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Mineralogy and rheological properties of some Egyptian bentonite for drilling fluids

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A R T I C L E I N F O

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The selection of drilling fluid is considering main factor for oil and natural gas well drilling processes success. Drilling fluids play important role in carrying and suspending drilling cuttings, high rates of penetration, maximizing bit life, minimizing fluid loss into the formation and stability of the formation. In this study, clays collected from claystone quarries in Gabal Hamza – um Qumar north Cairo-Ismailia Desert Road, Egypt for its application as water base drilling mud. These clays consist mainly of montmorillonite in addition to kaolinite as indicated by X-ray diffraction (XRD) and scanning electron microscope (SEM). The rheological and filtration properties of drilling fluids were designed with different types of additives such as Caustic soda, CarboxiMethyl Cellulose (CMC) and polyanionic cellulose polymer (PACR). Although designed different types of polymer compositions did not meet the required rheological and filtrate properties; the addition of Caustic soda, CarboxiMethyl Cellulose (CMC) and polyanionic cellulose polymer (PACR) gave better rheological and filtrate properties of bentonite suitable for drilling medium depth wells.

1. Introduction

With increasing drilling operations for hydrocarbon exploration and production, the need for specific drilling fluid of efficient, friendly environment formation becomes more important.

Aqueous bentonite dispersion's are important to many industries and are especially essential to hydrocarbon well drilling (Kelessidis et al., 2007).

Drilling fluids properties such as apparent viscosity, plastic viscosity and yield point play important role in designing efficient and optimized drilling operation. These properties serve many purposes:

- Well cleaning by transport rock cuttings to the surface,
- To cool and lubricate the rotating drill string and bit,
- To apply hydrostatic pressure in the well bore ensuring well safety and to minimize fluid loss across permeable formations by forming a filter cake on the walls of the well bore (Gray and Darley, 1988; Adam and Bourgoyne, 1986). In order to perform these tasks, many additives are added to the base fluid, water or oil, to make the water or oil based mud (Caenn and Chillingar, 1996).

Drilling-fluid viscosity control additives are basically categorized as viscosifiers (viscosity enhancers) and viscosity reducers. Bentonite is a major additive, used worldwide for increasing viscosity of the drilling fluid to reduce fluid loss to the penetrated rock formations (Bol, 1986). Bentonite when exposed to water attracts water to its negative face. This unique characteristic allows bentonite to adsorb seven to ten times of it's own weight in water, and swelling up to 18 times of it's dry volume. Wyoming Bentonite is the most commercially common viscosity enhancer. It is composed essentially of montmorillonite clay mineral (Dyke, 2000). Several other viscosifiers commonly used are asbestos, attapulgite and polymer (such as starch and carboxy methyl cellulose).

The suitability of clay's for use in drilling fluid may be determined by.

- The yield, (i.e., the number of barrels of drilling fluid (mud) of a given viscosity (15 cp) obtained from a ton of clay in fresh water),

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- Suspension capacity in salt water, plastic viscosity, apparent viscosity, yield strength, thixotropic properties, the wall building properties
- And thickness of filter cake produced in the standard API water loss test.

Drilling fluid viscosity reducers are used to reduce viscosity and gel strength and to provide some fluid-loss control. Commonly used viscosity reducers are phosphates, tannates and lignites. Viscosity reducers are dependent on temperature, but the viscosity reducing properties have temperature limitation. Phosphates generally are limited to a temperature environment of 150 °F, whereas lignites are stable in temperature up to 375 °F (Azar and Samuel, 2007; Fink, 2003).

Selection of the best drilling fluid to meet anticipated conditions will minimize well costs and reduce the risk of catastrophes such as stuck drill pipe, loss of circulation, etc. Falode et al. (2008) stated that, viscosity, density, filter cake or filtration of water loss and wall cake thickness, solids content and quality of water make up are usually defined as the basic properties during drilling.

The viscosity of drilling fluid is defined as it's resistance to flow (Growcock et al., 2005) and it's a function of plastic viscosity, yield point which measures the forces between the particles in fluid and gel strength which measure the same inter-particle forces of the drilling fluid at rest.

