

Effectiveness of the Traffic Light Protocol (TLP) for Induced Seismicity and its Implications to Shale Gas Regulation in British Columbia and Alberta, Canada

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We have systematically re-examined seismic records from stations in northeast BC and western AB for the years of 2014–2016. Various seismic phases were identified and picked to determine the hypocentral locations of regional and local earthquakes. This significantly improved earthquake catalogue is compared with a comprehensive database of hydraulic fracturing, wastewater disposal, and enhanced recovery operations in the region to identify possible relationship between injection parameters and seismogenesis of induced earthquakes. In particular, we analyzed the pattern of seismic activity immediately before and after the occurrence of significant ($M \geq 4$) induced events to verify if the occurrence of smaller events ($2 \leq M < 4$) can be used as meaningful precursors for the mainshock. We have observed many cases where the occurrence of induced earthquakes dropped significantly as the injection operation was quickly reduced. Such a pattern suggests that a properly designed TLP for induced seismicity can be effective in mitigating the associated seismic risk. However, we also noticed a number of examples where no precursory events could be observed before the $M \geq 4$ mainshocks. In this case, the warning stage (i.e., yellow light) of the TLP could not properly serve its purpose. Given the variety of observed seismic patterns and their complex relationship with injection operations, a simple magnitude-based TLP may require some improvement to better fulfill its expected role.