1-1-2021

Vertical Fault Migration Potential of Subsurface Contamination into the Ozark Aquifer: Greene County, Missouri

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ABSTRACT

Migration of fluids are commonly handled differently in subfields within the geosciences. In petroleum systems, bedrock evaluation, isopach stratigraphic models, and fault throw estimation are key tools for assessing reservoir quality. Because of the similarities between petroleum systems and groundwater/well-head protection investigations, there is significant opportunity to retask tools and approaches between these two specialties.
In southwest Missouri, horizontal to subhorizontal strata are offset by small displacement (throw ranging from 3-55 meters) normal faults. Stratigraphic units also contain karst heterogeneities in carbonate units, which dominate the stratigraphy. The Mississippian Northview Formation contains shale with minor interbedded siltstone that varies between 0 and 27 meters and acts as a regional confining unit for the underlying Ozark aquifer. In recent years, the connection and potential for surficial contaminants to infiltrate the Ozark aquifer through the Northview Formation along major normal faults has been of concern to state and local officials.

To assess the risk of migration through the Ozark Confining Unit along faults, we constructed (a) isopach thickness maps constructed from publicly available well data and (b) maximum fault throw models based on geologic maps and field investigations. Using these two map products, a series of fault migration risk map are presented by subtracting the maximum fault throw from the Northview Formation thickness map to identify areas where fault offset is insufficient to allow downward migration through faults (Northview thickness exceeds fault throw), and therefore there is a low risk of contamination into the Ozark aquifer from the surface or near surface. High risk areas are identified by zones where Northview thickness does not exceed maximum fault throw and, therefore, surficial contaminants could conceivably travel downward along fault conduits into lower stratigraphic units. We propose this decision-making tool may improve site-by-site evaluation of the potential for vertical migration via faults and allow for more focused remediation techniques to fit the actual risks.

RATIONALE AND METHODOLOGY

Detailed well strip logs, which are publicly available through the Missouri Department of Natural Resources (MoDNR) Geosciences Technical Resource Assessment Tool (GeoSTRAT) GIS database, were utilized to create an isopach thickness map of the Northview formation; the dataset was comprised of over 900 well logs across the study area. Wells which did not fully penetrate the Northview Formation were excluded. For logs where the unit was logged as "Kinderhookian" (which includes the Northview, Sedalia, Compton, and Bachelor formations), a thickness of 10 feet was utilized based on average for the area. ArcMap's Spatial Analyst – Interpolation tool was utilized to generate the isopach thickness model, with a cell size of 500 meters.

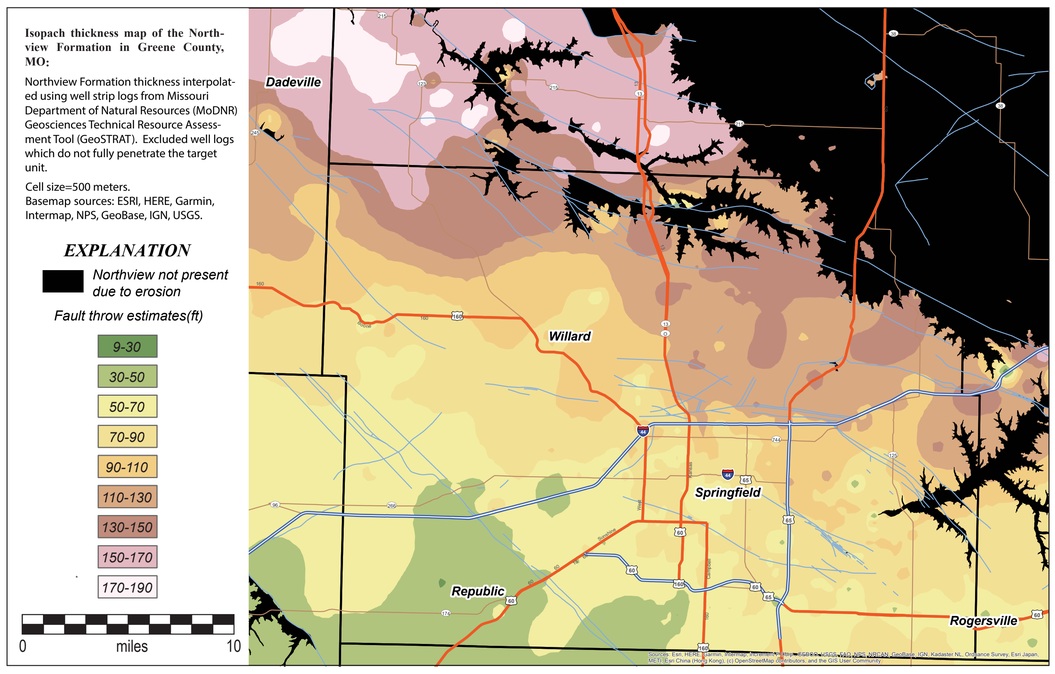
Missouri Geologic Survey (MGS) 1:24,000 quadrangle geologic maps were utilized, along with known fault locations from GeoSTRAT, to calculate throw along faults within the study area. To estimate throw, the elevation of matching unit contacts (example: Kinderhookian/Pierson) were located on either side of a fault; the offset between the two elevations was recorded as a point along the fault. This process was continued along the length of each fault in the study area, to capture any variations in offset. Contour intervals for the geologic maps were 10 feet; therefore, if no offset was observed, a value of 9 feet was recorded at that point as a conservative estimate. The Spatial Analyst – Interpolation tool was utilized to generate the maximum fault throw model, with varying cell sizes (500, 1000, and 2500 meters).

