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JIWA DBase: Integrated Geothermal Data Management and Analysis in Cloud System

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ABSTRACT

A variety of geoscientific and engineering data is collected by respective subject matter experts in every stage of a geothermal project. This valuable data is the basis for understanding resource uncertainties to develop and sustainably manage a geothermal steam field. Therefore, a multidisciplinary approach to updating, accessing, and analyzing the data is essential. JIWA DBase, a web-based database application is introduced to promote agile collaboration between geothermal scientists, engineers, and related stakeholders in data management and analysis from the 3G survey, drilling, well logging, well testing, well stimulation, well workover, to operation and maintenance. Every DBase module has been built according to geothermal subsurface, engineering, project management, and information technology best practices with embedded analytical functions and user management to ensure reliable data storage and holistic evaluation. Built with a graph model, JIWA DBase provides robust and data-driven decision-making to support organizations in striving for excellence in geothermal projects.

1. INTRODUCTION

Practicing data collection, entry, and governance by experts working together is essential in almost all work areas so it can be analyzed thoroughly for decision-making. In the geothermal power sector, the procedures previously mentioned are of higher significance. The foremost factor is due to the uncertain nature of the site-specific geothermal resource that requires capital-intensive exploratory well drilling as a data-gathering method to devise a suitable field development plan. Moreover, the sustainability of geothermal production can only be maintained through strategic reservoir management by properly harnessing insight from a large amount of surveillance data of various domains.

Some practices have been implemented by geothermal organizations for managing data. The common one would be compiling data of several formats in the working folder of each geothermal prospect and knowledge domain (for instance, geology, geochemistry, reservoir engineering, etc.). Cooperation between organization members in utilizing data is accommodated manually via USB data transfer, email communication, or messaging services per requests, and periodically as shared folders through private networks and cloud storage. Although the recent inclusion of cloud file sharing has improved data accessibility and protection, this approach is still prone to fundamental issues such as plentiful data versions, metadata inconsistency, dealing with large data, and unproductive time as a consequence of crunching geothermal data with diverse disciplines in multiple digital reports, spreadsheets, and modeling software files stored in folders and sub-folders.

Owing to the advancement of software engineering, some institutions have also utilized web applications for handling geothermal data. These software are usually of oil & gas or mining origin, databases with specific functionality (for example, wellbore monitoring data storage), or modeling software implemented as a data management platform. Even though basic problems as in folder-based systems are infrequent, the capacity of tools earlier mentioned to capture and systematically validate, integrate, calculate, and visualize large geothermal datasets with multiple relations and types is none or insufficient. In addition, an effortful process of data preparation is still required for sophisticated modeling techniques in separate software (for example, detailed well characterization, history matching, production forecasting, etc.).

To address this problem, AILIMA introduces JIWA DBase, a web-based geothermal database application to advance the collaboration in data management and analysis among geologists, geochemists, geophysicists, reservoir engineers, production engineers, drilling engineers, and related stakeholders of geothermal developers and regulators from the 3G survey, drilling, well logging, well testing, well stimulation, well workover, to operation and maintenance (O&M) under a single platform. Modules in JIWA DBase have been deployed as a graph database based on in-depth research in geothermal subsurface and engineering, project management, and information technology best practices to assist in agile data storage and analysis of interconnected geothermal data. Embedded with analytical functions and a user administration system, this database enables comprehensive evaluation for data-driven decision-making and is integrated with other web applications in JIWA System. A standardized user-friendly interface based on common application designs is also offered in JIWA DBase to support end users of cross-functional teams.

2. JIWA DBASE

Extensive multidisciplinary research by AILIMA's personnel consisting of geoscientists, engineers, IT developers, and UI/UX engineers is conducted prior to software development. Furthermore, a series of testing, troubleshooting, and in-depth reviews are also conducted,

implementing best practices of a software development process. These careful steps are done to ensure JIWA DBase fits the intended use. Technical specifications of JIWA DBase are described in detail as follows:

2.1 Data Design & System Architecture

To ensure rapid traversing of geothermal data with a complex nature, JIWA DBase's data system is built with a graph model approach, one of the NoSQL (not only structured query language) designs, where data are stored as a network of nodes and relationships, instead of traditional tabular formats of relational database management system (RDBMS). This choice is owing to several comparative research on database systems (Jaiswal and Agrawal, 2013; Lazarska and Siedlecka-Lamch, 2019; Lorincz et al., 2020) that found graph model significantly outperformed RDBMS in the query execution time and modification of big data. Furthermore, the graph database is also much more efficient regarding the cost of processing and provides flexibility to add new properties and connections. An example of JIWA DBase's data structures is shown in **Figure 1** below, where basic field information, surface geoscientific surveys, drilling operational records, formation evaluations, and voluminous production test data operated by a geothermal developer with multiple assets are linked as a network to improve the capacity of analytics that can be run during an exploration drilling campaign.

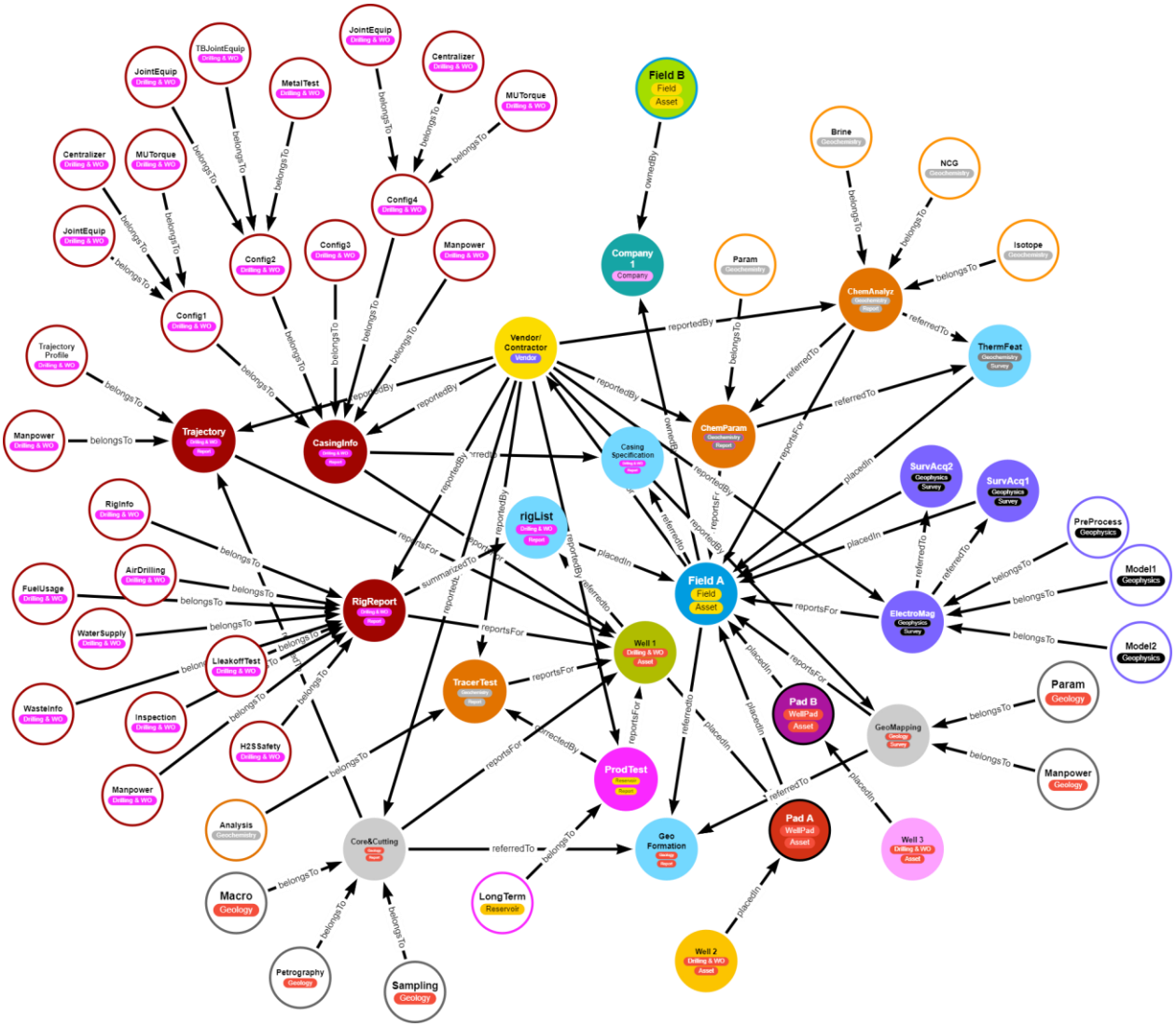

Figure 1: Simplified model of geothermal data stored in JIWA DBase's nodes, child nodes, and relationships, symbolized in colored circles, transparent circles, and arrows, respectively.

