DATA SHEET

HALLIBURTON

GEOSCIENCES SUITE | A DECISIONSPACE® 365 SOLUTION

Assisted Lithology Interpretation

Accelerate workflows and help reduce interpreter bias by using a supervised machine learning approach that leverages trained models for consistent data interpretation across your enterprise.

FEATURES

- Leverage customer trained lithological models
- Suite of pre-trained models available
- Model Manager
- Automatic Model Selection
- Manual Model Selection
- Curve Alias Mapping
- In-built data validation process
- Lithological prediction
- Uncertainty measures
- Run History
- Lithology Dictionary Conversion
- Built-in datastore connection

BENEFITS

- Standardizes interpretation through consistent lithology predictions, using trained models
- Outputs quantifiable measures of uncertainty
- Accelerates and simplifies workflows
- Can lower subsurface risk, through multi-scenario testing and greater understanding of uncertainty
- Seamlessly integrate interpretation data

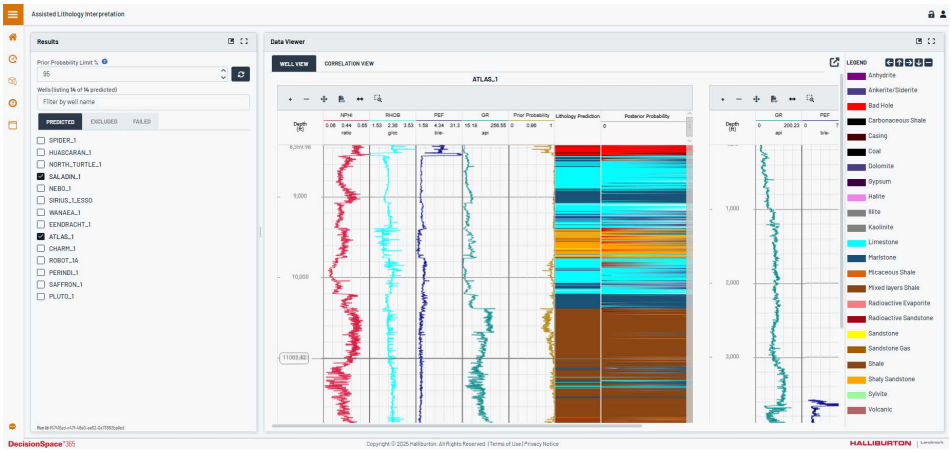

Figure 1: The Supervised Machine learning pipeline used by DecisionSpace® 365 Assisted Lithology Interpretation incorporates domain expertise with the latest data science techniques.

Overview

Manually interpreting hundreds of wells can be time-consuming and can introduce inconsistencies through human bias of the interpreter. Now you can speed up the process and obtain consistent, lithological prediction across your enterprise with the help of a supervised machine learning (ML) technique offered by Assisted Lithology Interpretation (**Figure 1**). This innovative ML technology predicts lithology, alongside measures of uncertainty, from wireline and logging-while-drilling (LWD) responses according to trained models that can run hundreds of interpretations, via scalable cloud computing, in minutes rather than days.

Benefits

Assisted Lithology Interpretation delivers integrated interpretation by using a supervised ML technique that predicts lithology from wireline or LWD log data responses according to trained models (**Figure 2**), and helps provide the following benefits:

Rapid, consistent data interpretation

Reduce interpreter bias by using a standardized process leveraging trained models for consistent data interpretation across your enterprise.

Preserve and apply expert knowledge to datasets

Models have been trained by experts and can be applied by anyone, anywhere. Custom models can be trained using proprietary data and interpretations, preserving the knowledge and expertise of your petrophysicists and geoscientists.

Accelerate and simplify subsurface workflows

Leveraging ML technology and cloud computing can save time and requires fewer resources, allowing you to focus on high-value decision making. Process thousands of wells in minutes for effective evaluation operations, improved efficiency, and reduced costs.

Understand subsurface uncertainty

Rapidly test multiple scenarios on the same data to aid lithology prediction and reduce subsurface uncertainty. Capture and track uncertainty of lithology predictions throughout the interpretation workflow on a well-by-well basis with numerical measures of confidence down each well section.

