ENDEEPER®

Guide to Value Creation from Geological Data in Oil Exploration

Technology is a strong ally for the acquisition of geological data. With the huge demand for fast and reliable results, changes and updates in the tools used by geologists are necessary. Investing in the generation of relevant data for aiding the interpretation and decision making during the exploration for oil reservoirs is critical for reducing the costs of these activities.

In this guide, you will understand the importance of the analysis of cores, outcrops and petrographic thin sections for geological studies applied to reservoir exploration, and you will learn why software are essential tools for digital geology.

Importance of the core/outcrop descriptions for geological studies

The consolidated rocks that you describe in cores or outcrops are product of transport and depositional processes that are recorded in the form of sedimentary structures and textures. To describe cores/outcrops is understand the processes of formation of the rocks. The more detailed and complete the descriptions, the more precise will be the interpretation of the source areas, transportation processes and depositional environment.

The description is important for the knowledge acquisition and the immediate visual perception of the rock package. With a good description, it is possible to interpret the succession (facies distribution and sedimentary cycles) of the sediments deposition events and to perform correlations with equivalent beds from other areas, in search of understanding the stratigraphic framework of the basin.

This descriptive and analytical work can be better performed with the use of specialized software, such as Strataledge, which helps the geologists in their routine data acquisition tasks. In the section below, we explore the advantages of using software in relation to paper for analyzing cores and outcrops.

Efficient analysis of cores and outcrops with Strataledge

Rock outcrops (Fig. 1) are surface expression of the internal and external dynamics of the Earth.

Figure 1. Outcrop of stratified sedimentary rocks. Source: link

The geologist usually uses a booklet or clipboard to draw a stratigraphic columnar log (Fig. 2). Information such as location, reference coordinates, date and time are recorded. Information relevant to the field work are also normally recorded, such as stratigraphic units, age, and structural observations. The work scale to be used must be selected according to the total size of the outcrop and the desired detail.

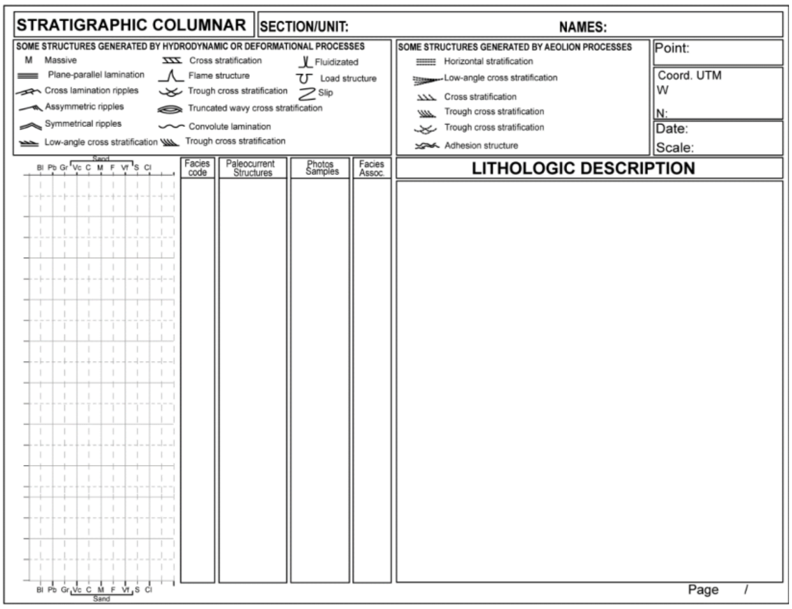

Figure 2. Example of stratigraphic log sheet.

Core description is performed in the laboratory on sequential log description sheets. Cores collected during drilling are placed in properly identified boxes following the stratigraphic stacking order (Fig. 3).

Figure 3. Core boxes.

The description is usually made from base to top, which reflects the order of deposition. The geologists describe the following aspects:

1) Rock types
2) Minerals and other constituents (e.g., fossils)

3) Textures
4) Structures indicating processes of deposition, deformation or other alterations
5) Thickness layers and types of contacts among them.

The geologists can interpret depositional facies, identifying them through a lithofacies code. After all this information has been recorded, the rock packages are stacked and the vertical succession assembled. From this, the geologist may ask the following questions:

1) Is there a stacking pattern of facies?
2) The pattern repeats itself? Is there cyclicity?
3) Are there interruptions or abrupt changes in the sedimentation process?

These questions define boundary surfaces that delimit facies associations. Each association of facies presents a distinct genetic meaning, allowing the determination of a depositional model.