As a web application in JIWA Cloud Computing System (Prabata et al., 2021) (**Figure 2**), JIWA DBase allows accessibility, flexibility, and cost-effectiveness to manage data. No prerequisite device specification and installation, private servers, network switches, or backup generators procurement and maintenance are needed, whilst end users can simply log in to JIWA System with their browser anytime,

anywhere. To provide data security, cloud encryption is fully embedded to uphold data privacy and cyberattack protection. According to statistics, more than 80% of companies have already utilized a multi-cloud approach and the amount of data stored in clouds has at least doubled since 2015 (Duarte, 2023).

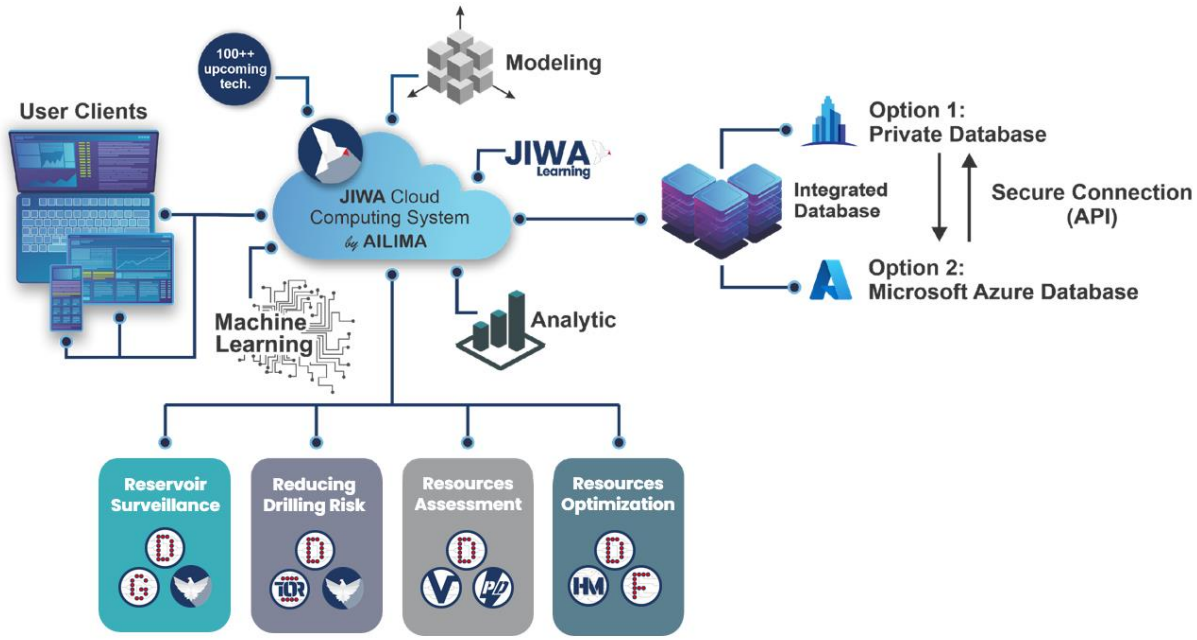

Figure 2: Simplified architecture of JIWA Cloud Computing System.

2.2 Modules

To provide end users with a holistic approach to managing and analyzing end-to-end geothermal data (**Figure 3**), JIWA DBase will consist of more than 5,000 types of properties of numerous nodes and relationships. This system will be structured in 40 modules from various groups of knowledge domains, namely geology, geochemistry, geophysics, drilling & workover, and reservoir engineering, with 15 of them already operating online. These modules are of coverage of systematic metadata based on the subject area, from data objectives, collaborators, related expenditure, spatial and temporal information, technical data (raw, processed, and/or interpreted), equipment specifications, to detail personnel involved. For instance, the core & cutting of the geology module in JIWA DBase consists of a considerable amount of lookup value and image attachment data on account of the qualitative descriptive nature of the information. Screenshots of JIWA DBase interface are showed in **Figure 4** and **5**.

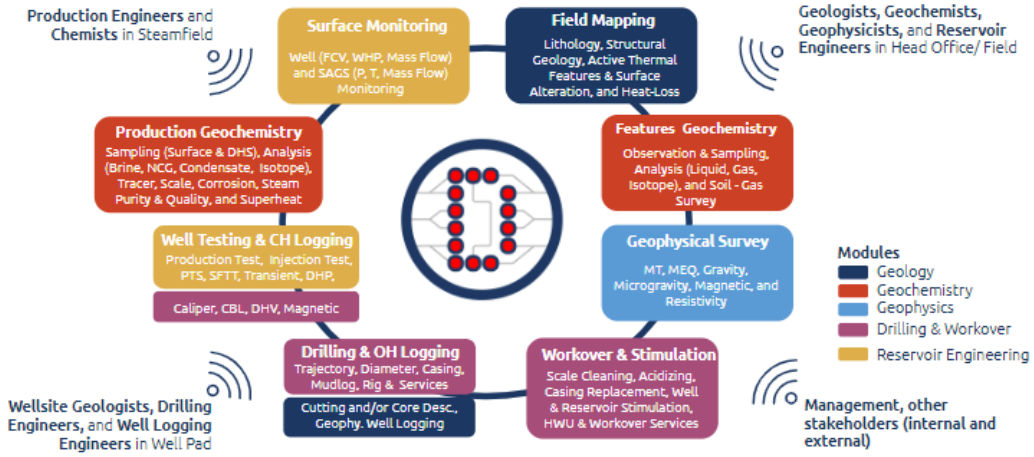

Figure 3: Types of geothermal datasets that can be managed and analyzed in JIWA DBase.

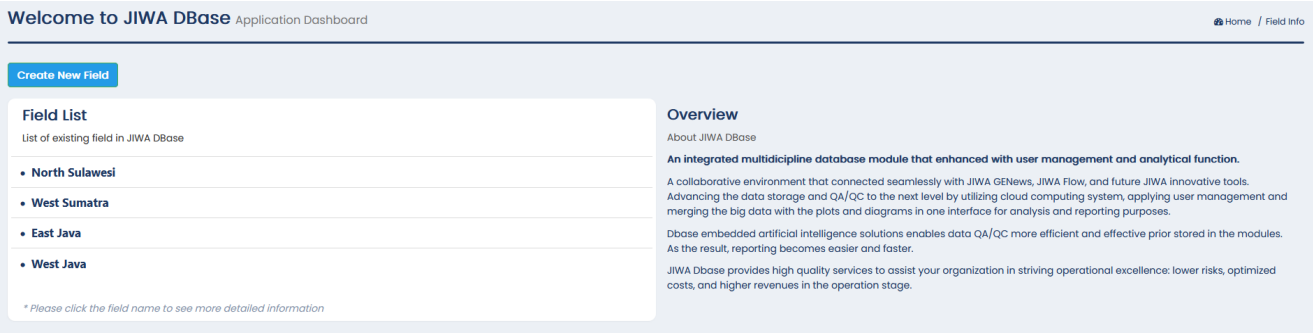

Figure 4: Geothermal field selector list.

