Comment on ‘Hydraulic fracture height limits and fault interactions in tight oil and gas formations’

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A short summary of the paper:

Flewelling et al., 2013, propose a worst-case scenario approach to determine the maximum possible hydraulic fracture height in tight oil and gas formations. The analysis is carried out in two parts:

1. A worst-case model is used to determine fracture height, based upon the volume of injected fluid used during hydraulic fracturing;
2. Shear displacement at faults, derived from the magnitude of microseismic events, is analyzed.

In part 1, a worst-case model is developed to show fracture growth. The volume of injected fluid is assumed identical to the opening volume of the created fracture. The maximum fracture height is calculated based upon assumptions of the fracture shape and opening width. It is a worst-case scenario approach in the sense that analysis of fluid loss is neglected, however, a true worst-case scenario model would consider pre-existing fractures; this model does not. The simulated fracture heights are compared with observed fracture heights (Fisher and Warpinski, 2011). Part 2 comprises the analysis of microseismic events and considers the fracture growth in pre-existing faults. The idea is that a positive correlation exists between the fracture height and the magnitude of a seismic event. The vertical extent of a fracture is deduced from the observed magnitude of microseismic events (based on data fromWarpinski et al., 2012). The authors conclude that it is physically implausible that fractures could create an hydraulic connection between deep black shales and shallow aquifers.

Several critical comments can be made on this paper:

Part 1: The assumptions on which the results are based are not implausible, but arbitrary to some extent. The shape of the fracture is assumed to be an ellipsoid, with a height of twice the length, without citation. Factors that may lead to an underestimation of the vertical fracture growth, e.g. different fracture shapes, are not discussed. A sensitivity analysis of the underlying assumptions is also not provided. Several observed fractures are up to 100 m higher than predicted by the so-called ‘worst-case approach’. The authors attribute this to overestimation of fracture growth in the dataset, due to shear displacement along pre-existing joints, faults and bedding planes. This is plausible under certain assumptions, however, no citation or at least conclusive consideration is given that would show the data from Fisher and Warpinski, 2011 did indeed overestimate fracture height. In the original article this effect is not addressed.

The authors claim the misfit between observed and simulated data occurs because their approach is more accurate than the data against which their approach is tested (paragraph 8). This argumentation is a circular argument and a basic contradiction.

Part 2: The authors also calculate shear displacement based upon seismic moments that were estimated by Warpinski et al., in 2012. The largest observed seismic events are not included in the analysis. The analyzed data include moment magnitudes smaller than -0.5, which is significantly below the observed magnitudes of 0.5 (given in paragraph 11) and 0.86 given in paragraph 3. Therefore, it is very likely that shear displacement is higher than calculated. Furthermore, a circular shear area is assumed; it is not considered that elongated shapes may increase fracture height. The papers conclusions suggest, however, that fault slip is also part of a worst-case scenario approach (paragraph 15, sentence 4: “...potential fault slip.”).

In part 1 the authors name an upper limit of 10 m for shear displacement. In Part 1 the authors imply that seismic events may occur 100 m above a hydraulic fracture. This contradiction is not addressed. In paragraph 10, the authors state that fractures would not be expected to grow vertically at shallow depths. The cited reference, however, (Fisher and Warpinski, 2011, Fig. 6) shows that although the vertical fracture component decreases with decreasing depth, on average about 50% of the volume still belongs to vertical fractures. In contrast to the authors’ statement, numerous entirely or predominantly vertical fractures do exist at shallow depths.

Conclusion

The paper displays an interesting approach for relating fracture growth to the volume of injection fluid. The theoretical considerations are plausible, but not sufficiently and critically discussed. Several presented values are contradictory. Instead the authors claim their approach provides more accurate data than the data against which their approach is tested (paragraph 8); this is a basic logical contradiction. The authors conclude that it is physically implausible that fractures could create a hydraulic connection between deep black shales and shallow aquifers. This conclusion is unjustified. The paper does not provide additional insight into the underlying datasets.