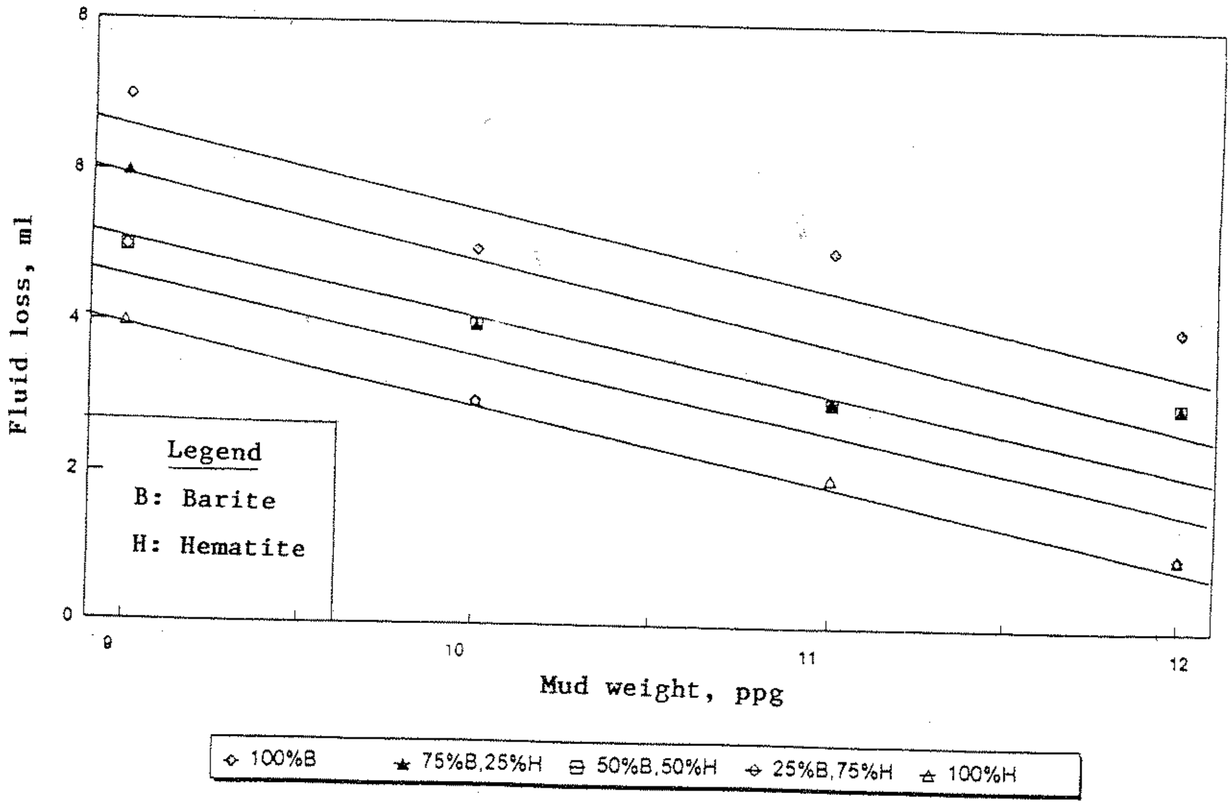

Figure 7: Fluid loss vs mud weight

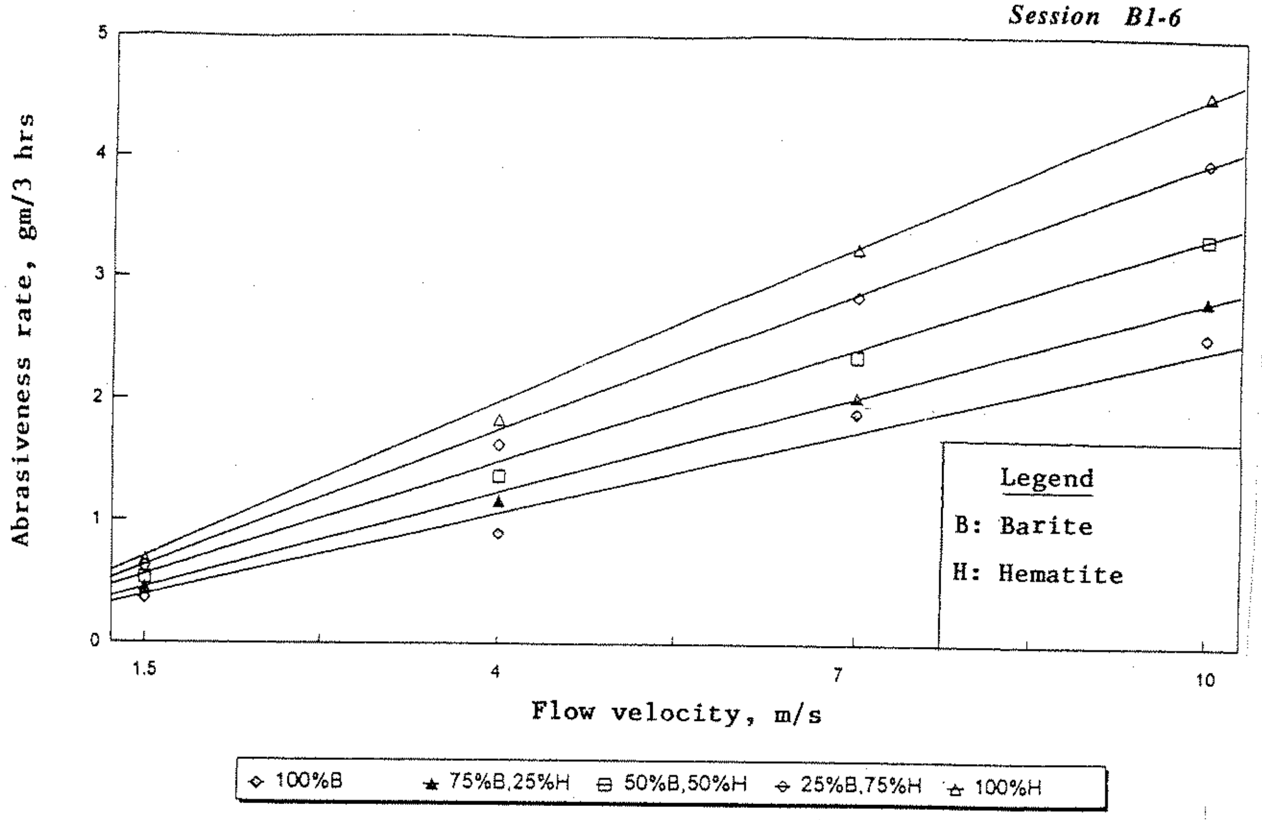

Figure 8: Abrasiveness rate vs flow velocity via aluminium test pipe