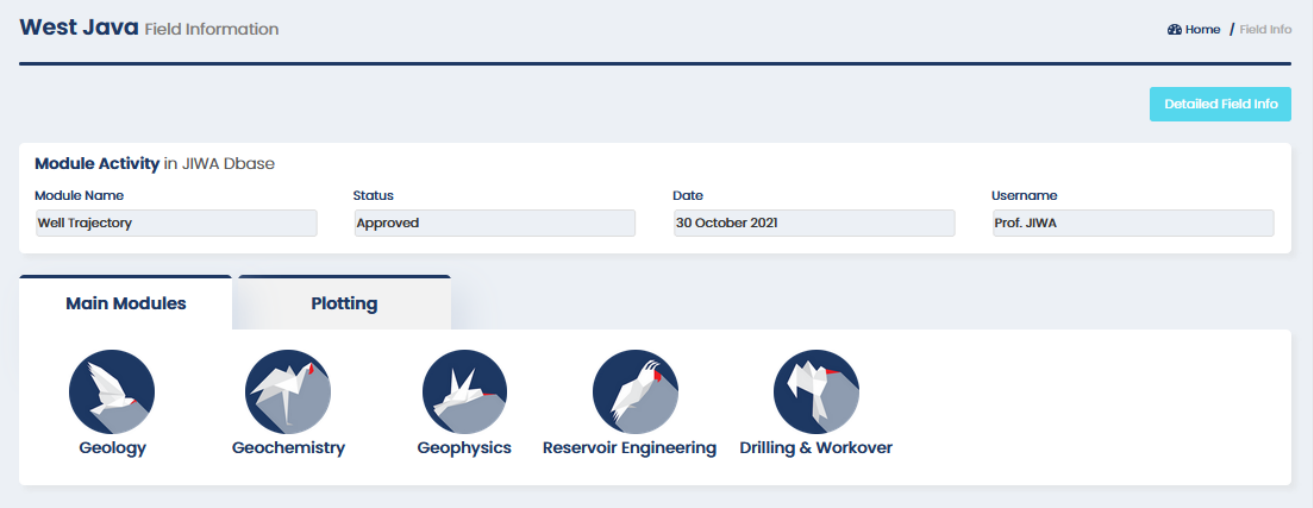

Figure 5: Home page of the selected field.

2.3 CRUD Operations

As in any database system, there are four essential functionalities for managing data in JIWA DBase: create, read, update, and delete (abbreviated as CRUD) (**Figure 6**). These operations are crucial to keep the data lifecycle in the system functional and updated. Datasets can be created, shown (read), and updated (edit) one or more times as necessary and deleted from the application if required. Each operation of CRUD is developed with features to enhance data handling and query process quality. For instance, head data consists of the job description, job type (for instance, drilling or post-drilling), job executor (in-house or third-party), project costs, and basic transaction records or module activity, namely created by, created date, status, last update by, and last update date are provided in modules. This component is connected with the data summary, data history table, and data approval system that will be deployed to allow on-point verified data tracking, monitoring, and boost communication among the organization's personnel through a digital platform. For example, a short-term injection test result can be collected and stored in JIWA DBase by well-testing engineers in the field and edited afterward due to a review process by the principal reservoir engineer in the head office. Samples of CRUD operations interface are displayed in **Figures 7 to 13**.

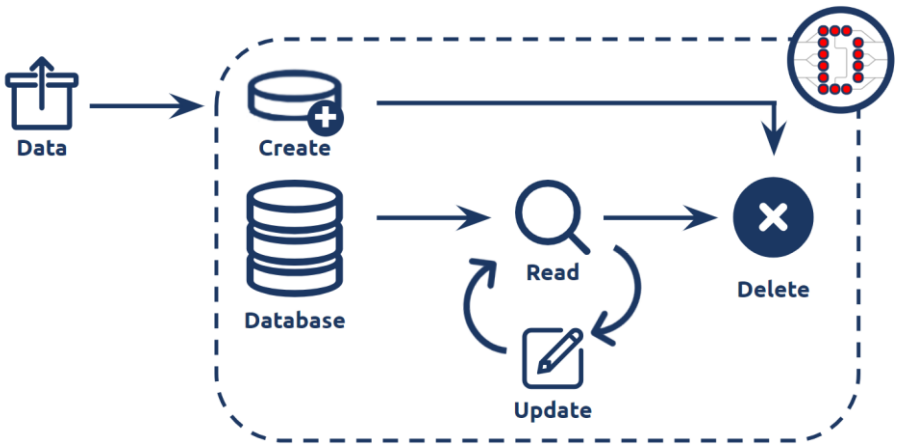

Figure 6: Illustration of CRUD Operation in JIWA DBase.

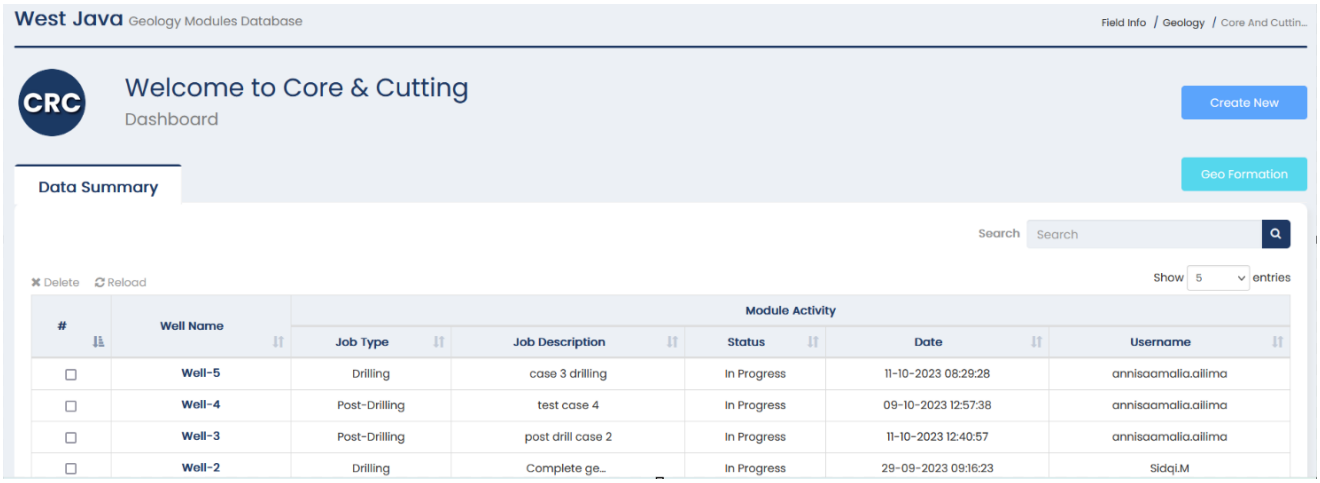

Figure 7: Data summary in the Core & Cutting module to keep track of updating static data of each wellbore with different geoscientific techniques since the well-site analysis.