Seamlessly integrate interpretation data

Enhance collaboration with immediate shared access to consistent lithology interpretations The open platform helps you to easily connect to, and integrate data from, industry-standard databases, such as OpenWorks® software.

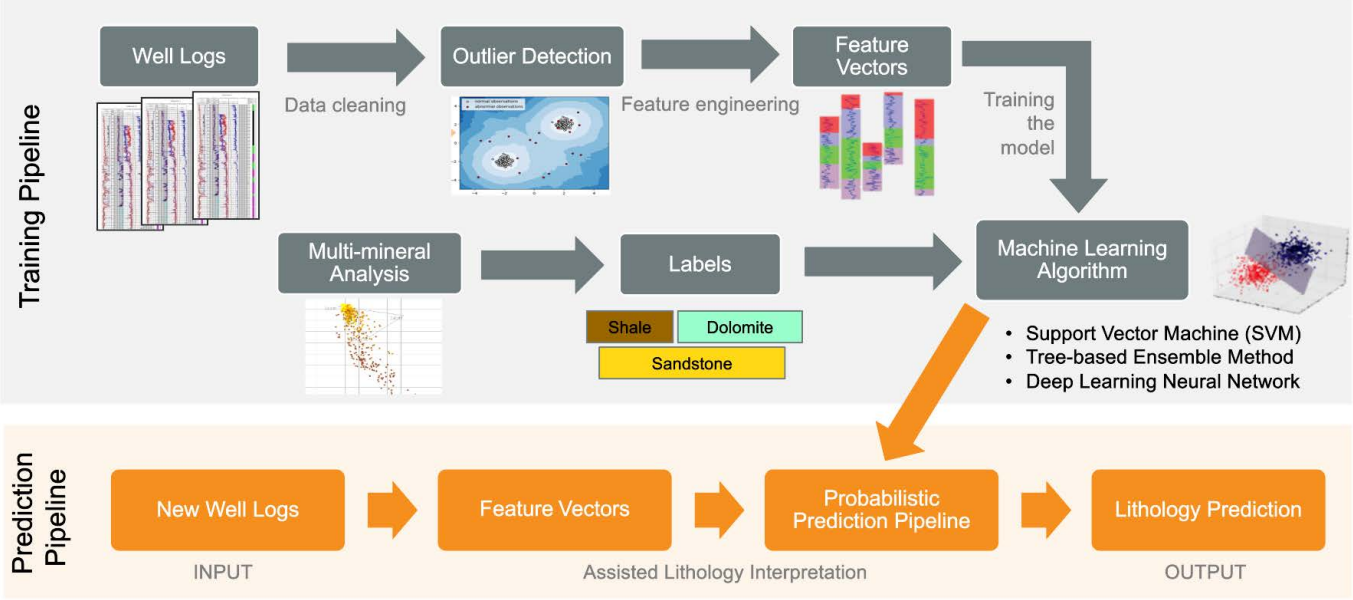

Figure 2: Predicted lithology and uncertainty outputs, for an example well, that have been generated by one of the in-built pre-trained ML models within DecisionSpace® 365 Assisted Lithology Interpretation.

Features

The benefits of Assisted Lithology Interpretation are realized through a series of technical features, including:

Trained lithological models

Trained lithological models, from a variety of geological provinces built by a team of petrophysicists and data scientists, are provided by default within Assisted Lithology Interpretation. These can allow rapid and consistent lithology interpretations at scale. The models have been trained using supervised machine learning (ML) techniques from wireline or logging-while-drilling (LWD) data. Algorithms are encoded with intelligence to help recognize combined features in well log curves and quantitatively assess the likelihood that these represent a particular lithology, based on previous examples seen by the system. Custom models using proprietary data and interpretations can also be used.

