Induced seismicity in carbon sequestration

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CSI Induced seismicity

- Brief introduction
- Probabilistic hazard prediction
- Fault curvature

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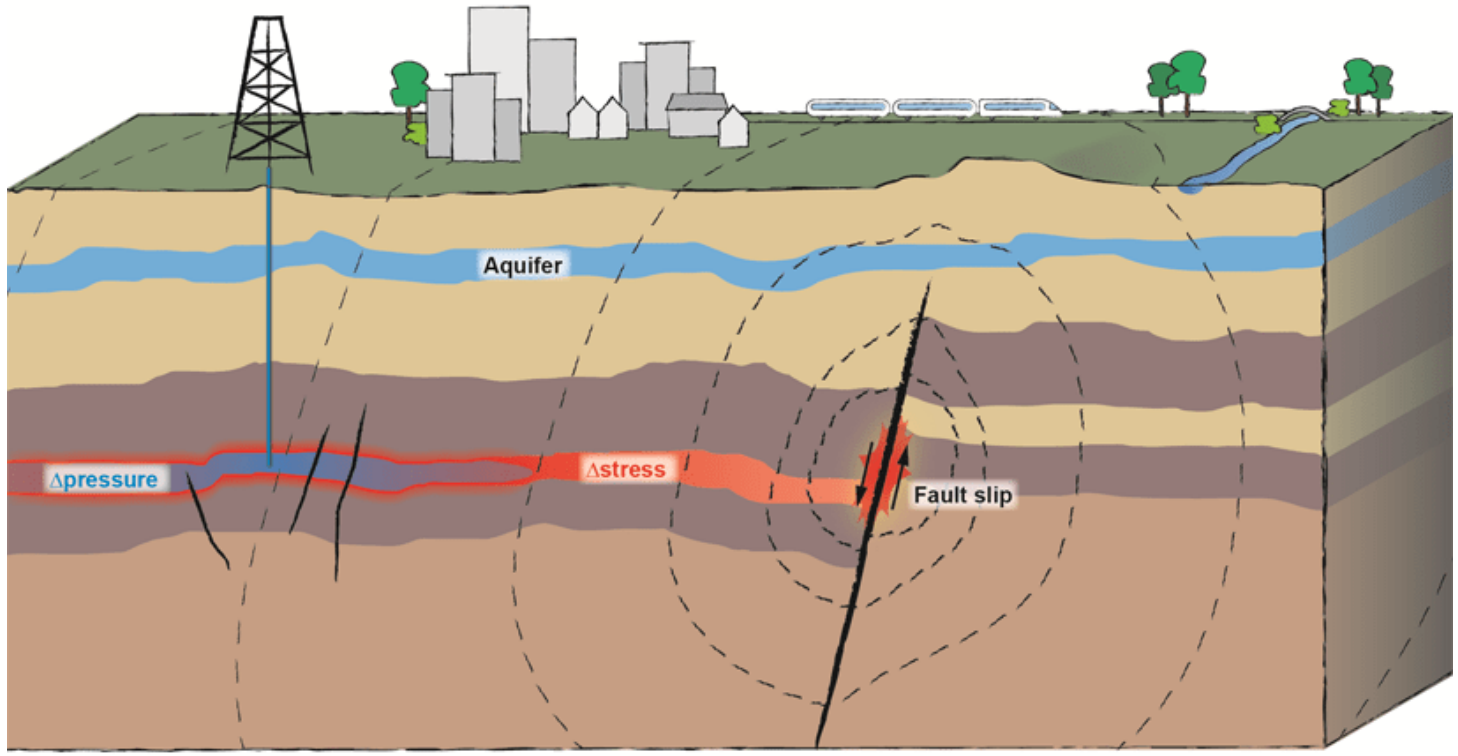
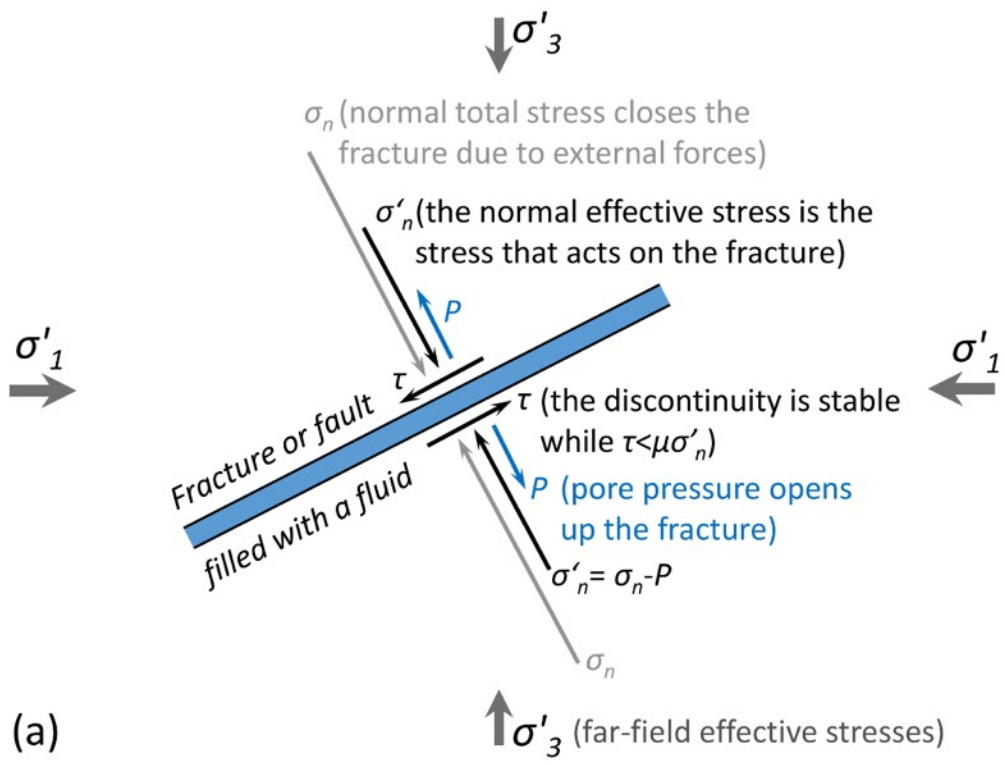
Geo-energy activities can and do induce earthquakes

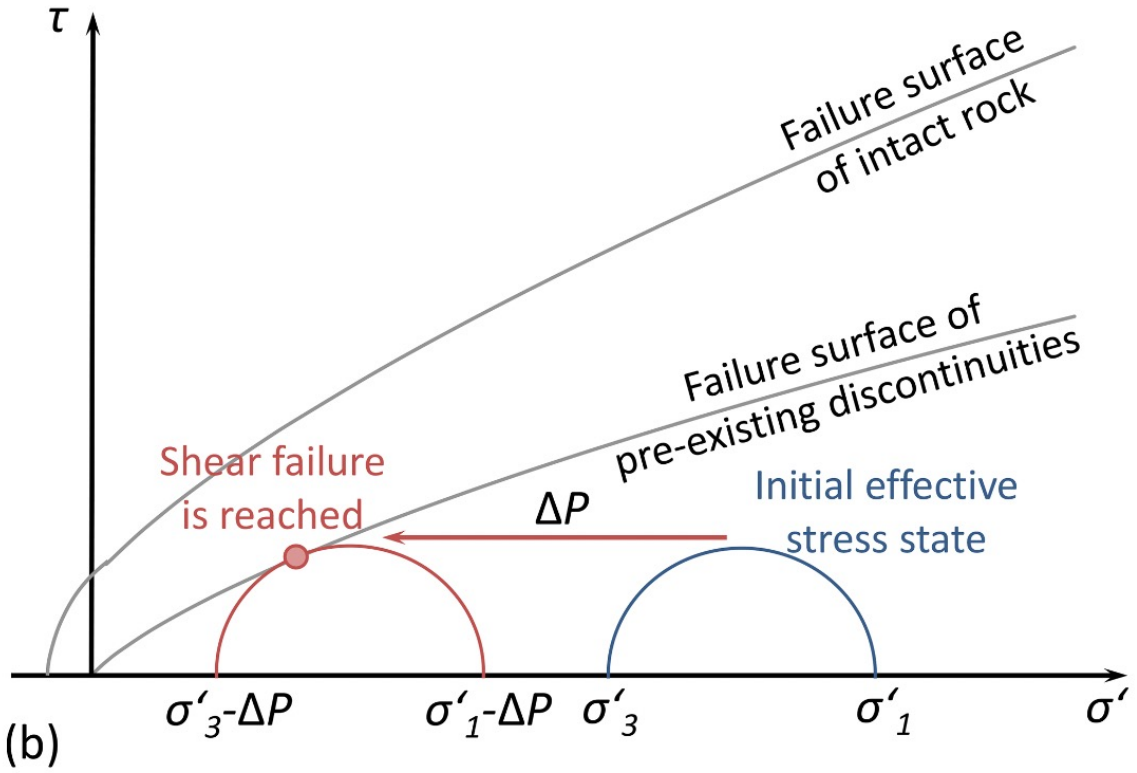


A magnitude 2.3 induced event caused an uproar in the UK that caused a moratorium on hydraulic fracturing

Mark Kerrison/Alamy

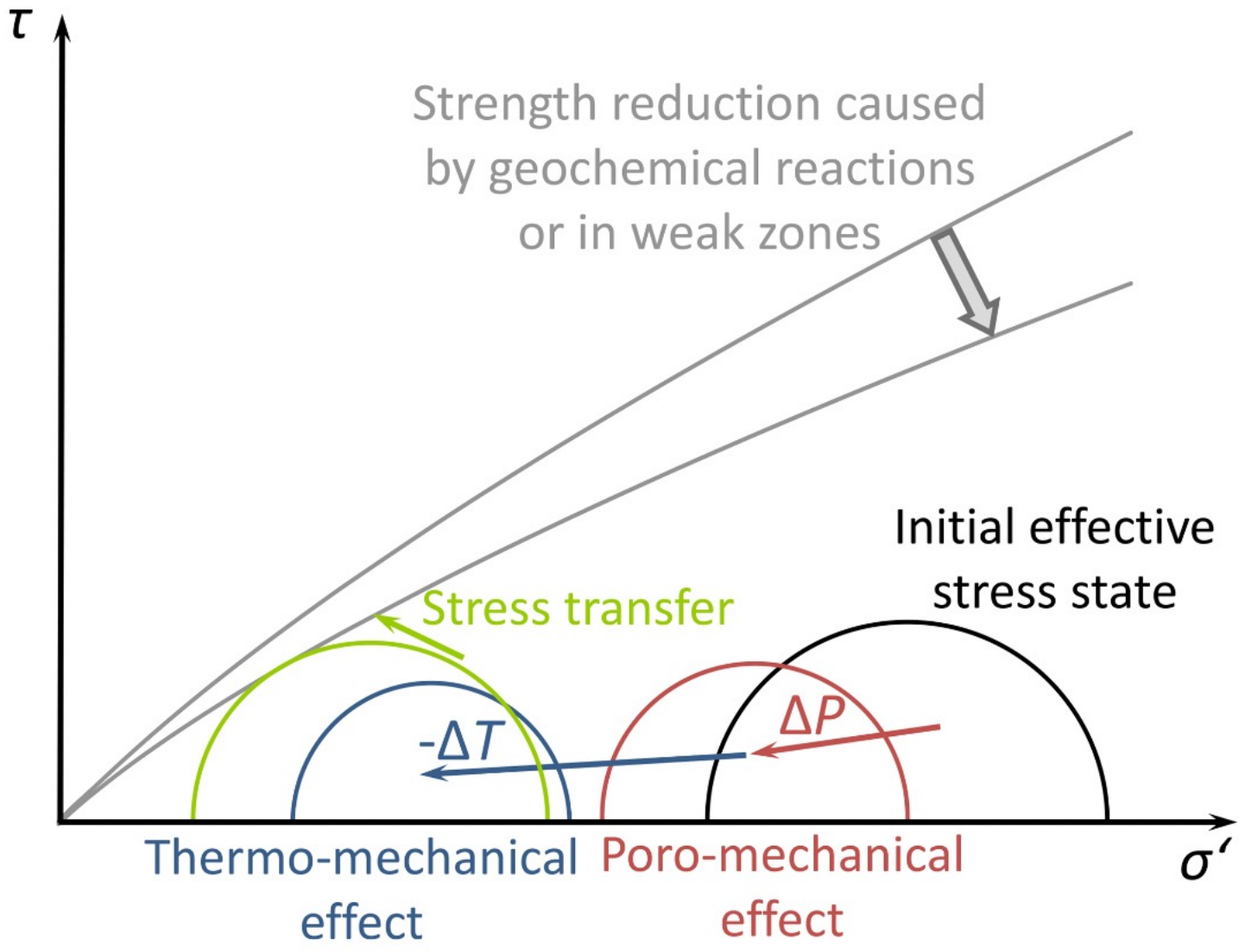
The primary mechanism of induced seismicity is through the reduction of the effective normal stress