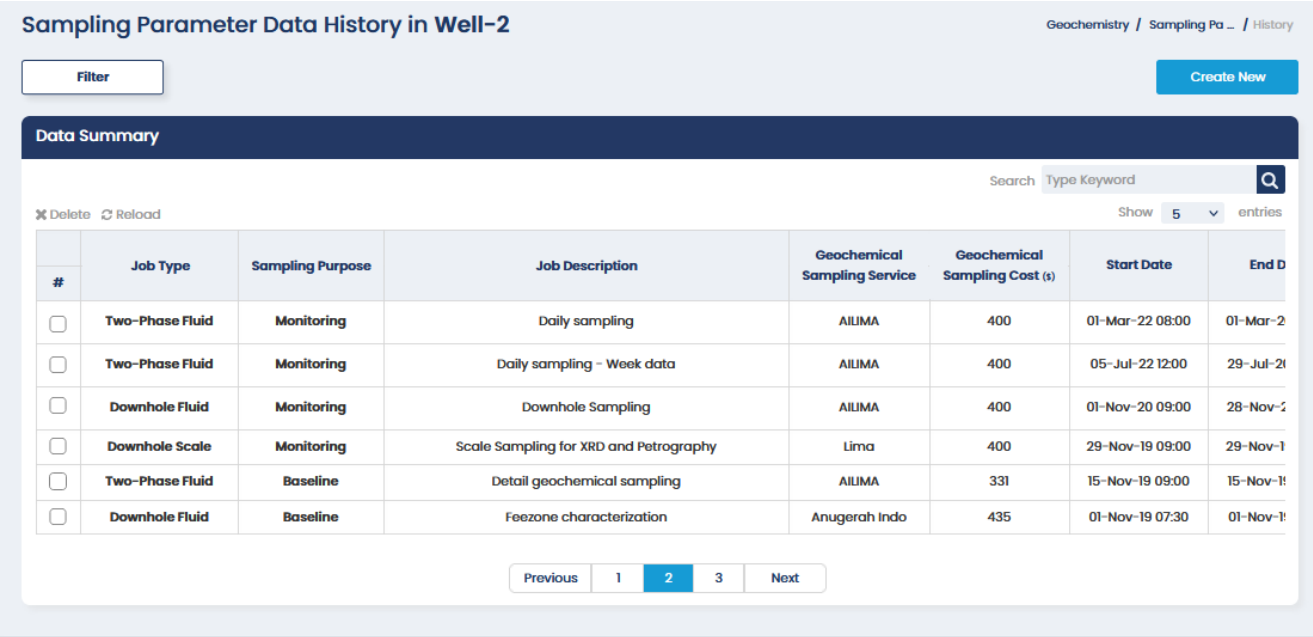

Figure 8: Data history in the Geochemistry's Sample Parameter module to periodically monitor geochemical sampling of reservoir surveillance.

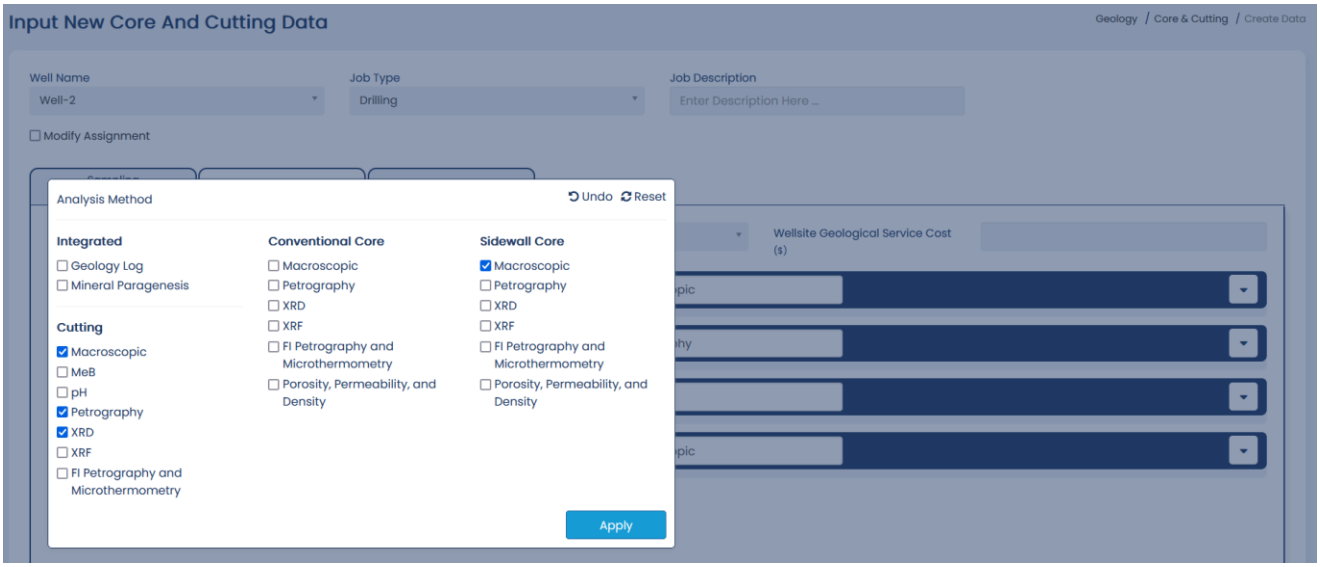

Figure 9: Data input selector in Core & Cutting module to accommodate numerous types of datasets in a single transaction (create or edit).

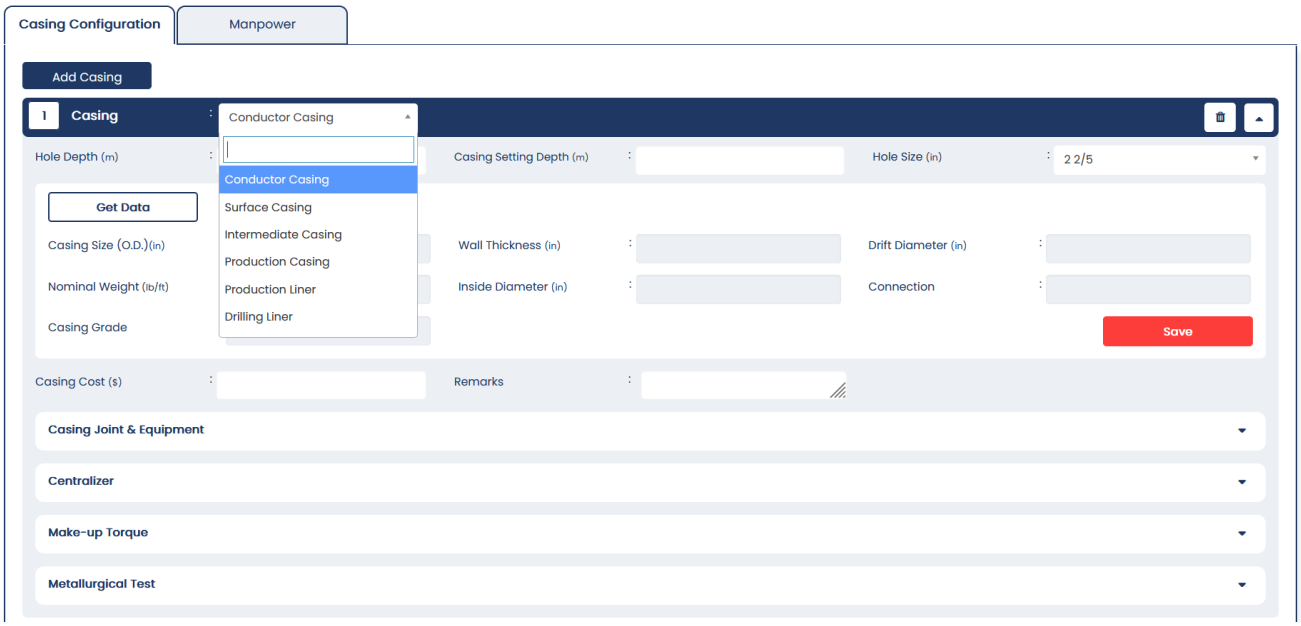

Figure 10: Organized data input in the Casing module transaction supported by collapse/expand buttons to accommodate casing data with nested objects, namely casing joint, accessories, centralizer placement, and other relevant records of each casing section.

