Squeezing image information for reservoir understanding

Using images as an advantage to infer properties from core to the entire reservoir

CAYROS
group

Introduction

Introduction

Core data

- Frequently, cores provide the only possible real contact with the reservoir environment. Nevertheless, in most cases only limited data is obtained from cores. This contrasts with the huge indirect information obtained from geophysical methods as well logs and seismic.

- Although cores studies are relevant, is not always easy to propagate them to uncored wells or even the entire oil field. This new set of tools allows to extrapolate core derived valuable data and interpretations to the entire reservoir.

CVT obtaining quantitative data from images

CAYROS group

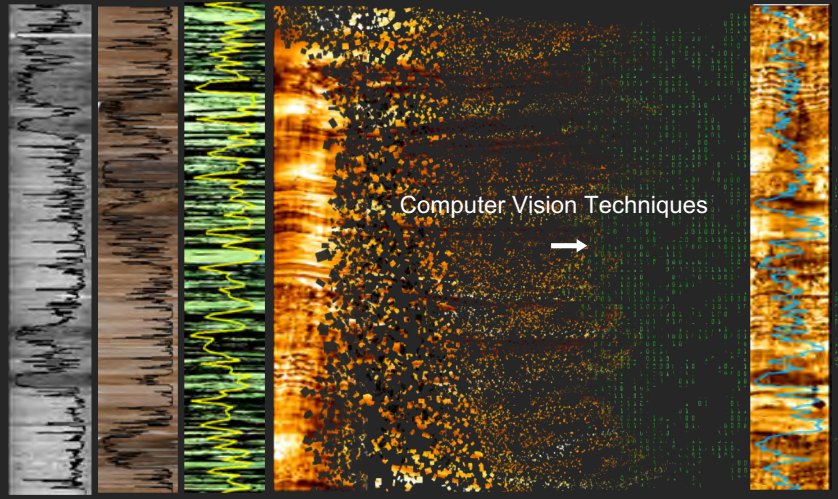
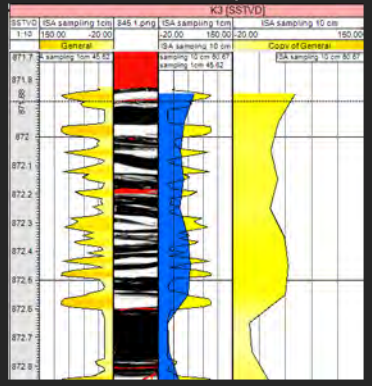


IMAGE BASED
new set of logs

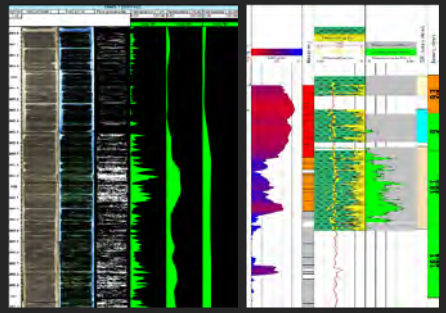
- Intensity
- Color bands
- Morphologic features (borders, blocks, etc)

CVT logs are useful for:

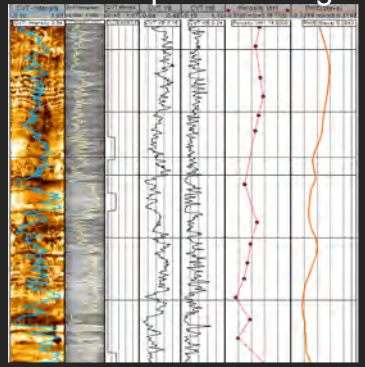
1. Net to gross in heterolithic deposits