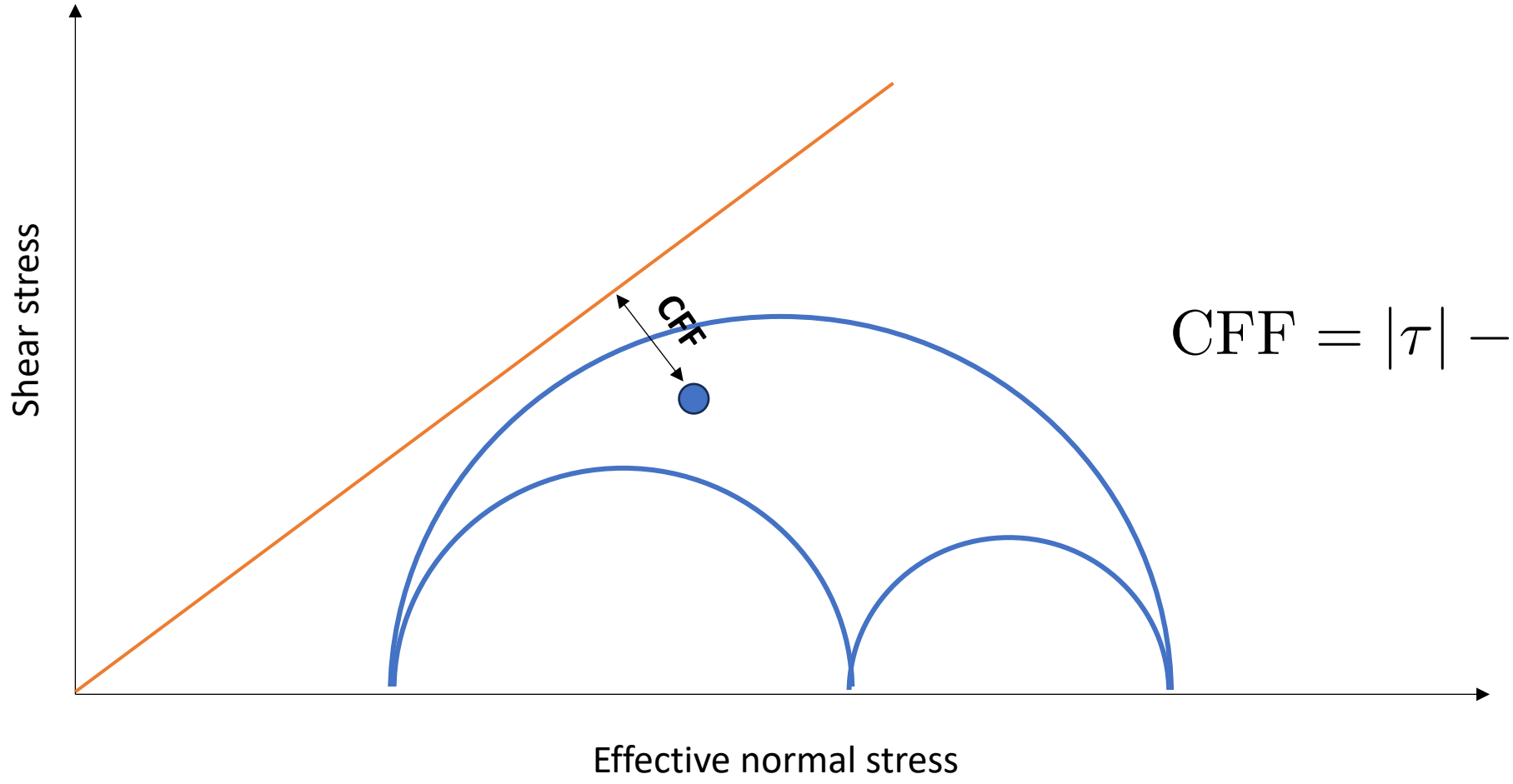
Vilarrasa et al. (2019)

Other mechanisms exist, however



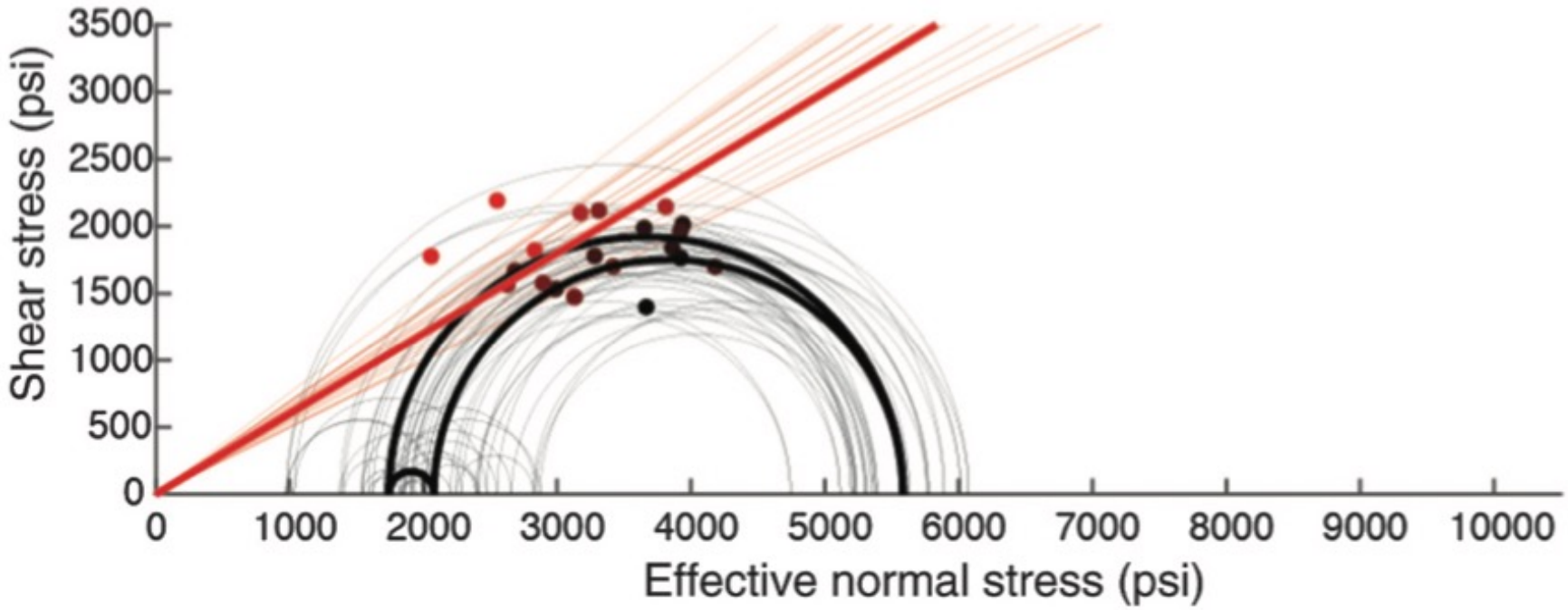
Vilarassa et al. (2019)

The Coulomb failure function (CFF) as means of describing earthquake potential is well understood



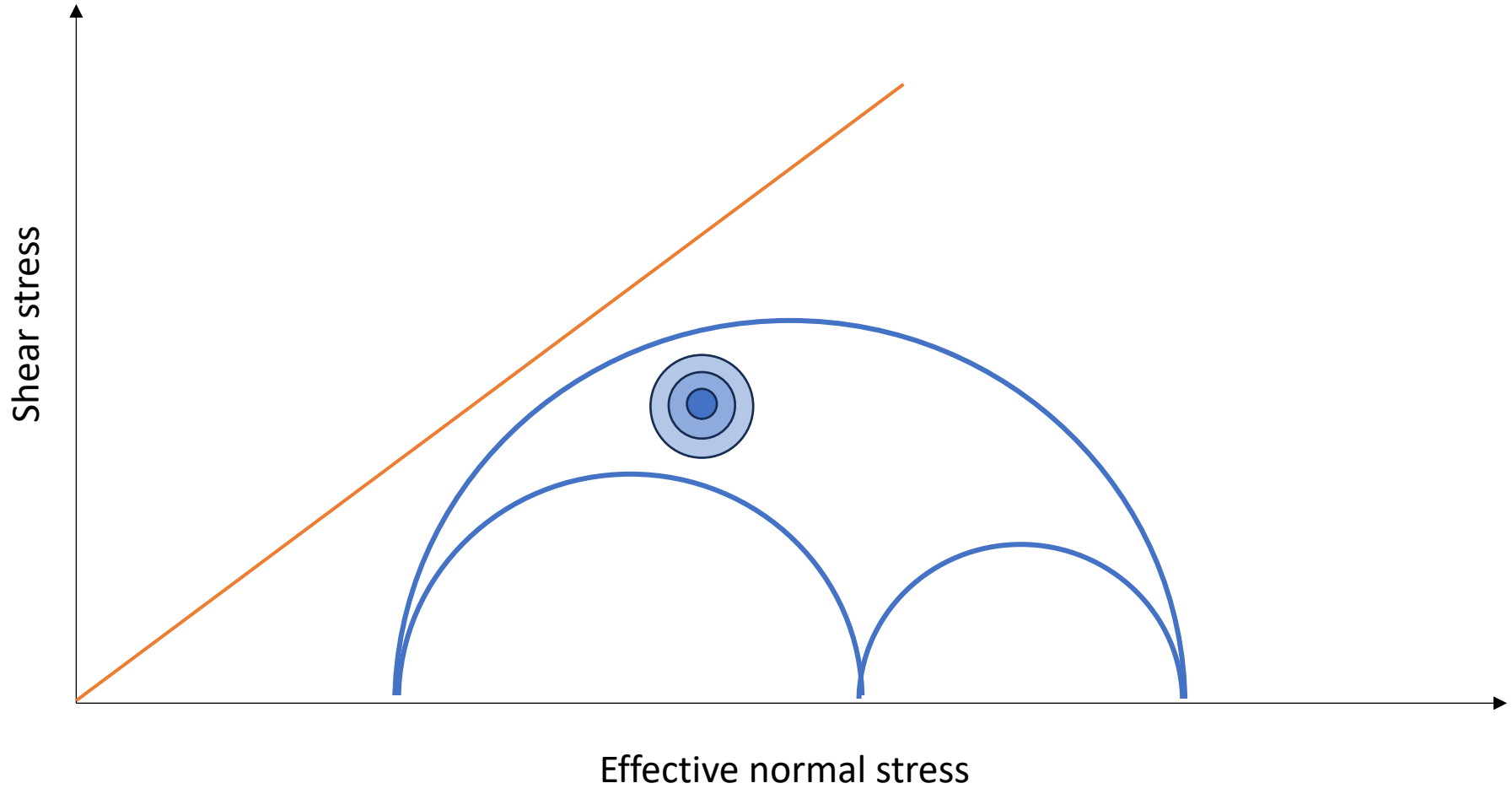
$$\mathrm{CFF} = |\tau| - \mu\sigma_n$$

In this talk, we will explore probabilistic approaches to uncertainties



McCormack et al. (2022)