If samples or fossils are collected, their exact location must be noted. Also, photos are recorded for inclusion in the description and in reports.

All the data is conventionally recorded on paper by the geologists and digitalized after description. This process requires a considerable amount of time. Fortunately, there are faster ways of generating data from core and outcrops.

Through Strataledge® (Fig. 4), the descriptions are performed directly in digital format, reducing drastically the acquisition time, as well as in a clear and organized way.

The system allows the detailed and systematic description of cores and sediments, providing quick access to all the required features for data acquisition and recording of sequential data.

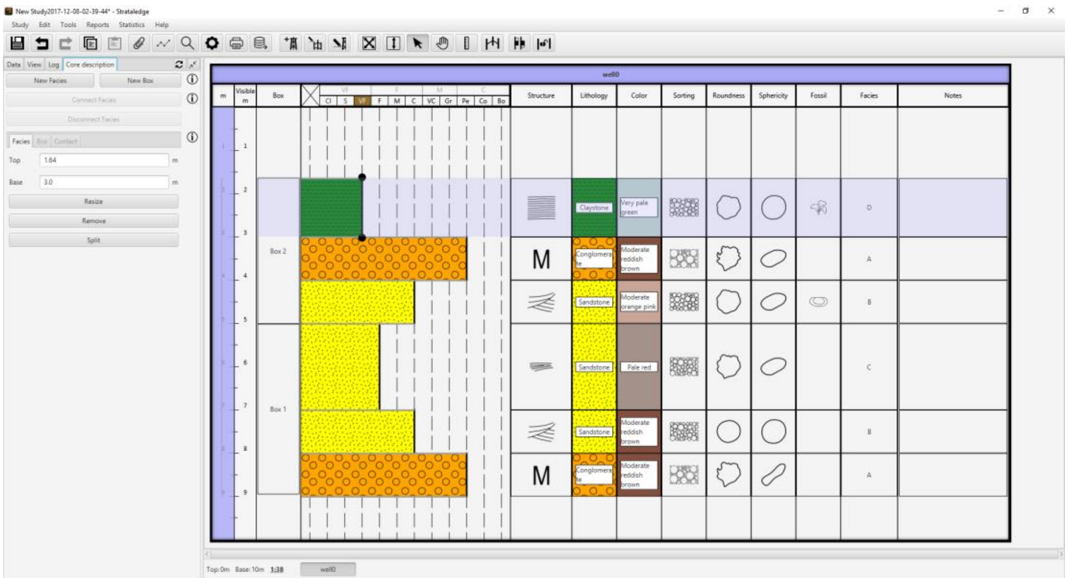

Figure 4. Strataledge Screenshot – Digital Core Data.

Strataledge® has a broad taxonomy of lithological units, sedimentary and deformation structures and petrological characteristics. All of this information, necessary to obtain a complete core description, has standardized nomenclature and is efficiently recorded under a clean and organized interface.

The use of Strataledge® optimizes and considerably reduces the time normally spent during description work, as well as allows reliable and quality records that will be compatible with other descriptions made by other professionals.

Descriptions recorded through Strataledge® are easily exported in a wide variety of formats, such as LAS, CSV and SVG (Scalable Vector Graphics).

In addition to the macroscopic description of cores and outcrops, petrography is also used to characterize rocks on a microscopic scale. See below…

The importance of petrographic characterization for geological studies

Petrography is a key tool for understanding the origin and evolution of rocks. Through the petrographic analysis of thin section, it is possible to determine the processes of sediments deposition and their transformation into rocks during diagenesis, including the precipitation of authigenic minerals, compaction, dissolution, replacement, and other mineralogical transformations. Their description and interpretation are important for the characterization of the quality of rocks as petroleum reservoirs.

Software for enhancing, systematizing and facilitating the petrographic description are important tools for the exploration and production. Know the Petroledge® system in the next section.

Description of petrographic thin sections with Petroledge® Software

Systematic petrographic analysis is performed using polarized light microscopes as shown in Figure 5. Quantitative analysis can be performed with use of a mechanical device (chariot) that allows moving the thin section along specific step over the microscope rotating table, recording the composition at each step, or modal point-counting (Fig. 5).

The modal analysis is performed according to transverses perpendicular to the lamination or orientation of the grains. This step is selected according the rock texture. At each step, the constituent located under the crosslines of the microscope eyepiece is recorded. This procedure is usually repeated to a total of 300 counted points to ensure a statistically reliable quantification.