Custom model building and compatibility via DS365.ai

Custom models using proprietary data and interpretations can be trained using a user-friendly workbench in DS365.ai , a cloud-native, open architecture platform with MLOps capabilities, to easily and rapidly train models. These models can be trained by users who have subscribed to the ALI Training Pipeline from the DS365.ai Marketplace (**Figure 3**). These models can then be used within Assisted Lithology Interpretation to make lithological predictions on unseen data. Custom models can be selected from the Manual Model Selection mode drop-down, following model configuration in the Model Manager.

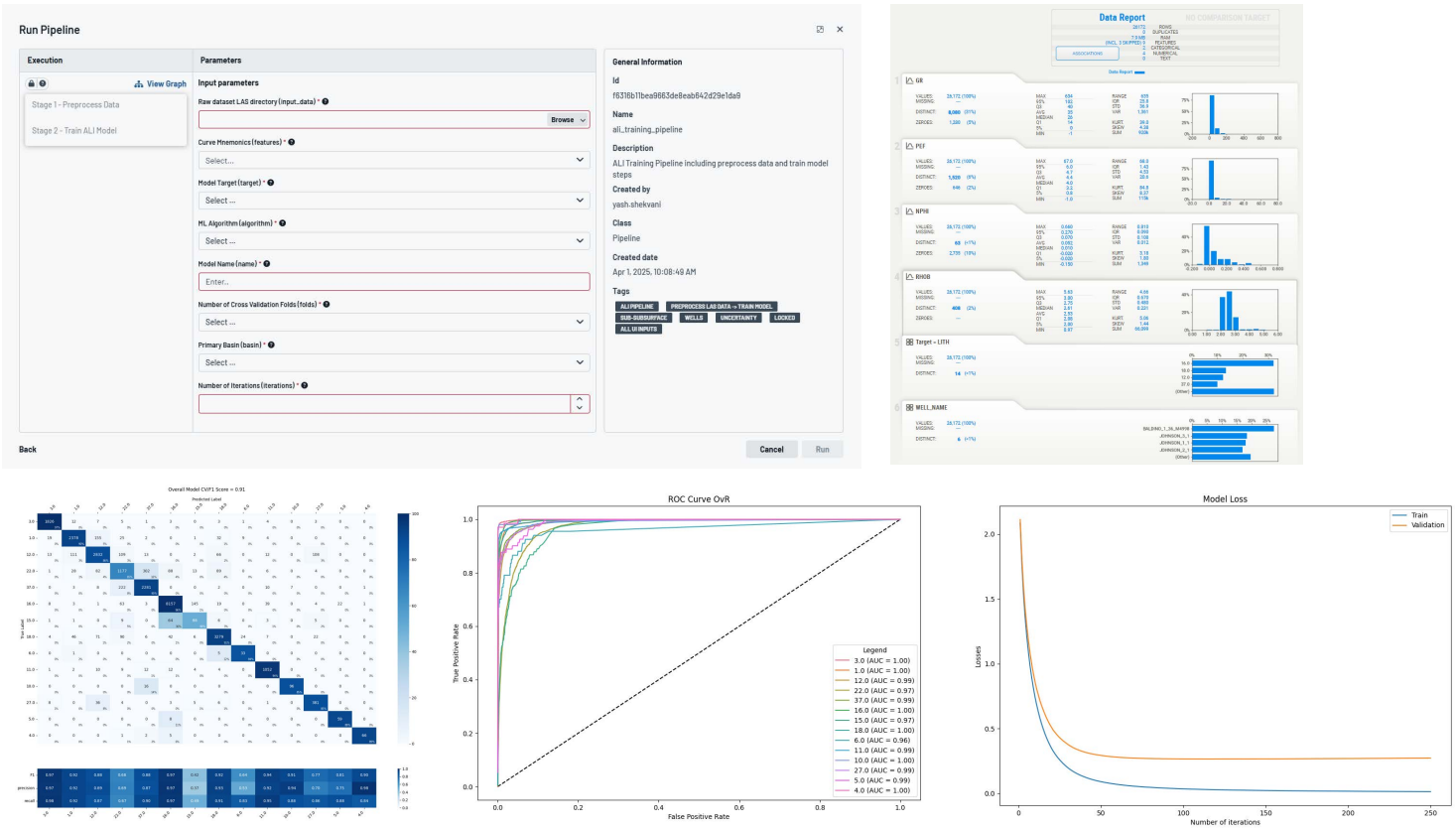

Figure 3: Custom model building pipeline in DS365.ai for training lithological models that can be used within Assisted Lithology Interpretation.