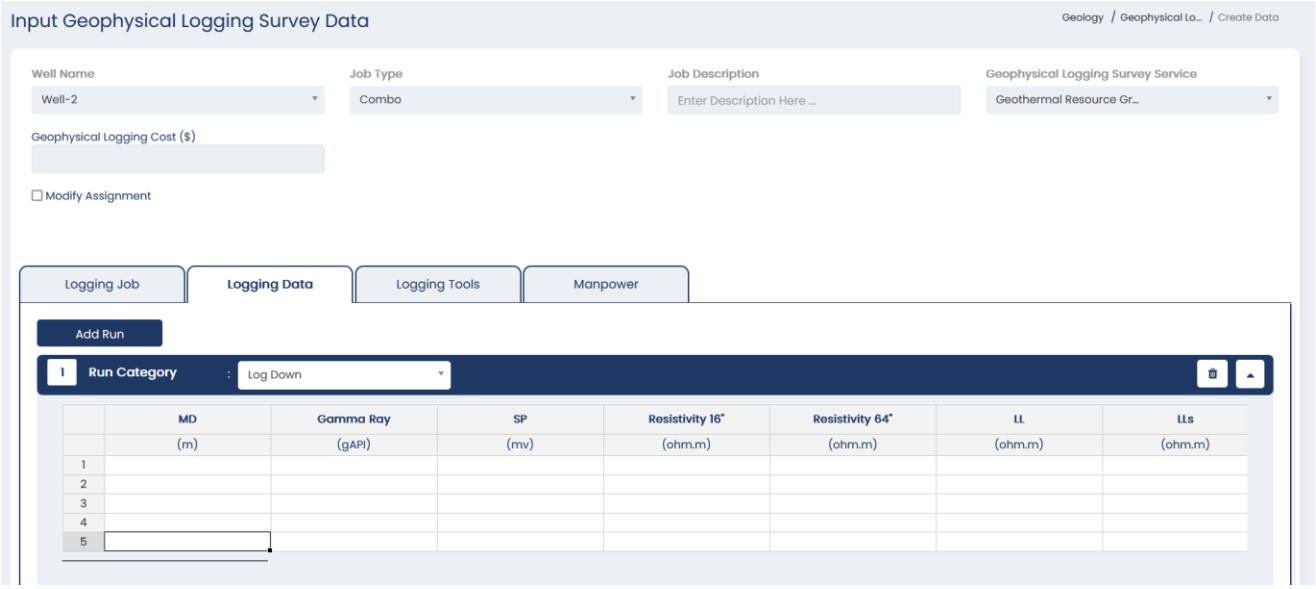

Figure 11: Spreadsheet feature embedded in Geophysical Logging Survey module transaction to provide instantaneous data entry of depth-based formation logging data.

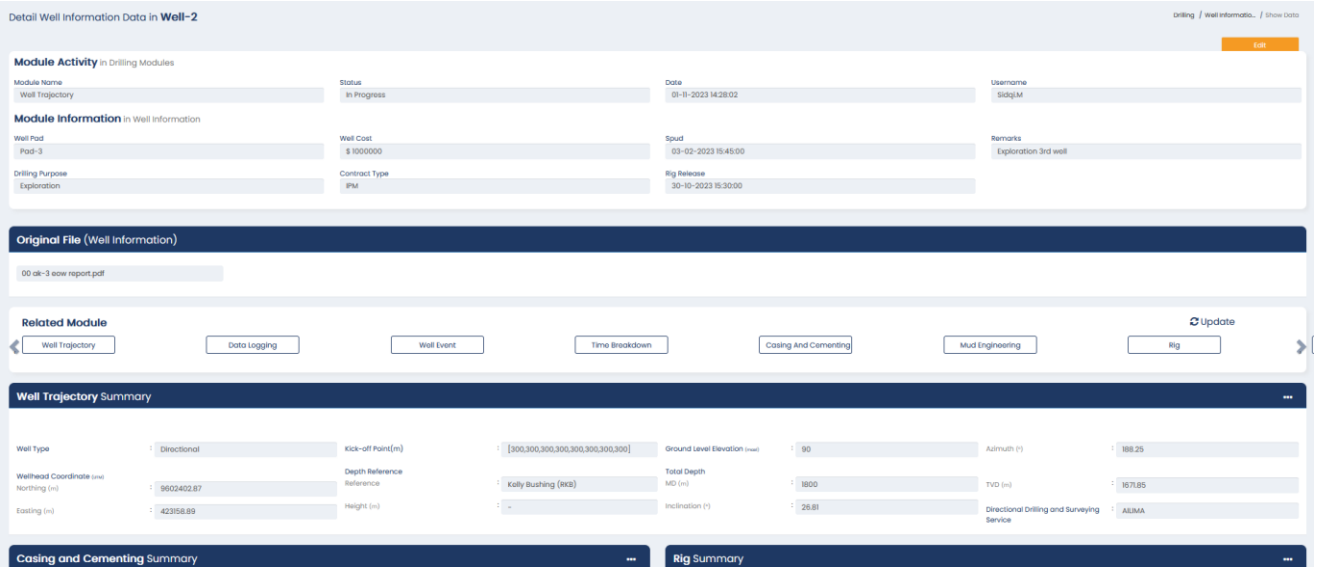

Figure 12: Integrated show data in the Well Information module to provide a comprehensive summary of the drilled well. Module activity information positioned in the header allows end users to track data transaction updates quickly.

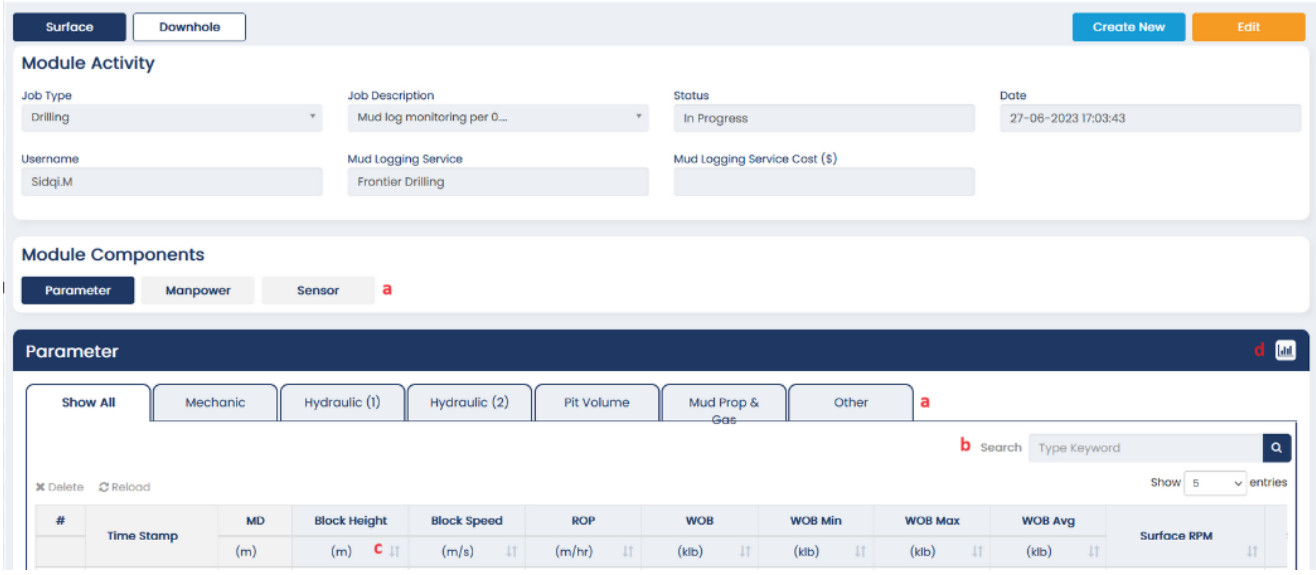

Figure 13: Example of data categorizing (a), searching (b), sorting (c), and plotting features (d) in the Data Logging module show data to enhance the capacity of viewing mud log data.