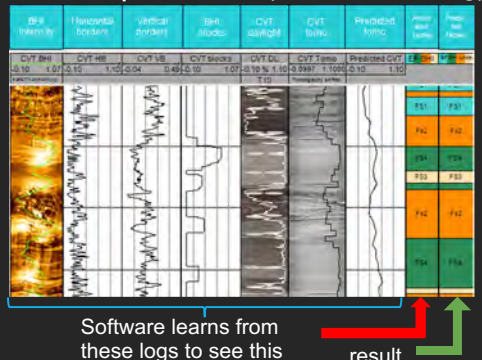
2. Fluorescence analysis (definition of fluid contacts)

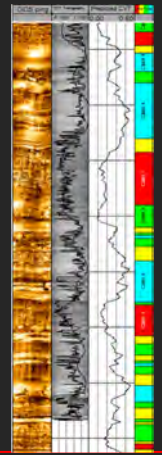


3. Core depth matching

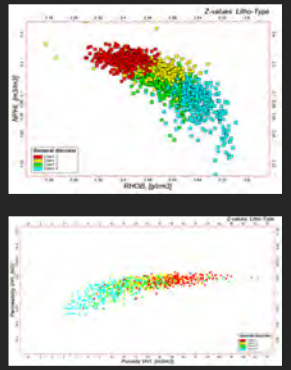


4. Facies prediction (Machine learning)





5. Rock types

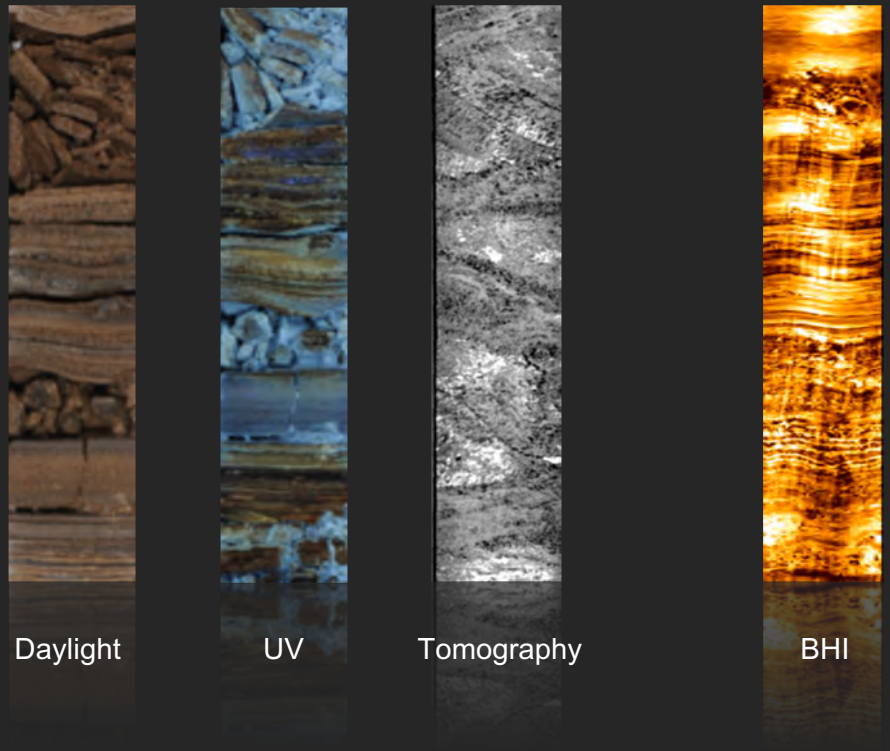


Introduction

Typical images available from reservoir

Core images

Well images



Usually core images are used only by sedimentologists to perform objective descriptions.

Obtaining rational or non-interpretive data from images has been underestimated.

Although core data in general are partial and localized, BHI well images become more common, and are often the bridge to extrapolate core interpretations to the rest of the well.

Introduction

How to extract and analyze data?

The use of new technologies such as computer vision added to machine learning allows to take image analysis to a higher level.

Some problems

Many attempts have been made in the sense of classifying facies from BHI with generally unsatisfactory results.