Model manager

The Model Manager provides details of models available to a user, including those trained in DS365.ai (**Figure 4**). The Model Manager also offers the ability for users to configure custom models to determine properties such as how the predicted lithologies will be displayed in the Data Viewer (**Figure 5**).

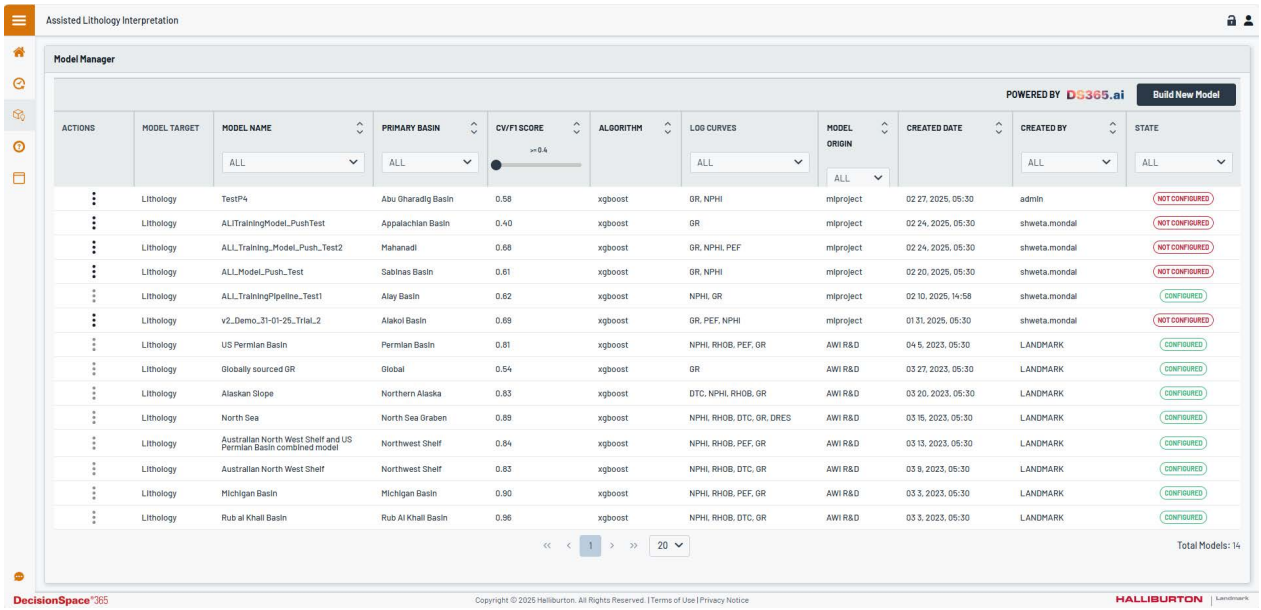

Figure 4: The Model Manager page in DecisionSpace® 365 Assisted Lithology Interpretation shows details of all the models available to a user.

