

## ***Interactive comment on “Fault reactivation by gas injection at an underground gas storage off the east coast of Spain” by Antonio Villaseñor et al.***

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General Comment: The manuscript “Fault reactivation by gas injection at an underground gas storage off the east coast of Spain” by A. Villasenor, R. Hermann, B. Gaite and A. Ugalde presents improved moment tensor solution for moderate magnitude earthquakes associated with induced earthquakes occurring offshore Spain in 2013. The motivation was to resolve a depth discrepancy for the earthquakes, which currently exists in the literature regarding the event sequence, in order to better understand the causal link between the gas storage facility, faults, and triggered seismicity. The study provides a careful analysis of moment tensors constrained using surface wave data and crustal reverberations to conclude that earthquake depths were between 6-9 km below the surface, in line with reactivation of presumed pre-existing NW-SE trending

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basement faults, rather than the 2 km depth in other papers consistent with injection levels. The study hypothesizes that to pore fluid pressure diffusion away from injection changes stress on the pre-existing fault structure enough to induce primarily strike-slip earthquakes consistent with the modern stress regime, in line with current research on induced earthquakes in Oklahoma, USA, for example. The paper requires minor changes to the text and figures to ensure consistency.

**Specific Comments/Questions:** The authors favor pore fluid pressure diffusion to link injection at <2 km to faulting at >6 km. The authors establish that there is a lack of geologic information for the crystalline basement in the study area publicly available. Is there any indication in the literature that faults in the basement offset the overlying units or that there is an extensive fault or fracture network that could serve to rapidly transmit fluid pressure? Lines 384-385 hypothesize that faults in the basement have a different orientation than faults in the shallow geologic formations. Is there any evidence from the regional data that this could be the case? Are there any faults that could be added to the figures to aid the reader in understanding the overall geologic setting? On lines 341-344 the authors reference faults as plotted in other studies but could these be added to the figures here for clarity? Is triggering via poroelastic stress change necessary?

**Supplementary Material:** It was not clear to me why the information in the supplement (1 paragraph essentially and 1 figure) was not included in the main text. It seemed a valid question worth addressing in the main text. I leave it to the authors' decision however.

**Citations:** In addition to Yeck et al. and McNamara et al., this paper could cite a review paper such as Keranen and Wiengarten (2018), Induced Seismicity, Annual Review of Earth and Planetary Sciences, Vol. 46:149-174, <https://doi.org/10.1146/annurev-earth-082517-010054>

**Figures:** In general, the graphics clearly illustrate the points made in the main text. The

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fonts on the legends are very small, however. There is also a change in color scheme for data vs modeled waveforms in the main text and supplemental figure; red should be consistently used for modeled waveforms with blue/black used for observed data.

In Figure 2, the size of the circles make it difficult to tell the difference between EGF phase and group velocity (though of course the offset in c/U makes this clear).

In Figure 5, the color bar is marked incorrectly. For example, red is 4 but having the 4 on the far left such that both 4 and 5 bound the red in the color box is not correct. This ends up making 9 and 10 km depth the same color, though there are at least 2 earthquakes at 10 km depth. Most importantly, what are the grey anastomosing lines? They are not referenced in the text or the caption for the figure.

In Figure 6, the open circles and font sizes associated with the cross-correlation column are too small. The open circles can just be made solid, which may solve the small line width issue.

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