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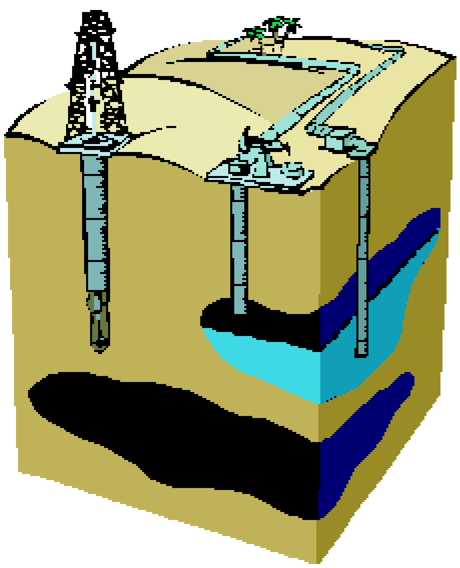
GEO

Drilling Fluids, Inc.

TECHNICAL SERVICES NEWS LETTER Volume 1, Number 5 September 25, 1997



SLATE WEIGHT ABANDONMENT FLUID

GEO has developed a low cost alternative to the standard Gel/Barite abandonment fluid. Using a Slate by-product from our mill in Sacramento, which we can sell at a cost significantly below that of Barite, as a weighting agent this product is attractive for us to sell. In addition, a slurry using this product requires less Gel to reach regulatory viscosity requirements. The material is non-hazardous and available in large quantities. If you know anyone who might be interested in this product please let me know or contact Jim, Tom or Don.

GRAPHICS FOR THE NEWS LETTER

I have been using graphics from various sources for this newsletter. We would like to pick out some distinctive oilfield graphic to associate with our publication to use in the event that we distribute it to our customers. You are cordially invited to send in any suggested graphics you run across. Anything on paper, either color or black and white may be appropriate.

SDIC UPDATE

Xanvis is used for viscosity in horizontal wells for its elevated low shear rheology. Following a completion in which the well bore is not cemented, production depends on removal of the wall cake. Traditional methods for removal of Xanvis or XCD (an almost identical product) have involved strong oxidizers. These include Sodium Hypochlorite (regular bleach) and Lithium Hypochlorite.

GEO has a product which breaks Xanvis and XCD as well as Polyacrylamide polymers (LP-701). This product is SDIC and is being used by a number of operators. We recommend one pound per barrel in the mud or in the final fluid circulated.

At 180EF for 18 hours the viscosity is completely destroyed and any residual fluid loss properties as well.

The MSDS for this product should be reviewed before using. Eye protection is very important. A dust mask is probably also advisable. Open sores may become very painful as well. Skin irritation to normal skin should be minimal but the product should be washed off as soon as possible. SDIC is not listed as a carcinogen.

SDIC is an oxidizer and should be kept free of water and organic materials such as oil or diesel. Avoid storing this product in the vicinity of bases such as caustic soda or soda ash.

BENTONITE

The following articles are copied, paraphrased or rewritten from a special issue of "Drilling & Completion Fluids" May/June 1994.

Anyone who sells to or works in drilling and completion operations will become involved with or concerned about clay-type materials at some time. These concerns will range all the way from waiting for a drill site to dry from mud to hard-pack to eliminating the movement of fine solids within a producing formation.

Everyone is concerned, but ignorance and misconceptions still prevail about the wide range of clay materials, how they affect field operations, and their impact on drilling and completion fluids. The following pages give you the information needed to use the "good" clays properly and to avoid the detrimental effects of the "bad" ones.

