was pumped through the coiled tubing. The N_2 ensured that the double check valve was operating properly. Also, overpull checks, at various depths, ensured that designed overpull limitations were not being reached. The checks also generated a data base for comparing simulated values to actual values. From 5 100 to 6 150 m, the N_2 pumping rate ranged from 18 – 27 m^3/min. The coiled tubing running speed was set at 7.8 m/min.

The well was jetted for 13 hr at 6 150 m with an N_2 rate of 18 m^3/min. A flare was established at surface, and liquid was unloaded at 7 – 10 bbl/hr. Sludge cleanout operations were then initiated by pumping 19 l/min of diesel/17 m^3 of N_2. Build-up was encountered at 6300 m and cleaned out to 6496 m. Tests found that the most effective coiled tubing setting depth for jetting was at 6 150 m. Jetting was maintained for 14 hr with an N_2 rate decreasing from 18 to 7 m^3.

Liquid unloading decreased from 7 – 10 bbl/hr to 1 – 3 bbl/hr.

After the coiled tubing was hung off, the check valve was blown off.

After six hours on production the well was shut-in because of wellhead valve failures. Thirty-six hours later the wellhead valve were replaced and production initiated up the coiled tubing by jetting operations. A stabilized continuous flow rate of 11 000 m^3/d unloading 3 – 4 barrels water per day against a line pressure of 33 bar was obtained.

Result and conclusions

1. This installation set a world depth record for a permanent coiled tubing installation and still is the deepest 1 1/4″ installation in the world. The success of this project showed the reliability and cost effectiveness of coiled tubing technology and opened the frontier of deep well hangoffs. Two successful 1 1/2″ coiled tubing velocity string installations have been performed in the Gomez (Ellenburger) Field that reached depths of 6 575 m.
2. An industry standard wellhead configuration and running procedure was established that reliably facilitates live well workovers. This was the first use of a master control preventor for a coiled tubing installation.
3. Better coiled tubing manufacturing and post manufacturing techniques within the coiled tubing industry were generated. This was the first project that a production company utilizing coiled tubing for oil field use supplied design criteria and performed a quality assurance inspection at a manufacturing plant.
4. Simulation results were accurate in indicating the most effective coiled tubing setting depth for liquid removal, unloading rates, and stabilized after workover production rates.
5. The close match between simulated liquid and gas production rates to actual rates confirmed the assumption that sludge encontered at 6 285 m had not contributed to the well's production loss.

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Water-Based Drilling Fluids Can Alter Rock Wettability

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Abstract

The main objective of this study was to investigate the effect of water-based drilling fluids on rock wettability using contact angle method. Water-based drilling fluid tends to make the system water-wet in all cases studied. It was also found that the contact angle tends to increase with increasing NaOH and KOH additives at both 25 °C and 65 °C. The contact angle tends to reach its original value after cleaning in the case of using limestone samples.

Introduction

Wettability is the tendency of one fluid to spread on or adhere to a solid surface in the presence of other immiscible fluids. It is the major factor controlling the distribution of fluids in a reservoir [1].

Some fluids used for core drilling damage the reservoir rock properties. The same damage may occur in reservoir-rock samples taken for the purpose of performing laboratory experiments. The changes in the wettability parameter in such a case are particularly important because the problem of the representativity of samples used in the laboratory may thus occur [2 – 7].

In a previous work, Sayyouh et al. [8 – 10] studied the effects of acidity, alkalinity clay mineralogy and polar compounds in oil on wettability. It was found that the contact angle increases with increasing crude oil acidity for all NaOH concentrations used. When the pH was alkaline, the rock surface tended to be oil-wet. The contact angle increased with increasing clay content, depending on the solution salinity and alkalinity, and with increasing polar compounds in crude oil.

Wettability evaluation method

Samples 1.5 inch (3.81 cm) in diameter and 1 inch (2.54 cm) long with a very smoothed surface were used to measure the contact angle. The mineralogical analysis of these samples is shown in Figure 1. The clay percentage in the cores ranges from 2 to 8 %. The cores consist essentially of quartz (>85 %) and the associated non-clay minerals are mainly feldspars and pyrite. Toluene mixtures were used for cleaning the samples. Drying was done under controlled humidity. The samples were then evaluated and saturated with the aqueous solution.

The oil droplet was put in contact with downward surface a core sample and then immersed in the aqueous solution in a glass container. The oil droplet was photographed at different time intervals to investigate the change of the contact angle with time, until equilibrium was reached. Equilibrium was attained with no change in the shape of oil

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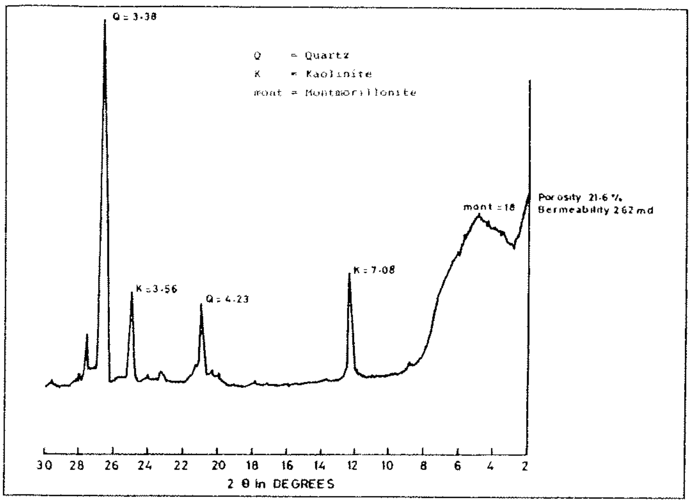