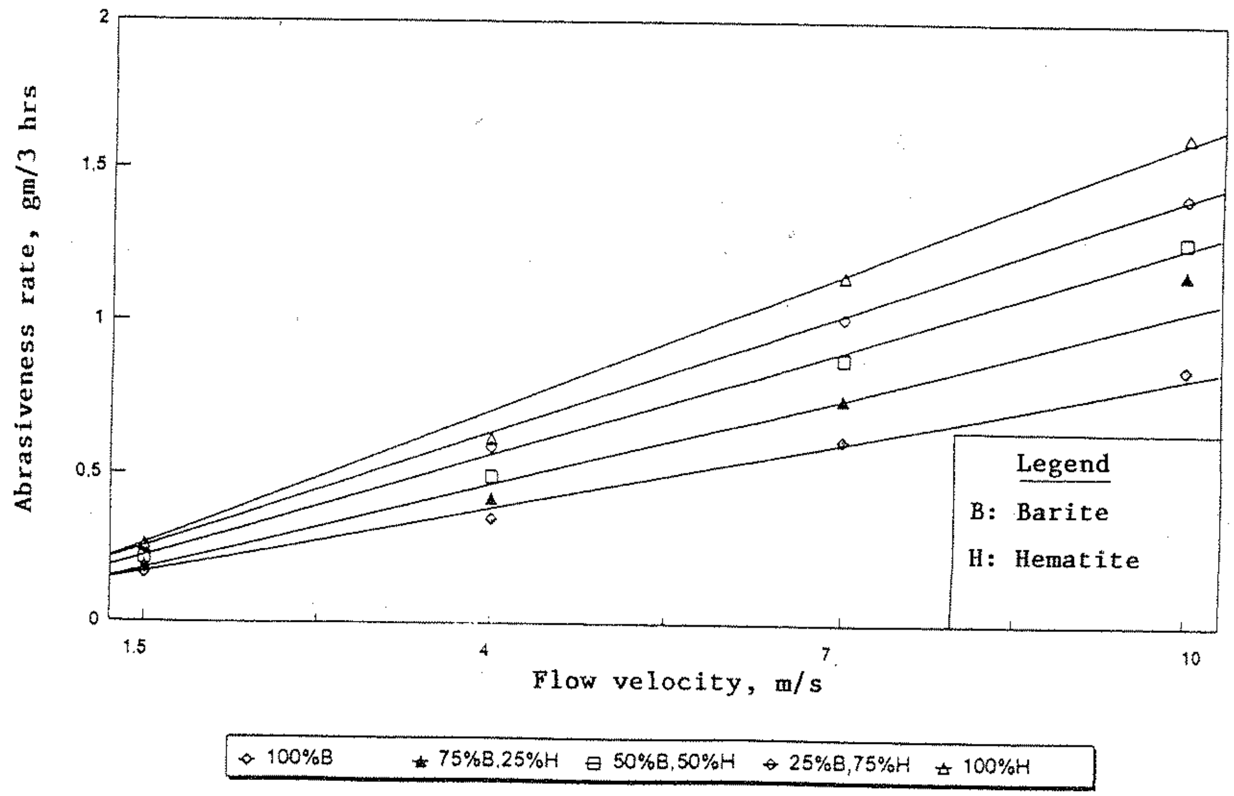

Figure 9: Abrasiveness rate vs flow velocity via steel test pipe

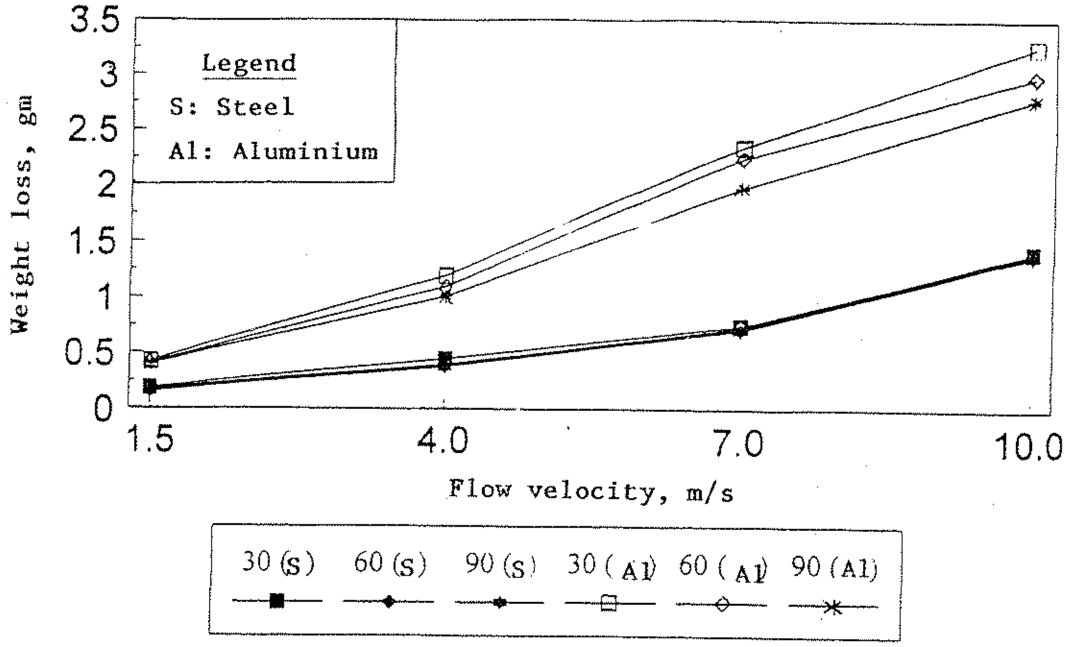

Figure 10: Abrasiveness rate by 100% barite on steel and