Barite reserves from mines like this one in Battle Mountain, Nev., which produced its 8 millionth ton in 2003, could be extended significantly with a switch to the alternate 4.1 sg grade.

Advanced technology makes new use of age-old drilling fluid agent

Days of using drilling-grade barite just to increase fluid density is changing

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THOUGH ALWAYS FRAUGHT with limitations, barite remains the time-honored weighting agent of choice for drilling fluids. However, highly complex well geometries, tightening supplies and soaring commodity prices are driving modifications to a product that has been a staple of the oilfield for 8 decades.

Since the petroleum industry's pioneering days, barium sulfate essentially had been used with no adjustments to its natural density or particle size. However, the recent development of micronized barite for oil- and water-based drilling and completion fluids has opened the door for expanded applications of a material that has been the industry standard for some 85 years. Even more recently, breakthroughs in the ability to model and manage the physio-chemical interactions of extremely small weighting agents with the base oils comprising non-aqueous drilling fluids have again challenged long-held conventional wisdom on the rheology of weighted fluid systems.

And, in a related development, a variation of long-standing density specifications for drilling-grade barite promises to extend dramatically the worldwide supply of accessible and economical reserves.

The most recent technical advancement in hydraulic modeling cleared the way for the development of ultra-thin weighted fluids that, in the field, have proven their capacity for lowering equivalent circulating densities (ECD) significantly, reducing surge and swab pressures, increasing flow rates and reducing pressure spikes, while possibly improving data transmission for downhole tools. Improved hole cleaning combined with their ability to bridge and plug fractures and permeable formations and reduce barite sag significantly make these fluids well-suited for technically demanding applications such as the deepwater, ultra-extended reach wells and the advancing development of mature reservoirs.

Today, approximately 45% of the world's oil production comes from reservoirs that have passed their peak production, thus generating increased interest in ERD, horizontal, through tubing and slim-hole drilling techniques to access reserves at the extremities of existing production zones.

Fluids with flat, low rheological values over extremes of temperature and pressure are engineered to deliver performance in an optimized operating window, which is constructed from hydraulic modeling of the specific details of each project using fluid parameters established in the lab and offset field data.

CHALLENGING LONG-HELD CONVENTION

The first attempts at well control with drilling fluids came in the early 1920s during the wildcatting days in Texas. With the shallow and vertical wells being drilled at the time, drilling fluids comprised no more than simple mixtures of water and clay. It was inevitable that as wells were drilled deeper, well control problems would became more and more prevalent.

Obviously, many drillers of that era thought that increasing the weight of the drilling fluid would help counter downhole pressures, but at the time the only way to increase density was to rely on the accumulation of drilled solids. The problem was, doing so often made the fluid too thick for drilling purposes.

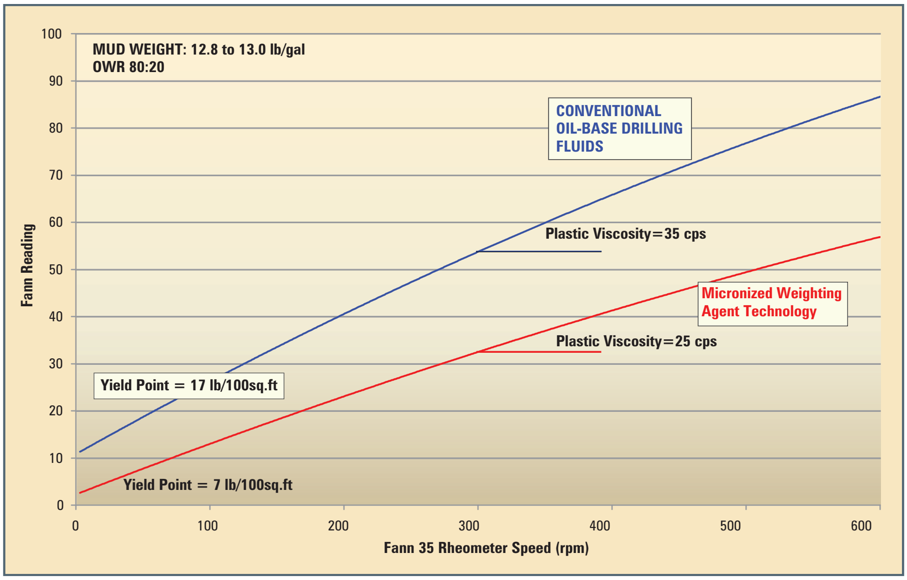
The original patent for barite as a weight control agent for drilling fluid was filed in 1924, but it was believed to have been first used around 1922, and it did not take long for its benefits to be realized. This is a material that is chemically inert, has a naturally high density of 4.2 specific gravity (sg), is non-abrasive, soft and easily ground, accessible and relatively inexpensive.