Clay Chemistry

"Clay is a very fine-grained, unconsolidated rock material which normally is plastic when wet, but becomes hard and stoney when dried. Common clay essentially consists of hydrous silicates of aluminum, along with a large variety of impurities ..."[1]

The above definition just about sums up all we need to know about the clays we encounter in everyday life. It also, unfortunately, describes an incredible number of different materials that can help and/or hurt us. The basic hydrous-aluminum-silicates can be either swelling or non-swelling, making either bentonite for good rheological control or inert solids that impede drilling operations. Swelling clays can dislodge and move within a producing formation causing damage by plugging pore throats. If these hydrous-aluminum-silicates are sodium based, they are good for fluid loss control and develop the maximum viscosity, but impurities can make them useless and non-commercial. These silicates can be hard and brittle, so that when drilled they loosen and fall into the wellbore. Inert clays not screened from completion brines will plug the formation face impeding the production of oil and gas.

Clays and shales are mixtures of minerals and chemicals. Clays, except for attapulgite or sepiolite, have a plate-like structure composed of large, flat sheets. One definition of a clay is that it will break up (disperse) into particles smaller than 2 microns when placed in water. The clay particle, however, retains its plate-like characteristic shape in water with the large

[1]Van Nostrand's Scientific Encyclopedia. May/June 1994

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surface to edge ratio. This characteristic is important in understanding many of the unique properties of clays which are related to surface activity.

Types of Clays

The Smectites

Wyoming bentonite, the best known member of the Smectite group is economically important for its extensive use in drilling fluids. Wyoming bentonite is primarily composed of the Smectite mineral, montmorillonite. In addition, it is the large amount of the sodium form of montmorillonite that makes Wyoming Bentonite better for viscosity and fluid loss control. Other bentonites from around the world contain more calcium montmorillonite which lessens their ability to swell and disperse in water. The crystal layers in smectites are such that oxygen atoms are adjacent to oxygen atoms resulting in weak bonding forces between layers. This allows more water in place between the layers giving smectites their characteristic high swelling tendencies.

The Illites

Also called hydrous micas, illite resembles montmorillonite but it has different cations internal to the clay lattice making it more stable. Water cannot readily penetrate between the layers resulting in much lower swelling than either sodium or calcium montmorillonite.

The Kaolinites

Kaolinite is a two-layer clay with such strong bonding between layers that lattice expansion is prevented. Most kaolinites do not readily disperse into small units in water.

The Chlorites

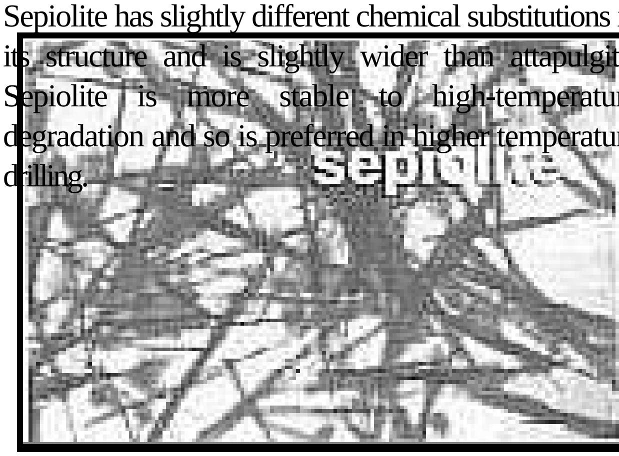
These clays have a very low net charge and normally, no interlayer water. They can swell and disperse to some extent.

Mixed Layer Clays

Many times shale formations do not contain clay with pure lattices as described in the text books. Different clay minerals can be stacked within the same lattice. The most common combinations are layers of Illite and montmorillonite and of chlorite and vermiculite (another three layer clay). Mixed layer clays disperse more readily than single clays, especially if one of the clays is an expanding type.

Attapulgite/Sepiolite

These clays have a completely different structure and shape from those previously discussed. They consist of needle-like particlles that are bundled together. The individual particles can be separated when added to water by vigorous agitation. They have a low surface charge and specific area. They develop viscosity by the physical interference of the separated particles but give essentially no fluid loss control. Sepiolite has slightly different chemical substitutions in its structure and is slightly wider than attapulgite. Sepiolite is more stable to high-temperature degradation and so is preferred in higher temperature drilling.