The supervised classification of BHI images will always be subject to the bias of the interpreter.

Introduction

How to solve these problems?

The unsupervised classification of BHI images must be guided from core data.

It is necessary to generate a set of logs derived from the images.

A robust workflow is essential to arrive at a reliable result, and it must be sufficiently lax to adapt data and problems to each case.

Introduction

Rethinking the use of images

Traditional approach:

- Multiple images are obtained from reservoir.
- Image data provided is considered “hard” since they are provided by sensors.
- In most cases, images confirm **qualitative aspects** of well segments.

CVT Approach:

- Since image data is highly reliable, CVT extract **quantitative logs from pixels**.
- New generated logs can be integrated seamlessly with existing quantitative data.
- Core image data can be extended to the reservoir.
- The set of CVT logs contributes to the inference of rock characteristics such as rock type and facies.

Introduction

Workflow

Get images from cores and reservoir (BHI, tomography, day light image, fluorescence image, etc.)

Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.)

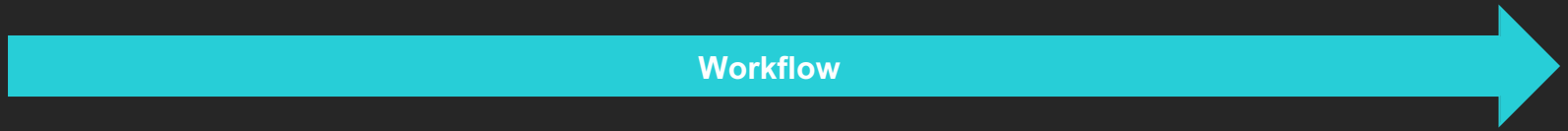
Match core depth using CVT logs

Select lithological wireline logs present in the reservoir (Spontaneous potential, gamma ray, Sonic, factor, etc.)

Infer core CVT logs from cores to the reservoir (CVT-tomo)

Classify common rock type

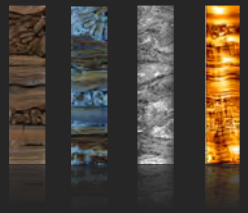
Label and infer facies




Methodology

Methodology: Input data

Image files
(png, jpg, tiff, etc)



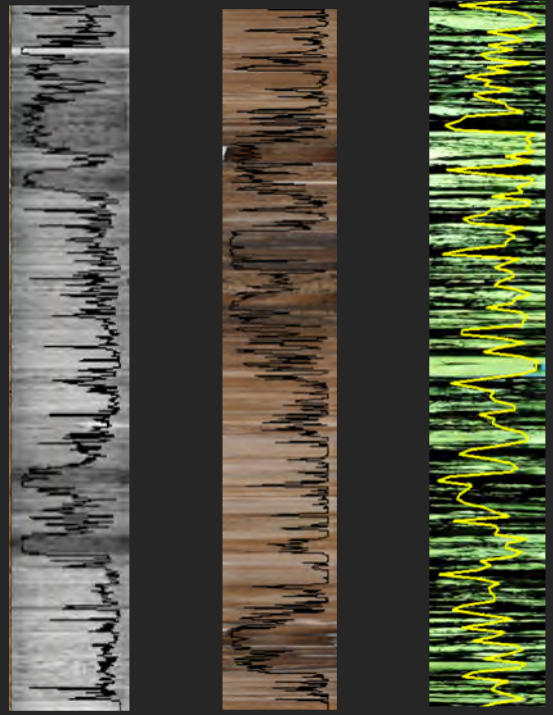
.pdf files

SUPPORTED DATA FOR PROCESSING

printed

.las files

Methodology: Core Images



CVT-tomography

CVT-DL daylight images

CVT-fluo fluorescence images

Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.)

Get images from cores and reservoir (BHI, mography, day ght image, fluorescence image, etc.)

Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.)

