



# Introduction

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Geophysical and hydrogeological investigations play a pivotal role in aquifer characterization. Here, we focus on a carbonate limestone aquifer in the Poitou region (France). We show how hydrogeology and geophysics have contributed to revising regional groundwater flow models and have provided significant new insights. The study highlights how a multidisciplinary geoscientific approach, integrating geophysical, hydrogeological, and stratigraphic analyses, can refine and strengthen a groundwater flow model.

The study area is located at a geological transition zone between the Aquitaine and Paris basins in France, known as the Poitou threshold. Chapter 1 of the book provides a geological overview of the threshold. Chapter 2 contains a detailed synthesis of the middle Jurassic limestone stratigraphy, which forms the basis for defining the regional geodynamic context. Particular attention is given to the Poitiers region, including newly developed geological cross-sections that delineate key stratigraphic features in the central part of the threshold. From a hydrogeological perspective, the Poitou threshold exhibits notable karst flows, despite its low hydraulic gradient, the relatively limited limestone thickness compared to the Périgord and Causses regions of the Aquitaine basin, and an altitude that does not exceed 150 m above sea level. Geologists of the 19th and 20th centuries unanimously attributed the origin of these karst systems to fissures formed under tectonic stress. The concepts underpinning the hydrogeology and karst morphology of the Poitou threshold are explored in detail in Chapter 3 entitled “Hydrogeology of the Poitou Threshold.”

The traditional understanding has been challenged by recent research conducted on a hydrogeological platform established near Poitiers under the leadership of

Gilles Porel: *Le Deffend* Hydrogeological Experimental Site (HES). Spanning an area of 12 hectares and comprising approximately 35 systematically distributed boreholes, the site represents a significant research initiative. The platform and its associated research objectives are detailed in Chapter 4, dedicated to the description of the experimental hydrogeological site: *Le Deffend*.

Among the investigative techniques implemented at the HES, geophysics—particularly seismic methods—holds a central role, offering a renewed perspective on groundwater flow geometry. In exploration geophysics and reservoir studies, seismic methods are primarily used for constructing subsurface models. These techniques are increasingly significant in geotechnical, hydrogeological, and site characterization studies, particularly in the context of seismic hazard assessments. Surface seismic reflection provides a three-dimensional (3D) representation of subsurface acoustic impedance contrasts, either in terms of time or depth. The resulting 3D seismic blocks generate interpretable images that can be used to develop porosity and karst models.

When combined with borehole measurements such as vertical seismic profiles (VSP) in low-frequency ranges (5–200 Hz) and full-waveform acoustic logging in very high-frequency ranges (1–25 kHz), seismic data enable robust estimation of petrophysical parameters, such as seismic porosity. These methods also facilitate the characterization of specific geological attributes, including karstic features. More recently, electrical resistivity tomography (ERT), conducted both at the surface and in boreholes, has been deployed at the *Le Deffend* site, with findings that corroborate the seismic results.

The results of the geophysical investigations are presented across two chapters. Chapter 5 highlights the contributions of various geophysical techniques, including seismic, acoustic, and electrical methods. Chapter 6 is dedicated to a borehole experiment conducted using Electrical Resistivity Tomography (ERT). Based on the geophysical data, a revised geometry of the karstic horizons has been established. Notably, the karstic horizons within the Middle Jurassic limestones were found to be sub-horizontal rather than vertical, challenging hydrogeological interpretations from the 19th and 20th centuries regarding the karstification process.

To assess the implications for groundwater flow, logging and tracer tests were conducted alongside initial pumping tests. Pumping and hydraulic slug tests were used to evaluate the interference geometry between boreholes. These tests were initially aimed at identifying a preferential fracturing pattern shaped by the tectonic constraints of the Poitou threshold. However, the three-dimensional seismic block revealed the sub-horizontal geometry of the karst levels, leading to a re-evaluation of hydrogeological flow patterns and the development of a new conceptual model, referred to as the “*Le Deffend* model.” Details of the logging and hydrogeological tests performed at the site are presented in Chapter 7 entitled “Hydrogeological flow logging and dye tracer tests.

The origin of the karstic horizons was also reexamined. While the distribution of karst horizons in limestone massifs is often considered random, a detailed stratigraphic

analysis was conducted at this site. The analysis included core sampling and optical televiewer (OPTV) imaging from open-hole drilling. These efforts, outlined in Chapter 8 entitled “Hydro-Stratigraphic study,” made it possible to clarify the stratigraphic controls on the distribution of karstic horizons in the *Le Deffend* model.

The *Le Deffend* model was subsequently integrated into a geodynamic framework. The results suggest that the distribution of karstified strata is closely tied to low stand system tracts (LST) within a broader depositional sequence affected by sea-level fluctuations. This geophysical and stratigraphic reinterpretation has significant implications for groundwater resource exploration and preservation. These findings are detailed in Chapter 9, “Hydrogeological Model of the *Le Deffend* site (HES).”

The book aims to demonstrate that seismic attributes derived from 3D seismic blocks and other geophysical methods can effectively characterize karstic horizons within carbonate sequences through stratigraphic interpretation. Beyond advancing geophysical methods, the research conducted at the *Le Deffend* site over two decades provides actionable insights for preserving drinking water resources in the region. It underscores the necessity of controlling water well stratigraphy and borehole completion to optimize groundwater resource management. This collaborative effort between scientists and engineers serves as a model for how applied geophysics can support hydrogeologists, engineers, and policymakers in sustainably managing groundwater resources amidst challenges such as scarcity and pollution.