2.4 Analytical Functions

JIWA DBase employed some analytical features from data entry to decision-making based on applied geothermal subsurface and engineering, and statistical methods relevant to each module. Firstly, a series of data quality controls (QC) will be done through properties validation, technical calculation (for example, ionic charge balance in geochemistry), and data visualization prior to data submission. This feature is employed to ensure data completeness, consistency, and reliability before further use by end users. An example of data plotting to aid in QC operation is shown in **Figure 14** below.

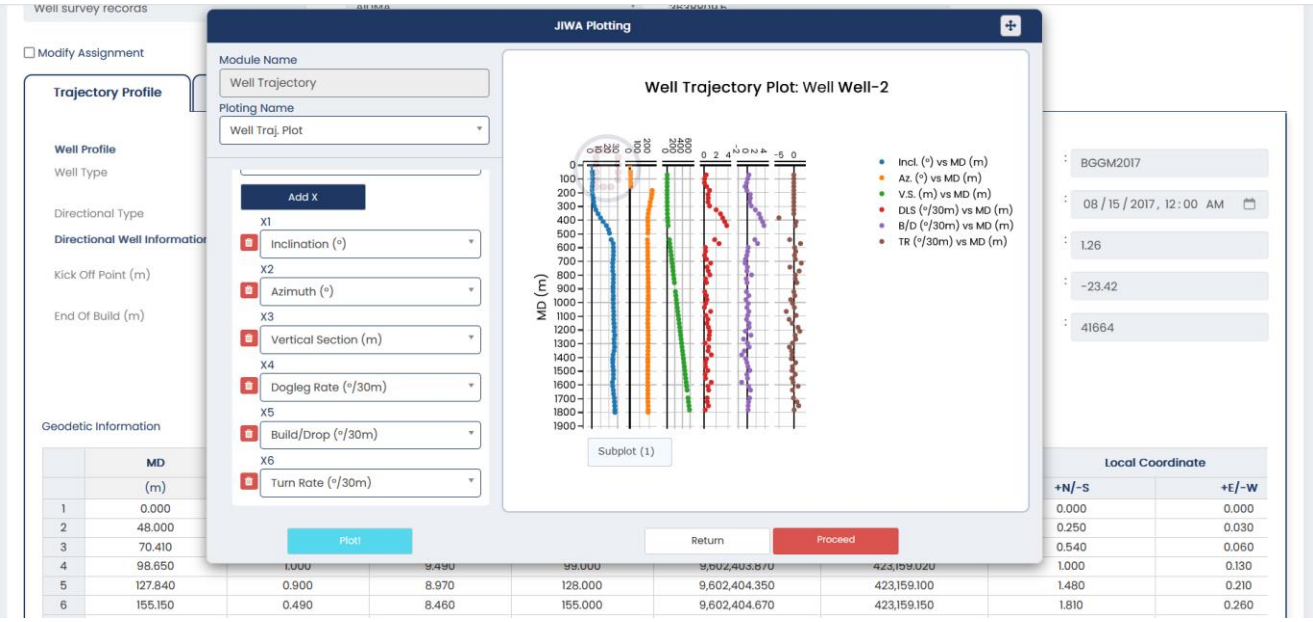

Figure 14: A screenshot of the pop-up feature in the Well Trajectory module for seamless QC of well survey information in the table during the data creation or modification process.

To support data analysis, technical calculations (for instance, discharge capability estimate and operational time breakdown, for reservoir engineering and drilling & workover module, respectively), data integration, data visualization, or a combination of them is provided within modules. In addition, an export data feature will also be implemented to ensure the flexibility of combining JIWA DBase with external processing applications. Samples of plotting features are displayed in **Figures 15 and 16.**

A data plotting dashboard builder is also provided in the application (**Figure 17).** This feature allows end users to integrate and visualize multiple charts of numerous datasets on a single screen. Compared to detailed show data and visualization of each module previously shown, this approach can provide decision-makers with a tool to swiftly visualize their most important parameters and harness insight. For instance, the subsurface team can design a dashboard consisting of production and injection well monitoring, chemistry sampling, downhole logging monitoring, tracer testing, and microearthquake events visualization to aid them in reservoir management.

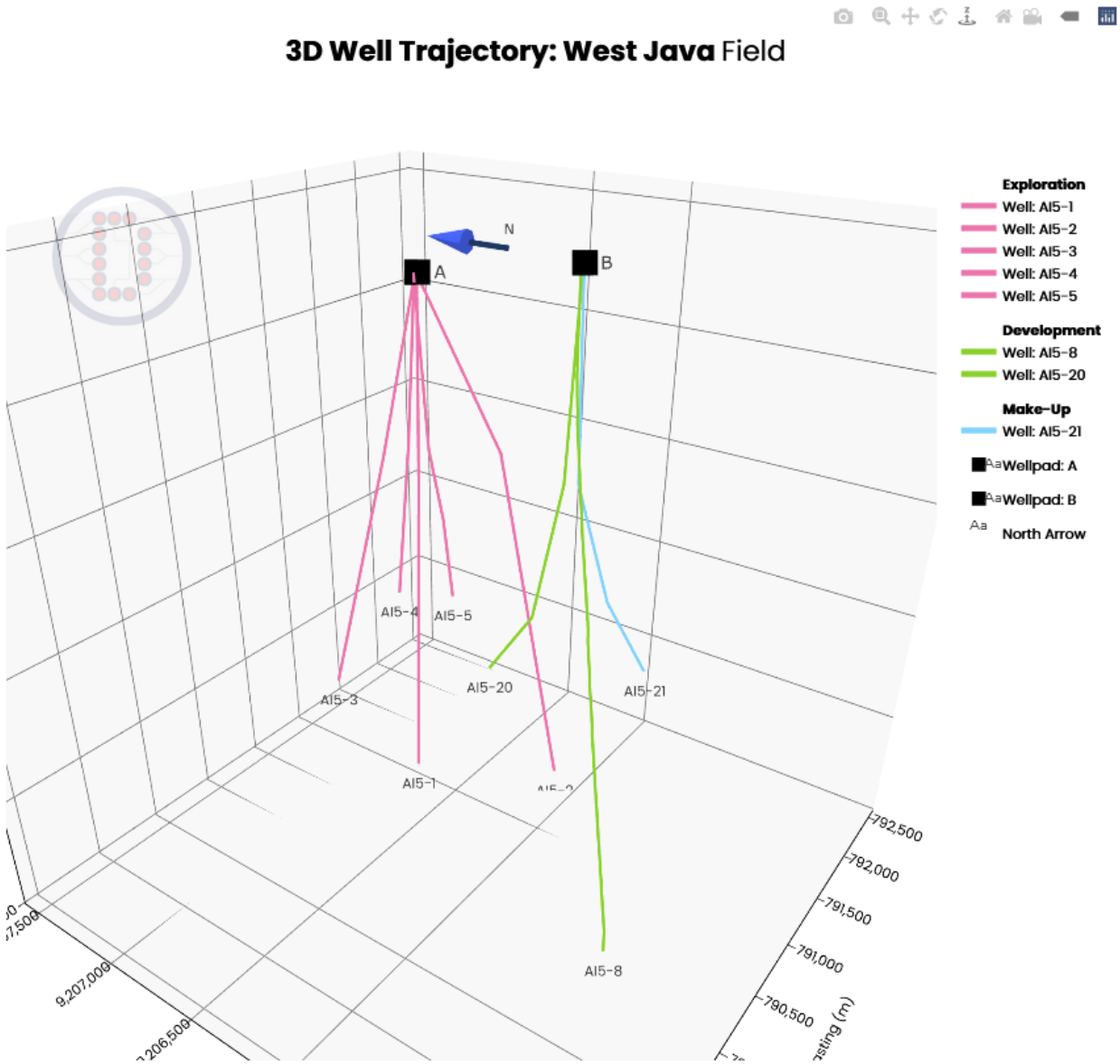

Figure 15: An example of well profile data integration and 3D visualization in field scale.

