5468 Where Gas is Water and Water Is Gas

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A gas accumulation in a field in North Oman has been quoted as an extreme example of high residual gas saturation underlying well-saturated pay, on the basis of the discovery well in the late 1990's. The residual gas and the free gas zones were tested separately: the residual gas zone produced dry gas at a low rate, with water, whereas the free gas zone tested dry gas at a high rate without water. A free-water level was established, with limited uncertainty, on the basis of pressure data collected.

In 2007, an exploratory appraisal well, targeting shallower objectives, was deepened to the Amin Formation, in a structurally down-dip location. As expected, residual gas saturations were calculated from the logs. However, during an operation to collect a water sample from the reservoir, relatively high gas content was observed and subsequently the reservoir was production tested. The result was a surprisingly high gas rate (above 100,000 m³ (st)/d). This is more than what can be expected simply from gas coming out of solution in water. No pressure information could be gathered because of tool failure. In a subsequent appraisal well, in 2008, again deepened to penetrate the Amin reservoir in the 'residual leg', pressure data collected confirmed the water gradient established in the late 90's. Production test is pending at the time of writing this abstract.

Water imbibition has been used to explain the high residual gas saturations. It can be recognized by the saturation-height distribution. In the late 90's, mercury injection drainage and imbibition capillary pressure data were measured on core samples from the first well. The saturation-height distribution in the field does not match the primary drainage capillary pressure curve, but the imbibition capillary pressure curve matches the log derived gas saturation very well, both above and below the FWL.

The question today is: despite high water-gas ratio production, how can a residual gas leg produce gas at the rate observed? Or: if we are dealing with a transition zone only, what is the explanation for pressures falling on a water gradient?

A working hypothesis is as follows: after an initial trap breach, likely due to movement along an earlier sealing fault, which resulted in water imbibition, subsequent and ongoing gas charge is feeding into the area and slowly filling up the trap once again. Evidence for that is the presence of a long well-saturated gas-column in a nearby well, drilled in a separate fault-bounded structural culmination, beyond structural spill of the main accumulation. The fault providing closure now is the same that must have been leaking in the geologic past in order to explain water imbibition.

Other explanations may be valid and will be discussed.