

Fluid Atlas for Geothermal Fluids and Critical Raw Materials

The online Fluid Atlas is a web-based, interactive mapping platform that presents geothermal fluids and their associated critical raw materials (CRMs) in a spatially integrated form across Europe and Eastern Africa. The main aim of the Atlas is to make complex geothermal, geochemical, and geological information accessible, transparent, and comparable by placing it into a clear geographic context.

The platform allows users to explore the spatial distribution of geothermal wells, to examine variations in fluid chemistry, and to identify regions showing enrichment in elements that are considered critical for modern technologies. By linking analytical data to their geographic location and geological setting, the Fluid Atlas supports both scientific interpretation and practical assessment of geothermal systems.

The Atlas integrates several types of data, including geothermal wells, fluid samples, rock samples, gas compositions, and mineral scales or precipitates. These datasets originate from previously published sources, including scientific literature and earlier research projects, as well as from newly generated field sampling and laboratory analyses. All data are harmonised using a common structure and are georeferenced, ensuring that information from different regions and sources can be compared consistently.

Each location shown on the map represents a geothermal well or site. From these map points, users can access detailed information on associated fluid chemistry, rock composition, gas content, or mineral deposits. Analytical results are accompanied by metadata describing sampling conditions, analytical methods, and references, allowing users to understand the origin and reliability of the data.

A core principle of the Fluid Atlas is openness and reusability. The platform follows FAIR data principles, meaning that datasets are structured so they can be easily found, openly accessed, combined with other data sources, and reused in future studies. The web interface is publicly available at: <https://crmgeothermal.iit.uni-miskolc.hu>. No registration is required to browse, visualise, or download published datasets. The Fluid Atlas is built entirely on open-source software components. The underlying database uses MySQL and is hosted on institutional servers rather than commercial cloud platforms. Data exchange relies on standard, open formats such as JSON and GeoJSON, and interactive map visualisation is implemented using the open-source Leaflet library within a web-based interface (Figure 1). No commercial software, paid APIs, licences, or subscription-based services are required to operate or access the platform, ensuring long-term sustainability, transparency, and independence from proprietary solutions.

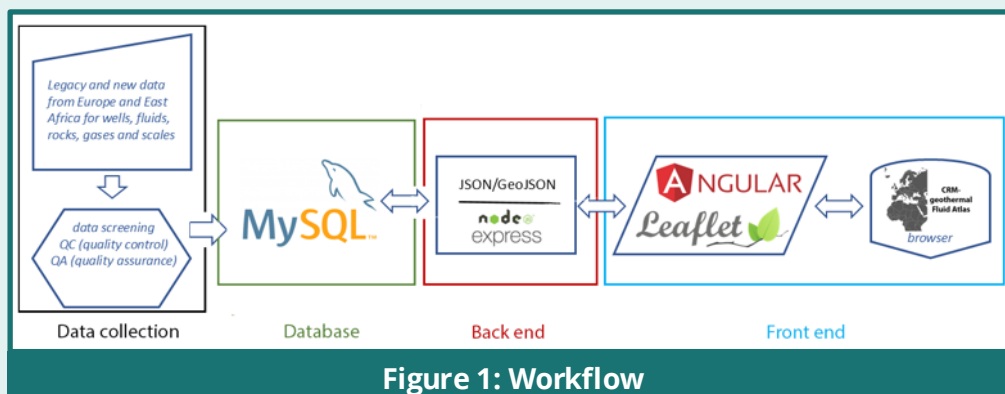


Figure 1: Workflow



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The Fluid Atlas follows a clear and transparent data workflow. Legacy and newly generated data on geothermal wells, fluids, rocks, gases, and scales are first subjected to data screening and quality control procedures to ensure consistency, harmonised units, and basic plausibility. The validated data are stored in a central database and delivered to the web interface through a server-side application using standard data formats. When users interact with the map or search tools, the relevant information is retrieved from the database and displayed as interactive maps and tables. Newly added data become visible in the Atlas automatically, without manual duplication or re-upload.