In this talk, we will explore the impact of curvature along a fault



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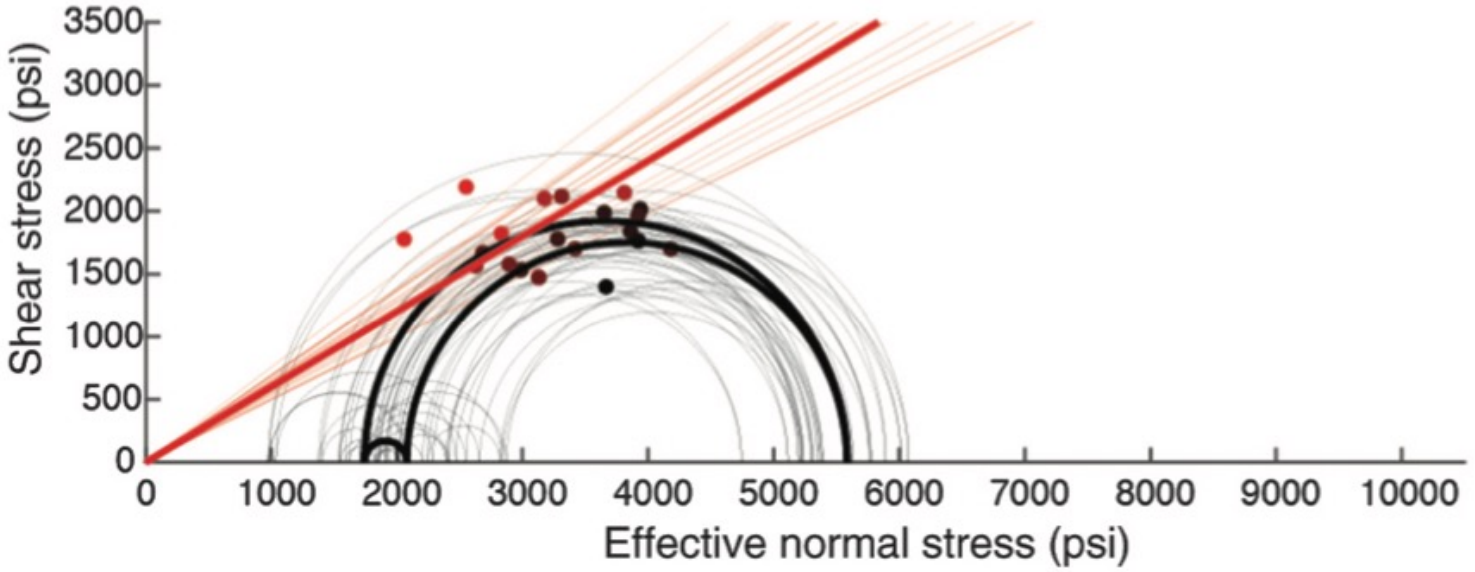


The San Juan Basin CarbonSAFE project is concerned with induced seismicity

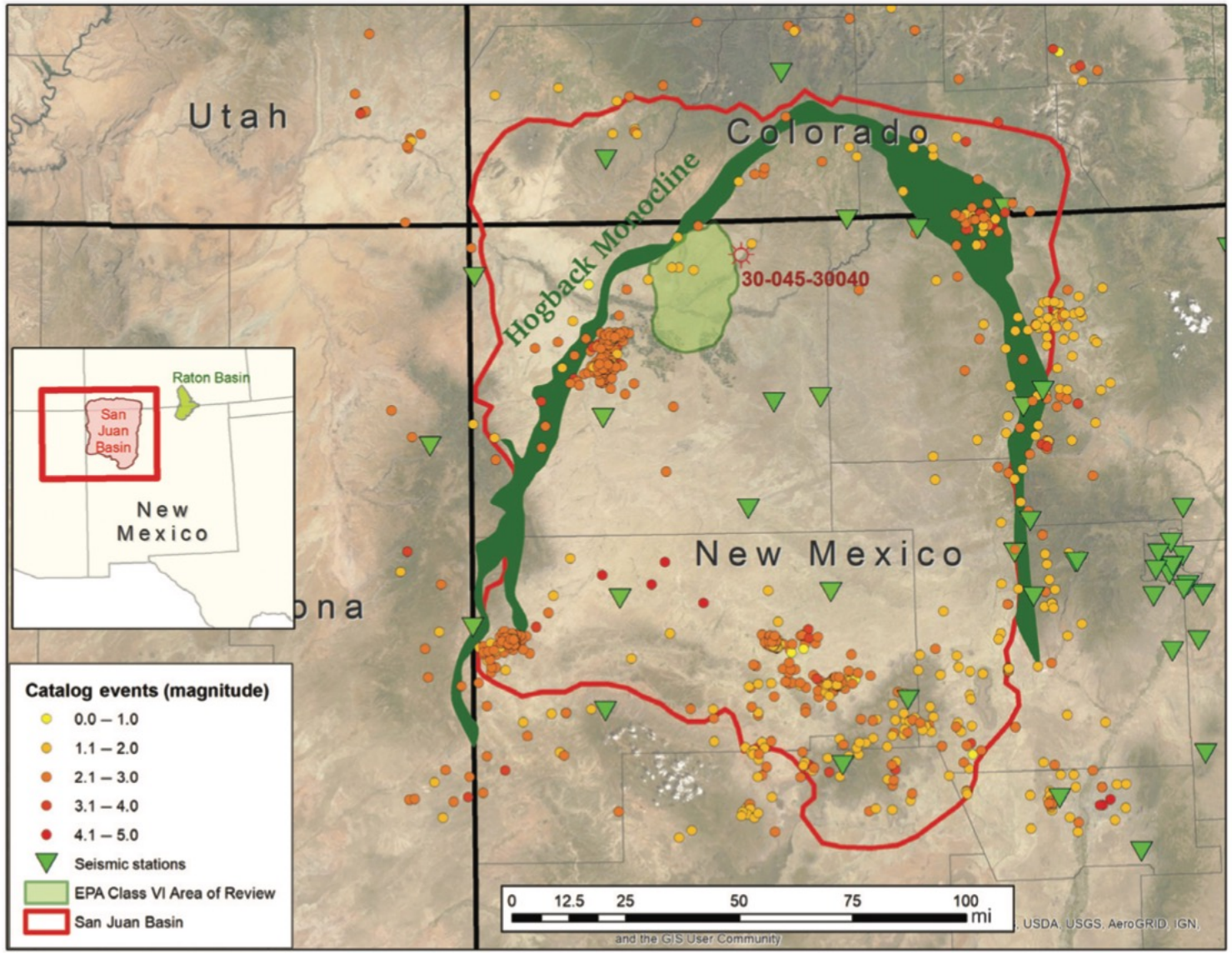
Commercial feasibility test of geologic carbon sequestration

San Juan Basin is in northwestern New Mexico

Intends to store 6-7 million tons per year over 12-20 years

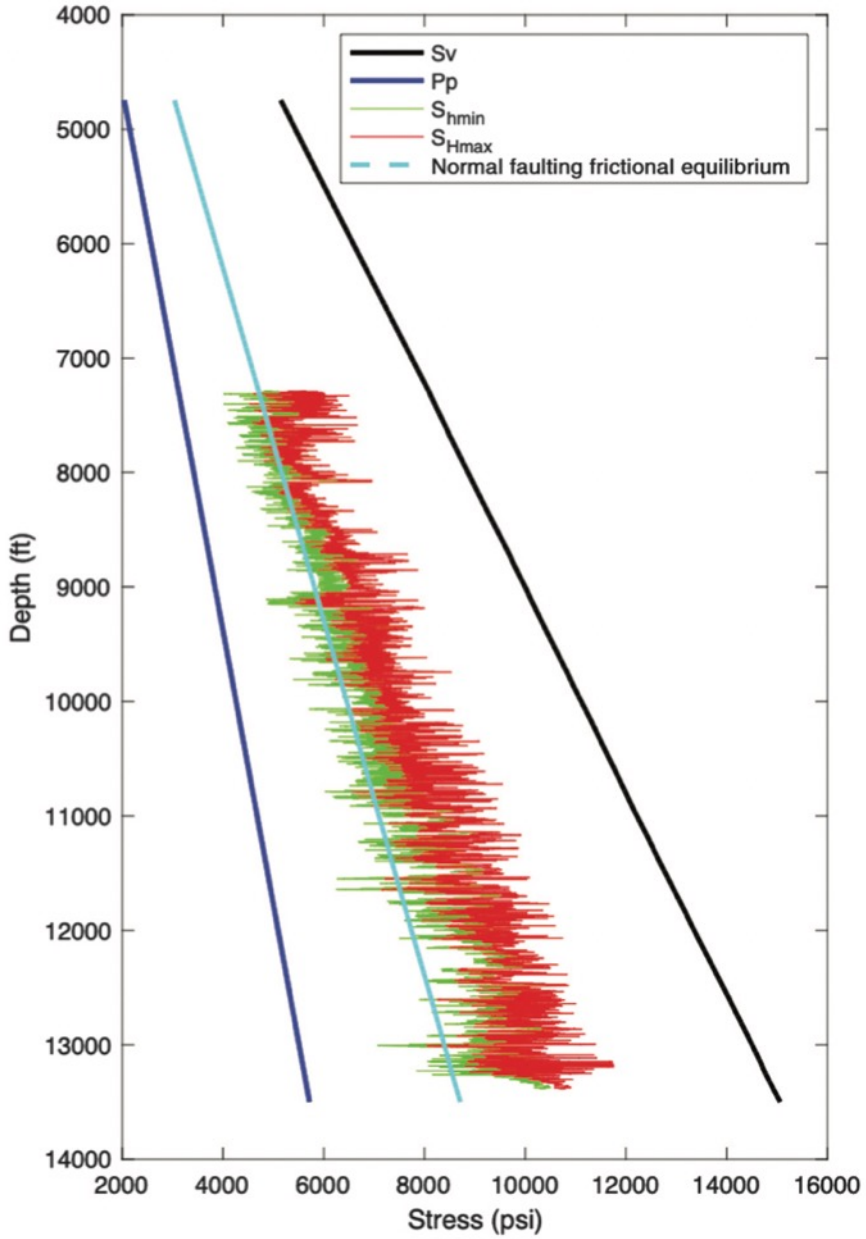
Currently applying for a Class VI UIC permit

