PRJ, Vol. 4. (January 1992); P. 46–51, 3 FIGS, 4 TABLES

EVALUATION OF BENTONIC CLAYS OF UMM AR RIZAM AREA, LIBYA AS POTENTIAL DRILLING MUDS

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تقييم طين البنتونيت بتكوين الفايدية منطقة أم الرزم ، ليبيا

ديفد واتسون وميلاد رحومة

يقع تكوين الفايدية الذي يرجع إلى العصر الأوليجوسيني والميوسيني الأوسط كأعلى الوحدات الصخرية بمنطقة درنة وطبرق. ويوجد عند قاعدة التكوين فوق تكوين الأبرق مباشرة طبقة من الطين. ويتكون هذا الطين من كميات متباينة من المونتموريلونيت وأنماط الطين الأخرى مع الجلوكونيت والجبس والجير والمعادن الأخرى. وقد تم التعرف على مستحاثات دقيقة في العديد من العينات كما إحتوت واحدة على أوستراكودات وأسنان سمك القرش وعجيرات وتبدلات عضوية من معادن الفوسفات.

وتتباين الصفات الطبيعية لخلطات مختلفة من الماء والطين من عينة إلى أخرى. وتتصرف الخلطات المختلفة كسوائل لدائنية كاذبة ، بالإضافة إلى أن لها المواصفات المطلوبة في سوائل الحفر. غير أن هذه المواصفات تختلف من مكان لآخر كما تختلف عمودياً بالقطاع. وعموماً فإن عينات الجزء السفلى من القطاع لها مواصفات أفضل من نصف القطاع العلوي.

وقد كان للطين المعد من العينات مواصفات تقدر بحوالي 25 متر مكعب/للطن ولزوجة تصل إلى 73 سنتبويز. وقد تم أيضاً التعرض لنتائج تجارب إستعمال الصودا الكاوية ، CMC للتحكم في فاقد التصفية واللزوجة.

ABSTRACT

The Upper Oligocene-Middle Miocene Al Faidiyah Formation occurs as the uppermost unit in the Darnah-Tubruq area. At the base of this unit, immediately above the underlying Al Abraq Formation, is a layer of clay. This clay unit is composed of varying amounts of montmorillonite and other clays, along with glauconite, gypsum, carbonates, and other minor minerals. In several samples, microfossils have been identified, while another contains ostracods, sharks' teeth and nodules and pseudomorphs of phosphate minerals.

The physical properties of muds made up of varying amounts of this clay with water vary from sample to sample. The different mixtures behave as pseudo-plastic fluids, and show many of the required properties of drilling fluids. Their properties do, however, vary from place to place, and vertically within the section. Samples from the lower parts of the section generally have better properties than those from the upper half.

Muds have been prepared from the samples having yields as high as 25 m^3/tonne, and viscosities as high as 73 centipoises. Results of tests using caustic soda and Carboxy-Methyl-Cellulose (CMC) to control filter loss and viscosity are also reported.

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INTRODUCTION

The Umm ar Rizam clay project was initiated by the Exploration Department of the Petroleum Research Centre, Tripoli, in 1981. The aim of the project is to identify resources of bentonitic material that could be used as drilling mud, thus replacing expensive foreign imports. The use of domestic muds could result in a saving of 2.5 million dinars (or foreign currency equivalent) per year in the cost of bentonite alone.