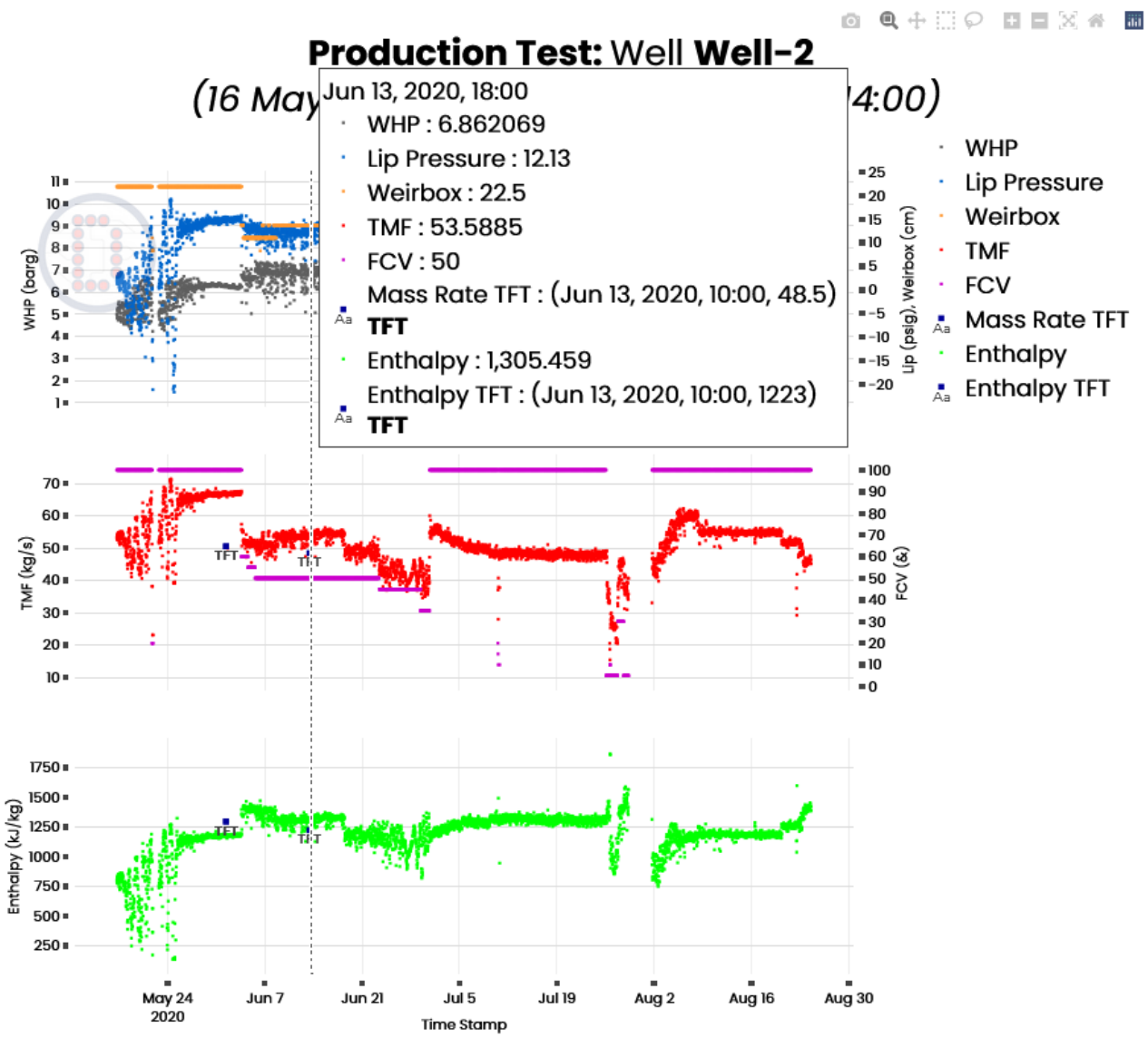

Figure 16: Sample of visualized production test data corrected with production tracer in a time series graph.

Figure 17: Visualization dashboard building.

2.5 Organization & End User Management

As a web-based application, the organization and respective members accessing JIWA DBase can be managed in a detailed manner. From divisions in the institution, roles and functions, to authority in DBase's modules can be customized however the organization's work process. This configuration makes certain of data integrity, accessibility, and confidentiality. Some screenshots of this feature are displayed in **Figures 18 to 20.**

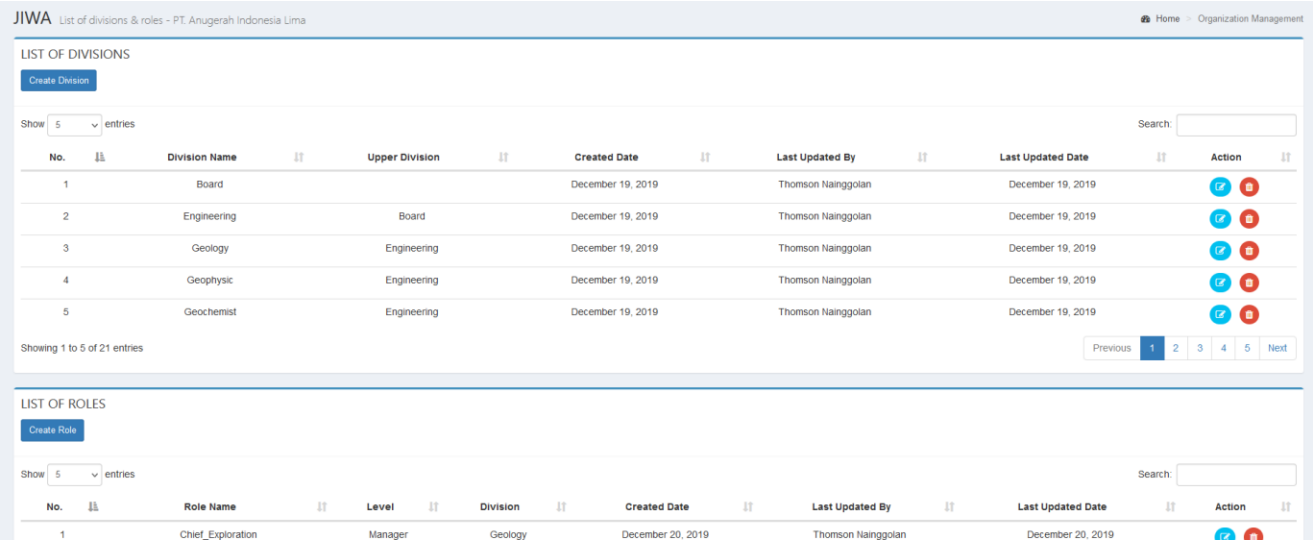

Figure 18: Divisions and roles.