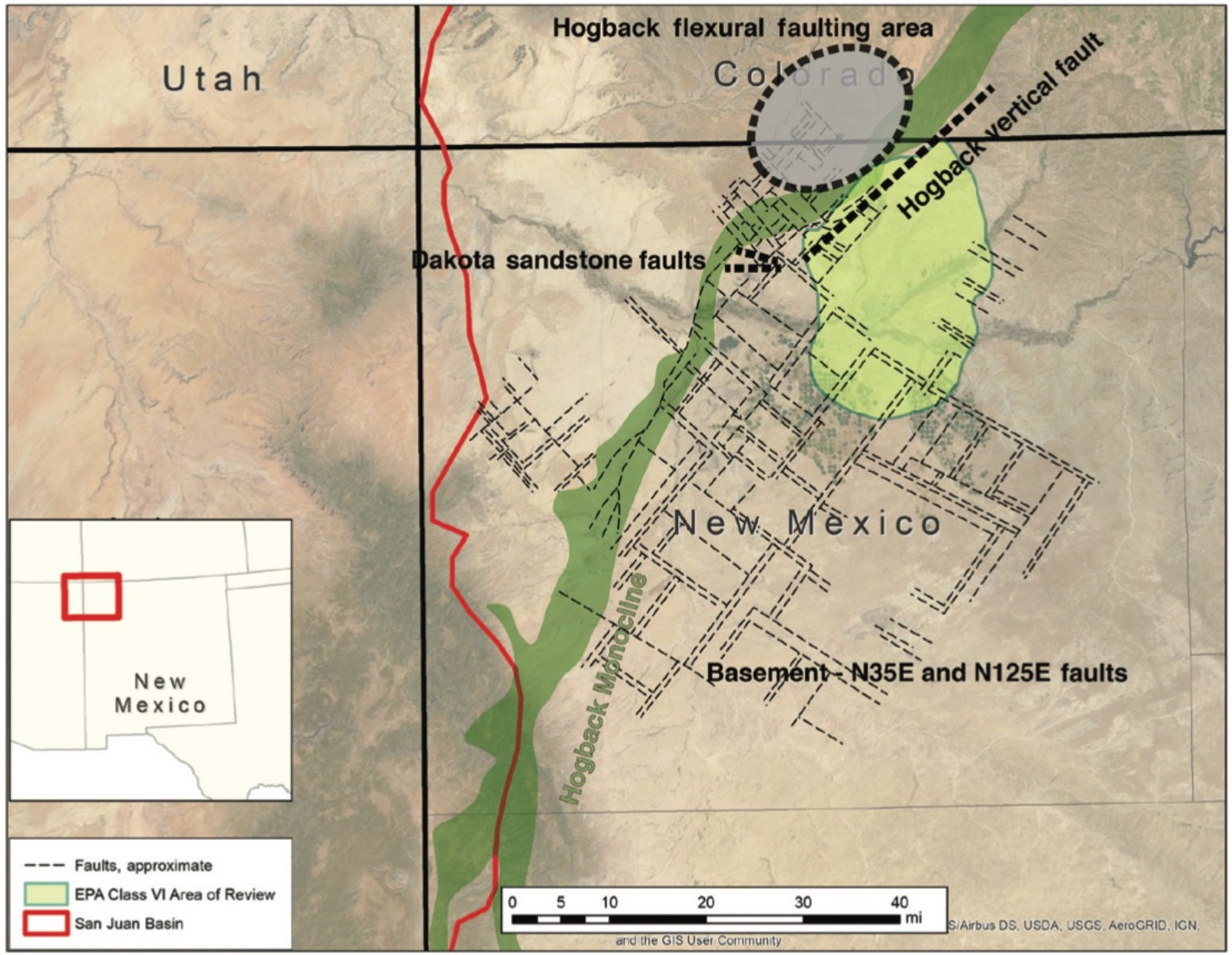
The past seismicity indicates low hazard



McCormack et al. (2022)

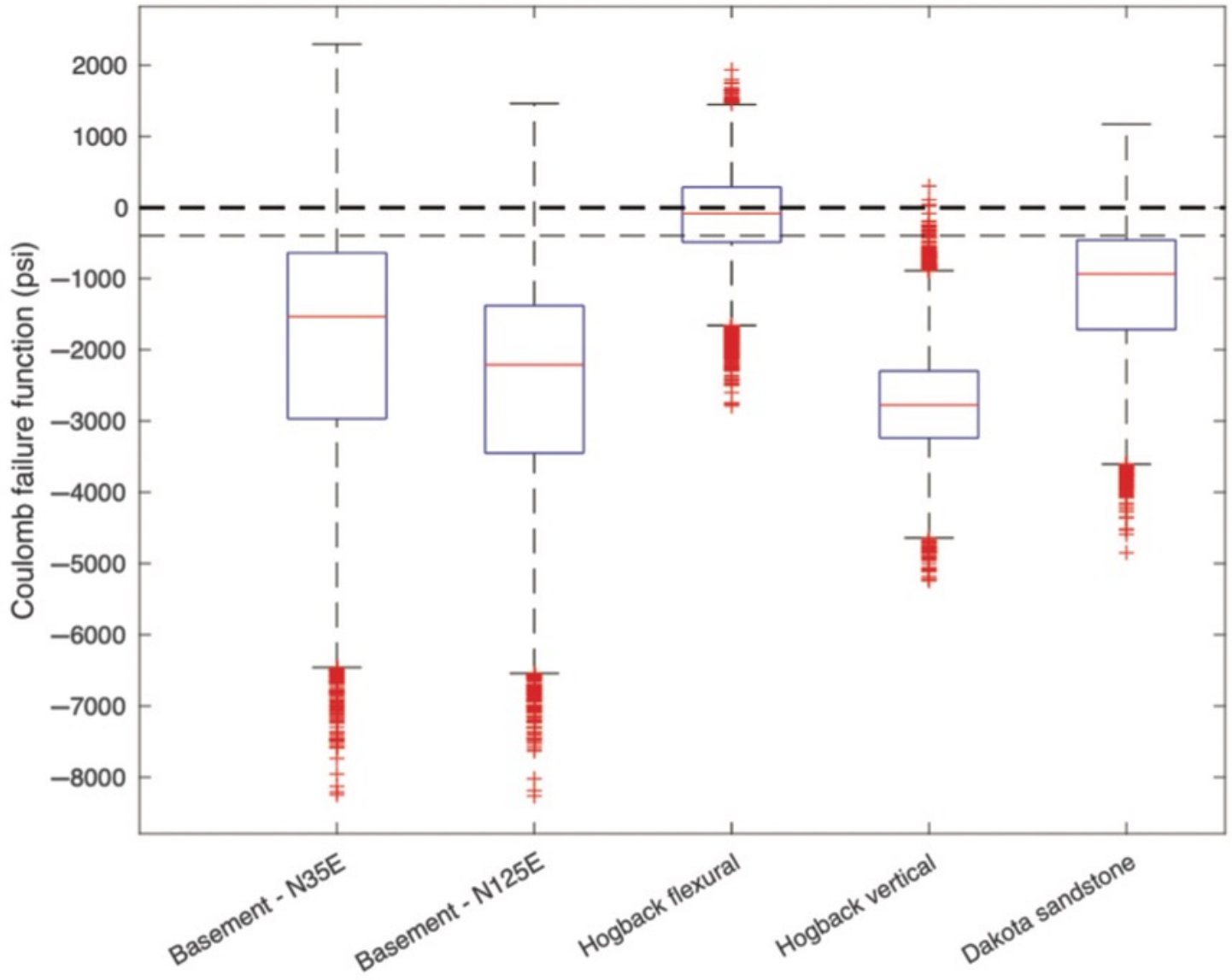
The stresses are obtained with Eaton's method and certain faulting scenarios are identified





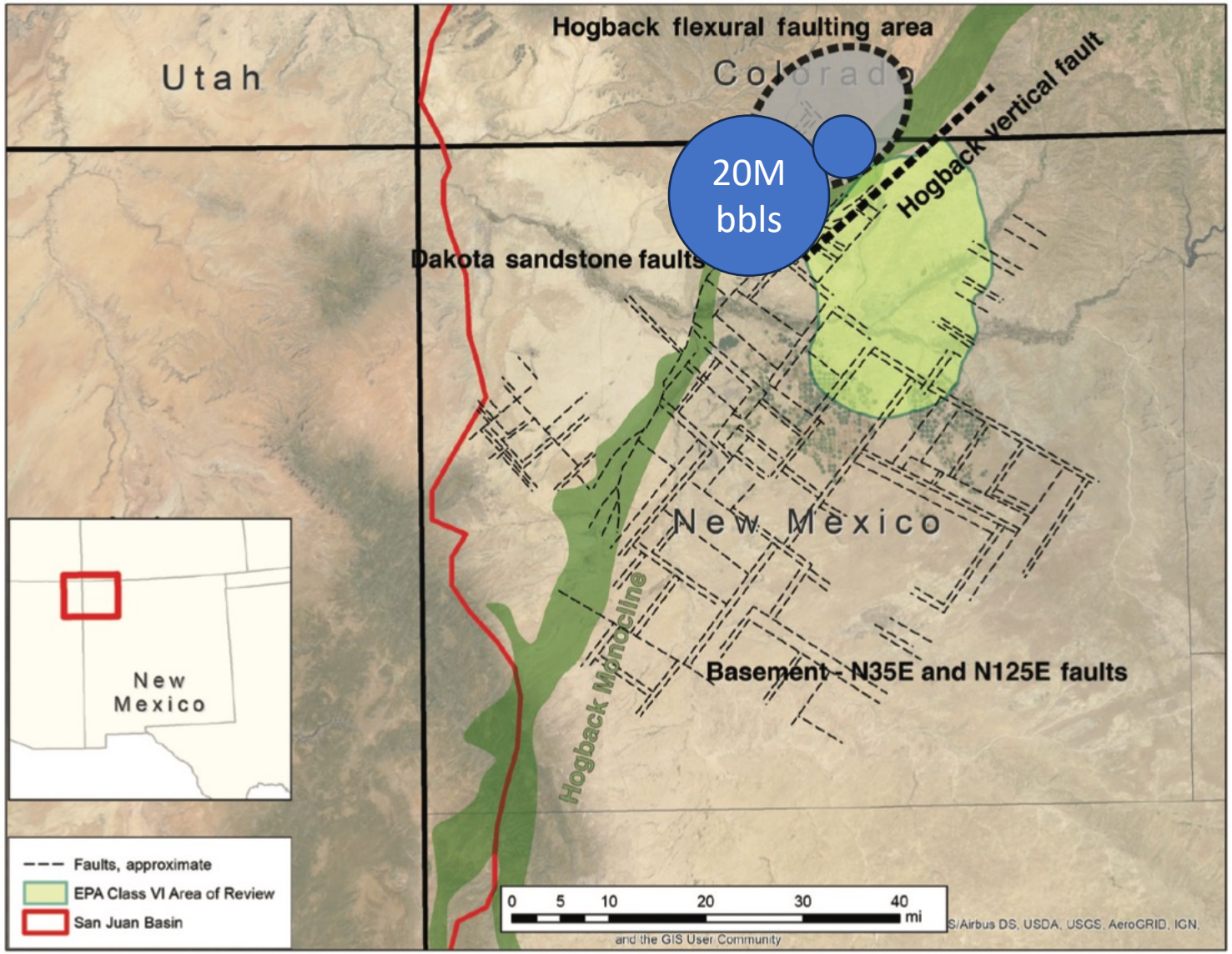
McCormack et al. (2022)