As early as 1939, specifications for drilling-grade barite were already in place both for density (>4.25 g/cm³) and particle size, which stipulated that 98.75% should pass through a 300-mesh (45-micron equivalent) shaker screen. Since then, several refinements to the specification have been made through the American Petroleum Institute (API) to the point that today, >4.20 g/cm³ has been adopted as the specified density. Moreover, API specifications provide that the maximum size particle retained on a 75-micron screen should be 3%, and particles less than 6 micron equivalent spherical diameter should be no more than 30%. The upper and lower particle sizes largely reflect the performance in a drilling fluid. Should the particle size be too coarse, barite is likely to segregate from the fluid in the surface mixing tanks and from the fluid in the wellbore.

Of the 7.6 million tons of barite currently produced annually, approximately 6.7 million tons are used in drilling fluids.

Property	Procedure	Spec	Test Result	
Density	Sec. 7.3	4.20 s.g. min	4.12 s.g.	Fail
Water-Soluble Alkaline Earth Metals, as Calcium	Sec. 7.6	250 mg/kg max	26 mg/kg	Pass
Residue >75 µm	Sec. 7.9	3.0 wt% max	1.76 wt%	Pass
Particles <6 µm in equivalent spherical diameter	Sec. 7.12	30 wt% max	24.95%	Pass

Above: Properties of 4.1-sg barite compared with the API-specified 4.2 sg grade. Below: Rheological comparison of conventionally weighted drilling fluids with systems incorporating the new micronized weighting technology.



Since the early days, API drilling-grade barite with the adopted density and particle size specifications has always been the preferred product for adjusting the weight of drilling fluids.

Arguably, for the horizontal, small bore, extended long-reach, and other challenging drilling techniques employed routinely today, many consider API specification barite a troublesome product that oftentimes is viewed as a necessary evil. Other than the density requirements, API specification barite provides little value to a drilling fluid. On the contrary, barite always has been prone to sag, thereby requiring the addition of viscosifiers and other gellants to keep it suspended. In addition, the drilled solids that are inevitably incorporated into a drilling fluid quickly assume the particle size of API specification barite, resulting in reduced, or poor, solids separation efficiency by the shakers and centrifuges.

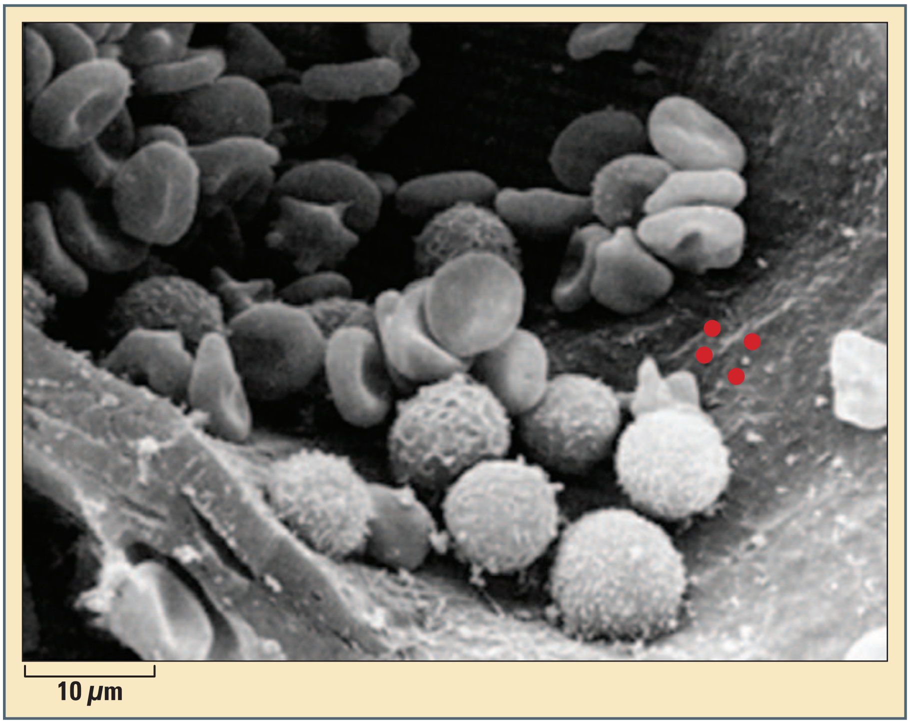
Furthermore, supplies of 4.2 sg barite are not as plentiful as they once were, and there is growing concern that the quality, economic viability and accessible supplies of ore are depleting rapidly. This is particularly true in North America, where significant imports from China and other global producers are required to meet high demands. With increasing demand and smaller reserves, the price of 4.2 sg barite produced outside the US, particularly those from perennial exporter China — where use internally is crimping reserves further — has doubled over the last couple of years. China currently produces between 45% and 48% of the worldwide total of available barite.

