Baker Hughes

Case study: Rousse, France

Reservoir Technical Services monitored fault stability and caprock integrity for CCS

A key component of moving energy forward toward a carbon neutral business model is successful carbon dioxide (CO_2) sequestration where CO_2 is permanently trapped in a reservoir. But carbon sequestration poses significant challenges. Migration of the captured gas out of the intended injection zone through a breach of the caprock or formation seal can pose serious safety risks to underground sources of drinking water or even asphyxiation to both human and animal life.

An additional risk present during any underground injection/production is the potential to induce fault slip and damages to property or life associated with a seismic hazard. These risks are assessed from reservoir modeling and geomechanical disciplines. An incomplete description of the subsurface, however, makes assessments uncertain.

To evaluate the quality of the reservoir model, monitoring is required. A major operator in southwest France conducted a pilot project for CO_2 capture and storage (CCS) from an industrial power plant in Lacq while the injection occurred near Rousse a few kilometers from the old Rousse gas field. The dolomitic formation Mano, in the Rousse reservoir, was chosen for the CO_2 sequestration pilot. The reservoir structure is a horst bordered with normal faults and was heavily depleted and may have been geomechanically unstable. Among the important considerations for this site was the nearby (2 km) Meillon/Saint-Faust fault, the close proximity to population centers, and other known geohazards.

Social acceptance was difficult as the community near the injection site expressed concern about the safety of the planned operation. Given the sensitive social and geologic context, the regulatory authority gave substantial scrutiny to the permit process. With Baker Hughes support, the operator was able to convince the regulatory authority that the proposed reservoir monitoring plan addressed the needs of the community by providing supporting evidence throughout the permit process.

To be fully compliant with the objectives of the project and the concerns of the public, the operator was required to monitor reservoir seal integrity, including seismic activity, 24/7 for a six-year period. Drawing on the results of a two-year study prior to injection that characterized the behavior of the regional seismicity, Baker Hughes's experience in monitoring injections, and experts to liaison with regulators, the operator turned to Baker Hughes for a customized solution.

Baker Hughes proposed a unique, multiscale monitoring methodology combining both an upgraded regional network and a highly sensitive local network near the injection site to accomplish the dual objectives of caprock monitoring and fault reactivation in a cost-effective manner. Reservoir monitoring can be

Challenges

- Monitor reservoir seal integrity and induced seismic activity on surrounding faults
- Inform local communities of changes in seismic activity
- Determine optimal placement of monitoring network to achieve monitoring objectives
- Ensure network operated 24/7 for a six-year period

Results

- Developed multiscale monitoring that combined both an upgraded regional network and a highly sensitive local network
- Detected 2,637 microseismic events over a six-year period
- Paved the way for reliable reporting that could last for more than 30 years with minimal operational costs
- Experienced no health, safety and environmental (HSE) issues or nonproductive time (NPT)

used to refine the reservoir model by comparing predicted response to observed. It can plan better operations by adjusting planned activity with actual field responses. Reservoir monitoring can act as the input to identify when mitigation procedures are required to mitigate damage or restore safety.

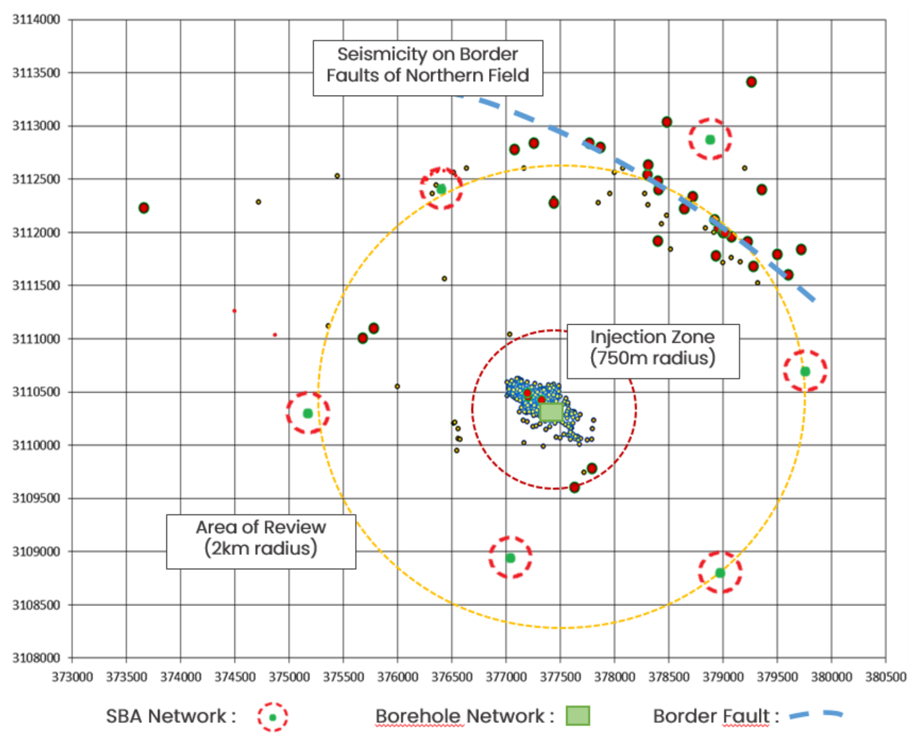
The regional network targeted the local fault and demonstrated that injection was not the cause of the seismic activity on the pre-existing fault. The deep, 4400-m (14,435-ft) geophone array detected the presence of seismicity within the storage reservoir and indicated that the caprock remained competent during the injection. Baker Hughes increased the accuracy of the national network by providing data to the national network, so activity could be reported with greater accuracy.

Over a period of six years, a catalog of 2,637 microseismic events were detected ranging from -2.6 to 1.1. Of these, 717 events were designated within a region that represents the perimeter of the reservoir. Consistent and reliable reporting allowed for injection to proceed with confidence over a culturally sensitive area. The magnitude of completeness for the seismic catalog was -1.7 for the reservoir perimeter and -0.1 for the local perimeter. These results met the project requirement to be fully compliant with the objectives fixed for the project (-1.5 for the reservoir perimeter and +0.0 for the local perimeter).

The results informed the operator about the response of the reservoir to injection. The operator was able to assess whether the injection was confined or not, and whether seismicity observed was associated with injection or naturally occurring. This information helped assess the feasibility of future injection programs and maintained the social license to operate.

Deploying and monitoring the seismicity prior to injection allowed for a characterization of the natural seismicity. These results proved to be the most critical piece of evidence supporting the interpretation of the regional seismicity. The early deployment allowed Baker Hughes to document the natural variability in the seismic activity of the region. This helped clarify that activity witnessed during operation was not due to CO_2 sequestration. Shallow buried geophone arrays (SBA), at a depth of 200 m (656 ft), are very well suited to monitor long term injection processes as they are extremely reliable and can last for more than 30 years with minimal operational costs.

Strong engineering principles from Baker Hughes's geophysical team ensured the project's success. They simulated seismic source propagation to predict the optimal monitoring configuration and utilized decades of field execution experience to guide the selection and technique for installing permanent seismic recording equipment. This multiscale seismic network design perfectly achieved the goals assigned in terms of risk management, population information, and injection mapping.



An overview of monitoring network and results. The diagram depicts the microseismic events located with the regional SBA network and the borehole network. Most data collected from the regional network is located outside of the expected injection zone. A great majority of the regional network data was found to lie on a neighboring fault network that exists on the perimeter of the network.

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