Finally, ArcMap's Minus tool was utilized to subtract the three maximum fault throw models (500, 1000, and 2500 meter cell sizes) from the isopach thickness map, resulting in the three Fault Migration Potential models. Cells fell into one of eight categories: shades of green indicate areas where at least 10 feet of shale-to-shale contact is present along a fault, limiting potential vertical migration. Yellow indicates a range of +9 to -10 feet of shale-to-shale contact, with a moderate possibility of vertical migration along a fault in that area. Shades of red indicate that the Northview formation is completely offset by the fault by at least 10 feet, with a higher potential for vertical migration along the fault.

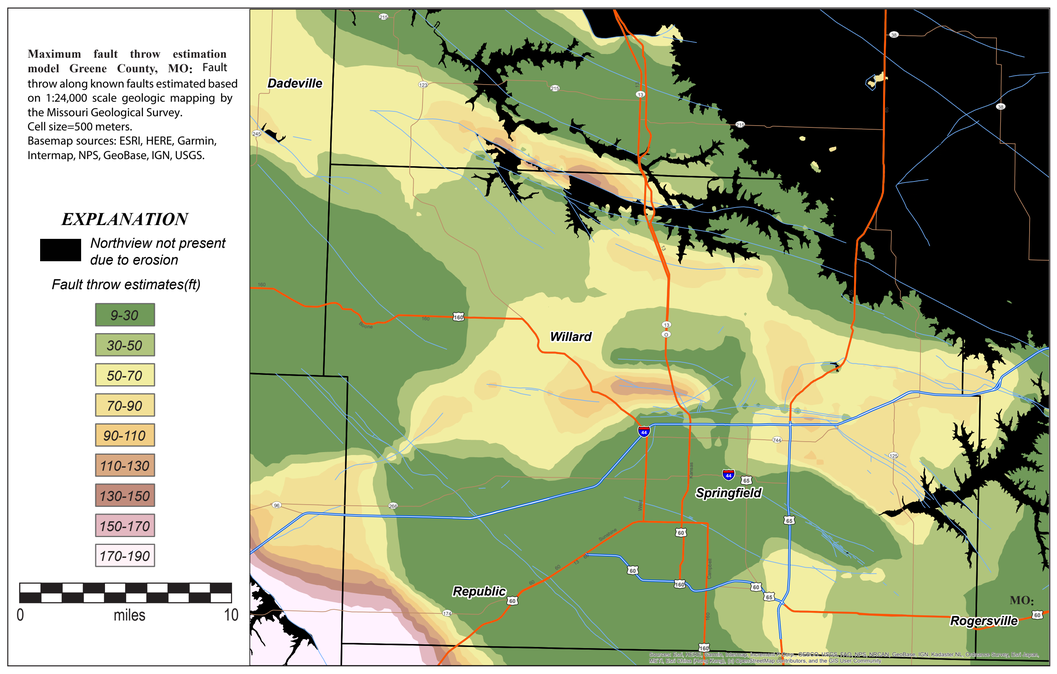
Areas where the Northview formation is not present due to erosion or lower elevations are excluded from the study (shown in black on the maps).

