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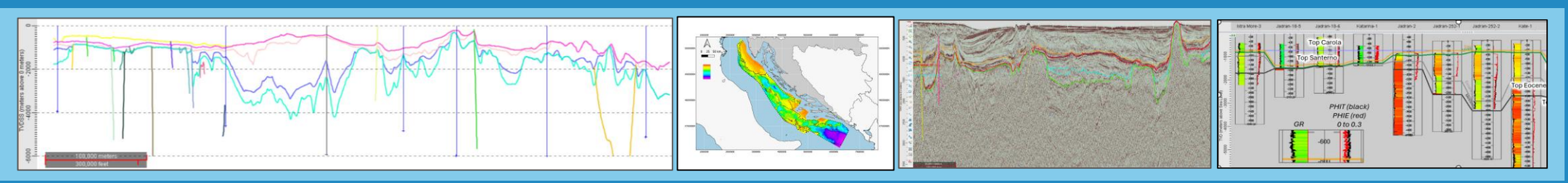
Croatian Hydrocarbon Agency

Croatian CO_2 Storage Atlas

Offshore

Executive Summary



1. Introduction

The Offshore Croatia CO_2 Storage Atlas provides the first integrated assessment of the geological potential for long-term carbon dioxide (CO_2) storage within the Croatian sector of the Adriatic Basin. The Atlas has been developed to support Croatia's emerging Carbon Capture and Storage (CCS) industry and to provide a technical foundation for future storage appraisal, project development, regulatory planning, and investment decisions. The study evaluates both deep saline aquifers and depleted gas fields (referred to as EPUs), which together represent the most mature and technically viable storage options currently available for commercial CCS deployment. As European CCS deployment accelerates in response to the Net Zero Industry Act and industrial decarbonisation objectives, offshore storage is expected to play a supporting role in providing potential storage resources. Croatia is well positioned to participate in this developing market due to its extensive offshore geological dataset, existing hydrocarbon infrastructure, operational subsurface expertise, and proximity to industrial and coastal CO_2 emission sources

2. Emissions Profile and CCS Demand

Croatia already possesses several elements required for a future CCS value chain. Existing and planned CCS initiatives, including projects associated with the Petrokemija ammonia plant, Sisak bioethanol facility, Molve operations, and the KOdeCO cement project, demonstrate a growing national CCS pipeline with an overall potential approaching 1.9 Mt CO_2 per year. The offshore sector provides an opportunity to complement these developments with potentially large-scale geological storage capacity capable of supporting both domestic and potentially regional decarbonisation objectives. Existing offshore infrastructure and pipeline networks provide potential opportunities for future reuse, while the Adriatic Basin offers a range of geological settings suitable for permanent CO_2 storage. The development of offshore storage sites could therefore form a key component of Croatia's long-term energy transition strategy

3. Geological Framework and Storage Potential

3.1 Basin Characteristics

The Croatian Adriatic Basin is a complex sedimentary basin shaped by Mesozoic rifting, carbonate platform development, and subsequent compressional tectonics associated with the Dinaride orogeny. This evolution has created multiple reservoir–seal systems and a variety of structural traps with potential for long-term CO_2 containment (Figure 1). Four principal saline aquifer intervals were identified and evaluated; Eocene–Mesozoic Carbonates, Miocene–Oligocene, the Santerno Formation, and the Carola Formation with the Eocene-Mesozoic carbonates providing the largest potential capacity. The Miocene–Oligocene, Santerno, and Carola intervals provide additional opportunities, although with smaller storage resources. These formations generally exhibit better understood reservoir-seal relationships but are constrained by limited areal extent, reservoir continuity, or storage efficiency.

Offshore gas fields provide an additional storage opportunity due to their proven containment history, extensive subsurface datasets, and existing infrastructure. The Atlas assessed all major Adriatic EPUs using a structured screening and ranking methodology. However, many of the EPUs in the Adriatic are not sufficiently deep enough for maintaining supercritical conditions for CO_2 storage. Those that do meet the required thresholds are in the most southerly sector of the Croatian license blocks.