Fig. 1 X-ray diffraction characteristics for sandstone sample

Table 1 **Composition of the drilling fluids used**

Contents	Type					
	DF(1)	DF(2)	DF(3)	DF(4)	DF(5)	DF(6)
H_2O, cc	1 000	1 000	1 000	1 000	1 000	1 000
KOH, gm	3	0	3	0	0	0
KCl, gm	15	0	15	0	0	0
CMC, gm	2.5	2.5	2.5	2	0	0
NaOH, gm	0	0.65	0	2	5	0
Bentonite, gm	30	20	10	20	0	0
Zeogel, gm	0	0	50	0	65	65
Q-Brokin, gm	0	0	0	0	1	1

drop was observed. Equilibrium time was about 24 hours. The measured contact angle in the water phase was determined by making a tangent to both sides of the oil droplet. The precision obtained when evaluating the contact angle through the tangent obtained on the photograph was with ± 1°.

Results and discussion

To investigate the effect of drilling fluids contamination on rock wettability, sandstone and limestone samples along with six different drilling fluids were used (compositions of these drilling fluids are shown in Table 1) for measuring the contact angles of the oil/water interface at 25 and 65 °C. All measurements were conducted at the same conditions.

Figure 2 shows the variation of contact angle with respect to the different water-based drilling fluids using limestone and sandstone samples at 25 °C. It is clear from this figure that the contact angle did not reach its original value in the case of using sandstone surface. This result has not yet been reported in the literature. The presence of NaOH in drilling fluids DF (2) and DF (4) made the core less water-wet. In the case of using drilling fluids DF (1) and DF (3), the contact angles obtained were similar. This may be attributed to the absence of alkaline additives. The variation of contact angle with respect to the drilling fluids at 25 °C and 65 °C is shown in Figure 3. This figure indicates that the contact angle obtained when using sandstone surface was higher than that when using limestone surface.

The variation of contact angle with KOH presence in the drilling fluids using limestone and sandstone core samples at both 25 °C and 65 °C is also shown in Figure 3. It is clear that contact angle increases with increasing KOH in the fluid in all cases. This may be attributed to the alkalinity of the solution due to KOH. The contact angle measured on the sandstone surface was lower than the angle measured on the limestone surface when KOH solution was used as an aqueous phase.

Conclusion

Based on the results obtained in this investigation, the crude oil/water-based drilling fluids/rock system was founded to be water-wet at both 25 °C and 65 °C. Contact angle tends to increase with increasing NaOH and KOH additives (higher pH) at both 25 °C and 65 °C. NaOH solution tends to make the sandstone surface less water-wet, while KOH solution tends to make the limestone surface less water-wet. The contact angle did not reach its original value when the sandstone sample was contaminated with drilling fluids, at 25 °C. However, when using limestone sample, the contact angle reached its original value in most cases at 25 °C.

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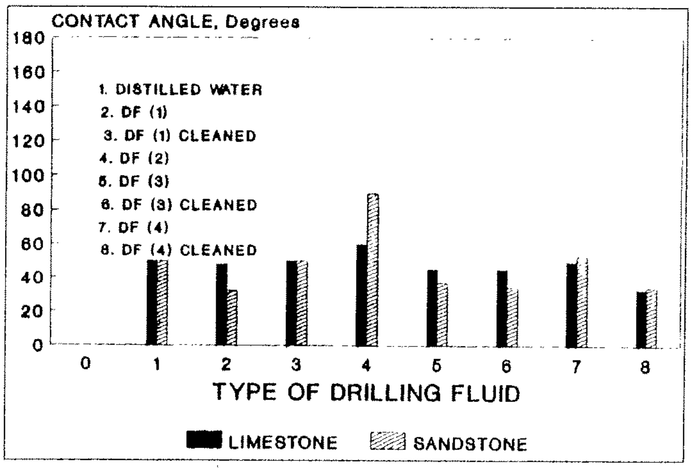

Fig. 2 Effect of type of drilling fluid on contact angle

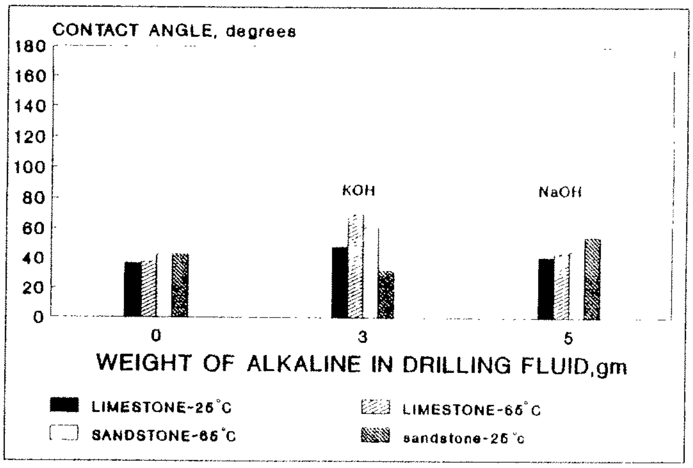

Fig. 3 Effect of alkaline type and weight in the drilling fluid on contact angle