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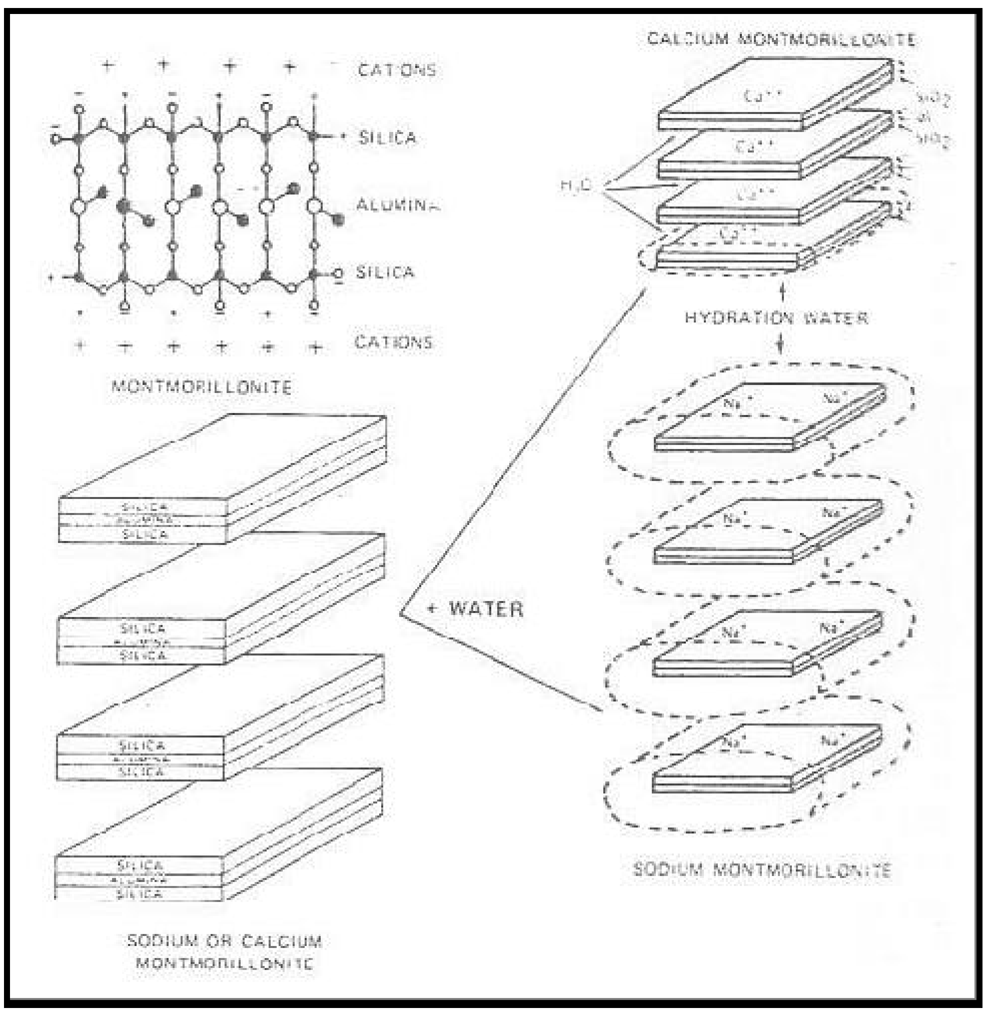
SOME OF THE MORE TECHNICAL ASPECTS OF CLAY CHEMISTRY

by Bill Miles, Bentonite Corporation

Clay minerals can be divided into two basic groups. The first contains the amorphous clay minerals such as allophane which can only be distinguished by chemistry and electron microscopy for basic morphological features. Amorphous clays do not give an X-ray diffraction pattern. The second group contains crystalline clay minerals which can be characterized and distinguished by X-ray diffraction, electron microscopy, and bulk and surface chemistry. This group contains: two-layer type sheet silicate minerals such as the polyorphs of kaolinite; the three-layer sheet silicate minerals or smectites such as montmorillonite, illite, saponite, hectorite, biedellite, nontronite, and others; the mixed layer clay minerals such as chlorite which are composed of alternate layers of different clay types; and the chain structure types such as attapulgite, palygorskite and sepiolite which are characterized by their elongate needle like morphology.

