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An Interpretation of Gasbuggy

Preliminary post-shot results of the Gasbuggy nuclear detonation in the Choza Mesa-Pictured Cliffs gas reservoir, Rio Arriba, County, N. M., have puzzled participants in the project,[1] and have resulted in speculation in the oil industry that the shot failed to achieve the extensive fracturing forecast for the technique. Basis for this speculation is that on re-entry one month after detonation, an extrapolated pressure of 977 psia at the 4,150-ft datum was encountered in contrast with an anticipated 1,050 psia. Subsequently, pressure buildup has been very slow—about 1.5 psi/D in Jan., 1968, and still increasing 0.6 to 0.7 psi/D in April, 1968, four months after detonation, when the pressure extrapolated to datum was about 1,080 psia.[2] Most analysts anticipated rapid achievement of pressure equilibrium based on creation of an 800-ft diameter (11.5 acre) fractured region. In addition, pressure buildup of only 1.5 psi/D in the estimated 2 MMcf chimney void would correspond to inflow of only 200,000 scf/D. The pressure differential of about 100 psi corresponds to an indicated early open-flow capacity of only 1.1 MMscf/D after blowdown of the chimney volume. This is only 10 times greater than the 30-day test capacity of a nearby test well completed open hole with no artificial stimulation.[3]

I should like to suggest an alternate interpretation based on reservoir performance and pre-shot testing of the nearby GB-1 test well. Published analyses of these pre-shot data and predictions of long-term post-shot performance either implicitly or explicitly utilize the assumption that performance of this very low-matrix permeability fractured reservoir can be simulated by a mathematical model based on radial flow in a homogeneous reservoir with very low effective permeability. In my opinion the pre-shot test results of GB-1 do not support this simplification. Extrapolated buildup pressure of 1,050 psia in this test well, down from the 1,259 psia initial reservoir pressure, would indicate a gas recovery of about 17.5 percent of gas in place initially in the vicinity of the test well if there is vertical pressure equilibrium in the 286-ft thick reservoir.

This contrasts with actual recovery of only 1 to 2 percent of gas initially in place for the entire eight-well field and 1.4 percent for the nearby centrally located Well 10. During 10 years this well recovered only 81 MMcf of 5,800 MMcf initially in place, corresponding to the nominal 160-acre drainage area of the well and to analyses of cores of the test wells GB-1 and GB-2. The wells had been drilled with gas to determine interstitial water saturation and to permit detailed production logging.[3] This ten- to fifteen-fold contrast between the volumetric estimate of gas in place and a material balance calculation based on the pressure found 275 ft out in the reservoir in GB-1 after 10 years' production is an important clue to the basic performance of this reservoir. If it is assumed that full vertical drainage occurred and that reservoir pressure varies logarithmically with radius from Well 10 beyond the GB-1 test point, trial calculations indicate an effective 40-acre drainage limit, a distance only 400 ft beyond GB-1 in 10 years. This contrasts with a report of very rapid pressure interference detected in Well 10 at a distance of 275 ft during test of GB-1.

These various considerations indicate the possibility that present limited gas production from the reservoir represents widespread areal recovery of gas from parts of the ultra-tight rock matrix (0.001 md in cores under simulated overburden pressure) immediately adjacent to an interconnected fracture system. Also very limited recovery can be expected from other parts of the reservoir in vertical section more removed from connected fractures. The significance of these data in interpreting the pressure observations in the re-entered Gasbuggy well is that higher pressure gas from previously undrained sections in and adjacent to the 440-ft radius, 14-acre, nuclear fracture region not only is pressuring up the chimney, but also is recharging the native fractured zones that were more fully depleted by past production. If this interpretation is correct, the sustained capacity of the well after blowdown of the chimney should be very much greater than calculations based solely on apparent fillup of the chimney. Its significance in predicting long-term performance of the well is that the bulk of the reservoir rock beyond the nuclear fracture region—90 percent of 160 acres and 98 percent of 640 acres—may still be dominated by the ultra-low-matrix permeability restriction of gas drainage from the rock matrix to the natural fractures. This contrasts with the original Gasbuggy concept in which the flow behavior was thought to be dominated by "radial" flow resistance. The purpose of the nuclear explosion was to create fractures that would extend the effective well radius and thus greatly reduce that flow resistance.[4]

References

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