One scenario is potentially problematic

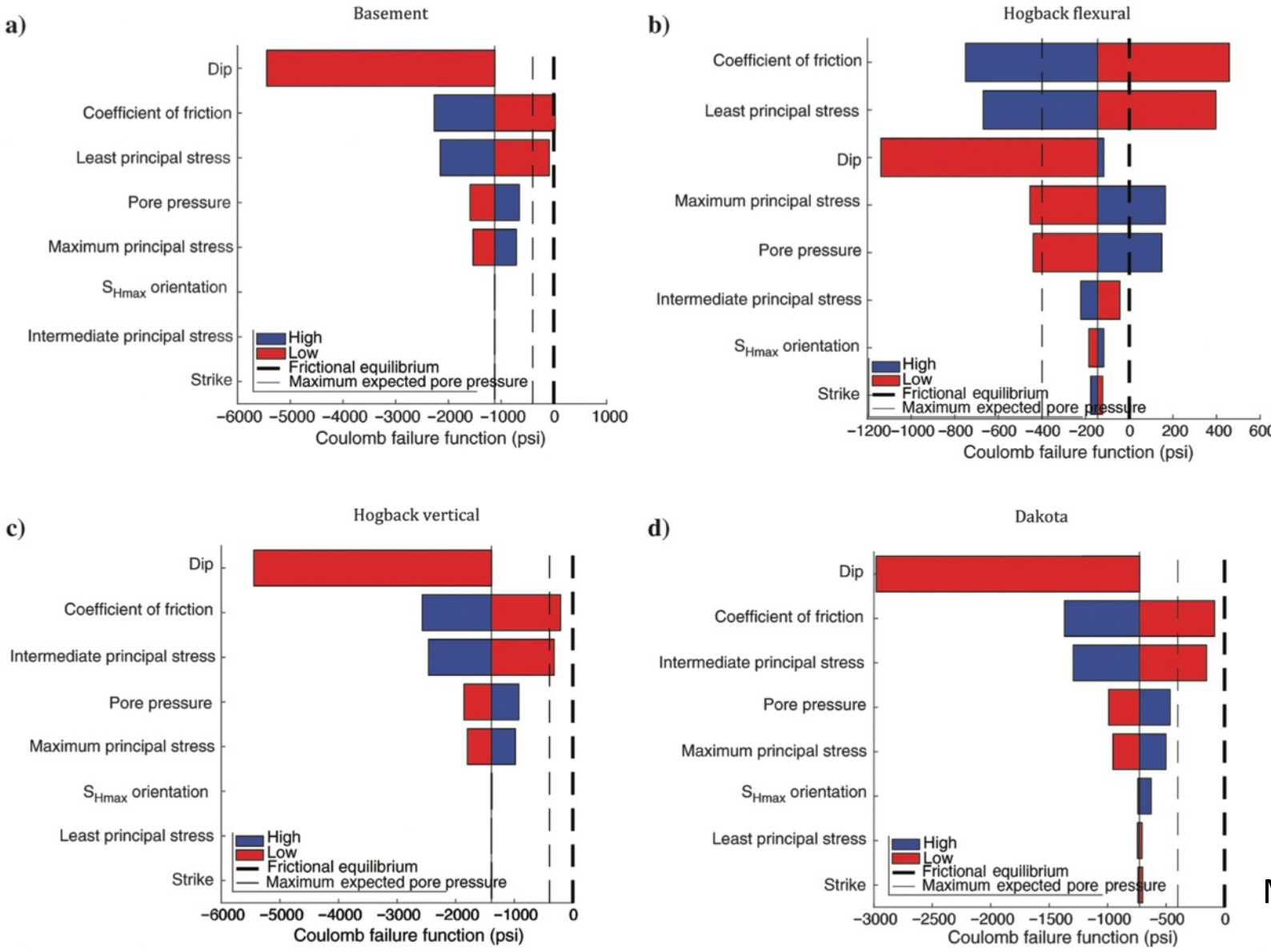


McCormack et al. (2022)

The saltwater disposal and geologic framework indicate that the hazard is low



Certain parameters are inherently more sensitive



McCormack et al. (2022)

Summary of probabilistic hazard prediction

- Inputs of stresses and orientation are required to run the Mohr-Coulomb analysis

- Injection appears to be safe in most of the region of interest, but the flexural faults may be problematic

- By looking at the saltwater disposal and geologic framework, the hazard is lessened

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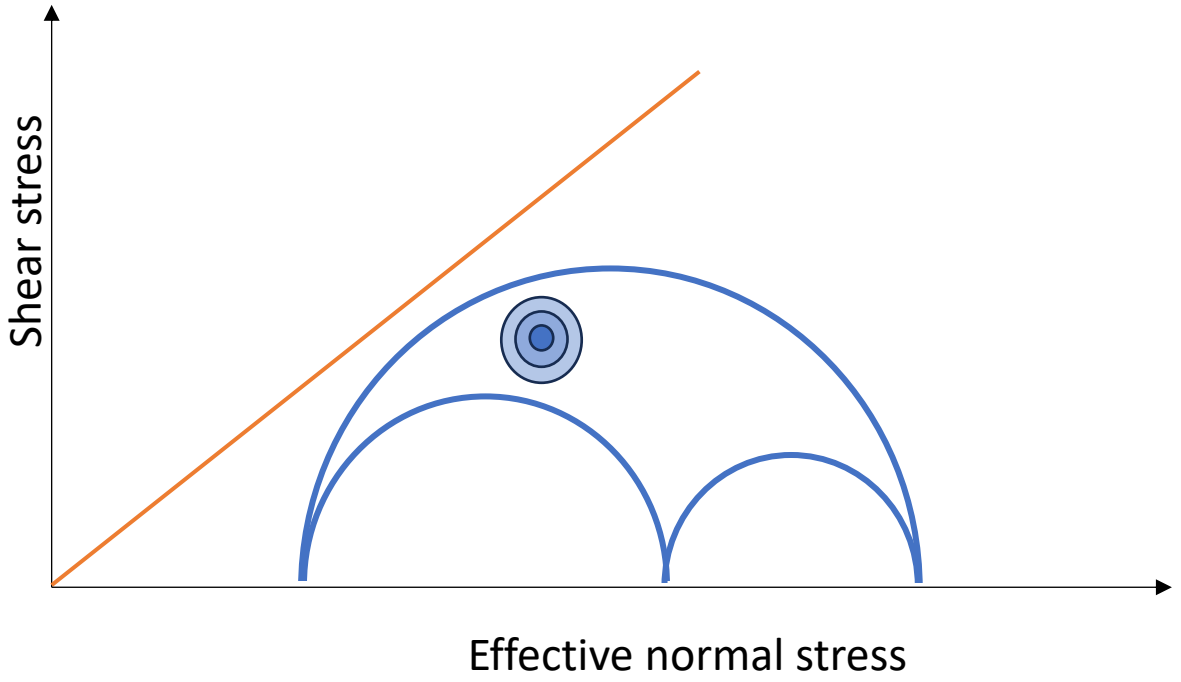
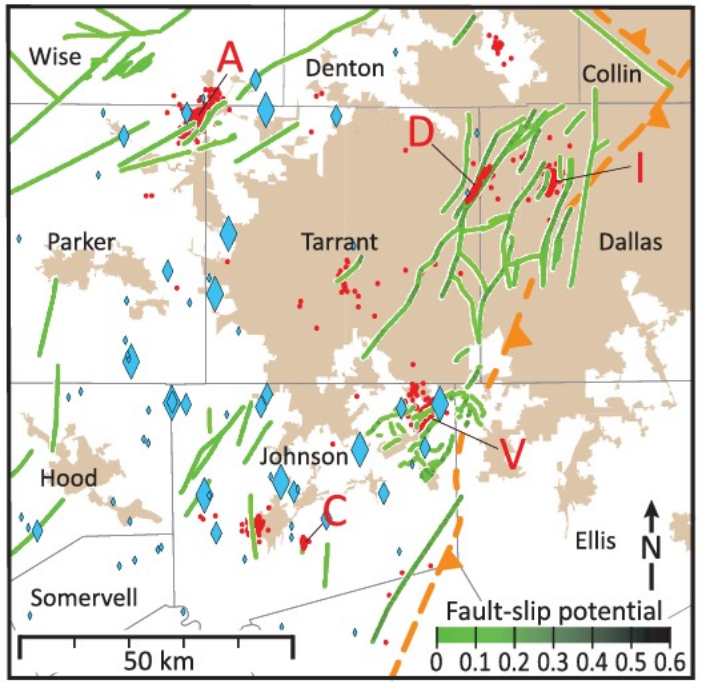
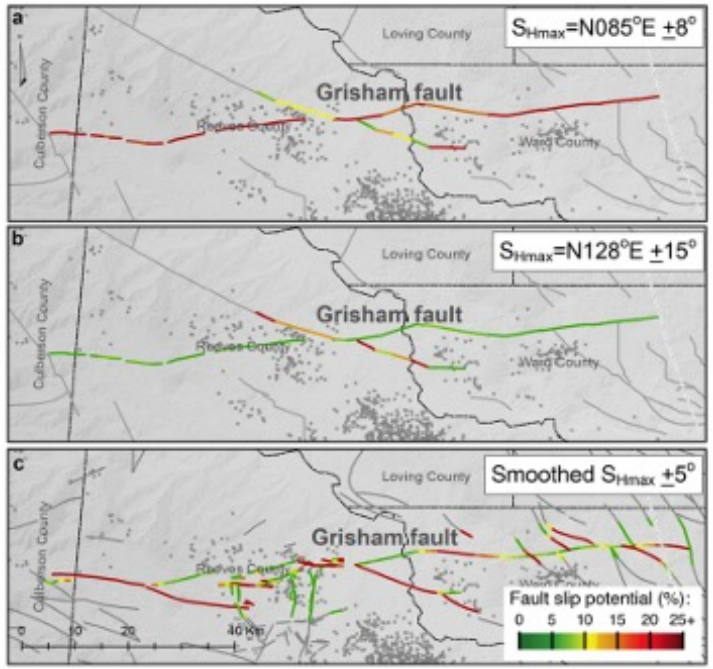


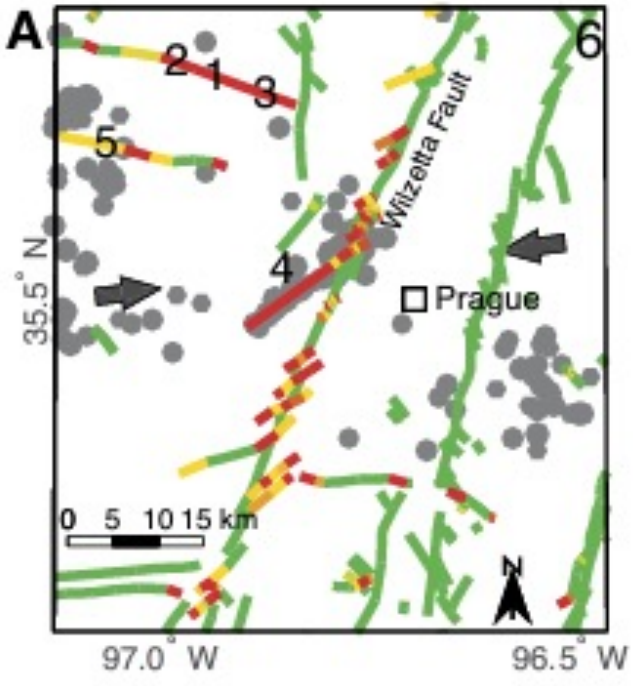
In previous studies, a single plane is fit to a fault



Hennings et al. (2019)