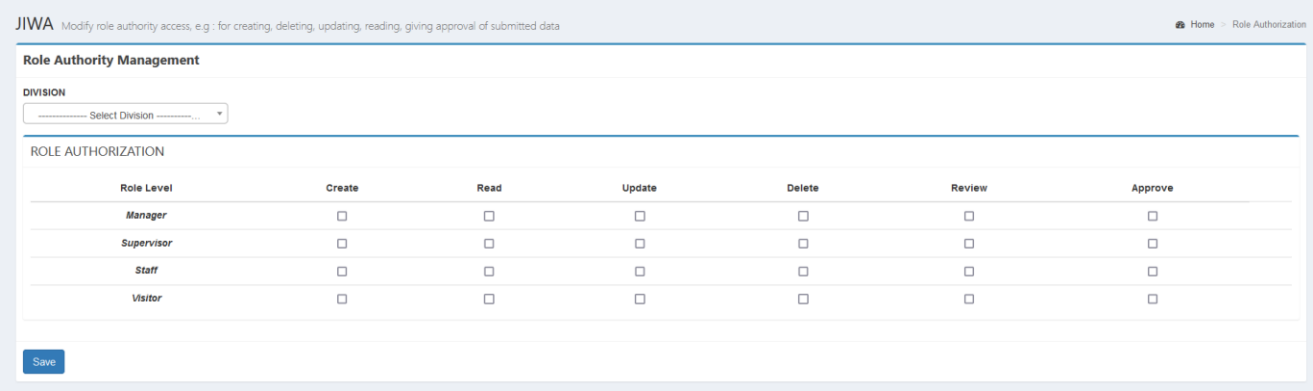

Figure 19: Personnel authority management.

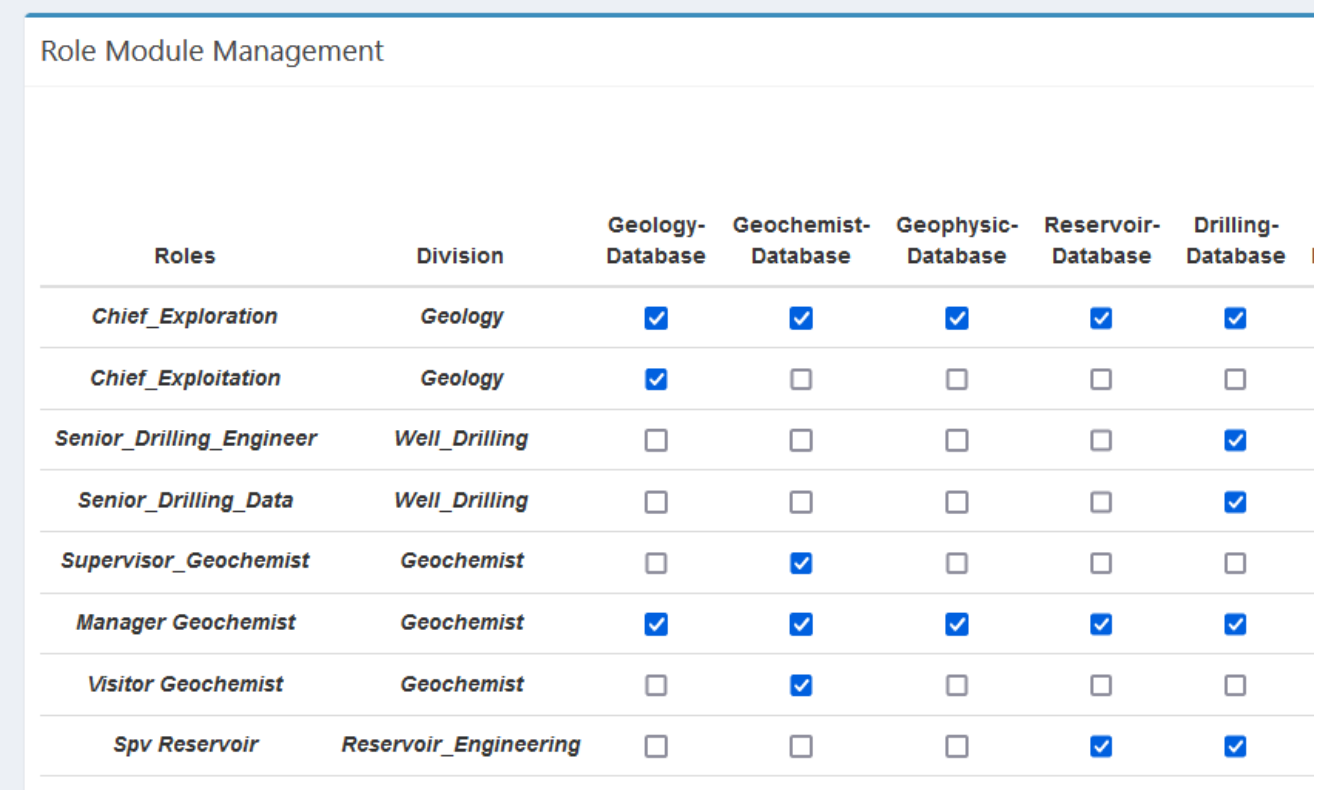

Figure 20: Role module management.

2. APPLYING JIWA DBASE FOR GEOTHERMAL PROJECTS

JIWA DBase provides a flexible and robust data platform to assist any form of geothermal entity, such as the geothermal power company, renewable energy directorate, geological survey agency, technical consultant, drilling & workover contractor, well testing service, and research institution in striving for excellence in geothermal projects since early exploration, resources assessment, to O&M. As part of JIWA Cloud Computing System mentioned earlier, JIWA DBase allows seamless connection with JIWA's probabilistic analysis, modeling, and machine learning applications (Sidqi et al., 2021, Prabata et al., 2021, Harry et al., 2021; Akhmad et al., 2021, Tandipanga et al., 2021) to maximize the value of data for decision-making (**Figure 21**).

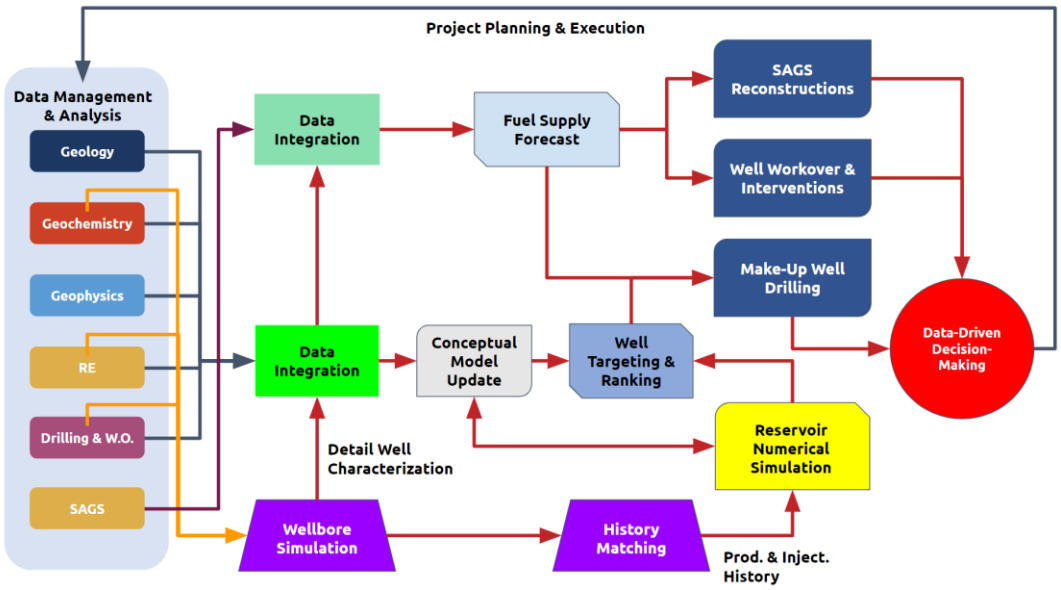

Figure 21:Maintaining fieldsteam supply with JIWA System web applications.

4. CONCLUSION

The web-based database application JIWA DBase has been developed by AILIMA in a cloud system to promote agile collaboration between scientists, engineers, and related stakeholders in data management and analysis of end-to-end geothermal projects under one digital platform. The data model, system architecture, and detailed specification of each DBase module have been thoughtfully designed under the collaboration of respective experts in geothermal and information technology to allow the aforementioned benefits for end users.

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