PETROLEUM EXPLORATION AND DEVELOPMENT
Volume 43, Issue 4, August 2016
Online English edition of the Chinese language journal

Available online at www.sciencedirect.com
ScienceDirect

Cite this article as: PETROL. EXPLOR. DEVELOP., 2016, 43(4): 717–723.

RESEARCH PAPER

Controlling bentonite-based drilling mud properties using sepiolite nanoparticles

AL-MALKI Needaa, POURAFSHARY Peyman*, AL-HADRAMI Hamoud, ABDO Jamil

Sultan Qaboos University, Muscat, Sultanate of Oman

Abstract: Sepiolite nanoparticles were added to the bentonite-based drilling mud to control its properties, and the effects of sepiolite nanoparticles on rheological properties and filtration loss of the bentonite-based drilling mud at different temperature and pressure conditions were studied by experiments. For the bentonite-based drilling muds with and without sepiolite nanoparticles, plastic viscosity, yield point, and fluid loss were measured at different temperature and pressure conditions, the core flooding experiments were also conducted at reservoir pressure and temperatures, and fluid loss and formation damage were measured. The results show that: sepiolite nanoparticles can be used to improve the plastic viscosity and yield point of saline and fresh bentonite-based drilling mud; the bentonite-based drilling mud with sepiolite nanoparticles shows a great stability of rheological properties over a wide range of temperature and pressure, especially at high temperatures and pressures; sepiolite nanoparticles reduce the fluid loss and the permeability reduction at reservoir pressure and temperatures. Sepiolite nanoparticles are an ideal additive for bentonite-based drilling mud.

Key words: bentonite-based drilling mud; drilling fluid property; high temperature-high pressure; sepoiolite; nanoparticles

Introduction

Bentonite clay is added to the drilling mud as a fluid loss control additive to provide a basic filter cake. It is also used as a mud viscosifier. Due to the flocculation of bentonite particles, at high temperatures, flocculation causes particles to join together to form a loose and an open network, which consequently increases filtration and affects the performance of bentonite[1]. Adding sepiolite to bentonite-based drilling mud could control its properties at high temperatures. Sepiolite-based mud is found to provide good rheological properties under 200 °C[2]. However, macro-size sepiolite mud is not recommended in the drilling industry because of its unacceptably high fluid loss[3–4]. ALTUN G et al.[3] reported that sepiolite-based drilling mud performs better when the grain size is reduced. The smaller the grain size, the better the performance of sepiolite to control the mud rhelogical properties.

Nanoparticles have special characteristics such as small size (1–100 nm), high specific surface area, and a high ability for adsorption. For any applications, it is cheap because of the low quantity of nanoparticles[5]. Nanoparticles were successfully tested to reduce mud invasion of the shale formation[6–7], decrease the mud cake thickness[8], and control the mud rheology at high temperature and pressure[9]. It is feasible to change the size of nanoparticles to control the performance of drilling mud[10]. According to CAI J[7], the effective nanoparticle size to plug a shale pore is between 3–10 nm. All of these previous studies used nanoparticles to inhibit the mud filtrate flow to the shale by plugging the formation pores, but using sepiolite nanoparticles as an additive of drilling mud is not reported.

In this paper, sepiolite nanoparticles ($H_{27.64}Mg_8O_{45.82}Si_{12}$) were added to bentonite-based drilling mud to improve its performance of rheology and fluid loss. First, mineral composition and qualitative analysis for sepiolite nanoparticles were conducted using X-ray diffraction system (XRD). Then, the effects of sepiolite nanoparticles on rheological properties of drilling mud at different temperatures and pressures were studied.

1. Experiments

In this study, The diameter of sepiolite nanoparticles was on average 50 nm as shown in Fig. 1. Three experiments were performed and the procedures are described as below.

(1) Experiment 1. In order to study the effects of sepiolite nanoparticles on the rheological properties of bentonite-based drilling mud, the plastic viscosity, yield point, and fluid loss were measured at low pressure and low temperature for the bentonite-based drilling mud with and without sepiolite nanoparticles. The experiments were performed with both fresh water-based drilling mud (600 ml of de-ionised water + 50 g of bentonite) and brine based drilling mud (600 ml of

Received date: 13 Sep. 2015; **Revised date:** 25 May. 2016.
* **Corresponding author.** E-mail: pourafshary@squ.edu.om
Copyright © 2016, Research Institute of Petroleum Exploration and Development, PetroChina. Published by Elsevier BV. All rights reserved.