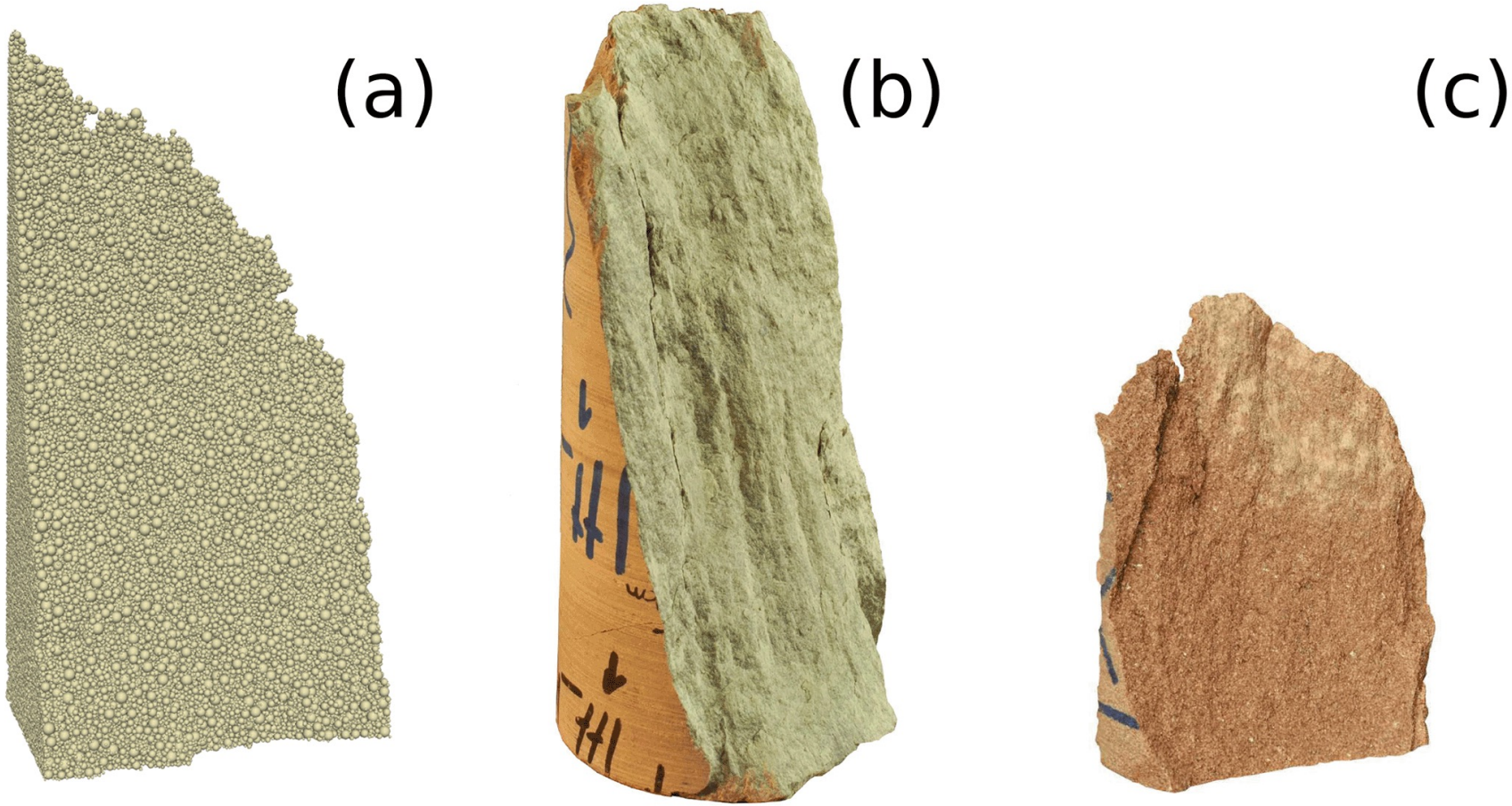
Dvory and Zoback (2021)



Walsh and Zoback (2016)

But we know that faults can have **roughness**, rugosity, and curvature

roughness

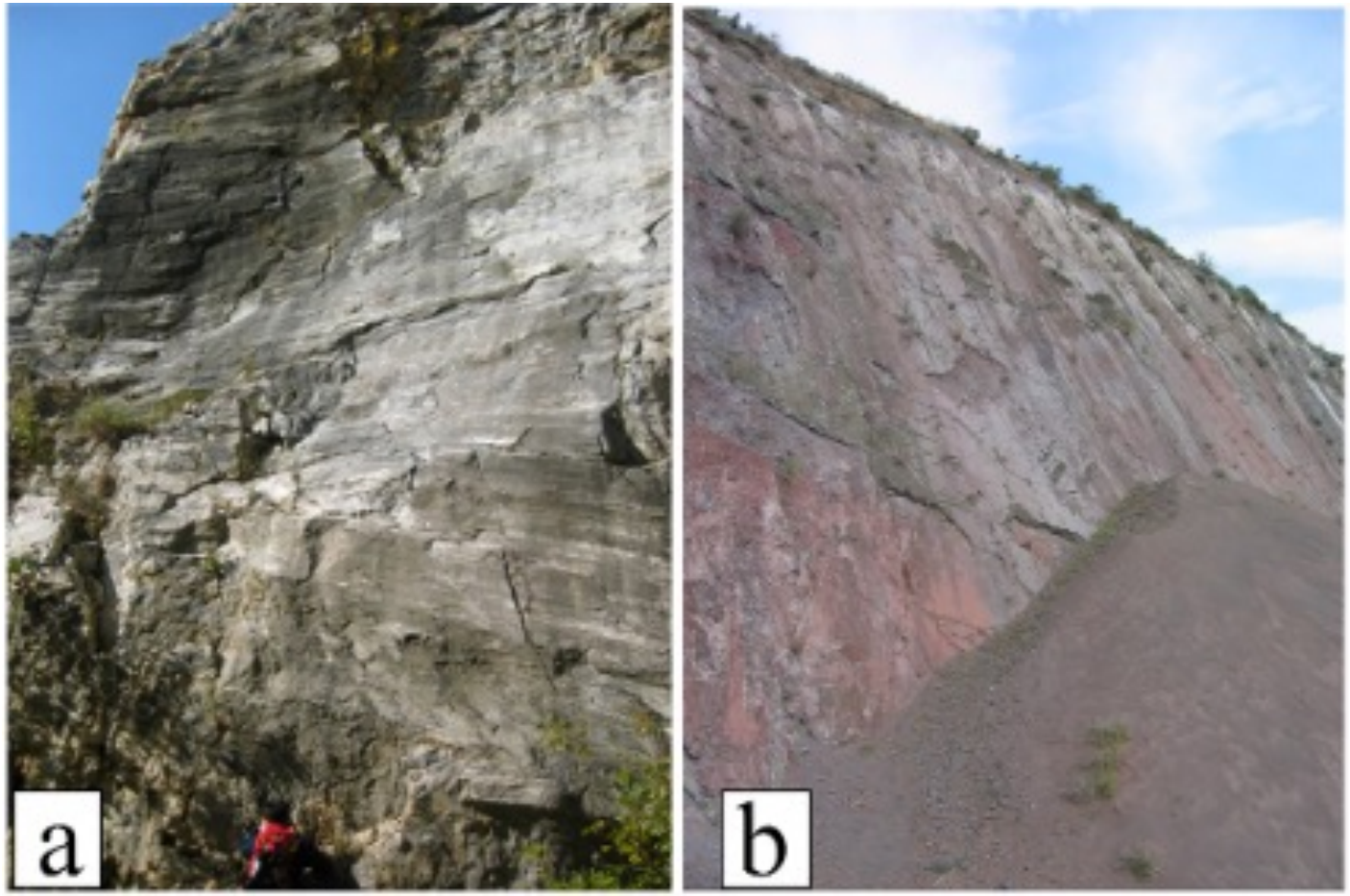


Abe and Deckert (2021)

But we know that faults can have roughness, **rugosity**, and curvature

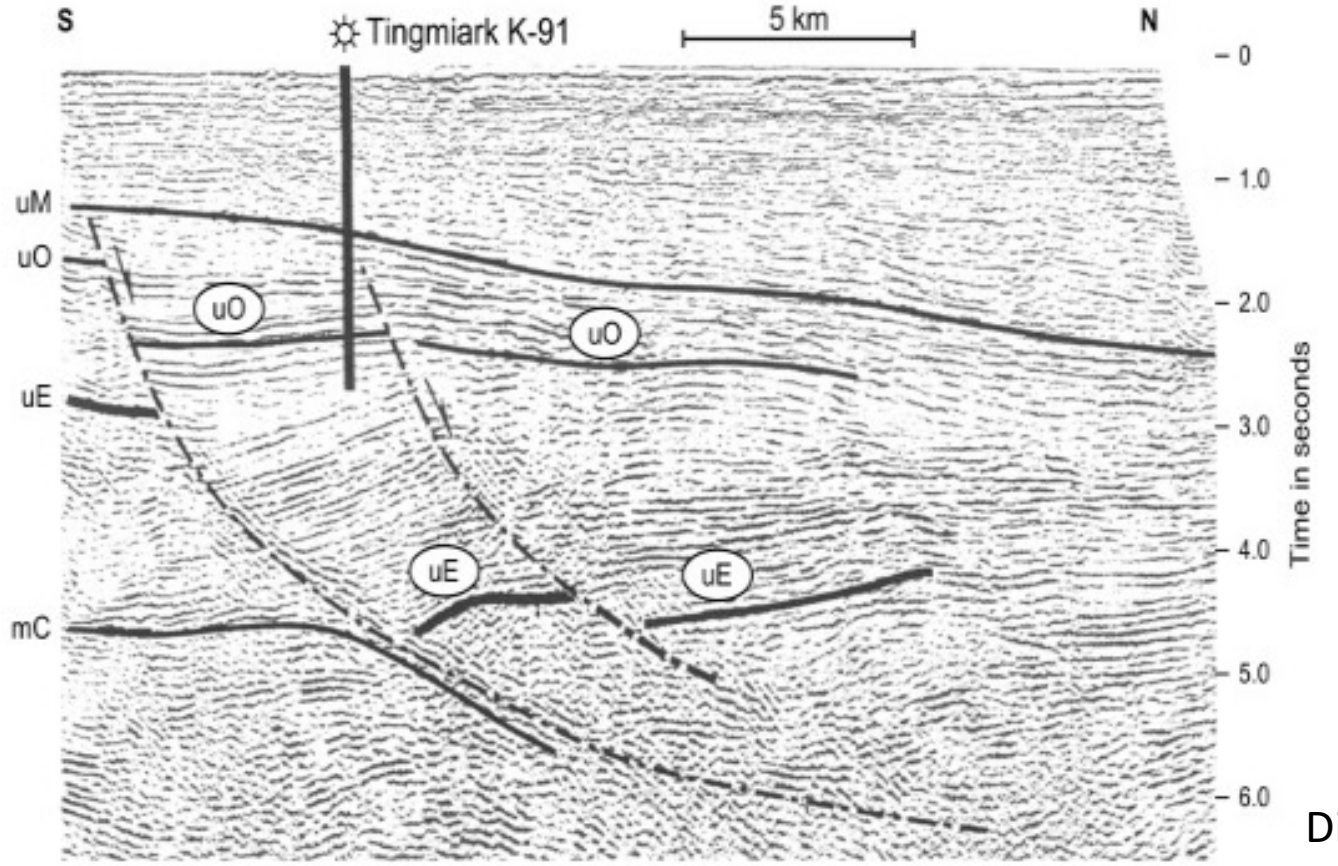
undulating

smooth

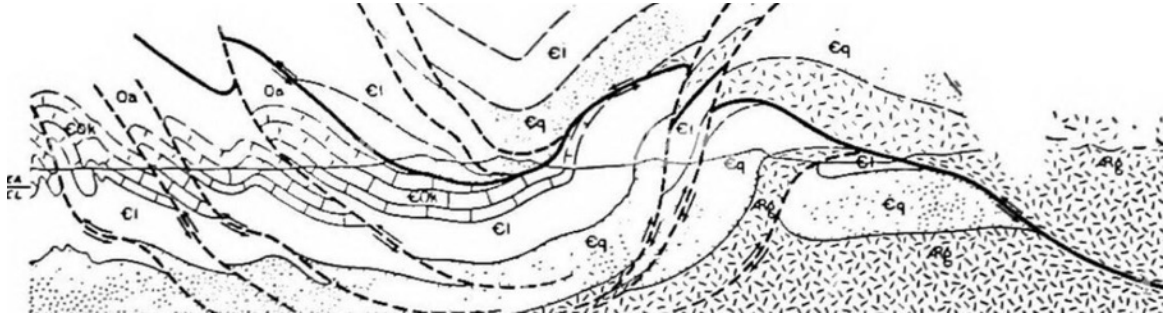


Sagy and Lyakhovsky (2019)

