Excess Pressure Development by Cementation in the Wolfcamp Formation of the Delaware Basin

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Abstract

The Wolfcamp Fm. in the eastern Delaware basin has high excess pressure (pressure in excess of hydrostatic pressure). In the War-Wink field area, about 2 km (6500 ft) of Mississippian to Bone Springs section has elevated excess pressure, with maximum excess pressure over 40 MPa (5800 psi) near the center of the Wolfcamp Formation. The eastern Delaware basin is not subsiding, and excess pressure cannot be explained by subsidence-related processes. Preservation of high excess pressure, even if generated in a Cretaceous burial pulse, is unlikely because permeability must be exceptionally low. Vertical and lateral excess pressure distribution is more consistent with excess pressure generation that has continued to today. Cementation of pore space is one possible mechanism for generating excess pressure in ancient basins. Cementation continues in almost all porous rock types where temperature is sufficiently high, including rocks in basins where subsidence has stopped. Cement volume displaces fluid from pore space. The displaced fluid will create an hyperbolic excess pressure distribution as it flows through low-permeability strata. The amount of excess pressure can be approximated by assuming one-dimensional quasi-steady flow. The excess pressure is controlled by the volumetric porosity loss rate, the thickness of rock squared, and the fluid mobility (permeability divided by viscosity). To maintain the maximum of 40 MPa in the War-Wink field area, upscaled vertical permeability must be approximately 0.2 nD, assuming a cementation rate of 0.0005 (5% porosity loss over 100 My). Modeled permeability is slightly lower than upscaled vertical absolute permeability expected in an old, mudrock-dominated system such as the Wolfcamp Fm (~ 1 nD). However, many beds in the overpressured section are partially saturated with petroleum.

Modeled permeability is consistent with upscaled vertical water-phase permeability expected in partially saturated rocks. Results of one-dimensional models are not proof that cementation and other temperature-activated porosity loss mechanisms are responsible for elevated excess pressures in the Wolfcamp Fm. Unlike other proposed mechanisms, cementation generates excess pressure that are consistent with basin burial history, the horizontal and vertical pressure distribution, and flow properties expected in older mudrock-prone basins.

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