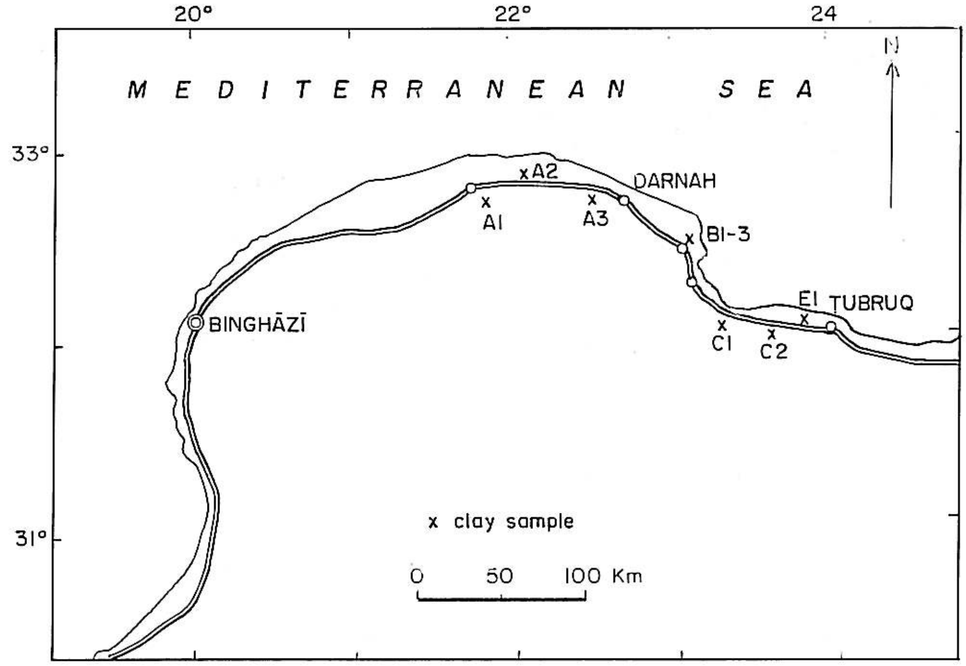

FIG. 1. Clay sample locations (1981).

Early work by Alami *et al.* (1981) (Fig. 1), Gent (1985) and others of the Petroleum Reseach Centre, consisted of searching existing maps and files from all available sources for reference to montmorillonitic clays or bentonite, and later, sampling several of the areas of interest. The result of this early work was encouraging in that, in the Umm ar Rizam area, some samples collected in the first phases proved to have properties approaching those of commercial bentonite. Follow up work resulted in the collection of additional samples from this area, some of which again gave encouraging results.

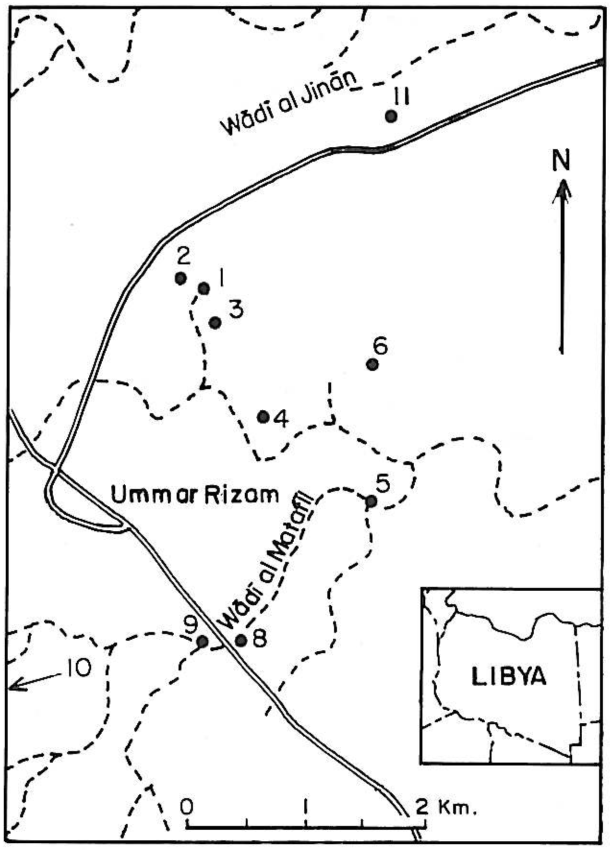

FIG. 2. Location of sampled sections (1986).

In the most recent phase of this project, carried out by present authors, more detailed sampling was done in the immediate vicinity of Umm ar Rizam (Fig. 2), along with extensive testing of the various clays collected. It is the result of this sampling and testing programme that are reported in this paper.

LOCATION AND ACCESS

The area of main interest in this study is centered on the village of Umm ar Rizam, approximately 60 Km SE of Darnah, and 120 Km NW of Tubruq. It is connected to both of these larger centres by a first class paved highway. A secondary paved road connects the main highway with the coast approximately 30 Km to the east. Access off the main road is either by secondary paved highway or by desert tracks, which although not maintained are good enough to allow access to virtually any area. The land surface is mainly bare stony desert devoid of vegetation aside from scattered palms and thorn bushes. Some shrubs are present in the bottoms of wadis and in areas irrigated for agricultural purposes. The wadis are generally narrow and very steep sided. They are usually not driveable along their length, and can be very difficult to cross. Any cross-country driving must take these obstacles into account. The desert surface itself is hard and relatively smooth and conditions are such that materials and equipment can be delivered to virtually any area.