But we know that faults can have roughness, rugosity, and **curvature**

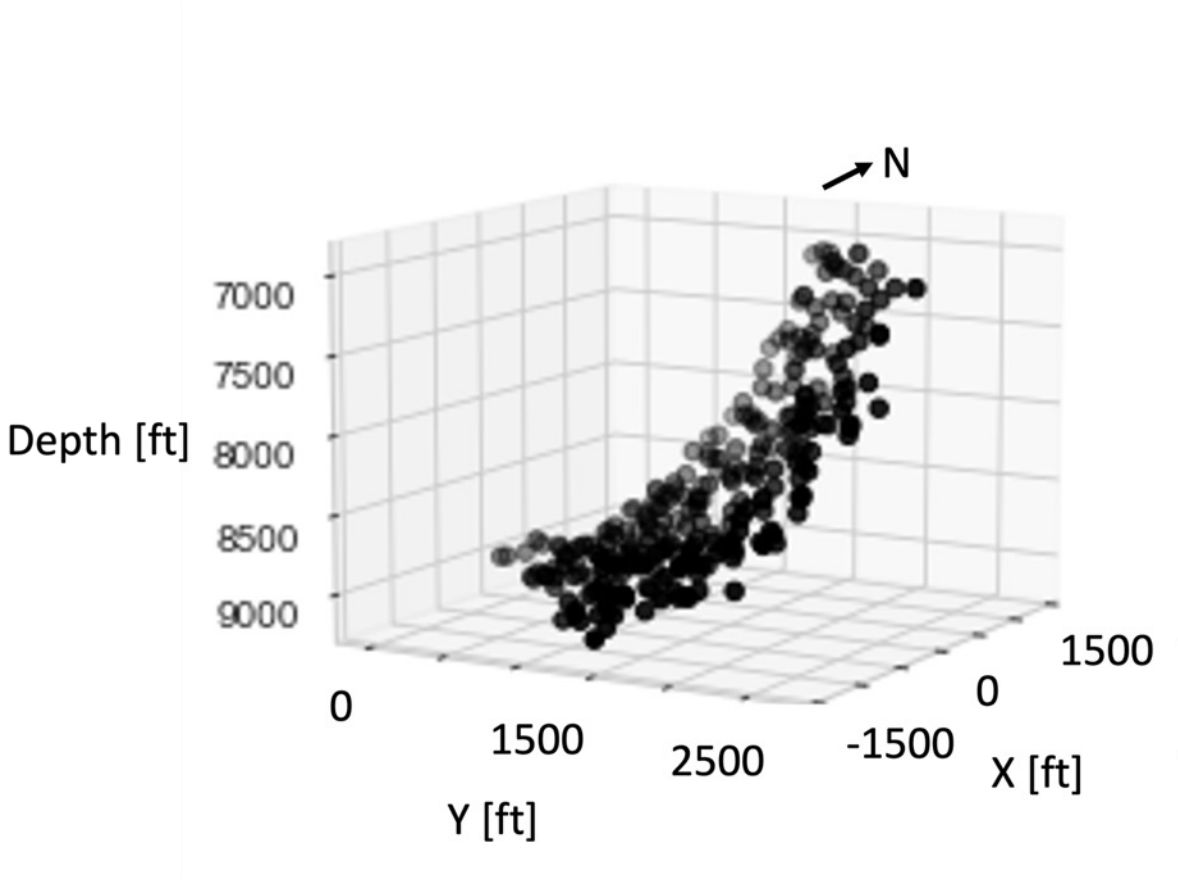


Dixon et al. (2019)