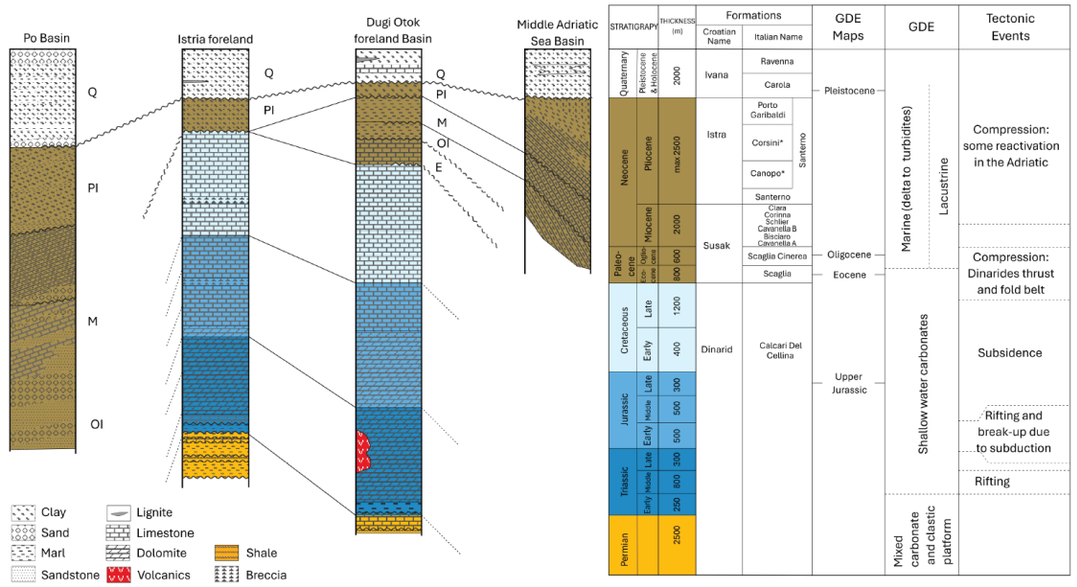


Figure 1. *Summary stratigraphic diagram for the Croatian Adriatic Basin (adapted from Saftić et al. 2019). showing the main formations that have been assessed in this CO_2 Storage Atlas. Saftić, B., Kolenković Močilac, I., Cvetković, M., Vulin, D., Velić, J., and Tomljenović, B. 2019. Potential for geological storage of CO_2 in the Adriatic offshore. Minerals 9(10): 577*

3.2 Storage Types and Resources

The Croatian Adriatic has significant offshore CO_2 storage potential, with a total capacity of all evaluated geological formations of 717 Mt. This estimate assumes injection into all parts of formations which meet the criteria for injection and is therefore considered theoretical. The largest potential capacity is within the deep Eocene–Mesozoic carbonate aquifer system, with a theoretical estimate of 600 Mt CO_2, although capacity estimates of this interval carry considerable uncertainty due to limited reservoir data and reservoir heterogeneity. Additional storage potential exists within the Miocene–Oligocene and Santerno sandstone aquifers, with capacities of approximately 48 Mt and 29 Mt CO_2, respectively. The Carola interval is generally less favourable because much of the formation does not meet the depth requirements for supercritical CO_2 storage, despite an estimated capacity of approximately 40 Mt CO_2. Several Eocene–Mesozoic carbonate structural traps in the central and southern Adriatic could support future storage developments and together contain a combined mid-range resource of approximately 61 Mt CO_2 spread over 3 traps, although reservoir quality, seal , and faulting is uncertain. Depleted gas fields (EPUs) provide a more mature near-term storage opportunity, with the Ika and Marica fields demonstrating favourable reservoir and seal characteristics and estimated storage capacities of around 10–13 Mt CO_2 each.

