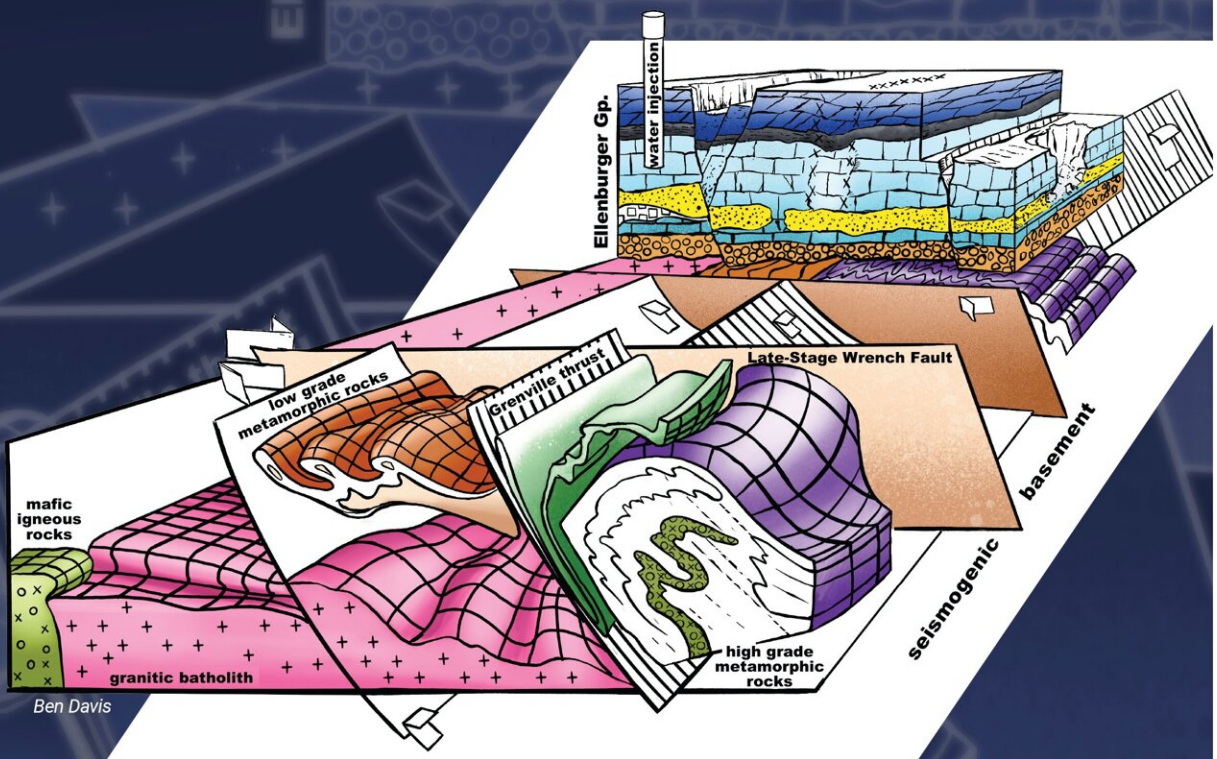
Research offers insights into Permian Basin earthquake hazards

December 2 2024

AAPG BULLETIN
VOLUME 108 • NUMBER 12 • DECEMBER 2024 • ISSN 0149-1423



Ben Davis

Special Issue:

The Geology of Injection-Induced Earthquakes in the Midland Basin Region

Edited by Peter Hennings

The cover of the special issue of AAPG Bulletin containing the seven Permian Basin studies led by researchers at the Bureau of Economic Geology at The University of Texas at Austin. The diagram illustrates the geologic complexity of Paleozoic strata used for wastewater disposal and the relationship to underlying seismogenic basement in the central Midland Basin of west Texas. Credit: Ben Davis

A new collection of published papers offers the most detailed and comprehensive breakdown yet of how water injected into the Permian Basin during oil and gas operations is changing subsurface pressures and causing earthquakes.

The Permian Basin in West Texas is the country's most prolific energy-producing region, accounting for more than 40% of the nation's oil production and about 15% of gas production. However, energy production has caused earthquakes and other challenges in recent years as oil and gas operators now manage roughly 15 million barrels of produced wastewater each day. This briny water comes to the surface as a biproduct of energy production. Most of it is disposed of by being pumped back underground.

The new work, published by scientists at The University of Texas at Austin, is a synthesis of the geology of the Permian Basin, with a particular focus on the Midland Basin, and its interactions with injected water over time. It offers more than a detailed explanation of the issue—it includes information that oil and gas operators and regulators can use in the future to reduce seismicity and associated hazards.

"There have been a lot of recent publications on trends of seismicity in the Permian Basin, but nobody yet has really taken a step back with the consideration, 'How do you break it down into the geologic and

engineering framework that can be used to really understand what's going on?'" said Research Professor Peter Hennings, the principal investigator for the Center for Injection and Seismicity Research (CISR). "We're working to provide a more holistic understanding of the impact of oil field wastewater injection in the Permian Basin region by providing a deep integration of geological data and information to assess the trends and the impact."

CISR, a research center at the UT Jackson School of Geoscience's Bureau of Economic Geology, has been investigating the link between seismic activity and injection since 2016. Its science has already helped reduce seismicity in many parts of the Permian Basin.

Hennings is the editor of the new seven-paper study on the Permian Basin, which was published as the December issue of the *AAPG Bulletin*. The papers build on each other to offer a highly integrated view of the sources and patterns of injection, subsurface reservoirs, faults, pressurization and earthquakes. The geologic maps, pressure models, and data trends published in the papers can help inform operators and regulators about which areas and conditions have been problematic in the past and can assist with mitigation of issues going forward.

Research Associate Professor Katie Smye said the CISR team was able to find many new potentially earthquake-producing faults in the Midland Basin by combining 2D and 3D seismic data with information provided by recent earthquakes and the horizontal wells drilled throughout the area.

"In some cases, they (the wells) track structural changes in the subsurface, and so the tens of thousands of horizontal wells drilled in the past 10 years in this basin are extraordinarily illuminating in our fault mapping efforts," she said.

The researchers split recent seismicity in the Permian Basin into seven separate induced seismicity systems. Smye said this is important because each system has its own unique geological and seismicity issues. For instance, in some areas the injection is focused deep in geological formations, which is more likely to cause earthquakes than injection into shallow geological formations. However, simply shifting to shallow injection carries other challenges. Increasing pressure in shallow injection zones can make drilling more difficult and potentially damage old wellbores, which can lead to the produced water mixing with groundwater.

Researchers expect production in the Permian Basin to continue at roughly current levels into the foreseeable future, making water disposal a long-term problem. CISR researchers said that understanding how much pore space is available in the Permian region for wastewater disposal is extremely important for sustainable petroleum operations and for safeguarding the environment.

"Pore space for injection has not been traditionally thought of as a resource to be managed effectively. It's been thought of as something to race to fill," Smye said. "We need to shift our thinking to the same sort of approach that is taken for sustainable production, so that the pressure space can be maximized for future disposal."

More information: The geology of injection-induced earthquakes in the Midland Basin region: Introduction, *AAPG Bulletin* (2024). DOI: 10.1306/intro10012424106 , pubs.geoscienceworld.org/aapg/ … duced-earthquakes-in

Provided by University of Texas at Austin