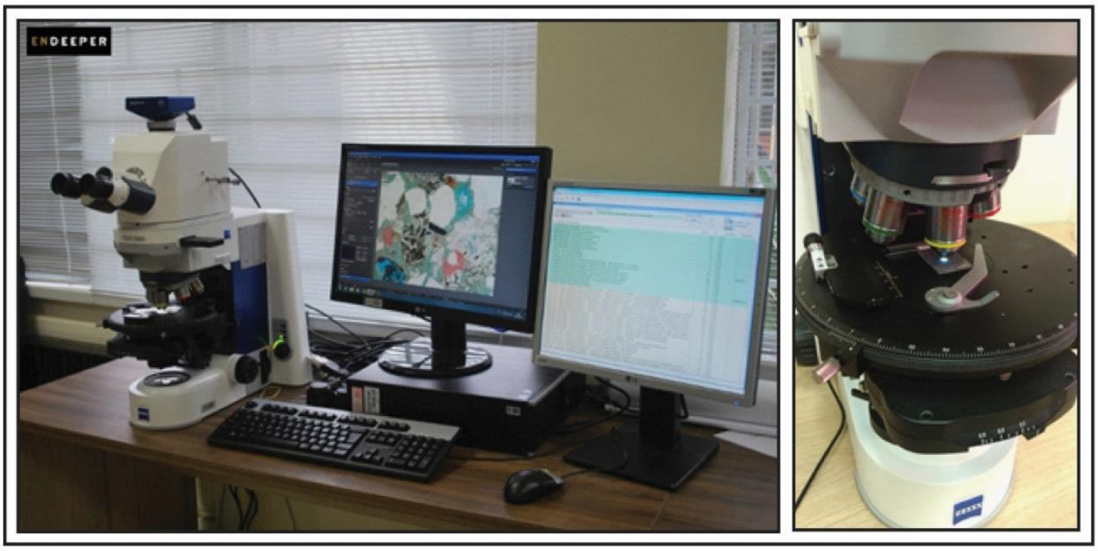

Figure 5. Workstation for digital systematic petrography, with a petrographic polarized light microscope and mechanical chariot coupled (left).

Currently, the conventional mechanical devices for point-counting can be replaced for Stageledge®, a high-precision digital stage (Fig. 6). Compatible with the main polarized microscope models available on the market, this automatic stage moves the thin section with precision recording the composition at each point. A compositional map can be generated, and the percentages of the constituents are automatically calculated. The recorded points can be consulted at any time, simply clicking on the desired point so that stage is automatically moves back to the exact location of the chosen point.

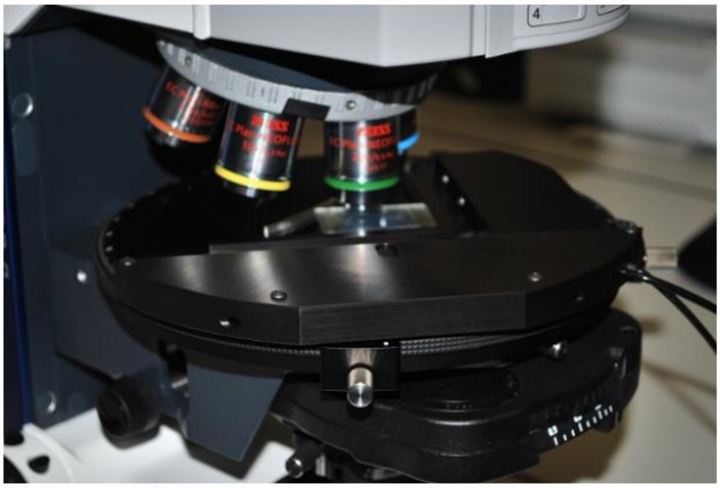

Figure 6. Digital Point Counter - Stageledge®.

The systematic description of thin sections is better performed with use of the Petroledge® system, including the description of texture, primary composition, diagenetic composition and sequence, pore types and classification.

When starting a petrographic analysis with Petroledge®, the identification window (Fig. 7) is used to insert well / outcrop name, depth, core and box numbers, basin name, stratigraphic unit, field name, country, state, and other location data. In addition, name of the petrographer, institution, purpose of the description and a brief summary of the thin section description, addressing the main aspects observed during petrography. This summary is important to facilitate future consultations.