The platform provides two complementary views: a Database view (Figure 2), where users can browse and query the underlying database using simple keyword search or advanced, attribute-based filters, and a Map view (Figure 3), where the spatial relationships between data points can be explored through interactive maps, also with the possibility to check the selected data and supported by multiple search and filtering options. The user interface is designed to be intuitive and accessible also for non-specialists. Users can zoom and pan across the map, select individual sites, and open detailed data windows. Search and filter functions allow the dataset to be narrowed based on parameters such as temperature ranges, chemical composition, or the presence of specific CRM elements. Selected datasets can be exported in standard spreadsheet format for further analysis.



The screenshot shows the 'Database view' of the CRM Geothermal database. The interface includes a search bar, navigation tabs (Database, Map, User Management), and a table of well data. The table has columns for ID, Country, Local ID, Well Type, Name Of The Facility, Power Thermal, Latitude, Longitude, Date Of Well Completion, Well Head Elevation, Surface Elevation, and True Vertical Well Depth. The data is filtered to show wells in Austria.

ID	Country	Local ID	Well Type	Name Of The Facility	Power Thermal	Latitude	Longitude	Date Of Well Completion	Well Head Elevation	Surface Elevation	True Vertical Well Depth	
W_AT_001	Austria	Burau 2	Production well			47.12	16.04					<input type="checkbox"/>
W_AT_002	Austria	Burau 3				47.12	16.04					<input type="checkbox"/>
W_AT_003	Austria	Burau 1a	Injection well			47.12	16.04					<input type="checkbox"/>
W_AT_004	Austria	Geopointe				47.02	14.41					<input type="checkbox"/>
W_AT_005	Austria	Marakeisquelle				47.02	14.41					<input type="checkbox"/>
W_AT_006	Austria	Ignatzquelle				47.02	14.41					<input type="checkbox"/>
W_AT_007	Austria	Michaelsbrunnquelle				47.02	14.41					<input type="checkbox"/>
W_AT_008	Austria	Heinrichsquelle				47.02	14.41					<input type="checkbox"/>
W_AT_009	Austria	Tiefbrunn Wies				46.17	14.04					<input type="checkbox"/>
W_AT_010	Austria	Ötschberg Mäggenbrunn				46.18	13.8					<input type="checkbox"/>
W_AT_011	Austria	Perneck-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_012	Austria	Eisenberg-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_013	Austria	Freysbergbach 2 Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_014	Austria	Freysbergbach 1 Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_015	Austria	Fürtschnitz-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_016	Austria	Gurtenbrunn-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_017	Austria	Hörsner-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_018	Austria	Suttsbach 2 Bad Hall				46.04	14.21					<input type="checkbox"/>
W_AT_019	Austria	Tschirn-Quelle Bad Hall				46.04	14.21					<input type="checkbox"/>

Figure 2: Database view



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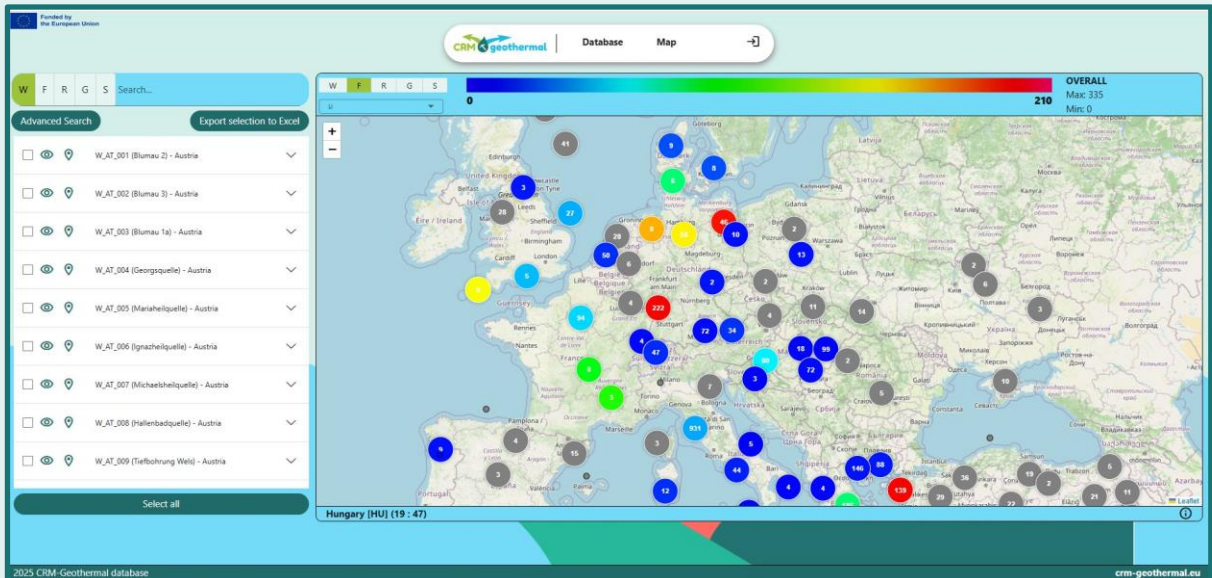