The smectite clay minerals are composed of two layers of tetrahedrally coordinated silica on the top and bottom of an octahedrally coordinated layer of aluminum and magnesium. Defects and substitution predominantly in the octahedral layer, and to a lesser extent in the tetrahedral layer, create negatively charged sites in the clay mineral sheet. Both monovalent and divalent cations are commonly



associated with these sites to neutralize charge. Both the charge density and the ratio of monovalent to divalent cations associated with the smectite control the ability of smectite clay minerals to disperse in water, which is the most important physical property for montmorillonite applications. Cation hydration water and water absorbed on the silicate surfaces of the smectites also influence the ability to disperse and subsequent physical properties. Removal of too much of this water during processing results in products which cannot fully disperse and optimize the physical properties of smectites.

Of the three layer sheet silicate or smectite clay minerals, montmorillonite is the most important from a commercial perspective. It is commercially known as **bentonite, a geological term for a rock which contains montmorillonite as its major component**. The surface chemistry of montmorillonite determines the physical properties of each deposit. It is widely used in significant quantities in several major applications, such as in foundry sand mold binders, drilling fluids, iron ore pelletizing; environmental sealants, or as a liner for containment ponds. Bentonite is also used in other diverse markets including pharmaceuticals, cosmetics, detergents, desiccants, bleaching of mineral and vegetable oils, absorbents, catalyst supports, industrial viscosifiers or thickeners, adhesive components, and in paints and coatings. It is reacted with organic chemicals to produce thickeners for greases, organic solvents, oil-based paints and coatings, and many other special applications.

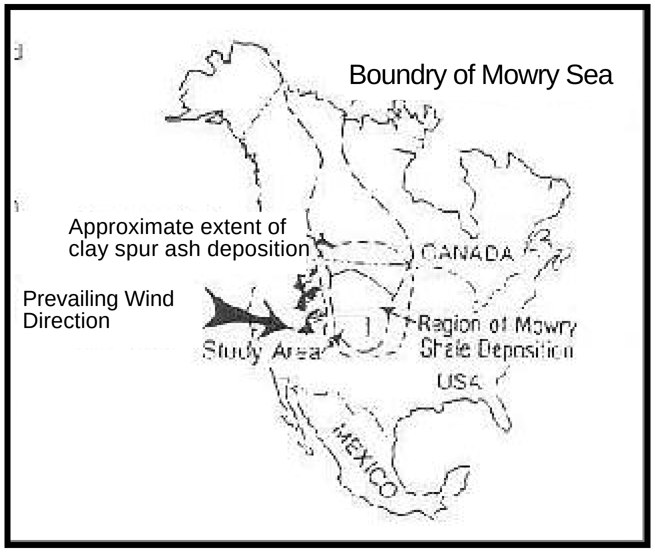
ASHES IN THE WIND

The Story of Wyoming Bentonite

by Monte Raber, Bentonite Corporation

Western bentonite, a most unique industrial mineral, also has uncommon origins. Bentonite's parent material, volcanic ash, is the direct by-product of plate tectonics. During the Cretaceous period, about 135 to 65 million years ago, the North American plate drifted westward, forcing the eastern edge of the Pacific plate deep into the earth's mantle. The pressure was relieved with tremendous volcanic eruptions in areas such as present day western Idaho.

Soon a chain of volcanoes stretching from Nevada to southern Canada were spraying huge quantities of ash and lava. During these near continuous eruptions, ash billowed up into the high



altitude winds. The prevailing winds carried ash eastward, similar to today's weather patterns which transport moisture saturated clouds across the continent.

As the ash laden winds cooled, particles began falling back to the earth. Where they fell on land in eastern Idaho, they accumulated into ash deposits that can be seen today. East of Idaho, however, there was a feature very different from today's landform. A large inland sea, the Mowry Sea, occupied much of the central United States. Closed at the southern end, these waters stretched northward in a narrow body to the Arctic Ocean. This sea was shallow, calm, and somewhat stagnant. It was also rich in dissolved minerals eroded from the surrounding landforms. The fine grained, glass-like ash particles fell into these waters and began reacting with the ocean's minerals while settling to the sea floor.