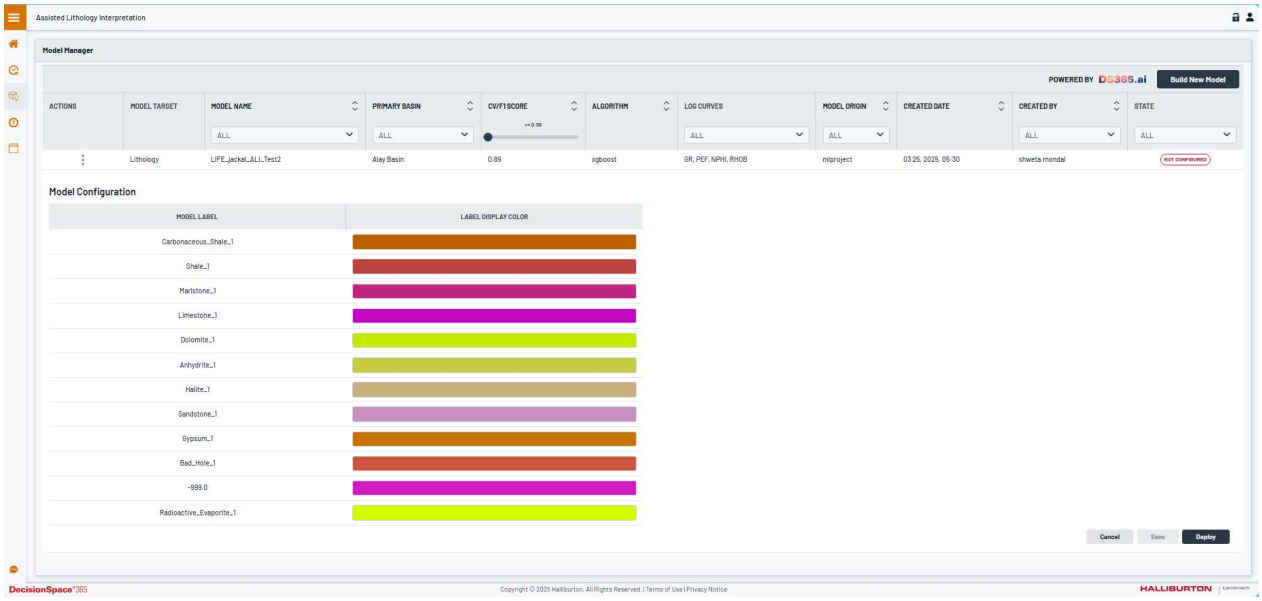

Figure 5: The Model Manager page in DecisionSpace® 365 Assisted Lithology Interpretation can configure the models ahead of use.

Manual model selection

The Manual Model Selection mode allows users to manually select a model from the model archive (currently, 64 models reside in the archive for the purposes of Automatic Model Selection) and use it for making a prediction on unseen data. Currently, users can select from 8 pre-trained models provided by Landmark, plus any custom models that they have access to.

Automatic model selection

The Automatic Model Selection mode permits the application to select the most appropriate model from the model archive (currently, 64 models reside in the archive for the purposes of Automatic Model Selection), based on the prior probability and the log curves present at any given well interval. This patented mode can enable a lithological prediction to be completed for the full-depth of each well, irrespective of the log combinations present throughout the well, as long as a suitable model is available. The minimum requirement for lithology to be predicted in any well interval, is the presence of a GR log.

Curve alias mapping

The Curve Alias Mapping tool offers functionality to map the curve mnemonics present in the selected unseen data to the mnemonics present in the trained lithological models used by the application. The tool can be used to map mnemonics sourced from either OpenWorks® software or zip upload. The user is presented with the state of their curve mappings and has the option to edit the in-app curve dictionary, if the mnemonics they require do not exist within the dictionary. Where multiple mnemonics are available for the same curve, there is the option to select a preferred mnemonic.

Data validation

Ahead of commencing the lithological prediction process, analysis of the well data input and its suitability for the prediction process is achieved through in-built validation steps that expose specific deficiencies, if they exist, for each well (**Figure 6)**. Validation tests include, but are not limited to, looking for wireline presence, valid wireline units and valid depth ranges.