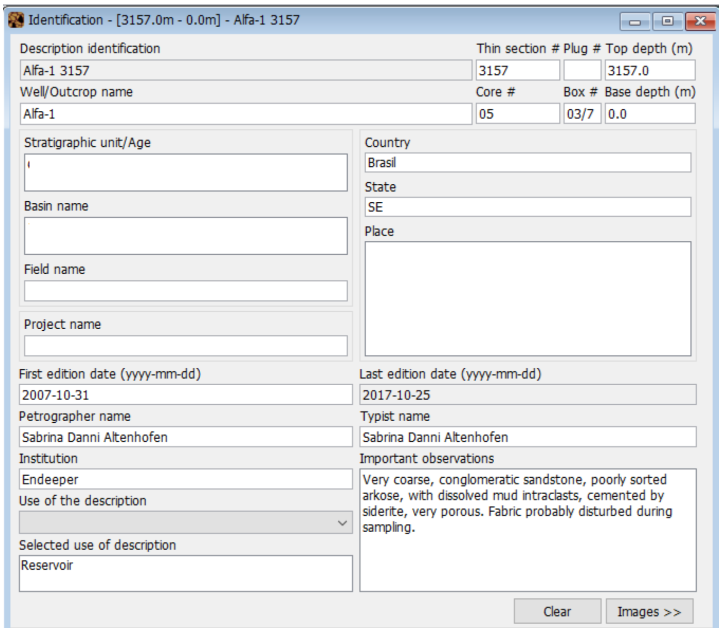

Figure 7. Thin section identification screen of Petroledge®.

Petrographic description with the Petroledge® software is performed in a logical order and follows taxonomy. This allows the program to recognize and process the recorded data and automatically generate compositional and textural classifications, recognize tectonic provenance modes and interpret diagenetic environments.

In Petroledge® microscopic description screen (Fig. 8), it is possible to describe textural, fabric and structural aspects.

The main aspects that can be recorded include a wide range of depositional, deformation and diagenetic structures, grain size and shape, orientation, support and other fabric aspects.

The types and proportion of intergranular contacts are used to calculate the packing index, relative to the degree of compaction.

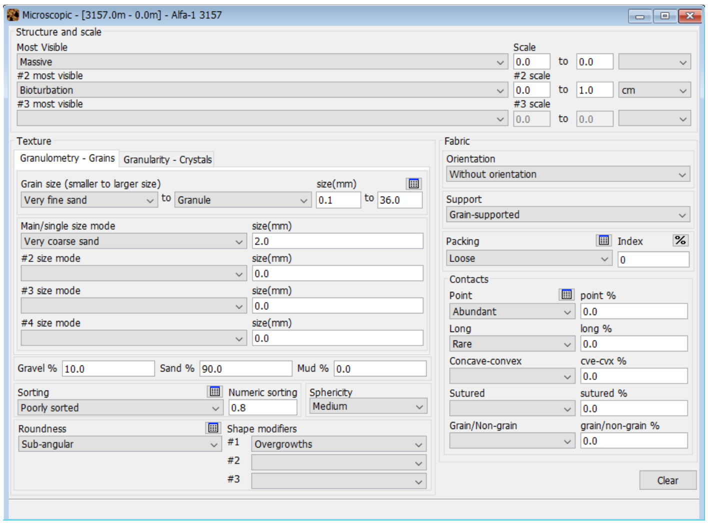

Figure 8. Microscopic structure, texture and fabric description screen in Petroledge®.

The next description step is performed in the compositional description window (Fig. 9). The description and quantification of primary and diagenetic constituents and pore types is carried out in an interface that allows recording in detail important aspects for reservoir quality characterization. Primary constituents are described for types, locations, and modifications. For diagenetic constituents, a detailed description allows recording habit, location, and paragenetic relations with other constituents or with porosity.