Drilling fluids density is the weight per unit volume of the drilling fluid. In a simple water base drilling fluids, density is a measure of the suspended solids. Excessive solids can cause several problems as wear on pumps, bits and drill strings; retard penetration rates; deposition of thick filter cake on permeable formations; increase fluids loss to the formation and causes unnecessary work for the pump to push unwanted weight in the circulating fluids. Salt may be added to increase mud weight without adding solids.

Good drilling fluids should deposit mud solids on the walls of the hole "filter cake" while fluid invading the formation is called "filtrate". "Filtration", or fluid loss, is the loss of fluid from the drilling mud to the formation.

Drilling fluids solids are either added to the fluid, or accumulate in the fluid. Solids that contribute to beneficial mud properties are particularly desirable. Solids increase viscosity or weight; they may accumulate in the fluid as drill cuttings, disintegrated clay particles, or re-circulated inert solids.

2. Aim of the work

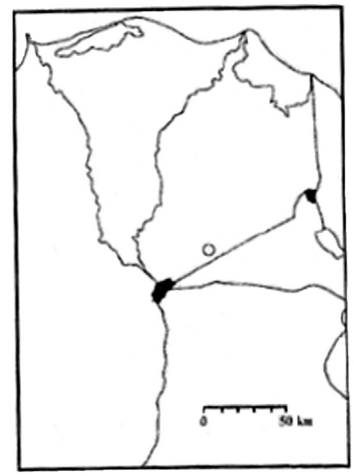
The goal of this work is to compare the unbeneficiated Gabal El-Hamza drilling mud rheological and filtrate properties with those beneficiated by carboxymethylcellulose (1% CMC), polyanionic cellulose polymer (0.5% PACR) and 1.5% coastic soada

3. Geologic setting

Gabal El-Hamza -Gabal Um-Qamar area (Fig. 1), which lies along the Cairo-Ismailia road, about 32 km from Cairo and is composed of a plunging anticline, trends ENE-WSW. Lower and Middle Miocene sediments form the flanks of the anticline, the core of which is represented by sands, gravels and basalt of Oligocene age (El Belasy, 2001).

The Oligocene is overlain uncomformably by Lower Miocene sediments which composed mainly of sandstone interbedded by claystone beds, with lateral changes into carbonate facies in the direction of Um Qamar, north of Gebel Hamza.

The Lower Miocene sediments are unconformably overlain by Middle Miocene deposits which composed mainly of sandy limestone and dolostone interbedded with some clays. Both the Lower and Middle Miocene sediments are marine facies deposited in a shallow sublittoral to reefal environment (Abdel Wahab and El-Belassy, 1987).



Stratigraphic Column of G. Hamza Area

Age		Sequence	Thickness
Miocene	Upper	Non-marine (gravels, sandstone)	40 m
	Middle	Marine deposits (sandy limestone, dolostone)	70 m
	Lower	Marine de[psits (sandstone, claystone, carbonates at top)	
Oligocene		Basalt (sheets, weathered)	0-15 m
		G. Ahmar Formation (sand, gravel)	100 m

Fig. 1. Location map of the study area and Gabal Hamza section drawn from information given by Abdel Wahab and El-Belassy, 1987).

The non-marine Upper Miocene deposits are composed mainly of gravels and sand, unconformable overlying the Middle Miocene facies. The smectitic clays sampled in the present work came from the Lower Miocene.

Several authors studied the clay minerals of Egyptian shale's e.g. (El-Baz, 1986; Abdou, 1992; Attia, 1996 and Said, 2004). They studied the clay minerals structures, properties and industrial applications in bleaching, in ceramics, bounding foundary sands, cosmetics, in paper making (Fahmy, 2004; Temraz and Hassanien, 2012; Abdou and Abuseda, 2014). studied some shale's in Egypt and determined it's physical, rheological and chemical properties.

4. Materials and methods

The rheological properties tests on ten (10) untreated Egyptian bentonite samples were conducted according to API (American Petroleum Institute) specification (API, 1983). The physical and rheological of the studied bentonites samples was analyzed and determined using the different apparatus for determination of these properties as : Mud balance for determination of mud weight,