Can we relate fugitive methane in groundwater to specific hydrocarbon exploration activities?

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A number of reported methane occurrences in groundwater in shale gas exploration areas have more or less been taken as evidence of leaks caused by the shale gas activities. Little consideration has been given to the fact that these same areas were previously the scene of conventional hydrocarbon exploration which may have been responsible for some of the leaking methane. Natural gas underground storage in exhausted in oil/gas reservoirs in some areas may have increased the chance of gas leaks even further.

The environmental monitoring program around the natural gas underground storage at Stenlille, Denmark, for the past 25 years may serve as an example on how to relate groundwater methane to a specific hydrocarbon activity. No groundwater methane had previously been reported for the Stenlille area, *c*. 70 km SE of Copenhagen. Yet, a baseline study in 1989 revealed low methane, 0.05-0.5 mg/L, of likely bacterial origin, $\delta^{13}C$: -90 to -62 ‰, in all water abstraction wells in the area. It was therefore considered fairly easy to be able to discriminate natural groundwater methane from the North Sea natural gas, $\delta^{13}C$: -47 ‰, C2+ ~10 pct, stored in the Triassic sandstone aquifer 1500 m below surface, in case of any leak. Insignificant amounts of hydrocarbons from the overlying rocks were expected to contribute to any leaking gas as indicated by the baseline study including material from a number of deep injection/withdrawel wells [1].

In 1995 while putting a newly drilled injection well into operation, underground gas escape of *c*. 5000 m^3 occurred from a leaking tubing and casing at *c*. 780 m depth. The leak was fixed soon after, but the gas had been able to move into a shallower, 100 m, Paleocene calcareous sand, dissolving in the brackish groundwater that was monitored by one of the control wells. Fortunately gas from the intermittent escape did not reach the shallow, 30-40 m, Quaternary melt water sands, exploited for fresh water supply. In 2009 traces of ethane together with an increase in methane, 0.4 mg/L, were observed during low production from a water abstraction well. When back in normal production methane decreased to former level, 0.1 mg/L, and ethane dropped below detection limit. Other groundwater constituents indicated that older and deeper water in the Quaternary aquifer may have been affected a little by the gas escape in 1995 [2].

[1] Laier & Øbro (2009) *Geol Soc Spec Publ* (London), **313**, 79–90. [2] Laier (2012) *Geol Surv Denm and Greenland Bull* **26**, 45–48.