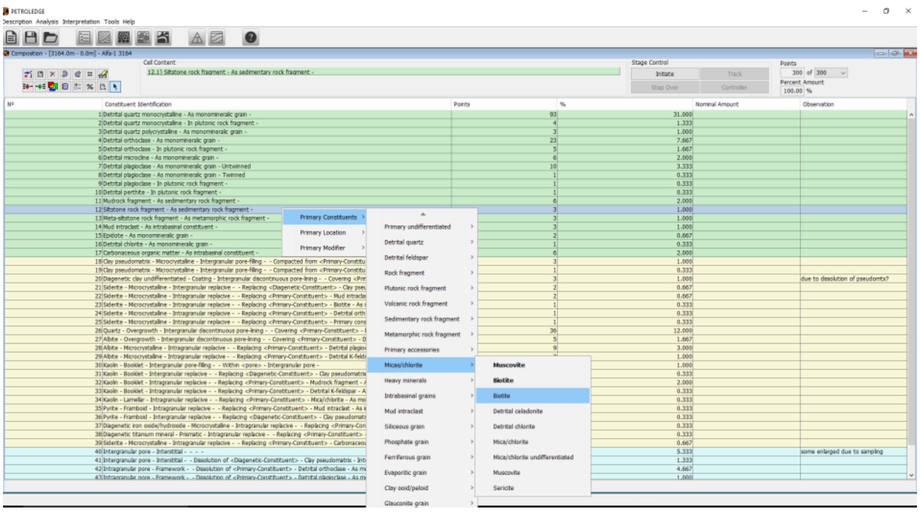

Figure 9. Example of the compositional description screen in Petroledge®, showing the degree of information detail allowed by the system.

This characterization is necessary in order to define the control of diagenetic constituents on the porosity and permeability of the reservoirs. Pore types are described relative to location and modifying processes, paragenetic relations, constituent types and location.

With proper quantitative description, the rocks can be automatically classified (Fig. 10) in a series of systems, including Folk (1968) and McBride (1982), for siliciclastic rocks, Dunham, Embry and Klovan (1962), Gabrau, Brankamp, Powers and Folk (1958) and Wright (1992), for carbonate rocks. It is also possible to define the tectonic provenance mode of the sediments according Dickinson (1985).

The automatic classification of groups of thin sections can be easily performed (Fig. 10).

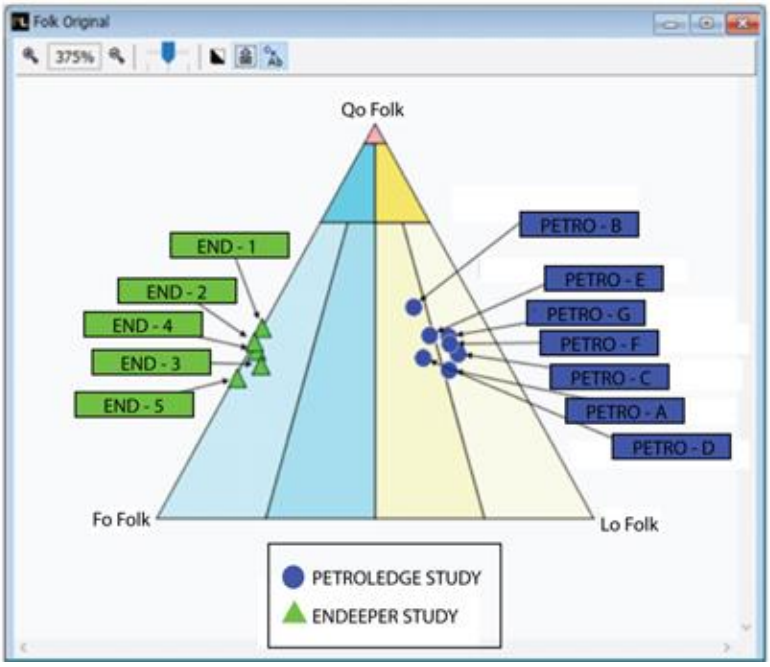

Figure 10. Example of thin section groups of classification in Petroledge.

Importance of systematic photomicrographic record for geological studies

Photomicrographic documentation is important to record the main compositional, textural, and structural features of the analyzed rocks.

The photomicrographs illustrate and support interpretation and data integration. Acquisition is performed through digital cameras attached to the microscopes.

A systematic digital catalog of photomicrographs is of great value for geological studies. See the case of RockViewer®.

RockViewer® system for photomicrograph organization and support to petrographic analysis

Data organization is a key factor for exploration and production research. Through the use of the RockViewer® system, a photomicrographic database can be created, allowing future queries in a quick and easy way. In addition, this database acts as a support for petrographic features identification and characterization, aiding in the process of thin sections description.

With the RockViewer® image editor (Fig. 11) it is possible to record aspects of the photomicrographs that can be easily consulted. The user can highlight important features in the image with shapes like arrows, outlines, letters, among others. All features are recorded through the Petroledge® taxonomy, allowing easy recovery of specific features. Other information, such as thin section identification (name of basin, stratigraphic unit, etc.) can also be added. Additional observations can be also added as notes.