GENERAL GEOLOGY

The Darnah map sheet, on which the area of interest lies, is covered by rocks of Eocene to Middle Miocene age. The formations exposed are, in order of age, the Appolonia, Darnah, Al Bayda, Al Abraq and Al Faidiyah. They all consist of sequences of limestones, marls and siltstones, with minor amounts of dolomite (Zert, 1974).

Al Faidiyah Formation, the youngest formation on the map sheet, is the unit of interest in this study. It is a transgressive unit, bound on the lower part by a discontinuity with Al Abraq Formation. This discontinuity is marked by a bed of clay ranging in thickness from 2 to 20 metres. In the eastern and central areas of the sheet, this clay layer is montmorillonitic, and probably developed as an extensive shallow marine deposit. The montmorillonitic clay is largely devoid of macrofossils. The more marly layers immediately above and below this layer contain abundant pectens and oysters. The age of this unit has been placed as beginning at the Upper Oligocene. Al Faidiyah Formation itself continues in age to the Middle Miocene.

GEOLOGY OF THE UMM AR RIZAM CLAYS

In the area of Umm ar Rizam, the youngest unit exposed is of course the Al Faidiyah Formation. It overlies Al Abraq calcarenite. Over the area examined in this study, Al Abraq limestone was the lowermost unit seen. The limestone consists of a yellow to cream calcarenite containing abundant pelecypod, echinoid and oyster shells. In places the rock could more correctly be called bioclastic. The facies developed is typical of shallow-water shelf seas (Zert, 1974).

Immediately above Al Abraq Formation and separated from it by a discontinuity, is the bentonitic clay, representing the basal portion of Al Faidiyah Formation. In the immediate vicinity of Umm ar Rizam, Al Faidiyah Formation consists of a few metres of blocky to rubbly limestone covering the clay unit. The limestone directly on top of this clay layer is fossiliferous, and contains abundant shells of *Cardium* and *Ostrea*. Remains of corals and echinoids are also plentiful in some sections.

Beneath this fossiliferous layer, and visible only in wadi banks and the sides of depressions, is usually a layer 0.5 m thick composed mainly of glauconite pellets. These pellets range in size up to 0.5 mm in diameter, and make up 90% of the rock. The remainder is clay and occasional gypsum and carbonate.

The boundary between the glauconitic layer and the underlying clay is sharp, with no glauconite appearing mixed with the lower layer. The main clay layer varies in apparent thickness from 5 to more than 20 metres. Due to its position in the sides of wadis, the exposure is limited due to slumping of the overlying limestone, and the thicknesses are in part estimates. This clay layer usually contains more than 98% clay minerals. The remaining 2% is made up of gypsum, phosphate pellets, carbonate minerals (calcite and dolomite) and occasional opaque grains. Upon dispersion in a water and methaphosphate solution (as for API residue test), less than 1% is usually left on a 200 mesh screen. In most cases this residue is undispersed clay, but in a few samples, there are some microfossils and phosphate pellets.

Some samples collected from the near surface contain up to 10% gypsum in the form of single crystals and aggregates to 10 cm diameter. These accumulations disappear completely at depths of 0.3–0.5 m. Their appearance in some samples is attributed to evaporation and subsequent crystallization from recent ground waters.

The clay has been examined by a number of methods. Chemically it fits under the broad definition of a mixed layer clay (Table 1).

Table 1. Chemical Analysis of Umm ar Rizam and Other Clays

	Illite*	Montmorillonite*	Umm ar Rizam Clay**
SiO_2	46–57	51–65	53.9
Al_2O_3	19–31	15–34	24.9
Fe_2O_3	4–7	0–15	6.6
MgO	1–3	0.1–7	2.8
CaO	0.2–2	0–4	1.7
Na_2O	0.2–0.6	0–4	1.0
K_2O	4–6	0–2	0.32
H_2O^+	6–8	5–14	8.8

*From Weaver and Pollard (1975).
**Average of 7 analyses.