Clearly, without significant worldwide investment to locate and produce material to meet the API 4.2 sg and contaminant specifications, it is likely that producers of drilling grade barite will be unable to supply the industry with low-cost product in just a few years.

The complex geometries being drilled today and the likely future shortages of barite have caused many to question whether strict adherence to the API specification for particle size and density is necessary in today's drilling climate.

An extensive analysis has uncovered an alternate grade of drilling-grade barite, which, other than its density, can be produced with the same quality, environmental and specification standards as 4.2 sg ore. In addition, 4.1 sg barite production will prevent rapid depletion of existing reserves and minimize ongoing and expected increases in end-user costs.

One report suggests that if 4.20 sg remains the only acceptable grade, the reserve depletions of leading US producer Nevada alone will require an industrywide investment of US $100 million to ensure 20 more years of supply. Conversely, widespread use of the alternate 4.10 sg material and a modest industry investment in the range of US $7.5 million over the next 2 to 4 years would allow Nevada reserves to handle today's demand load into at least 2016.



How fine are micronized barite particles? About 1/8 the size of the human blood cell.

Technically, the only property of the 4.1 sg grade that does not meet the current specification is density. All other properties fall well within the current specification, and investigations confirm the material will consistently maintain this level of quality throughout its lifetime.

In assessing performance, a series of laboratory tests were conducted comparing the 4.1 sg barite with the current 4.2 sg standard in several commonly used drilling fluid formulations at varying densities. The formulations included a weighted "pad" mud normally employed in deepwater surface-hole applications, conventional clay-based lignosulfonate fluids, and invert-emulsion system and 2 aqueous, non-dispersed polymer fluids. The testing parameters compared similarly treated fluids before and after rolling heat aging tests. The intent was to determine the effects on viscosity by comparing differences between plastic viscosity and yield point. Several formulations were contaminated with clay solids to ascertain differences in properties or performance when the fluids were subjected to drill solids contamination. Results showed performance between the 2 grades were either identical or exhibited negligible differences.

While wide acceptance of lower-density barite would go a long way to mitigate the supply predicament, patented advancements in colloidal barite has been shown to alleviate settling and other interminable problems inherent with barite-weighted fluids.

AN OLD PRODUCT

Conventional wisdom holds that micron-size particles are detrimental to drilling fluids. It has long been believed that too many fines in the fluid will increase rheology, which is particularly problematic when drilling complex well geometries. However, extensive research and field experience has shown that reducing particle diameter by 100 reduces settling, or sag, by a factor of 10,000. With this development, barite is ground from an average of 75 to less than 5 microns, with an average size of 1 to 3 microns, or about 1/8 the size of a human blood cell.

In field applications worldwide, in some of the most challenging well trajectories, the technology delivers benefits never before observed with conventionally weighted fluids. The system has been shown to eliminate or minimize dramatically the occurrence of sag, improve wellbore hydraulics and reduce drilling risk. Moreover, its lower rheological profile effectively reduces ECDs for drilling in narrow mud-weight windows. Owing to higher permissible pump rates and non-laminar flow regimes, fluids formulated with the micronized weighting agent technology enhance bit hydraulics, thus improving hole cleaning while increasing rates of penetration and pipe-running and casing speeds. Compared with offset wells drilled with conventional weighted fluids, the system also has been shown to reduce torque by as much as 25%, allowing for greater horsepower at the bit, faster drilling rates and less drag.

