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Relationships between Induced Seismicity and Fluid Injection: Development of Strategies to Manage Injection

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Induced seismicity during or following the subsurface injection of waste fluids such as well stimulation flow back and production fluids has recently received heightened public and industry attention. It is understood that induced seismicity occurs by reactivation of existing faults that are generally present in the injection intervals. We seek to address the question why fluid injection triggers earthquakes in some areas and not in others, with the aim toward improved injection methods that optimize injection volume and cost while avoiding induced seismicity.

A GIS database has been built of natural and induced earthquakes in four hydrocarbon-producing basins: the Fort Worth Basin, South Texas, East Texas/Louisiana, and the Williston Basin. These areas are associated with disposal from the Barnett, Eagle Ford, Bakken, and Haynesville Shales respectively. In each region we analyzed data that were been collected using temporary seismographs of the National Science Foundation's USArray Transportable Array. Injection well locations, formations, histories, and volumes are also mapped using public and licensed datasets. Faults are mapped at a range of scales for selected areas that show different levels of seismic activity, and scaling relationships used to extrapolate between the seismic and wellbore scale. Reactivation potential of these faults is assessed using fault occurrence, and in-situ stress conditions, identifying areas of high and low fault reactivation potential. A correlation analysis between fault reactivation potential, induced seismicity, and fluid injection will use spatial statistics to quantify the probability of seismic fault reactivation for a given injection pressure in the studied reservoirs. The limiting conditions inducing fault reactivation will be compared to actual injection parameters (volume, rate, injection duration and frequency) where available.

The objective of this project is a statistical reservoir- to basin-scale assessment of fault reactivation and seismicity induced by fluid injection. By assessing the occurrence of earthquakes (M>2) evenly across large geographic regions, this project differs from previous studies of injection-induced seismicity that focused on earthquakes large enough to cause public concern in well-populated areas. The understanding of triggered seismicity gained through this project is expected to allow for improved design strategies for waste fluid injection to industry and public decision makers.