aluminium test pipes at 3 différent elevation.

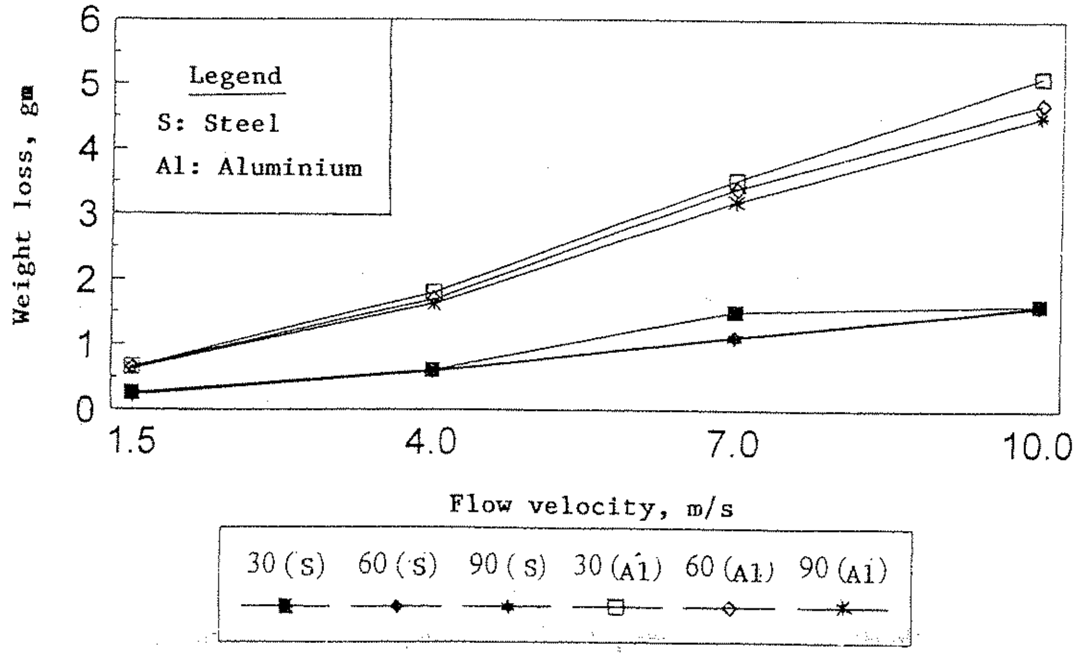

Figure 11: Abrasiveness rate by 100% hematite on steel and aluminium test pipes at 3 different elevations.