Diagenetic and Compositional Controls of Wettability in Siliceous Sedimentary Rocks, Monterey Formation, California*

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Abstract

In spite of a century of production in California, the Monterey Formation still holds tremendous quantities of recoverable oil, and much of it may be in truly unconventional reservoirs. Maximizing recovery and developing accurate reserve estimates requires understanding all factors influencing reservoir quality. Little is known concerning the importance of wettability variations in the fluid distribution of Monterey Formation porcelanite reservoirs. Observed differences in charge and producibility of opal-CT- and quartz-phase rocks have previously been attributed to pore throat size and geometry that relate to the silica phase and clay content. Yet with significant variation in bound water content of common clay and silica phases, it is reasonable to expect differences in fluid-solid surface interactions exist and may influence oil movement through the rocks. This study will be the first comprehensive investigation of variation in wettability in siliceous sedimentary rocks because of silica phase, crystallographic ordering and clay content. Contact angle measurements directly demonstrate the affinity of a fluid to a substrate, thus eliminating variables inherent in other wettability measurement methods. Wettability measurements in this study will accordingly be determined by the contact angles of distilled water and mineral oil on a suite of Monterey Formation siliceous rocks collected from subsurface cores. Multiple samples from each silica phase — opal-A, opal-CT and quartz — will be measured over a range of clay content from 0 to 30% in both natural and hydrocarbon—cleaned states. The composition of each sample will be determined by XRD. For uniformity in measurement, samples are crushed and sieved to <500 micrometer, then cleaned of hydrocarbons through methylene chloride extraction process, and then compressed into discs in a hydraulic press. Water and oil are placed onto the sample discs and the drop process is photographed with a high-speed camera.
tensiometer. Contact angles and surface free energy are then calculated. Multivariate statistical analysis will quantify the correlation between the variables of silica diagenesis (phase and ordering), clay content and wettability.
Abstract

In spite of a century of production in California, the Monterey Formation still holds tremendous quantities of recoverable oil, and much of it may be in truly untested and untested areas of the basin. Laboratory and field studies have provided a greater understanding of Monterey Formation reservoirs, but understanding the nature of wettability controls makes the task of recovery more complex. Wettability is a natural characteristic of reservoir materials that affects fluid phase interaction and is an important factor in recovery. Monosilicic acid rocks, known for their wettability, are known to be more productive than other types of rocks. Wettability, however, has not been studied in detail in Monterey Formation reservoirs.

Purpose & Significance

Understanding fluid migration and change in low permeability, low-gained rocks is critical to improved development of Monterey Formation研究. The study of wettability is key to understanding the nature of fluid migration in these rocks. A comprehensive study has been published for biogenic and diagenetic diatomite. Although these studies have provided limited wettability studies of siliceous rocks, a part of the Monterey Formation reservoir characterizations, the attention to wettability of biogenic diatomite is needed. This study focuses on wettability studies of siliceous rocks, specifically in the Monterey Formation, to understand the nature of wettability and its impact on fluid migration.

Hypothesis

The hypothesis is that the transition from opal-A to opal-CT to quartz entails a release of siliceous fluid from the opal mineral lattice. We hypothesize that the loss of pore water molecules with progression of silica diagenesis will result in a decrease in wettability to water and increase in wettability to oil with each siliceous phase transition in siliceous rocks. We also hypothesize that clay content is very important to the bulk wettability properties, that increased clay (even minor amounts) can make the bulk rock watertight to water.

References

Michele et al., 2001

Wettability Measurements

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<tr>
<th>Method</th>
<th>Analysis</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Amott-Harvey</td>
<td></td>
<td>Measures the rate of spontaneous imbibition of a fluid into a solid rock sample, usually a core.</td>
<td>Pre-established and industry standard wettability index.</td>
<td>Cost, variability of permeability, geometry and distribution of porosity, untested and potentially problematic in low permeability sandstones and very tight reservoirs.</td>
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<tr>
<td>USSM</td>
<td></td>
<td>Measures the rate of imbibition into a core plug with known pore pressure, by use of a centrifuge</td>
<td>Suitable to powder samples, pathogen conception, and other measurement methods.</td>
<td>Difficult to control packing, accurately measure fluid, potential to mask the effect of wettability in standard USBM permeability tests.</td>
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Permeability as a Stand Alone Saturation Control

Character of Siliceous Rocks

Acknowledgements

Acknowledgements

Contact angle test data will provide the primary results for this study. Sample preparation for this method is currently in progress, and preliminary imbibition tests performed a means of determining relative wettability to water until contact angle measurements can be successfully performed.

Water Imbibition Test Methods

Contact angle test data will provide the primary results for this study. Sample preparation for this method is currently in progress, and preliminary imbibition tests performed as a means of determining relative wettability to water until contact angle measurements can be successfully performed.

Water Imbibition Test Results

A key observation from water imbibition tests is a marked decrease in wettability to water with the phase transition from opal-CT to quartz, until clay content exceeds approximately 15%. Above clay concentrations of 15%, all samples demonstrate a strong and similar wettability to water, regardless of silica phase.

Contact Angle Test Plans

Test Subjects: Monterey Fm. rocks from 5 wells in the San Joaquin Valley, including diatomite, opal-CT and quartz phase rocks will be tested for their interaction with distilled water and mineral oil. For contact angle measurements, glass slides will be prepared with double-sided Scotch tape covered on one side with sample powdered to <62 microns, insuring the grain size and powder coverage is small enough to prevent interaction between fluid and large surface. Using a CAM101 tensiometer, test fluids will be dispensed on each prepared sample surface and the contact angle measured using the Young-Laplace equation.