The micronized barite technology has been used successfully in the North Sea, Gulf of Mexico and elsewhere in a variety of technically demanding applications. In the Norwegian sector of the North Sea and the Gulf of Mexico, the technology has been employed widely for the development of maturing reservoirs where such criteria as ECD management, hole cleaning, sag, downhole tool performance, quality cement jobs and wellbore productivity are paramount.

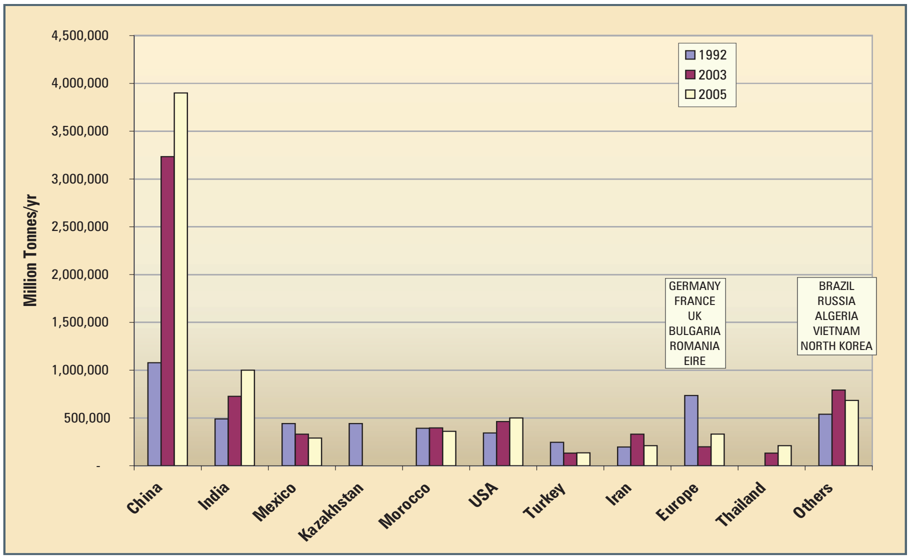
In one Norwegian well, the system was used in a 3,189-ft 5 7/8-in. TTRD reservoir section drilled from 13,441 ft with a maximum inclination of 78° and fluid density of 13.2 lb/gal. The original producing well had been plugged and abandoned in the 7-in. tubing, thus requiring a new well to be drilled out into a new formation from the existing completion to access known pools of hydrocarbons.

Drilling fluids using the micronized barite system were engineered with characteristically low fluid rheologies (3 rpm reading of 2-3 Fann Units) to control ECD without risking barite settlement at this critical mud weight and to deliver between 135 and 185 gal/min to the geosteering tool. The section was completed trouble-free at an average ROP of 52.48 to 59.04 ft/hr, which was 10% above the planned program of 49.2 ft/hr. Overall fluid costs were under budget by 18%.

Following modeling with a proprietary hydraulic software package, an ultra-thin version of the micronized barite technology was used in the Gulf of Mexico, where it has been employed successfully in ERD, depleted sand and managed pressure drilling ERD applications. In each, key properties of the system were low sag tendency, ECD and gel strengths.

The system was introduced to the Gulf as an alternative to a conventional synthetic-base system. It was first used in a 9 ¼-in. production interval of a 31,500-ft MD well with 25,000 ft of horizontal displacement. In this application, the system reduced the losses that could occur had ECD exceeded the fracture gradient, while also eliminating sag, reducing well-control issues. The system also reduced surge/swab pressures, while delivering lower pressure drops. The higher annular velocities, turbulent flow potential and easier cuttings bed removal characteristic of an ultra-thin fluid effectively cleaned the high-angle hole.

The days where drilling-grade barite is just used to increase fluid density are changing. Technological advances and world supply of this crucial mineral for drilling is changing the manner in which this age-old drilling fluid agent is used.



Above: Historical production trends of 4.2 sg barite by country. Below: Percent by volume solids of 10.0 lb/gal fluids using 4.20, 4.10 and 4.00 sg barite.