Characterizing the Behavior of Modified Cement Contaminated with Oil Based Drilling Mud

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Abstract
In this study contamination of modified cement with oil based muds (OBM) was investigated. Electrical resistivity was used as a monitoring tool to capture the contamination of cement with up to 5% OBM. The results indicated that increased mud contamination, increased the electrical resistivity of the slurries, and reduced the 1-day compressive strength of the cement. A linear correlation was obtained between the 24 hour change in electrical resistivity and the compressive strength of the contaminated samples.

1. Introduction
Oil based muds (OBM) contamination can have a severe impact on cement performance in wellbores. This occurs when cement and OBM become mixed during normal well cementing operations or during disaster conditions. Contamination of cement with OBM will compromise the integrity of well cement, and cause disastrous failures (Harder and Carpenter 1993). Hence, there is a need to monitor the well cement during placement and operation to determine if it is contaminated with OBM. Harder and Carpenter (1993) laboratory tests indicate that OBMs, even at very low concentrations are extremely detrimental to cement performance

2. Objective
The main objective of this study was to quantify the contamination of well cement with oil based muds by monitoring its electrical resistivity during curing. Also to investigate the effect of OBM contamination on short-term compressive strength of cement.

3. Materials and Methods
Class H cement was modified with conductive fillers and was prepared according to the API procedure with water to cement ratio of 0.38. To contaminate the cement, 1 to 5% percent of vegetable oil based mud was mixed with cement. Electrical resistivity was measured continuously by the developed data acquisition system during 24 hours of curing age as shown in Fig. 1. Standard compression test was done to determine the contaminated cement strength development after 1 day.

Figure 1. The developed data acquisition unit apparatus for measuring the electrical resistivity

4. Results and Analysis

As shown in Fig. 2, the initial electrical resistivity of the cement increased with the mud contamination. Since the electrical resistivity of oil based muds is higher than that of cement, the contaminated specimens exhibited higher initial resistivity. As cement hydrates, electrical resistivity response characterizes the behavior of curing cement. In this experiment, short term resistivity response of samples showed that initially after mixing cement with water, resistivity decreased to a minimum point which is due the presence of mobile ions in the liquid phase. With the formation of solid hydration products, resistivity increased rapidly and after that, increase was at a lower rate. Change in electrical resistivity with respect to minimum resistivity, quantifies the decrease in porosity and other property development. The 1-day compression test results showed that mud contamination degraded the compressive strength of cement. A summary of electrical resistivity measurement and compressive strength of the samples are provided in table1. A linear correlation was obtained between 1-day electrical resistivity change and 1-day compressive strength which is shown in Fig 3.

Table 1. Summary of electrical resistivity response of the uncontaminated and OBM contaminated samples

	ρ-initial (Ω-m)	ρmin(Ω-m)	ρ24 (Ω-m)	(ρ24-ρmin)/ρmin	Compressive strength (Ksi)
Cement	1.15	1.04	1.66	59%	1.41
Cement+1%OBM	3.35	2.96	4.47	51%	1.28
Cement+5%OBM	3.85	3.43	4.53	32%	0.32

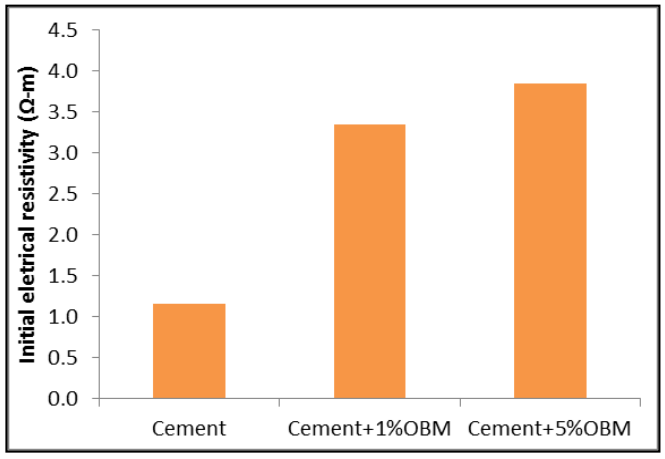

Figure 2. Initial electrical resistivity of specimens

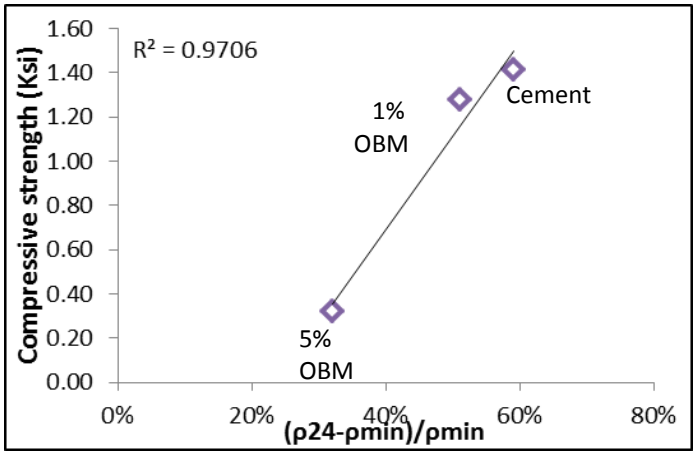

Figure 3. Change in resistivity vs. compressive strength

5. Conclusions

(1) Addition of 1% and 5% OBM to modified cement increased its initial resistivity more than 290% and 330%, respectively.

(2) OBM contamination roughly reduced the 1-day compressive strength of cement.

(3) Electrical resistivity change linearly correlated with the 1-day compressive strength of cement.

6. Acknowledgment

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7. References

C.A. Harder and R.B. Carpenter, “Optimization of oil-base mud chemistry for cementing”, IADC/SPE 025183 presented at the Drilling Conference, Los Angeles, CA, March 1993.