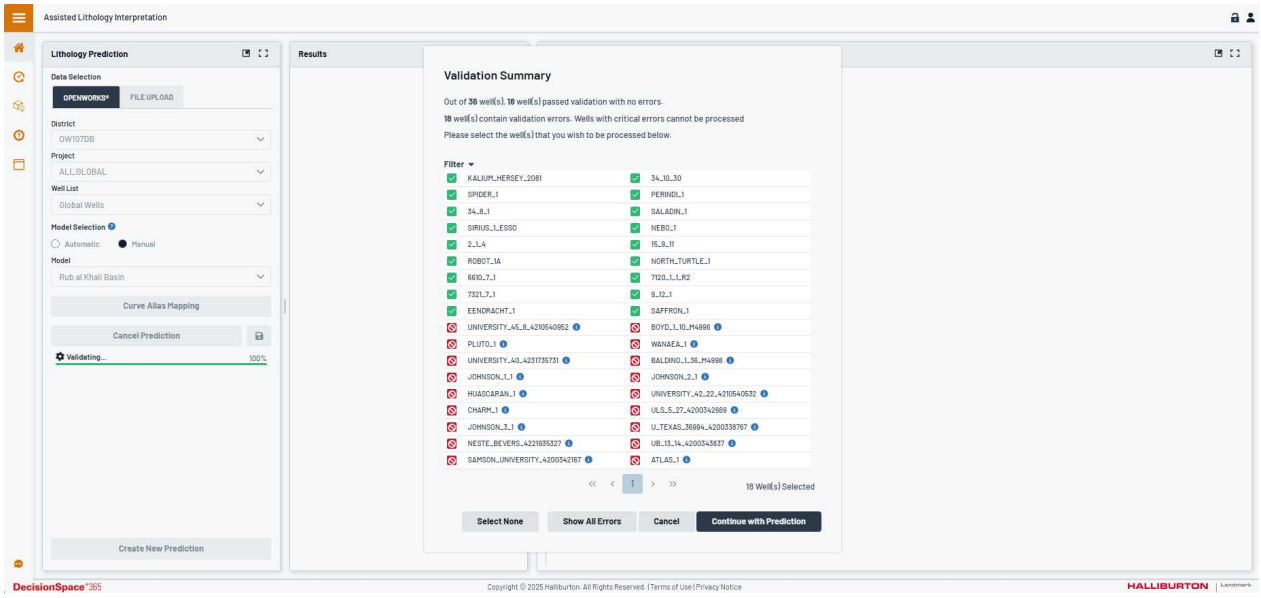

Figure 6: Validation results are shown in the Validation Summary using a traffic light system to allow easy identification of any data quality issues ahead of input into the ML pipeline.

Lithological prediction

The lithological prediction process uses trained lithology models to interpret unseen wells, following Data Validation. Wells that have passed the required Data Validation checks and have been selected for prediction will then be processed. Once the lithological prediction process is complete for each well, a predicted lithology is provided, alongside confidence in that prediction, through prior and posterior probability calculations. Log features are classified into expected lithology categories, using the trained predictive model, and the resulting classification undergoes post-processing. This workflow delivers rapid, detailed, and consistent lithology predictions for a well in a matter of seconds.

Prior probability

Prior probability calculations measure the similarity between the training data and the test data. When plotted together with the lithology prediction down a well, the prior probability score highlights those predictions that are likely to be of lower confidence, allowing interpreters to focus rapidly on areas of the well where further analysis may be required. The application provides the ability to set a Prior Probability cut off limit, so interpreters only see the most confident predictions.

Posterior probability

Many machine learning algorithms are probabilistic classifiers that are able to predict the likelihood that input data belongs to a given class. These posterior probability distributions can be output to provide additional information for geologists when validating or refining the initial prediction results. This measure appears as cumulative likelihood of a particular lithology.

Run history

The Run History pages offers the ability to track and access previous runs to monitor historical work and retrieve stored output. Previous runs results can be viewed, saved back to OpenWorks® software or downloaded as .csv files.

Lithology dictionary conversion

Ahead of saving predictions to OpenWorks® software, predicted lithologies can be saved using the default lithology dictionary or they can be converted to custom names using a custom dictionary using the Lithology Dictionary Conversion save option. The OpenWorks® lithoclass symbols can also be defined using this feature to determine how the predicted lithologies are displayed in other applications such as DecisionSpace® Geosciences.

OpenWorks® software connection

The system seamlessly connects with, and saves, lithological data to OpenWorks® software, so that lithological predictions can be easily incorporated into your subsurface workflow.

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