As the ash accumulated on the sea bed, it is believed that thermal currents helped pile the material into "ash drifts." This explains why some bentonite beds are now found in random lenses much like snowdrifts on a field after a blizzard.

As the ash fall subsided, the only activity was the slow accumulation of sediment eroding from the surrounding land. For millions of years, minerals from within the ash and elements in the sea water combined to form the intricate chemical lattice that makes bentonite so unique. Silt and mud accumulated into massive layers above this mineral-rich soup. The weight slowly compacted the bentonite beds into distinct layers within Cretaceous formations.

This scenario happened over and over again. There are over fifty recorded deposits within 1,000 feet of shale and sandstone sediments. Most of these are less than an inch thick, representing a relatively brief ash fall. Some deposits are several feet thick, but did not have the right chemistry to alter into an economic grade of bentonite. But a few of these volcanic events had everything going for them: abundant ash fall, chemistry, and environment. Sixty million years ago a period of intense mountain building caused folding and raising of the North American plate. This action elevated the formations and drained the Mowry Sea. The rising land mass began drying as water trapped within the formations migrated downward. This action further refined the ash by carrying dissolved silica out of the bed, down into the underlying mud. The Black Hills of Wyoming and South Dakota and the Big Horn Mountains of Wyoming were two of the mountain ranges thrust skyward by tectonic forces. In the millions of years since, thousands of feet of sediment have eroded from these mountains re-exposing the bentonite layers. Today, these deposits are found in an arc on the flanks of Wyoming's mountain ranges, where they are actively mined and processed into high grade products for a variety of uses. Created through volcanic violence, carried high above the earth on global winds, altered over the ages in ocean depths, western bentonite is indeed unique.

WHAT IS A GOOD CLAY?

by Bill Miles, Bentonite Corporation

A “good” bentonite has the appropriate physical and chemical properties for one of the major or minor applications that have already been described. For example. a good bentonite for a drilling fluid requires montmorillonite with sodium and calcium as the minor cations associated with it's exchange sites. A drilling grade bentonite must readily disperse in water to produce a thixotropic or shear thinning fluid which possesses gel strength and a low fluid loss to the formation. In contrast. a good bentonite for acid activation and oil bleaching is composed of high purity montmorillonite with relatively large crystallite size and calcium as the only cation associated with the montmorillonite.

Mining and Processing Bentonite

Commercial grades of bentonite occur as relatively thin beds of altered volcanic ash very close to the surface, consequently. bentonite is almost exclusively recovered by strip mining method. An integral part of mining bentonite is preliminary core drilling to determine the thickness and extent of the deposit and to provide samples for estimation of the physical properties and ore grades within the deposit. After this geological and commercial evaluation of the bentonite in a deposit. mine planning leads to delineation of one or more pits that will supply the needed grades of bentonite for the markets of the company. Each new bentonite pit is stripped of any overburden soils and rocks. These soils and rocks are usually used to fill and reclaim a mined out pit. The pit is drilled for 50-foot centered core samples for final evaluation of ore quality and assignment of ore grade. The surface of the bentonite is cleaned of any contact material by removal of approximately 8 inches of the top layer to prevent contamination. The bentonite is then mined with open pan scrappers and transported to designated ore piles located at the manufacturing facility.

For the major markets and many of the speciality markets, bentonite products are processed by blending the various grade ores to give appropriate physical and chemical properties for each intended application. For example. drilling grade bentonite products must meet American Petroleum Institute criteria found in API Specification 13A, which includes minimum viscosity characteristics and fluid loss. Foundry grade bentonite products, on the other hand, are composed of low viscosity ores which must form durable films joining the sand grains of a foundry mold. To meet these product requirements, the bentonite ores are fed as is to the plant processing facility. Most bentonite products require that the ore be dried in a rotary drier to less than 15% moisture content. Additional drying occurs during further processing.