Match core depth using CVT logs

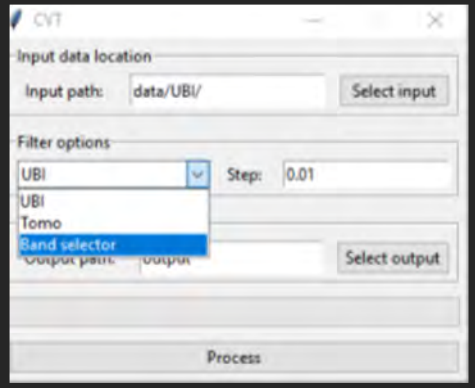
Select lithological wireline logs present in the reservoir (Spontaneous potential, gamma ray, Sonic, factor, etc.)

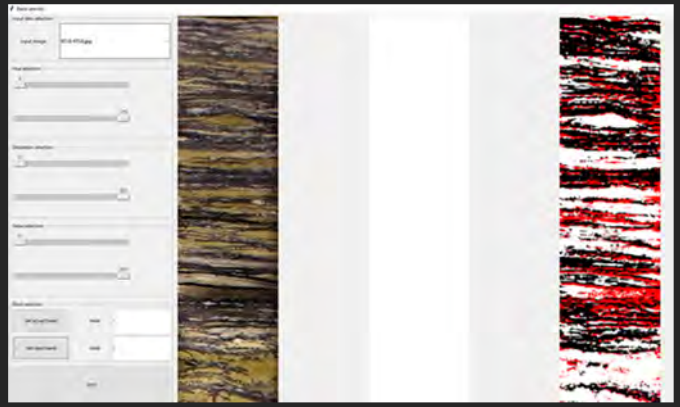
Infer core CVT logs from cores to the reservoir (CVT-tomo)

Classify common rock type

Label and infer facies

Workflow





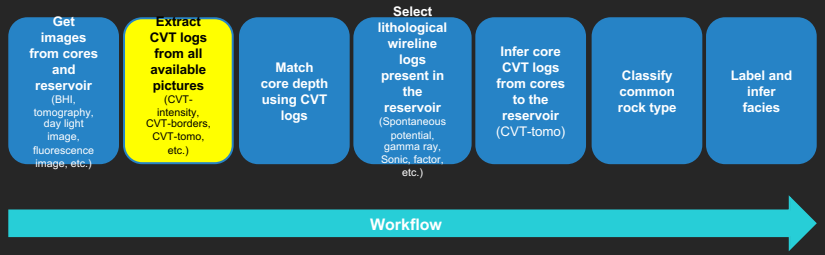
Methodology: BHI images

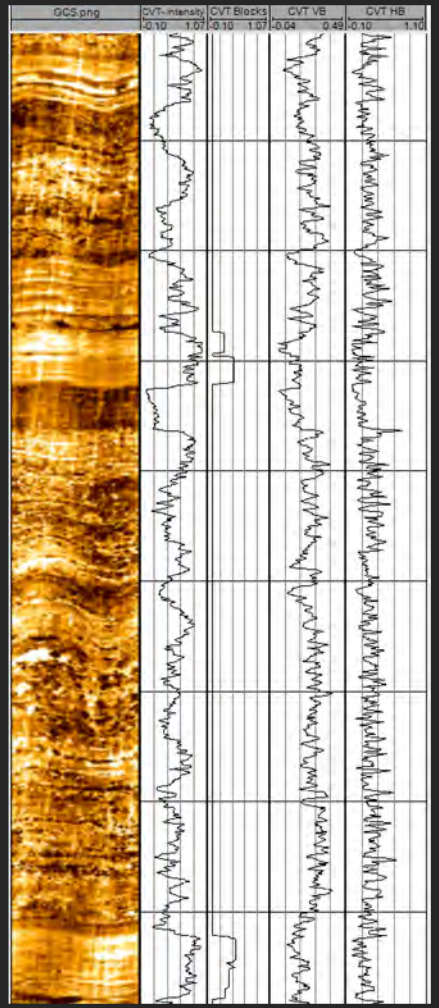
Four types of logs are obtained from BHI images