Table 2. Cation Exchange Capacities of Some Clays

Clay	Cation Exchange Capacity in ME 12/100 gr Dry Clay
Montmorillonite	70–130
Vermiculite	100–200
Illite	10–40
Kaolinite	3–15
Chlorite	10–40
Attapulgite	10–35
Umm ar Rizam (avg of 7)	84.0 ± 8.1

After Gray and Darley, 1980.

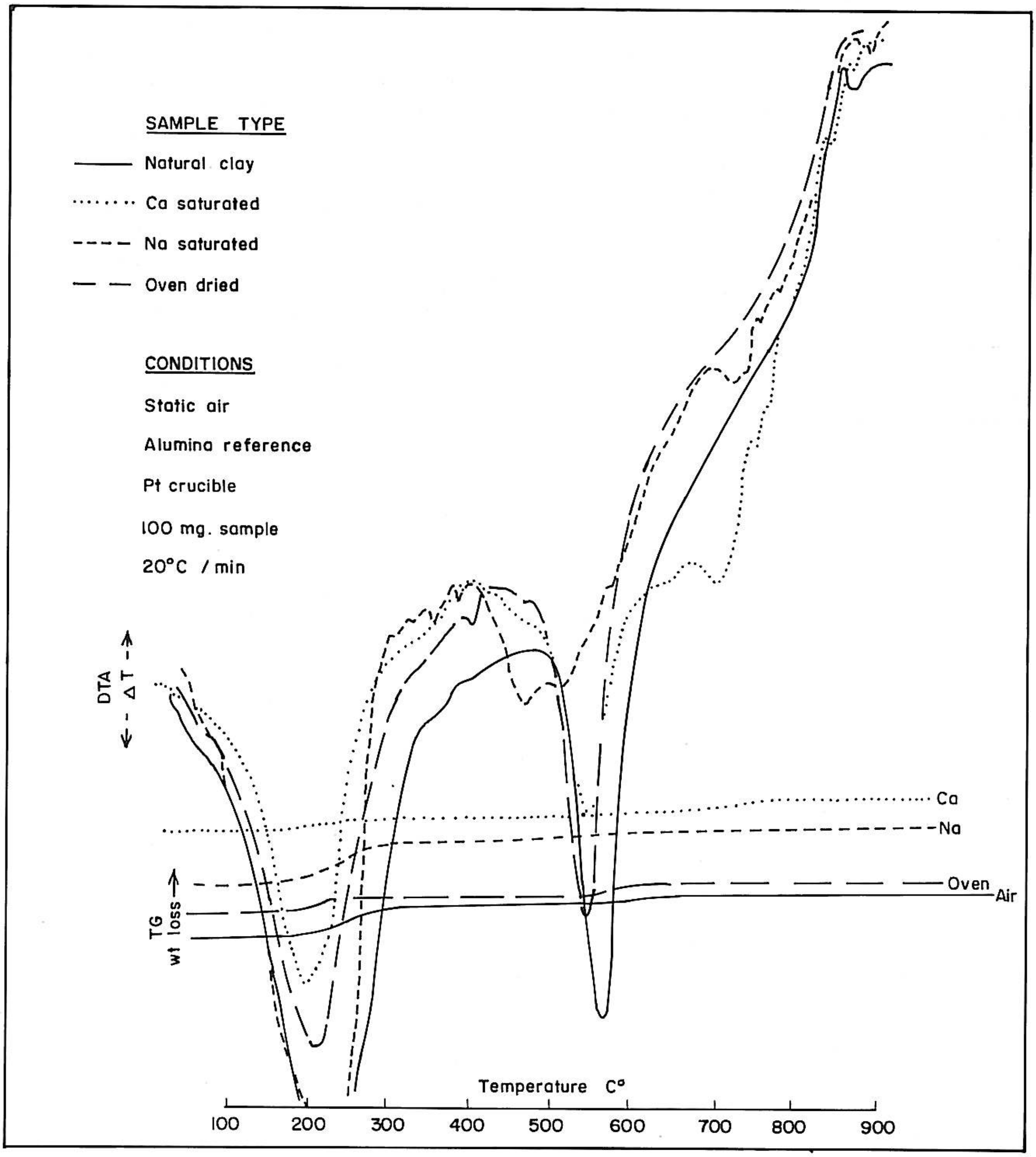

FIG. 3. DTA-TG curves-natural and treated clays.