Products required to be granular in nature are recovered by sieving the drier discharge. Finely ground products are typically produced by milling the dried ore through a roller mill which grinds to less than 200 mesh or finer particle sizing. The processed material is typically stored in silos for bulk shipments or bagging operations.

Drilling Grade Bentonite

There are two drilling grade bentonite products described in API Specification 13A for Drilling Fluid Materials. Section 4 describes the normal grade of bentonite that allows for soda ash or polymer enhancement of rheological properties. Soda ash is added in concentrations up to 20 pounds per ton to lower grade bentonite ores which contain an excess of divalent cations at the montmorillonite exchange sites. improving the viscosity properties of the final product.

Anionic polymers, such as a Polyacrylate, are used to increase the yield per ton of a bentonite blend. In concentrations as low as 0.1 pound per ton of bentonite, these polymers can increase the viscosity of 6% dispersions of the bentonite to produce an over 90 barrel yield per ton product. The current API specifications ensure that bentonite is not over treated with the polymer. In addition, non-dispensable particles (grit) of 75 micrometers or larger must be maintained below 4.0 wt%. These non-dispensable particles are from quartz, feldspar, mica and other minerals in the natural deposits. Their particle size is controlled in processing by grinding to less than 200 mesh (75 microns). Finally, the API Spec 13A, section 4 bentonite must contain a maximum of 10% moisture.

Specification 13A section 5 describes a non-treated Bentonite product. No additives are allowed in this premium drilling fluid bentonite product to enhance viscosity or fluid loss properties. This product requires a yield point/plastic viscosity ratio of 1.5 maximum, a dispersed plastic viscosity of 3.0 cP minimum and a dispersed API filtrate volume of 12.5 ml maximum.

This product has no requirements for grit sizing or moisture content. The lack of a moisture specification is recognition that over-drying a bentonite product is detrimental to its viscosifying properties. In Bentonite Corporation's operation, samples are taken at intervals during the drying and grinding operations to provide statistical process control. Composite samples are collected by automatic samplers to evaluate the physical and chemical properties of each product and determine conformity to product specifications.

BENTONITE IS STILL THE PREFERRED VISCOSIFIER FOR MOST DRILLERS

by Jack Estes, Chairman of the API Task Group on Drilling Fluid Testing

Bentonite clay has been the preferred viscosifier for drilling fluids as long as I've been working in the business (since 1965), and probably was for many years before. One of my early studies into drilling fluids research was a 1939 masters degree thesis on drilling fluids by Sam Oliphant from the University of Texas. He studied Gulf Coast drilling muds, and the effect that bentonite and other clays had on fluid loss and filter-cake development, with a device similar to the present API room temperature cell.

When I went to work for Pan American Petroleum, they had me run bentonite specification tests using a procedure in American Petroleum Institute Bulletin 29A. A 21 lb/bbl Wyoming bentonite slurry gave an average room temperature fluid loss of 6 cc over 30 minutes, with a standard deviation of +1-1 cc. Three years ago, API Committee 13 decided that such variations were caused by variations in gasket size, so the recommended practice now is to check the gaskets with a go-nogo gage.

About ten years ago, Committee 13 members found that the holdup volume differences between cells made by different manufacturers were causing specification testing variations. The testing procedure in Specification 13A was changed to measure the filtration rate after the holdup volume is filled and a filter cake has been formed. The fluid loss specification for 22.5 lb/bbl bentonite using this procedure is now 15.0 cc per 30 minutes. However, this is not the same procedure that the mud engineer uses on the rig, which is the traditional API RP 13B, 30-minute test.

Sometimes the mud engineer uses a shortcut procedure in which the test is run for only 7½ minutes, and the result in volume measured is doubled; this gives a reasonable approximation for a mud with solids contents above 6% by volume, but it will give grossly high results for a low solids mud with high "spurt loss". for which the filter cake takes longer to form.