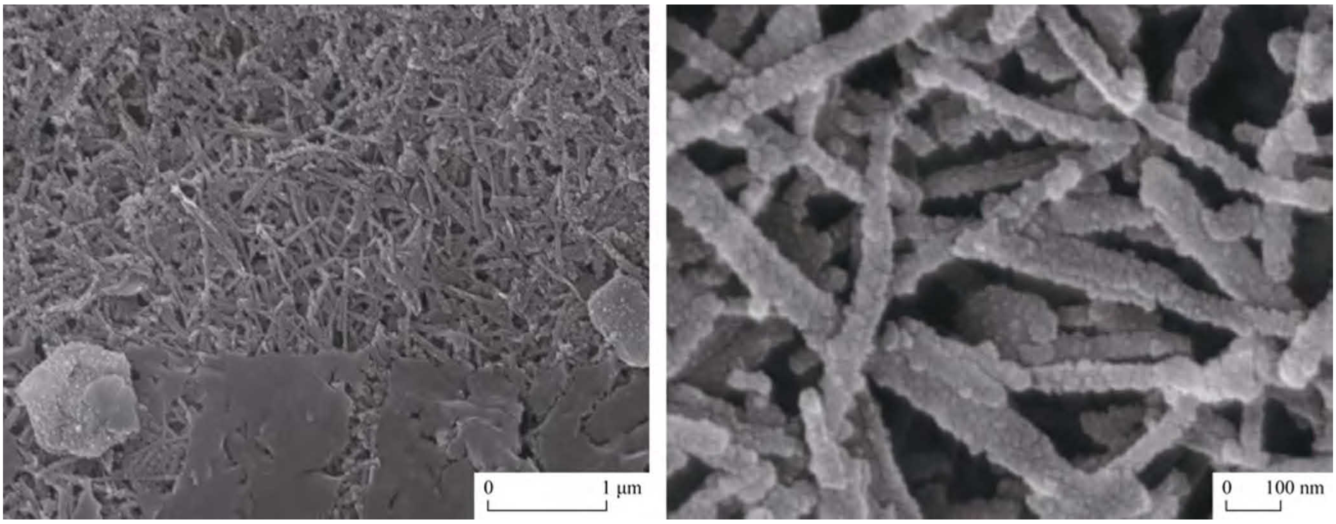

Fig. 1. SEM images of sepiolite nanoparticles.

de-ionised water + 50 g of bentonite + 2% NaCl) respectively. The compositions of the different designed drilling muds are shown in Table 1. The plastic viscosity and the yield point were measured using a Fann viscometer (FANN® Instrument Company, Houston) and the fluid loss was performed using a Filter press (FANN® Instrument Company, Houston).

(2) Experiment 2. Drilling deep wells has big challenges due to the change of mud properties under high pressure and high temperature conditions. Hence, using a OFITE HTHP viscometer, the plastic viscosity and yield point were measured at high pressure and high temperature conditions for bentonite-based drilling mud with and without sepiolite nanoparticles. Bentonite-based drilling mud without sepiolite nanoparticles is composed of ionised water + 7.9% bentonite; bentonite-based drilling mud with sepiolite nanoparticles is composed of de-ionised water + 6.1% bentonite + 1.4% sepiolite nanoparticles. Both of these drilling muds have pH value of 10.

Table 1. Amount of bentonite and sepiolite nanoparticles added to different drilling muds

SN	Drilling mud type	Amount of bentonite		Amount of sepiolite nanoparticles	
		Mass/g	Percentage/%	Mass/g	Percentage/%
1	Brine based	1.35	0.2	0	0
2		4.60	0.7	0	0
3		8.80	1.3	0	0
4		13.50	2.0	0	0
5		17.00	2.5	0	0
6		0	0	1.35	0.2
7		0	0	4.60	0.7
8		0	0	8.80	1.3
9		0	0	13.50	2.0
10		0	0	17.00	2.5
11	Fresh water based	1.35	0.2	0	0
12		4.60	0.7	0	0
13		8.80	1.3	0	0
14		13.50	2.0	0	0
15		0	0	1.35	0.2
16		0	0	4.60	0.7
17		0	0	8.80	1.3
18		0	0	13.50	2.0

(3) Experiment 3. Berea Sandstone core samples were used to compare the amount of fluid loss in the formation and the extent of the formation damage caused by the bentonite-based drilling mud with and without sepiolite nanoparticles. The bentonite-based drilling mud without sepiolite nanoparticles is composed of de-ionised water + 7.5% bentonite + 2% NaCl; the bentonite-based drilling mud with sepiolite nanoparticles is composed of de-ionised water + 7.5% bentonite + 1.3% sepiolite nanoparticles + 2% NaCl.

Berea Sandstone samples were the most widely used homogenous[11] sandstone sample for research in petroleum industry. The basic parameters of Berea sandstone core are shown in Table 2. Gas permeability was measured using a Steady State Gas Permeameter (GasPerm, VINCI Technologies, USA). Porosity was measured using Helium Porosimeter (He Porosimeter, VINCI Technologies, USA). The formation damage due to mud invasion was studied by using the reservoir-condition formation damage testing apparatus in Sultan Qaboos University. First, after saturation of core with brine by a vacuum desiccator, the core was loaded and positioned horizontally in the core holder in the core flooding device. Then, a confining pressure of 10.35 MPa (1500 psi) was applied to the core. Brine was injected with a flow rate of 0.5 mL/min and initial permeability was measured. The mud was circulated from the other side of the core with the pressure of 1.04 MPa (150 psi). Displacement of mud was for 6 hours followed by the standing time of 6 hours and the dynamic and static filtrations were measured. Finally, brine was injected and recovery permeability was measured. The core flooding experiments were conducted under a temperature of 60 °C.

Download English Version:

https://daneshyari.com/en/article/4719915

Download Persian Version:

https://daneshyari.com/article/4719915

Daneshyari.com