Figure 3: Map view

In Map view, users can select any numerical variable from the control panel. The system then displays the minimum and maximum values of the selected variable for the entire database, as well as for the currently visible map extent, together with a corresponding colour scale. Map points are dynamically coloured according to the selected variable, while the numbers within the points continue to indicate the number of wells represented. This functionality allows users to quickly assess the spatial distribution of any selected parameter at a glance. It supports rapid comparison between regions, helps identify spatial trends and anomalies, and provides an intuitive basis for data-driven interpretation and decision-making.

To ensure data quality while remaining open, the platform uses a role-based access system. Public users can freely view and download data. Registered contributors may upload new datasets or edit their own entries. Administrative oversight ensures quality checks. Data submission follows harmonised templates and validation rules, including checks for unit consistency, coordinate accuracy, and basic plausibility, helping to maintain a reliable and coherent dataset.

Geographically, the Fluid Atlas covers a wide range of natural geothermal environments in Europe and Eastern Africa, including volcanic regions, sedimentary basins, and rift-related systems. This broad spatial coverage enables comparison of geothermal fluids across different geological contexts and supports the identification of regional trends in fluid chemistry and CRM enrichment.



Fluid Atlas for Geothermal Fluids and Critical Raw Materials

Beyond research applications, the Fluid Atlas supports practical use cases. It provides a transparent knowledge base for assessing the potential of geothermal fluids as sources of critical raw materials, supports early-stage resource evaluation, and contributes to informed discussions on sustainable resource use. The platform is also suitable for education and training, offering a clear and interactive way to demonstrate geothermal processes and data-driven analysis.

The long-term operation of the Fluid Atlas is ensured through institutional hosting on secure servers, regular data backups, encrypted communication, and controlled updates. Its modular design allows new regions, datasets, or analytical features to be added over time without restructuring the system. This makes the Atlas a durable digital infrastructure that can continue to grow and remain relevant as new geothermal and CRM-related data become available.

Overall, the Fluid Atlas provides an open, reliable, and easy-to-use gateway to harmonised geothermal and critical raw material data. By combining spatial visualisation, quality-controlled datasets, and open-source technology, it supports research, innovation, and evidence-based decision-making in the field of geothermal resources.

Browse the fluid atlas:

<https://crm-geothermal.eu/go/crm-geothermal-database>

Additional resources:

[User Guide for the CRM-geothermal Database and Fluid Atlas](#)

[CRM-geothermal Database - Data Publication \(D1.2\)](#)

[CRM-geothermal Database: Geoscientific and Geochemical Data on Geothermal Systems, with Emphasis on Fluids and Critical Raw Materials in Europe and Eastern Africa. GFZ Data Services.](#)

[Online GIS-based CRM-geothermal Fluid Atlas for Europe and Eastern Africa \(D1.3\)](#)

[Download the data collection excel template](#)

[Guidelines for data collection template](#)

[Provide feedback](#)

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