Bentonite is described by several names. Wyoming bentonite is primarily sodium montmorillonite. Other bentonites are mostly calcium montmorillonite which do not readily swell, and are thus less desirable for a wide range of troublesome hole conditions, but are usually suitable for most top hole drilling.

The API has specifications for three different bentonites. The main specification is for the original API Wyoming bentonite. This specification sets minimum viscosity and fluid loss

Bentonite Specifications from API Spec 13A, Specification for Drilling Fluid Materials, section 4.

Suspension Properties	
Viscometer Dial Reading at 600 rpm	30, minimum
Yield Point to Plastic Viscosity Ratio	3, maximum

Filtrate Volume	15.0 cm^3, maximum
Residue greater than 74 microns	4.0 wt%, maximum
Moisture	10.0 wt%, maximum

values, a particle size check, a maximum moisture content, and a maximum yield point to plastic viscosity ratio. This last value is to limit the amount of beneficiation that may be added during processing.

Several years ago, the API agreed to support the defunct OCMA specifications for non-Wyoming bentonites. These are usually regionally available drilling clays that are suitable for drilling in non-difficult hole conditions. The use of these clays saves on transportation costs in international operations, but clays meeting the OCMA specifications are not intended as substitutes for Wyoming bentonite.

The third specification is for non-treated bentonite. This is for a high quality clay that will give lower fluid loss (13 cc/30 minutes) than the regular API bentonite, but usually will not pass the standard viscosity specification without beneficiation. This type of bentonite is intended for hot holes, since under these conditions it is fluid loss control, not viscosity development, that is of major concern in drilling operations. API non-treated bentonite usually consists of high quality clay, but may contain a substantial amount of inert silica. This type of bentonite is usually specified for use in low solids, non-dispersed muds systems.

The API mud report form also lists other items of interest to drillers. The solids content of drilling fluids is known to Moisture affect virtually all other properties, including hole stability and drilling rates. Volume percent solids is measured by a retort, and is sometimes grossly inaccurate. In unweighted muds, it is usually calculated from mud weight, assuming an average density of the solids.

Some confusion may result because weight percent is frequently reported in laboratory reports, as this is a weighed quantity. To make the conversion, assume that bentonite has a specific gravity about 2.2, and drilled solids specific gravity usually average 2.65, with a drilled solids to bentonite ratio of 2:1; thus, a 1% mud solids volume is approximately equal to 2.5% by weight.

For low solids muds, drillers usually try to keep the solids content around 5.0 by volume, which is about 42 pounds per barrel. Using this guideline, an ideal clay-based mud should have no more than 14 pounds per barrel of bentonite, and no more than 28 pounds per barrel of drilled solids. Outside this range, if the drilled solids exceed three times the bentonite, mud quality and wellbore stability usually degrade.

Fluid loss control is difficult if the bentonite concentration is less than 10 lb/bbl, because there just are not enough colloidal particles to form a tight filter cake. Drilling rates rapidly fall off as bentonite concentrations increase above 20 lb/bbl or as the low density solids content rises above 5%.

Therefore, the desirable range of bentonite concentration is between 14 and 20 lb/bbl. Even this concentration range may not be sufficient to give good viscosity properties and fluid loss control. However, several types of water-soluble polymers come to the rescue here, and have allowed drillers to obtain good mud properties, within this rather narrow range of bentonite content.

Good solids control processing equipment is needed to keep the total low density solids from rising above 0.5%, otherwise dispersants must be used. Dispersants will allow reasonable mud properties at higher solids content, but their use usually results in lower drilling rates, compared to low solids, non-dispersed muds.

For even lower bentonite content, some partially soluble hydroxides have given bentonite good viscosity properties below 10 lb/bbl concentration. Starch-based fluid loss additives are usually used to increase the colloidal content so that a tight filter cake can form in these ultra-low solids systems. Such systems need specially trained people to properly maintain them, but they are very fast drilling, and actually provide better hole cleaning in highly directional or horizontal holes than muds having normal concentrations of clay and drilled solids.