



Multiscale assessment of micro-seismicity and slow earthquakes



Today we witness the economical throes and uncertainties created by the dramatic cratering of oil prices in 2014 from \$115 dollars per barrel to \$38 dollars. This dramatic nonlinear phenomenon reminds earth scientists of the disintegration of the Laurentide ice sheet, some 14,000 years ago. One of the contributing factors of the precipitous drop in oil prices is super-fracking. This is used for oil as well as for gas production and became economically feasible about twenty years ago. Thanks to this technological breakthrough Americans had enjoyed a renaissance in oil production since 2005. This process, however, has some drawbacks, such as the induced earthquakes occurring in rejuvenated or new fields (Fig. 1).

Much controversy has surrounded these implications which also have impact in general on geothermal drilling such as found recently in Basel, Switzerland and elsewhere. We have learned that the induced seismicity was in a formation below the fracking, primarily caused by waste water injection rather than directly by the fracking itself.

In late October 2014, under the kind auspices of Professor Xu Chang and Yibo Wang from the Institute of Geology and Geophysics Chinese Academy of Sciences, Beijing, Professor Sidao Ni from Institute of Geodesy and Geophysics at Wuhan and Dave Yuen from University of Minnesota, Minneapolis and China University of Geosciences at Wuhan organized a special session at the China Geological Union meeting in Beijing, where we invited both foreign experts from United States Switzerland, Australia, Greece and Italy and domestic Chinese investigators for an exciting one day session including both oral and poster presentations. This special issue is a product from this gathering and we have also invited other international specialists to contribute. This volume is very eclectic and intends to disseminate this vital problem to a broad audience and not just to geophysicists. The topics in this issue cover many areas of a frontier nature, ranging from many scales in both time and space. Fifteen years ago Earthquake tremors and slow earthquakes were not on the radar screen. Today studies

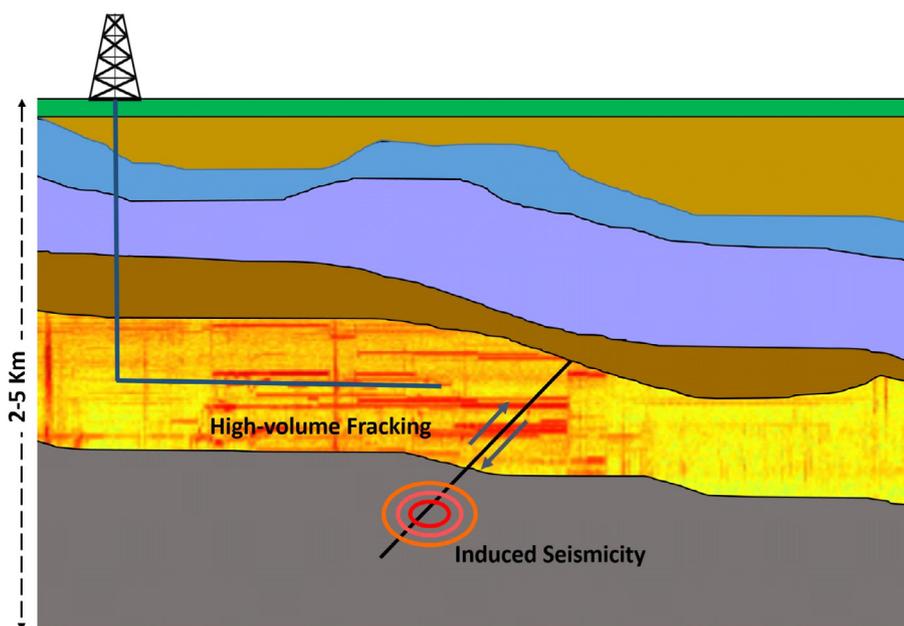


Fig. 1. Schematic diagram showing induced micro-seismicity produced by high-volume fracking prevalently used in U.S.A.

of the earthquake tremors have become a cottage industry for many graduate students and postdocs.

This volume has articles on supercomputing, seismic inversion methods and other innovative schemes. We hope that this volume will stimulate further innovative research in this still growing field, because of its impact on oil, gas, mineral resources and, lastly, the nascent field of geothermal resources. The different topics covered in this volume are unique in nature and can be used in graduate seminars.

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Further readings

- Beroza, G.C., Ide, S., 2011. Slow earthquakes and nonvolcanic tremor. *Annu. Rev. Earth Planet. Sci.* 39, 271–296.
- Scarpa, R. et al, 2008. Slow earthquakes and low frequency tremor along the Apennines, Italy. *Ann. Geophys.* 51, 527–538.
- Turcotte, D.L., Moores, E.M., Rundle, J.B., 2014. Super fracking. *Phys. Today* 67. <http://dx.doi.org/10.1063/PT.3.2480> (page 34).

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