Assumptions & Limitations: The study assumes that 10 feet of shale-to-shale contact is sufficient to limit vertical migration along faults. Formation contacts have not yet been ground-truthed. The study also does not account for vertical migration on preferential pathways, such as karst voids or water wells which perforate the Northview shale and are not cased through this zone.

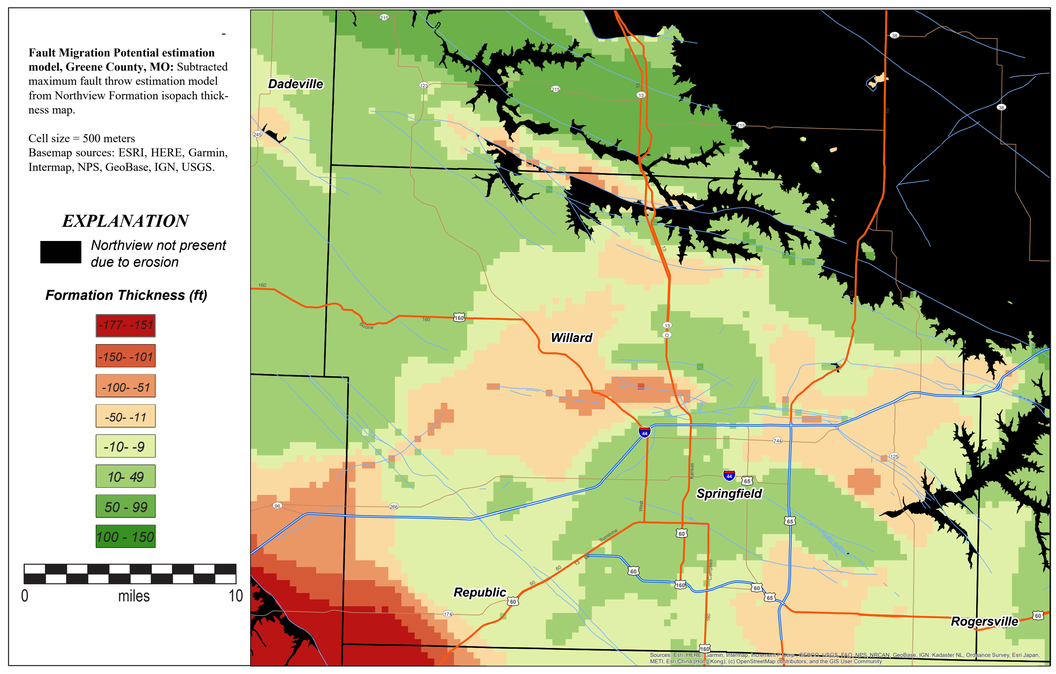
ISOPACH MAP OF THE NORTHVIEW FORMATION IN GREENE COUNTY, MO



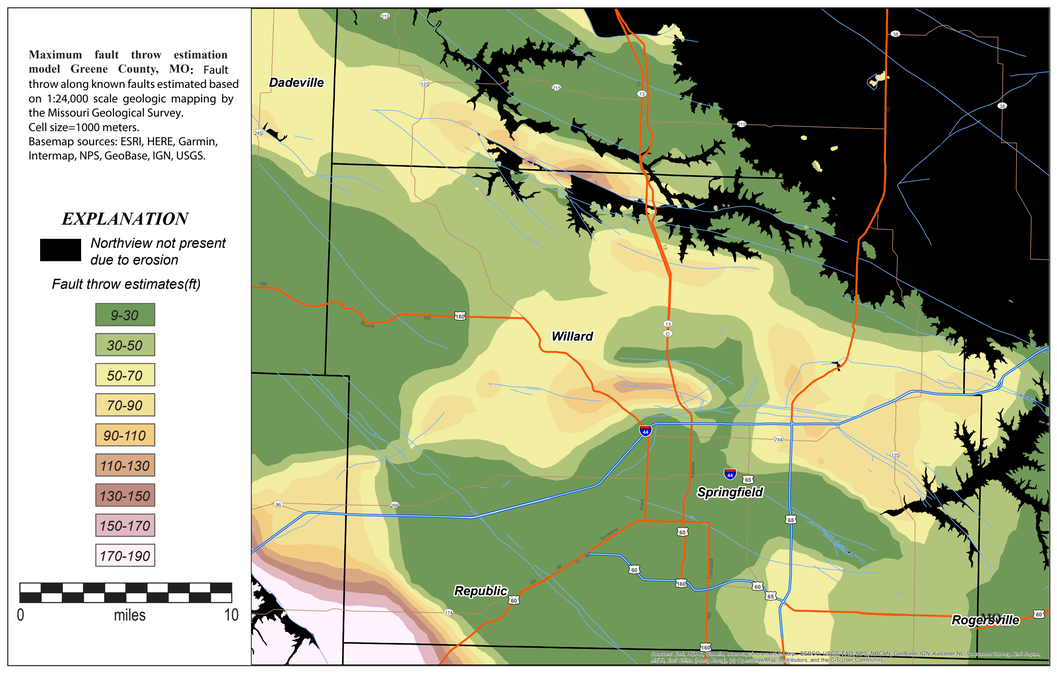
MAXIMUM FAULT THROW MODEL (500 meter cells), GREENE COUNTY, MO



