Paleopressure, Overpressure, Normal Pressure, and Underpressure and Their Coexistence in the Anadarko Basin

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Well logs, mud weights, and drillstem tests are used to map the state of pressure in the greater Anadarko Basin. We find that the pressure regime has evolved from one that was generally overpressured throughout much of the basin to the present one in which the deep basin is overpressured with normal pressure and underpressure on the flanks of the basin. In the deeper portions of many wells, resistivity logs show departures from a normal compaction gradient over extensive depth intervals. These departures are attributed to the existence of a broad area of original overpressure (paleopressure) that extended from the deep basin to the Kansas-Oklahoma border. This paleopressured volume has contracted to a smaller volume that remains overpressured today in the deep Anadarko Basin, extending vertically from Mississippian strata to the base of Missourian strata. The areal extents of paleopressure and present-day overpressure are compared for Desmoinesian, Morrowan, and Missourian strata.

Cross sections and maps of potentiometric surfaces show why normal pressure exists on the northeast flank of the basin while underpressure exists on the northwest flank. Downcutting and exposure in the late Tertiary of Lower Permian and Pennsylvanian strata along, and east of, the Nemaha fault zone in central Oklahoma form the discharge locus where hydraulic pressures are close to atmospheric pressure, hydraulic head is close to surface elevation, and reservoirs are normally pressured. Westward from the Nemaha fault zone, as elevation increases by thousands of feet, hydraulic head in each major rock unit increases by only several hundred feet, resulting in a progressive increase in the vertical separation between the two surfaces from east to west. As a consequence of this increasing vertical separation between surface elevation and hydraulic head, aquifer-supported oil and gas fields become progressively more underpressured going from east to west. (The Hugoton gas field in western Kansas is a well-known underpressured reservoir.) A 1,000-ft thick cap of Permian evaporites and shales isolates the underlying strata from the surface, preventing re-establishment of a normal hydrostatic gradient. Thus, the present-day pressure regime of oil and gas reservoirs is the result of a series of geologic events widely separated in time: 1) rapid burial and hydrocarbon generation during Pennsylvanian-Permian time caused overpressure to develop throughout much but not all of the basin, 2) the paleopressured area contracted to the present-day overpressured deep basin over a span of (unknown) time, and 3) uplift and erosion during the late Tertiary caused the underpressure on the northwest flank of the basin.

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