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The impact of seismogenic faulting on gas reservoirs: case-histories from northern and central Italy

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Over the past few years much attention has been paid to the seismicity potentially triggered by fluid withdrawal and injection, but still little is known about the reverse problem, i.e. the impact of active faulting and earthquakes on hydrocarbon reservoirs. To gain insight on this issue we first focused on the area affected by the 20 and 29 May 2012 earthquakes in Emilia, northern Italy (Mw 6.1 and 6.0), than extended the investigation to a large portion of the southern Po Plain and of the Adriatic foredeep. In this region hydrocarbon reservoirs are hosted by growing anticlines driven by faults that extend to seismogenic depth.

In a pilot study we investigated the relationships between hydrocarbon fields and seismicity by focusing on a 150 km x 70 km portion of the central-southern Po Plain straddling the Ferrara-Romagna arc (see Mucciarelli et al.,2015: http://www.nat-hazards-earth-syst-sci.net/15/2201/2015/). The analysis was based on data from 455 wells reported in the ViDEPI database (http://www.videpi.com). All gas and oil-and-gas fields in the study area lie in or just above the structural highs forming the architecture of the Ferrara-Romagna arc.

The analysis revealed an irregular distribution of productive/sterile wells, likely resulting from differences in the evolution of each gas field. We then plotted all wells along with the surface projection of the Individual Seismogenic Sources (ISS) and Composite Seismogenic Sources (CSS) identified in the study area (DISS Working Group, 2015; http://diss.rm.ingv.it/diss/). These sources are assumed to be able to generate earthquakes of Mw 5.5+, and hence are capable of rupturing a considerable thickness of the seismogenic layer, possibly damaging the reservoir caprock and allowing fluids to migrate upwards.

Based on this first test we contend that in an active area like the Po Plain, the lack of gas in a potential reservoir formation may reflect the state of fracturing of the reservoir and of the caprock, and ultimately the presence and state of activity of a fault capable of M 5.5+ earthquakes. We used a binomial test and a Monte Carlo simulation to check if the observed correlation between gas production and anticline/fault location and size is statistically significant. The analysis revealed that the largest number of productive wells falls outside the Composite Seismogenic Sources, suggesting that past earthquakes caused the loss of all natural gas from the potential reservoirs lying above their causative faults. We are currently extending the work to a several hundred additional wells lying in the Adriatic foredeep, between Romagna and Abruzzo, partly onshore and partly offshore.

Our results have three potential outcomes: 1. in any active area subjected to compressional tectonics, the consistent absence of productive gas wells within fault-driven anticlines may help identify areas lying above a large seismogenic fault; 2. reservoirs hosted in smaller anticlines are more likely to be intact than those created by larger folds; 3. when designing an underground natural gas storage facility in a tectonically active area, depleted gas reservoirs are more likely to be intact, thus greatly reducing the hazard of triggered seismicity.