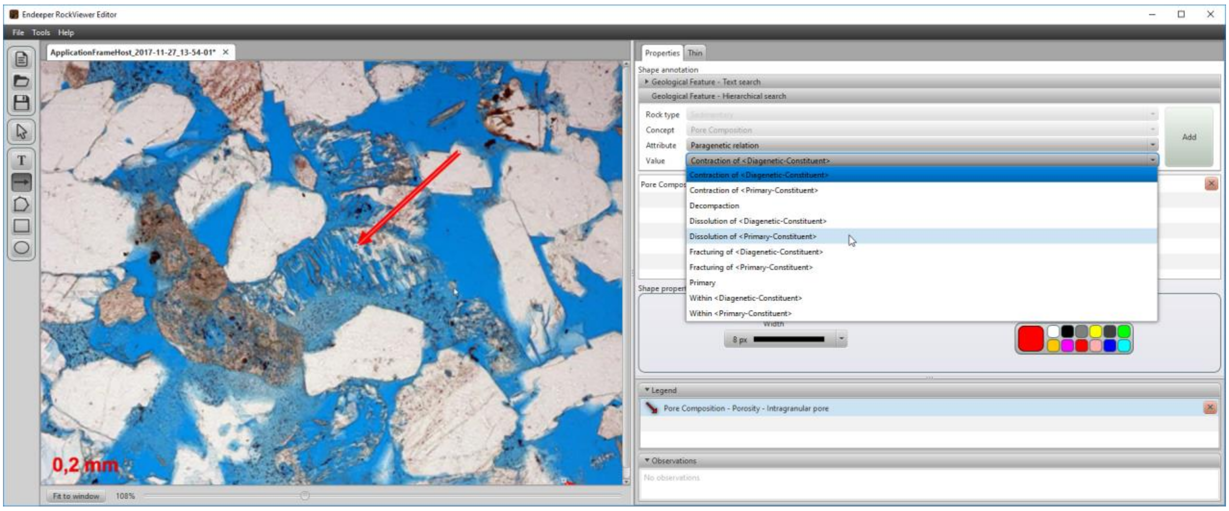

Figure 11. Image editor screen in RockViewer®.

All added images can be easily accessed (Fig. 12) and searched in a hierarchical order, where the terminology of geological features is available in four separate lists: rock type, concept, attribute and value. According to the items selected in each list, the concepts are automatically filtered.

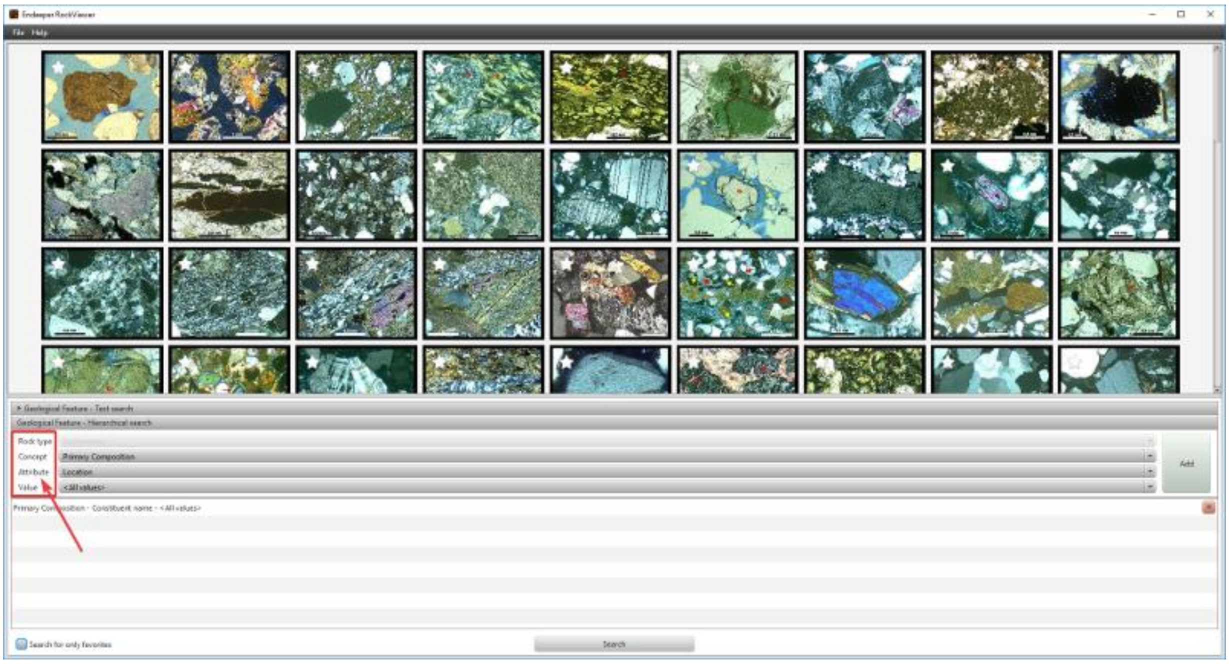

Figure 12. Search screen in the RockViewer® image catalog.

