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An overview of research at the Latera Caldera, Italy, natural CO_2 analogue site

Lombardi, S.[1], Bigi S.[2], Beaubien S.E.[2], Graziani S.[2], Tartarello M.C.[2], Ruggiero L.[2]

[1]Ce.Ri.- Sapienza Università di Roma "La Sapienza", P.le Aldo Moro, 5, 00185, Rome, Italy; salvatore.lombardi@gmail.com
[2]Università di Roma "La Sapienza", Dipartimento di Scienze della Terra, P. Aldo Moro 5, Rome Italy.

The Latera caldera, located in central Italy, is a natural CO_2 leaking site that is internationally recognised thanks to years of research conducted within various European Commission (EC) funded projects focused on Carbon Capture and Storage (CCS), including NASCENT (2000-2003), CO2GeoNet (2004-2009), and RISCS (2010-2013). Through a series of well-received articles on a multitude of topics, such as gas migration pathways and processes [1, 2], monitoring method development [1, 3, 4], and ecosystem impact [5, 6], this research has shown the importance of studying such sites. In particular, "natural laboratories" like Latera help bridge the gap between short-term, small-scale laboratory experiments and long-term but, by necessity, simplified mathematical models. By integrating large-scale and long-term processes occurring within complex geological / structural / stratigraphic systems, a more realistic picture can be developed regarding the true risks and impacts that may develop in the unlikely event of leakage from a geological CCS site. In addition, the continual release of CO_2 at multiple points and at different flux rates makes these sites ideal for testing the sensitivity and effectiveness of proposed monitoring methods.

Figure 1: Gas vent within the Latera caldera.

Now that Latera has been included within the ECCSEL CCS Laboratory Infrastructure and is set once again to host international CCS researchers, it is fitting to summarise the major findings of the past studies to help focus future research. Here we will summarize over 15 years of study, integrating published findings with unpublished data and recent results to give a complete picture of what has been learnt thus far. For example, detailed soil gas and gas flux surveys have shown how different gases behave in the unsaturated zone, with the heavier and more stable CO_2 tending to spread laterally while co-migrating greenhouse gases like CH_4 are spatially restricted due to biochemical oxidation. Similarly, gas injection tests have shown how CO_2 was rapidly dissolved in the groundwater and transported laterally whereas co-injected, low-soluble He leaked more quickly and immediately around the injection well-head. Structural surveys combined with gas flux measurements have shown how fault architecture controls leakage rates, both relative to fault core / damage zone distribution as well as along strike induced by differential stress fields. 3D modelling has shown how movement is also greatly influenced by conjugate fracture network interconnectivity. Geophysical results are highly correlated with anomalies and have helped to define leakage pathways. Groundwater studies have highlighted natural attenuation processes and the influence of aquifer mineralogy on pH buffering and trace gases on redox reactions. Ecosystem studies have illustrated the spatially restricted nature of impact which also varies as a function season and species. The authors would like to acknowledge the fruitful collaboration with the many researchers that have joined us in studying the Latera site, including those from BGS, OGS, BRGM, BGR, and TNO.

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