Under the microscope it is devoid of any visible structure, with no recognizable crystals or form even to the limits of resolution of the SEM. Curves obtained by DTA-TGA (Fig. 3) are typically montmorillonite, although falling between calcium and sodium varieties in character. As may be seen in the following description of the mud-making characteristics, these too fall between the properties of calcium and sodium varieties, or between poor mud and good.

The cation exchange capacity (CEC) of the clay was determined using sodium as an index ion. The values obtained for several samples all fall within the range of values normally accepted for montmorillonite. The determined values are given in Table 2, along with values for various clay minerals.

MUD TESTING

While the chemistry of clay, along with its many other physical properties is important, it is the actual mud-making properties that are of importance to the well drilling industry. The muds made from the clay and water must have the right combinations of gel strength, viscosity and density in order to perform as necessary. In addition, a certain amount of clay must yield at least a minimum amount of mud in order to be economical.

These properties vary with the amount of clay used in the mud as well as with the type of clay. Larger amounts of clay increase the viscosity, but may also increase the mud cake thickness and have a less than desirable effect on another properties. The properties usually tested, and their recommended values are given in Table 3.

In order to evaluate the performance of the Umm ar Rizam clays as drilling mud additives, a series of standard tests were performed. These tests, carried out using API recommended methods, included measurement of apparent viscosity with a standard Fann VG meter, and filtrate loss using a standard filter press. The results of some of the tests along with the recommended values are given in Table 3.

In addition to the tests performed on the muds as collected, several additional tests were carried out to determine the effects of additives on the muds and to see if marginal materials could be upgraded at reasonable cost to make acceptable muds. These tests showed that additions of CMC soda ash and NaOH could alter the filter loss and viscosity sufficiently to make almost any of the clays tested acceptable for drilling muds. The results of these tests are summarized in Table 4.

Table 3. Physical (Mud) Properties of Clay/Water Mixtures

Sample	Apparent* Viscosity cp	Plastic* Viscosity cp	Yield m^3/tonne	Filtrate* Loss cc/30 min
API/OCMA Recommended	15 (min)	–	15 (min)	15 (max)
1a	9.5	3	13.6	27.2
1b	4	3	–	n.d.
1c	5.25	3.5	–	n.d.
1d	14	4	16.53	25.5
3	10	3	13.4	21.0
4	4.5	3	–	n.d.
6a	7.5	3	11.9	33.3
6b	9.5	6	12.0	29.0
6c	5	3	–	n.d.
6d	3.5	3	–	n.d.
6e	14	6	–	33.7
6f	18.75	6.5	18.6	32.2
8	12	4	15.8	20.3
9	9	3.5	11.3	n.d.
10	8	4	12.9	42.0
11	3.5	2	–	n.d.
12	31	7	25.4	30.0

*For 6% clay/water muds.
n.d. Not done.

Table 4. Effect of Additives on Filtrate Loss and Viscosity

	Sample 12		Sample 6a	
Test No.	Additive	Filtrate loss (cc/30 min)	Additive	Viscosity (cp)
A	Nil	36	Nil	9.5
B	0.1% CMC	20.5	0.1% NaOH	12.3
C	0.15% CMC	19	0.2% NaOH	14
D	0.2% CMC	15.5	0.3% NaOH	20
E	0.5% CMC	12.3	0.5% NaOH	29
F	1.0% CMC	9.5	1.0% NaOH	38

As can be seen from Table 4, several of the muds have sufficient viscosities and yields to be used as drilling muds. The filter losses are high but additions of CMC can reduce this loss to acceptable levels (Table 4).

CONCLUSIONS AND SUMMARY

The bentonitic beds of Al Faidiyah Formation in the area of Umm ar Rizam can be used to prepare drilling muds that pass the tests for viscosity and yield. Their properties can be upgraded by additions of small amounts of CMC in order to pass the requirements for filter loss.

The bentonite is found as a bed of varying thickness (2–20 m) over a very wide area. It appears at this time from the amount of field work done that the mud-making properties vary from place to place, but are reasonably consistent over the sort of distances that would be of concern to a mining operation. Likewise the thickness while variable is reasonably consistent over short distances.

Using an average thickness of 5 m of mineable bentonite, it has been calculated that there would be approximately a 750-year supply of bentonite per square kilometre in the Umm ar Rizam area, enough to supply Libya's needs for the foreseeable future.

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