By selecting the images from the result set, all of the information described by the user will appear, highlighting the searched terms (Fig. 13).

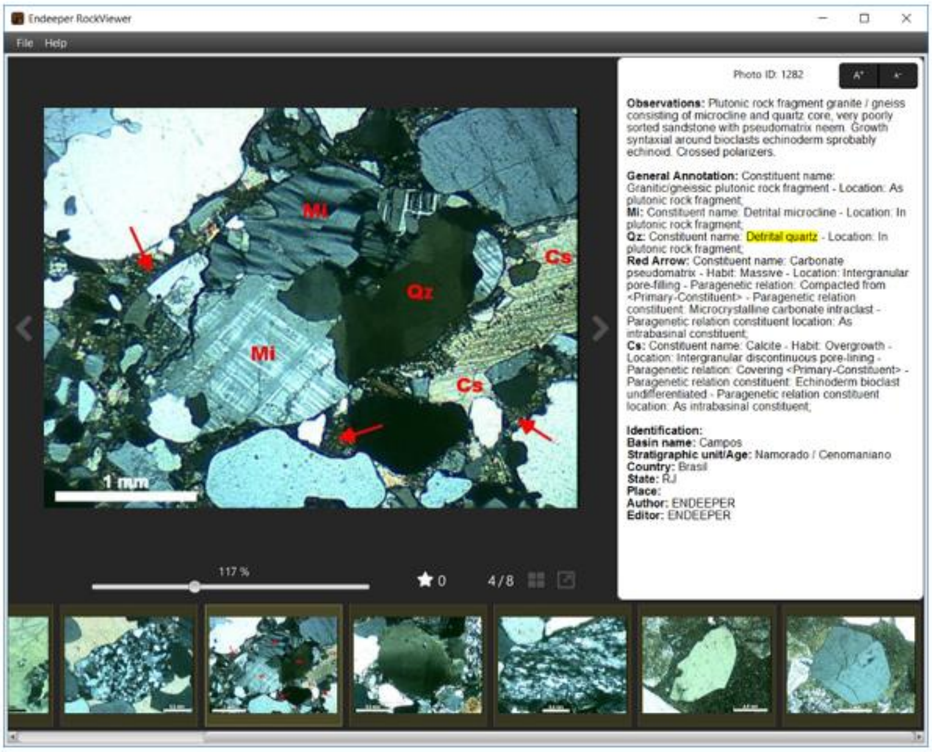

Figure 13. Detail of an annotated image created in RockViewer®.

Key for creating value from geological data: Integrated data analysis

The systematic acquisition and organization of digital data allow efficient integration and interpretation.

Strataledge® software allows the complete integration of cores and outcrops descriptions with or detail photos, petrographic descriptions, geophysical logs and other media (Fig. 14).

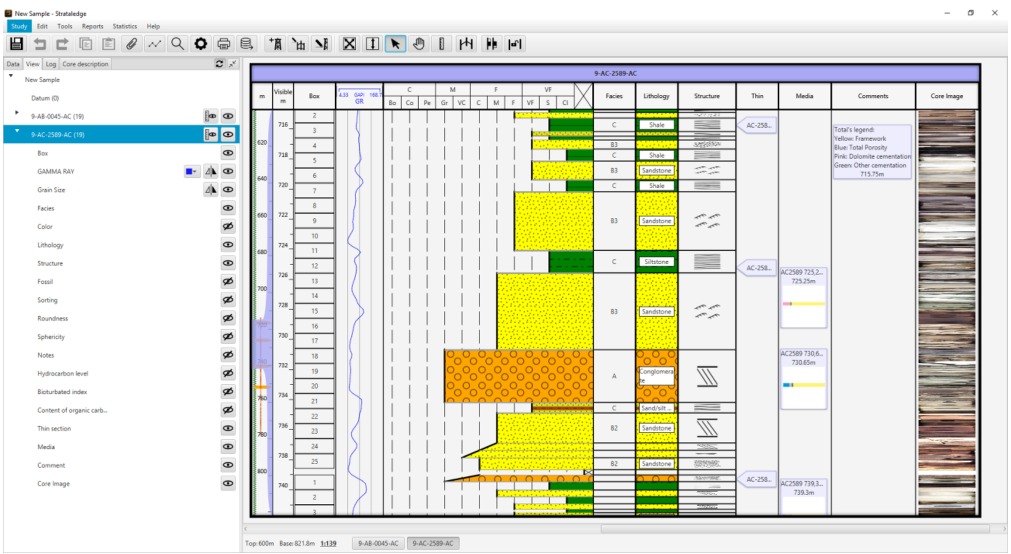

Figure 14. Example of a study performed in Strataledge® integrating core descriptions, geophysical logs, petrographic data and core photos.