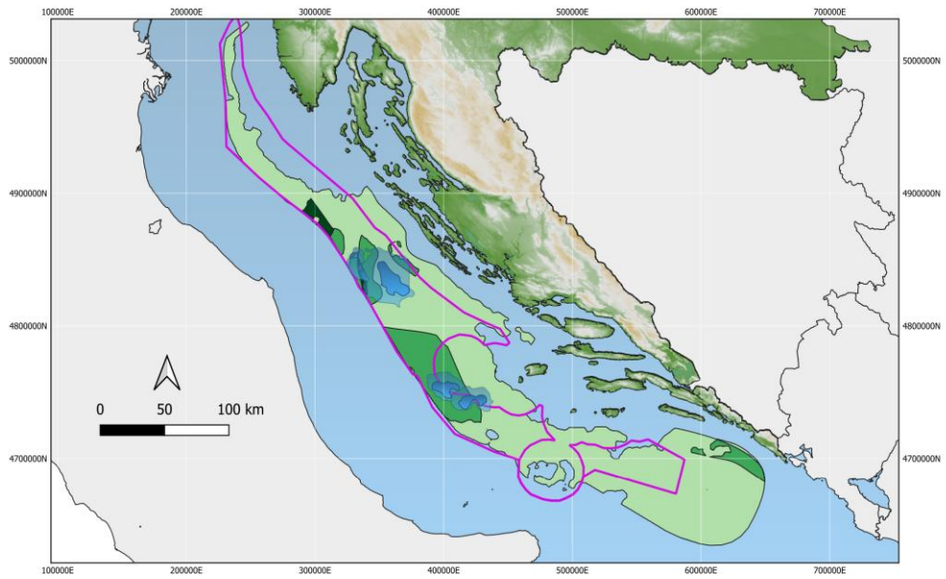


Figure 2. *Map showing saline aquifers at a formation level that are potential areas for storage of CO_2 in the Croatian Adriatic. Polygons only show those areas where suitable reservoir-seal pairs exist. Also shown are the location of potential saline aquifer traps. The most favorable traps are studied in detail in the Atlas.*

4. Data set

The offshore Adriatic benefits from a substantial legacy dataset acquired during hydrocarbon exploration and production activities. The Atlas utilised more than 5,000 km of 2D seismic data, approximately 6,600 km^2 of 3D seismic coverage, and information from 179 exploration and development wells (Figure2). This dataset provides a strong foundation for future storage appraisal and significantly reduces early-stage exploration uncertainty. Although data coverage is strongest in the northern Adriatic, sufficient information exists across much of the basin to support screening-level storage assessments. Future site-specific appraisals will require additional reservoir characterisation and targeted data acquisition.