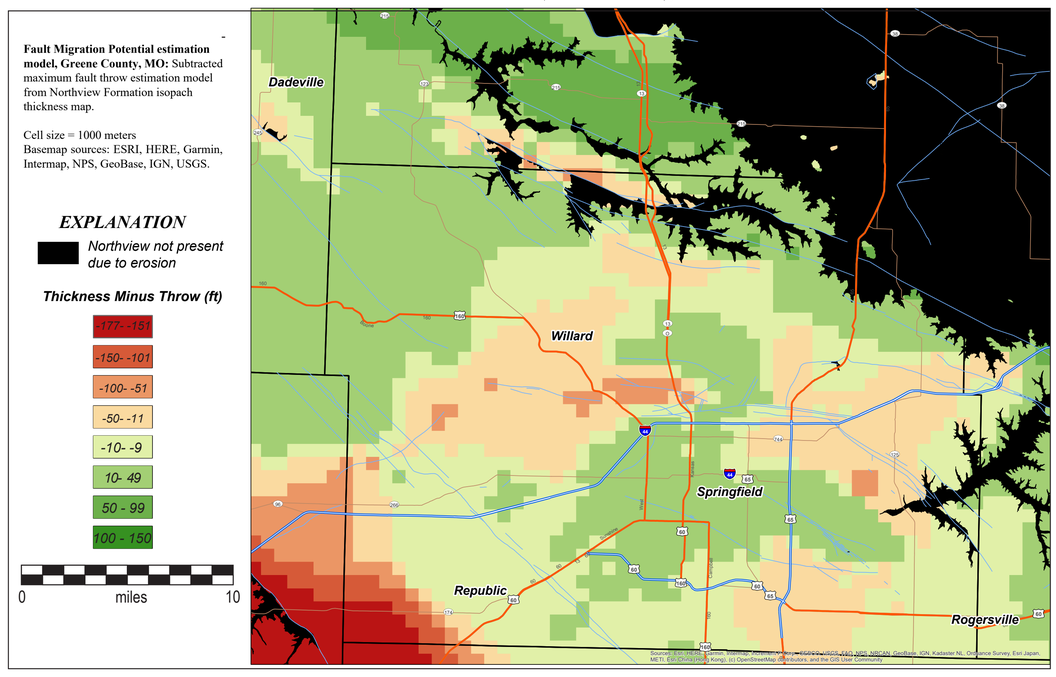
FAULT MIGRATION POTENTIAL (500 meter cells), GREENE COUNTY, MO