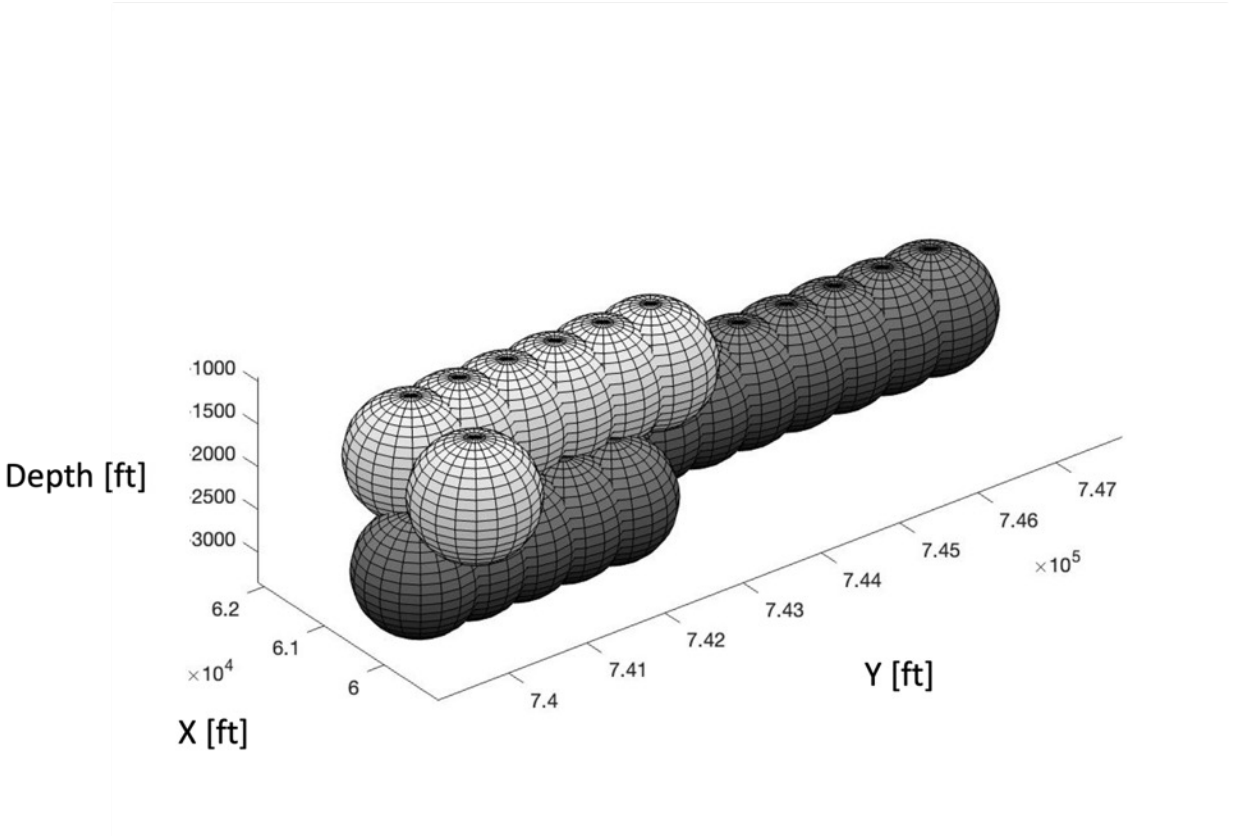
Alamy – stock photo

We will revisit the Hogback flexural faults and model them as listric



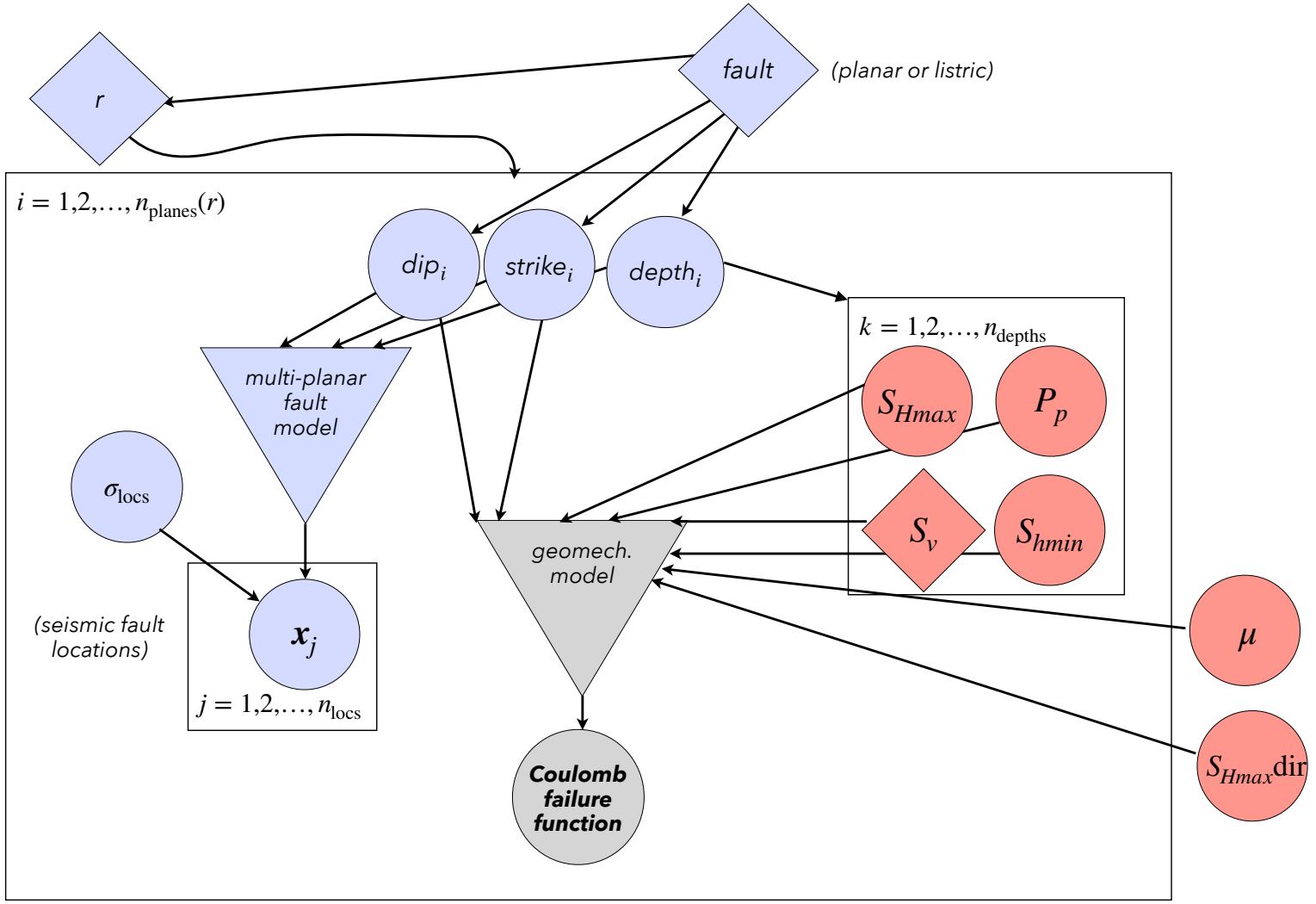
McCormack and Smith, *under review*

There are many ways to discretize the surface



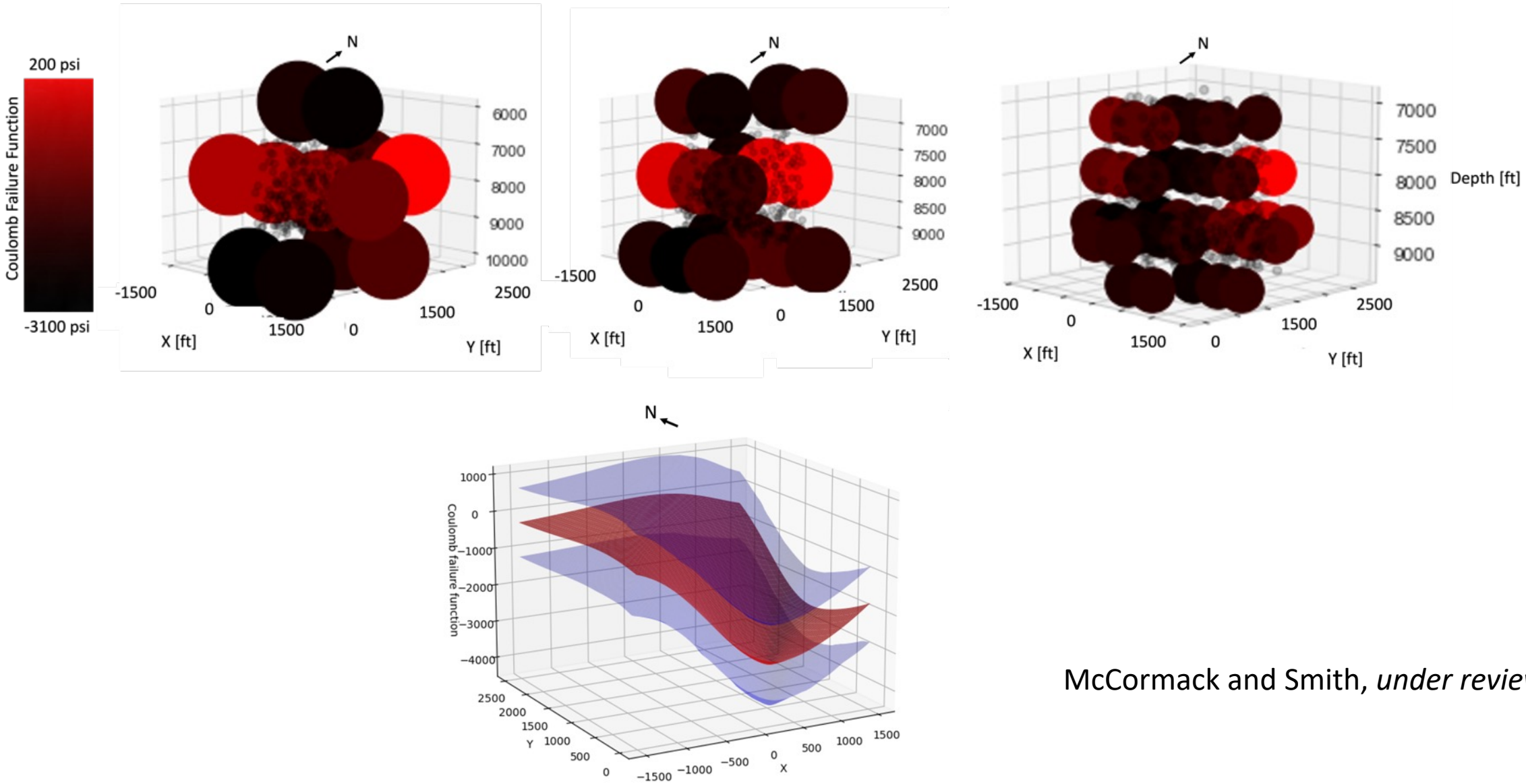
McCormack and Smith, *under review*

Bayes' law can help, but only up to a certain point



McCormack and Smith, *under review*

The beauty of this approach is that spatial variances are captured within a single fault



McCormack and Smith, *under review*

Summary of fault curvature

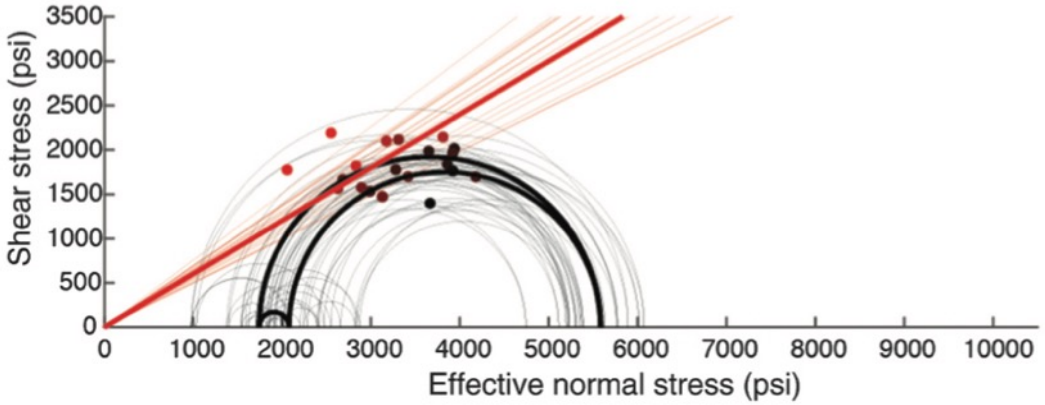
- When information about the curvature of a fault is known, kriging the surface can produce an understanding of hazard in a spatial sense within the fault

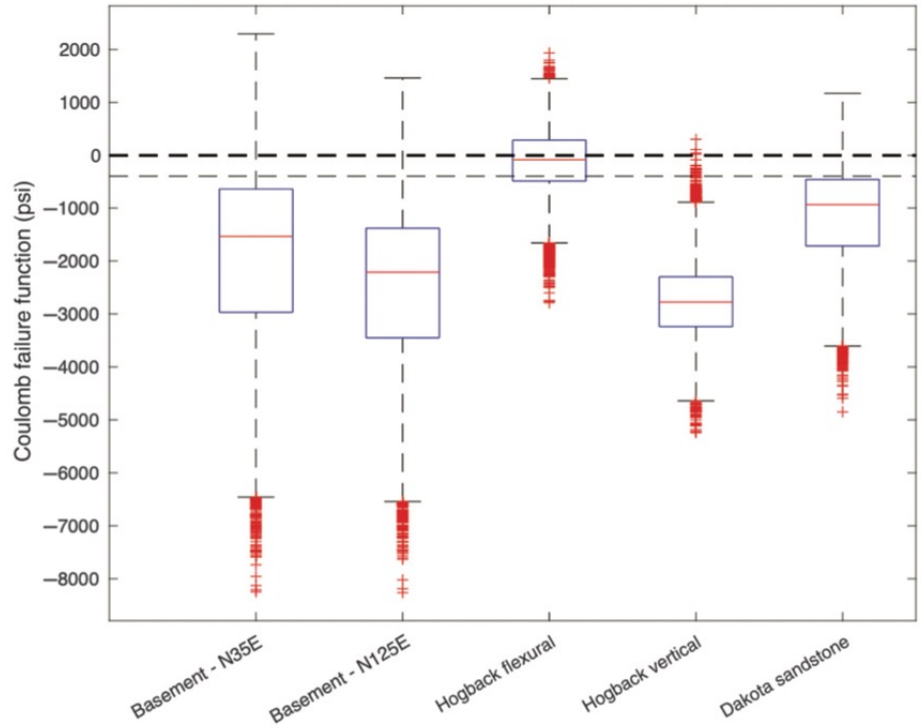
- It is not only the orientation of the fault that impacts these results – the stresses also change in space, especially with depth

- This is not applicable for all situations

Summary of CSI Induced Seismicity

Probabilistic hazard prediction





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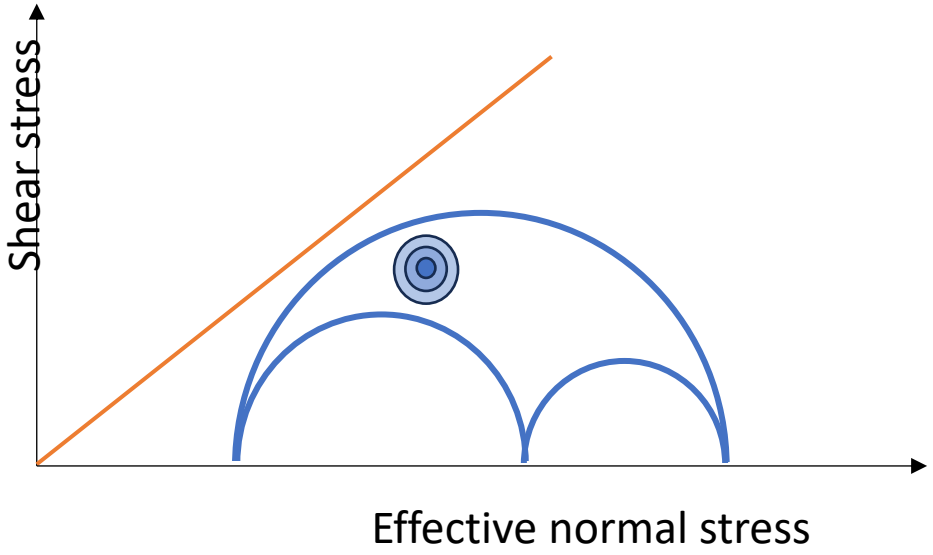
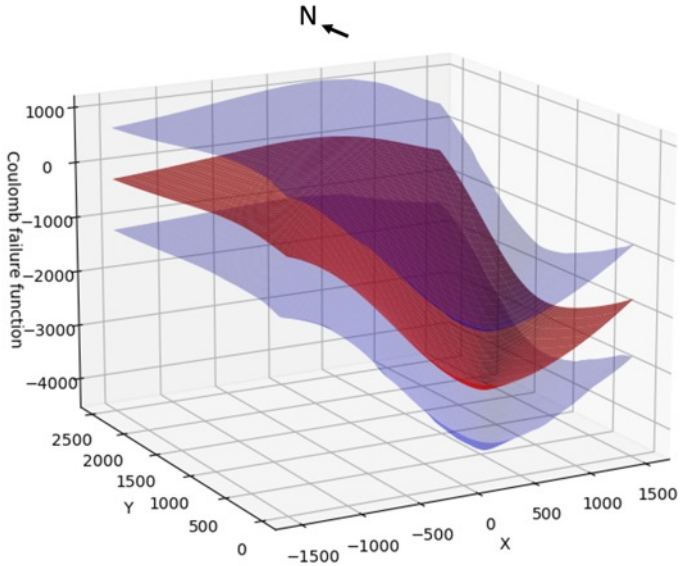
Fault curvature





Thank you