

## Clare McMullan

---

**From:** Robert Westaway  
**Sent:** 10 November 2014 15:59  
**To:** [REDACTED]  
**Cc:** paul.younger@gla.ac.uk; Ross Barker  
**Subject:** RE: Earth tremors - queries  
**Attachments:** qjegh2014-011parser2.pdf

[REDACTED]

Thanks for this. Paul is away today, I am afraid, and has just e-mailed me to ask if I can respond.

I have attached a final version of the proofs. The published version will appear tomorrow and I can send it to you then. Please note the publicity embargo specified by the university press office.

The present regulation is ridiculous; it was recommended rather casually by people with no particular expertise in the field, and became officially adopted by DECC before anyone had a chance to query it. The regulation is ridiculous because its purpose is to regulate nuisance ground vibrations but it does not make any attempt to treat such vibrations on a par with other sources of nuisance ground vibrations, such as those which might be caused by people slamming doors or by buses driving along a residential street. The natural comparison that we make, in terms of an appropriate way of regulating ground vibrations, is with the effects of quarrying. The present regulation is a deterrent to investment and will need to be changed before energy companies are willing to invest the large sums that will need to be spent to develop shale gas in the UK. Shale gas is needed as a bridging fuel for the next few decades until other energy sources consistent with a low carbon energy future, such as geothermal, can be developed.

The amount of energy associated with the deformation of the rock mass as a result of the occurrence of an earthquake scales up by a factor of  $\sim 30$  for each increase by 1 in terms of magnitude. So a magnitude 3.6 earthquake would involve the release of about 40,000 times as much energy as a magnitude 0.5 earthquake would. However, that is not the issue; the issue is how the strength of the ground vibrations scale. Here the dependence on magnitude is much less strong, because the larger an earthquake is the narrower the range of frequencies at which it radiates any significant amount of energy in the form of seismic waves. Thus, we show that the maximum ground velocity caused by a magnitude 3.6 earthquake will be maybe 100 times larger than for a magnitude 0.5 earthquake. A magnitude 0.5 earthquake will produce such weak ground vibrations that only a very sensitive person would be likely to feel it, and then only under very quiet conditions (say, in the middle of the night), whereas a magnitude 3.6 earthquake will produce ground vibrations that are about at the threshold for causing minor damage (cracked plaster, etc).

The significance of a magnitude 3.6 earthquake is that it is at the size limit that might be produced if the largest fracture that might possibly form during hydraulic fracturing, given the volumes and pressures of fracking fluid that are used, forms in a single rupture. However, this is unlikely; fracture growth almost always occurs incrementally, but it exists as a notional 'worst case scenario'. Another reason why a magnitude limit of 0.5 makes no sense is that it corresponds to a size of earthquake source that is within the size range that the fracking process is attempting to create in the first place.

I hope this helps. I am happy to answer more questions if you have any.

Best wishes, Rob Westaway

Dr Rob Westaway  
Senior Research Fellow

---

**From:** [REDACTED]@telegraph.co.uk]  
**Sent:** 10 November 2014 14:59  
**To:** Robert Westaway  
**Subject:** Earth tremors - queries

Dear Prof Westaway,

I spoke to your colleague Paul previously so had emailed him a few queries on your joint paper out tomorrow but just got an out of office response from him. Might you be able to help me out on them please?

Many thanks

[REDACTED]

----- Forwarded message -----

From: [REDACTED]@telegraph.co.uk>

Date: Monday, 10 November 2014

Subject: Earth tremors - queries

To: [paul.younger@glasgow.ac.uk](mailto:paul.younger@glasgow.ac.uk)

Dear Paul

I wondered if you might be able to help me out with a few queries on your study that's out tomorrow? I'm out in a meeting for next hour so if possible a response via email would be hugely appreciated.

- 1) do you have a copy of the study you could send me?
- 2) what exactly are you recommending - do you think there should be any restriction on the earth tremors that fracking can cause, and if so at what level? Or are you saying the max it could cause isn't catastrophic and so shouldn't be limited at all (and just have a compensation regime in place in unlikely event of any damage)?
- 3) I think from the PA copy I've seen you're saying max possible tremor fracking could cause is 3.6 on Richter scale? For avoidance of doubt how many times bigger than the current 0.5 limit is that? I'm conscious that it's base10 scale and my maths probably isn't up to knowing how to calculate it...
- 4) why do you feel the regulations should be changed -- is this actually hindering the industry as things stand?

Look forward to hearing from you, many thanks

[REDACTED]

--

[REDACTED]

Landline: 020 7931 [REDACTED]

Mobile: [REDACTED]

Twitter: @ [REDACTED]

telegraphmediagroup  
111 Buckingham Palace Road  
London, SW1W 0DT

--

Emily Gosden  
Energy Editor

Landline: 020 7931 [REDACTED]

Mobile: [REDACTED]

Twitter: @ [REDACTED]

telegraphmediagroup  
111 Buckingham Palace Road  
London, SW1W 0DT