Well Testing Investigation of Faults as Complex Subsurface Flow Barriers

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We are conducting an interdisciplinary geoscientific investigation at the Loma Blanca Fault in central New Mexico. One of our group's key research objectives is to better understand how non-idealized barrier faults impact subsurface flow regimes. Fault zones can act as flow barriers, conduits, or complex barrier-conduit features. Conventional flow theory and modeling packages often represent subsurface flow barriers as perfectly vertically impermeable linear boundaries. However, faults observed in the natural world commonly reveal properties including thickness, dip angle, and anisotropic permeability that violate numerous assumptions implicit in linear boundary representations.

The Loma Blanca Fault was chosen as the candidate for this field study because it deviates dramatically from idealized linear barrier models. The fault strikes north, dips at approximately 45°E, is cemented with abundant calcium carbonate, and has variable thickness ranging from 2 to 5 meters visible in outcrop. The calcium carbonate cement is inferred to act as a local groundwater flow barrier based on its low permeability relative to surrounding host sediments. However, multiple lines of interdisciplinary evidence suggest that the fault cement is discontinuous in the northern portion of the study area. Preliminary findings of a site geologic and depositional reconstruction suggest that a nearby ephemeral stream (Rio Salado) previously scoured the fault cement and surrounding sediments in the northern area. This interpretation creates an even more complex study-area subsurface, as it implies the presence of a cemented flow barrier that terminates perpendicular to a lateral erosional contact.

A series of 21 wells were installed in the study area's shallow unconfined aquifer in order to perform constant rate pumping tests. Time drawdown analysis and pressure derivative diagnostics of pumping and observation well data were processed with nSIGHTS open source software. Preliminary aquifer test analyses reveal extreme differences in hydraulic properties between the north/south study area, attributed to the erosional and depositional history. In addition to the presence of the cemented fault barrier, we propose that contrasting aquifer permeabilities on opposing sides of the inferred erosional contact represent an additional hydrologic boundary at this site.

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