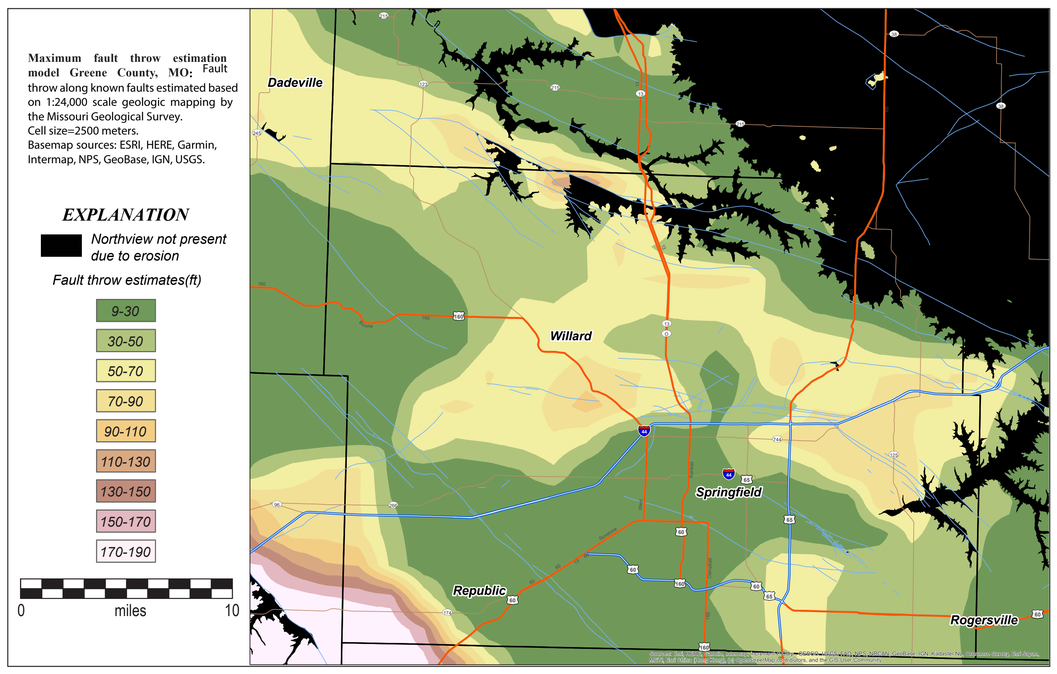
MAXIMUM FAULT THROW MODEL (1000 meter cells), GREENE COUNTY, MO



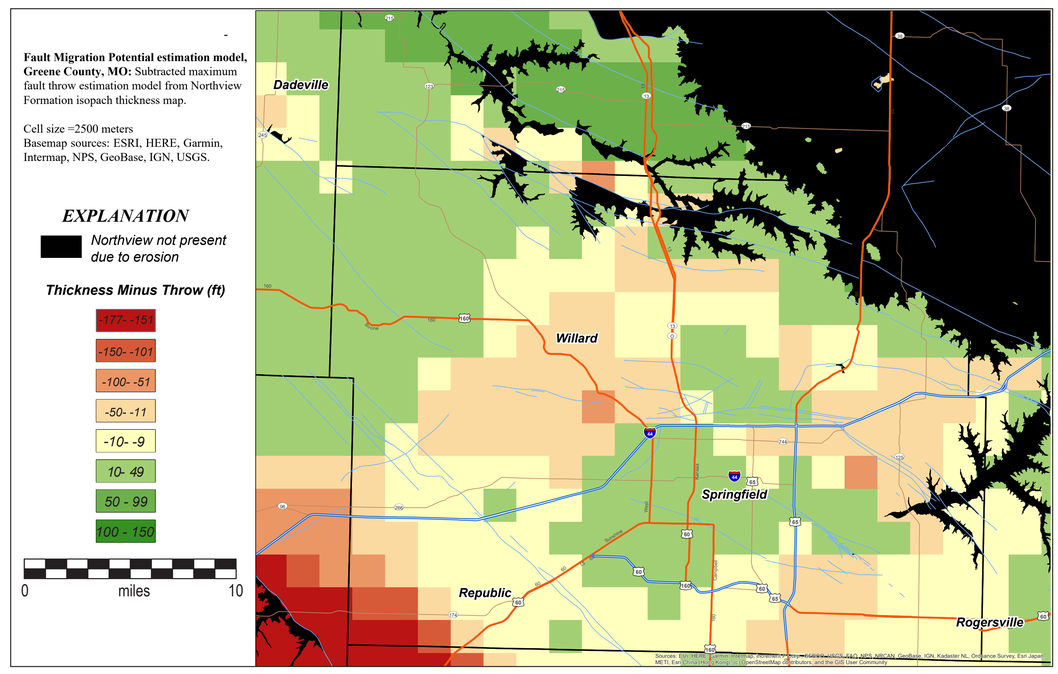
FAULT MIGRATION POTENTIAL (1000 meter cells), GREENE COUNTY, MO



MAXIMUM FAULT THROW MODEL (2500 meter cells), GREENE COUNTY, MO



FAULT MIGRATION POTENTIAL (2500 meter cells), GREENE COUNTY, MO



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2021

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