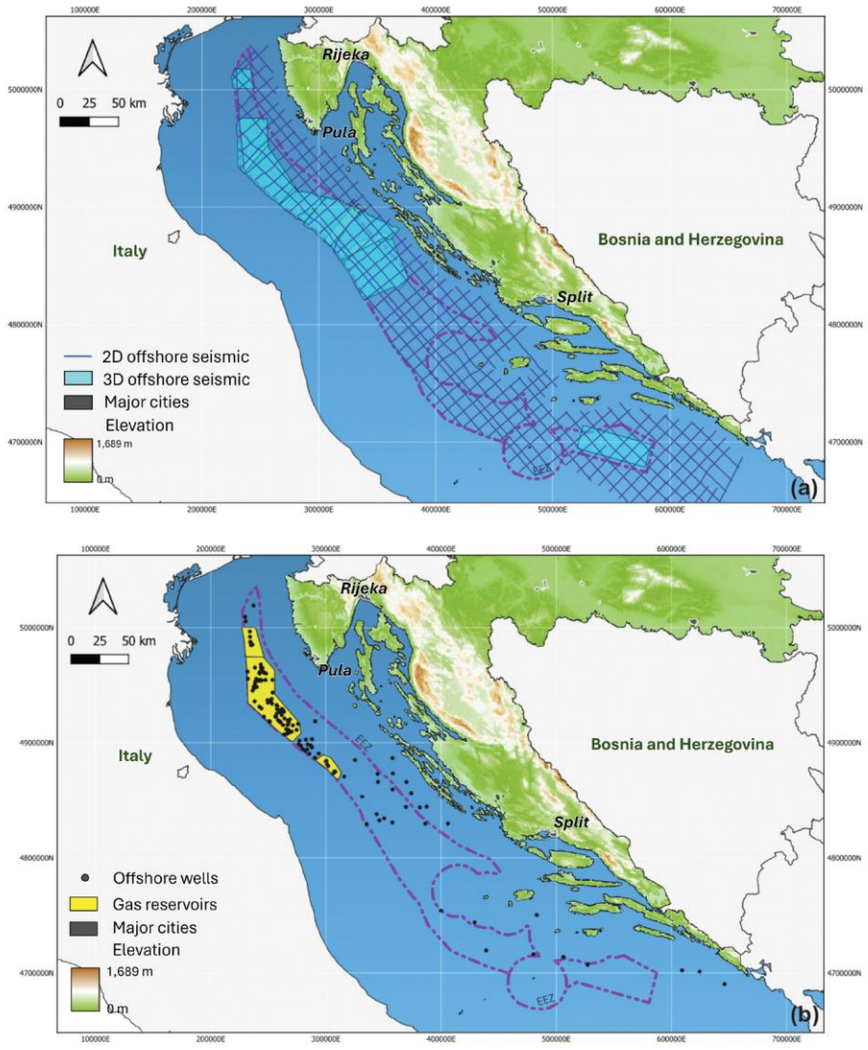


Figure 3. *(a) 2D and 3D seismic legacy data through the Croatian Adriatic. (b) Hydrocarbon wells and fields in the Croatian Adriatic.*

5. Methodology and Evaluation Framework

The Atlas applies a structured, multi-phase methodology to ensure consistent identification and ranking of potential storage sites. For saline aquifers, a six-phase workflow is implemented, encompassing area of interest definition, site qualification based on fundamental geological criteria, screening for reservoir–seal pairing, detailed characterisation of properties, location-based risk assessment, and final ranking using a heatmap scoring system.

A parallel five-phase workflow is applied to EPUs, incorporating additional data-driven evaluation and also dynamic modelling of injection scenarios for representative fields. Screening criteria include depth constraints between 800 and 3,500 metres, CO_2 density thresholds exceeding 300 kg/m^3, reservoir thickness and permeability, seal integrity, and proximity to infrastructure and emission sources.

The Storage Resource Management System (SRMS) is used to classify storage resources according to their maturity and commercial readiness. This system distinguishes between discovered, prospective, and contingent resources, thereby enabling standardized reporting and facilitating comparison across projects and investment decisions.

6. Risks and Constraints

Several technical risks must be addressed before commercial deployment can proceed. The most significant risks identified include low reservoir quality, particularly in the Eocene–Mesozoic carbonates, fault-controlled migration pathways, legacy well integrity, reservoir compartmentalisation and heterogeneity, seismicity and fault reactivation potential, and cross-border regulatory considerations for some storage sites. The Atlas incorporates risk-based screening and ranking procedures designed to identify these uncertainties early and guide future appraisal activities towards the most technically robust storage opportunities.

7. Opportunities and Outlook

The Offshore Croatia CO_2 Storage Atlas demonstrates that the Adriatic Basin contains geological potential for long-term CO_2 storage. The basin offers a combination of large saline aquifer resources and smaller but better-characterised depleted gas field opportunities. The Eocene–Mesozoic carbonate play represents the largest theoretical storage resource, while the Ika and Marica EPUs potentially provide attractive near-term targets. Future work should prioritise detailed characterisation of the highest-ranked aquifer traps and EPUs, including reservoir quality assessment, seal validation, fault analysis, pressure management studies, and dynamic simulation. Particular attention should be given to legacy wells, plume migration, and uncertainty reduction through higher-resolution geological modelling. Overall, Croatia's offshore sector represents a strategically important component of the country's future CCS portfolio. With substantial theoretical storage capacity, existing infrastructure, and strong alignment with European decarbonisation initiatives, the Adriatic Basin has the potential to support Croatian and wider regional emissions reduction objectives.