A typical integration example involves the integration of petrographic data with geophysical logs of physical properties of the rocks, such as radioactivity, resistivity, density, acoustic wave propagation and others.

This continuous record generated by the geophysical logs allows to evaluate the petrophysical or geometric characteristics of the geological formations traversed by the well.

With the use of Strataledge®, geophysical profiles can be effectively integrated with core descriptions, photos and petrographic descriptions, facilitating the integrated data analysis.

Furthermore, it is possible to easily make stratigraphic correlations (Fig. 15), important for the determination of lateral rocks continuity, or the spatial equivalence between several lithologic units in subsurface. At this step, the importance of the integration of all the data previously generated is highlighted.

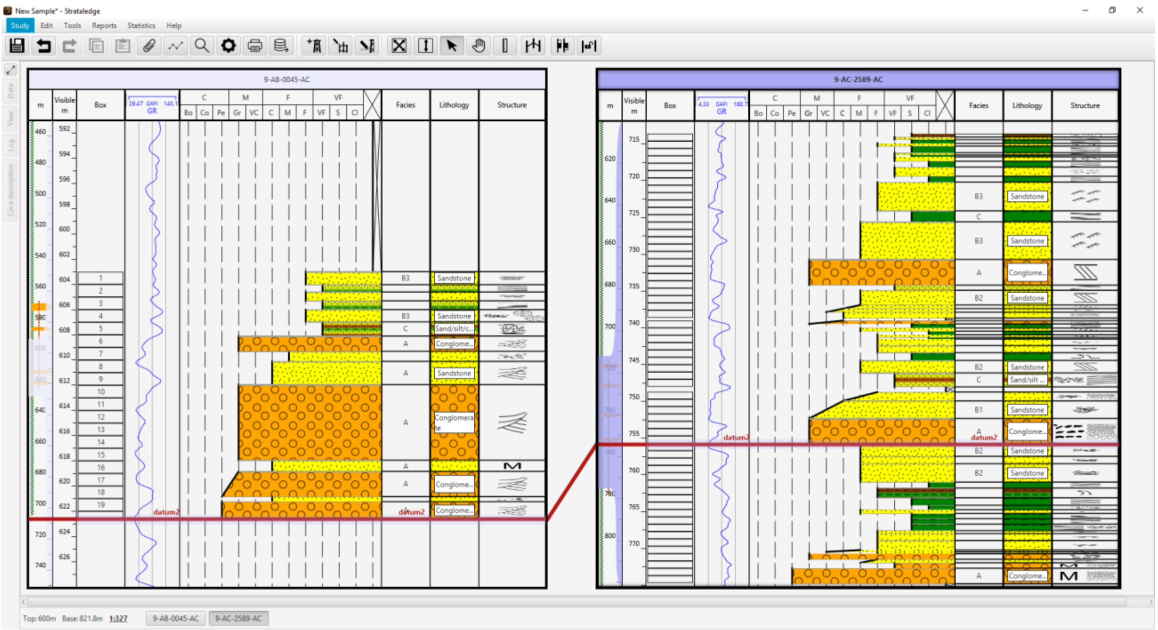

Figure 15. Example of datum created through the stratigraphic correlation in Strataledge®.

The search for hydrocarbon reservoirs during exploration should integrate organized geological information to aid decision making and reduce the risks associated with the exploratory activities.

All of the steps discussed in this guide be incorporated in the routine work of exploration, but this often take a long time due to the lack of integration between the tools. At each step, important data is generated, which must be integrated and interpreted. The modern exploration and reservoir professionals must rely on intelligent and innovative tools that, in addition to speeding up systematic description, and storing the data in an organized way, also aid the integration and interpretation.

Software developed for knowledge management such as Strataledge® and Petroledge® guide and standardize the description process through the combination of ontologies and taxonomies. This combination enables the construction of valuable geological databases, simplifies information quality control and enables the automatic extraction of knowledge using artificial intelligence. Simplifying tasks reduces data analysis time and ensures decreased exploration costs and risks.

Visit www.endeeper.com for more information about Endeeper oil exploration software.