AFM Force Mapping as a Fast Alternative to Core Plug Tests for Optimising Water EOR in Sandstone and Limestone

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Traditional core plug tests for optimising water enhanced oil recovery (EOR) have limitations. Each test requires a fresh sample, sophisticated and expensive equipment and several months because cores must be cleaned, restored and aged before the tests can begin. It is also difficult to compare data from one core with results from another because no two cores are identical, making it difficult to distinguish between effects resulting from different conditions and effects resulting from different cores. Thus, our aim was to explore the possibility of a cheaper, faster alternative.

We have developed a method that uses atomic force microscopy (AFM) to investigate the relationship between the wettability of pore surfaces and water salinity. We bring our “oil” wet AFM tip close to the pore surface and measure the work of adhesion between the tip and the solid. Repeated probing of the surface with the tip produces data that can be converted to maps of adhesion and we can estimate contact angle. Small changes of the contact angle is know to produce more oil. We have verified our technique by studying the low salinity response in sandstone where we found the threshold values for the onset of the low salinity response is 5,000 to 8,000 ppm, which benchmarks remarkably well with observations from core plug tests.

The AFM experiments can be done relatively quickly on very little material, it gives the possibility of testing other water EOR techniques on large sample suites from many locations throughout a reservoir and for gathering statistics, cheaply and quickly. The generation of statiscially robust data can then be used to screen conditions to maximise the value of the core plug testing and to provide extra data (such as surface charge etc.) that can only be recorded with AFM. Thus AFM force mapping is an excellent complement to traditional core plug testing. Here we show how to apply the method to test for low salinity EOR in sandstone and limestone and surfactant flooding in chalk and limestone.