1. CVT-intensity
2. CVT-horizontal borders
3. CVT-vertical borders
4. CVT-blocks

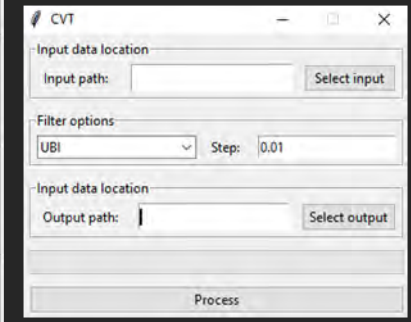
INTENSITY

MORPHOLOGICAL





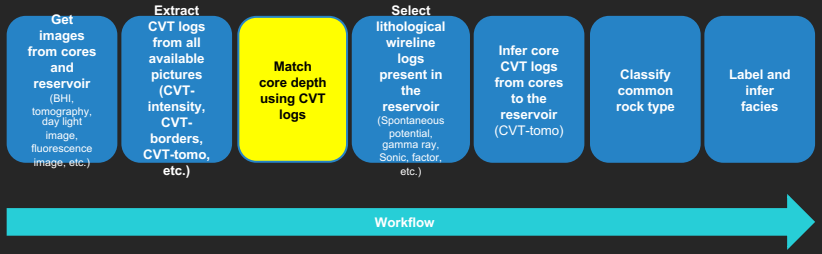
CVT SOFTWARE GCS

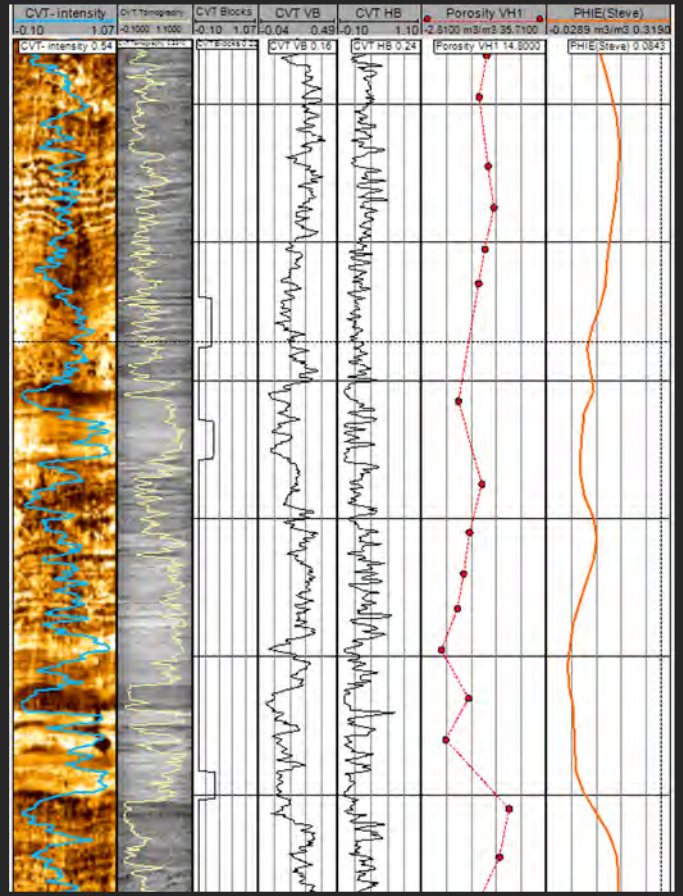


Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.)

Methodology: Core Depth Matching

- CVT is a useful tool to achieve a “perfect” matching among:
  - Core
  - BHI
  - Tomography
  - Plugs
  - Logs

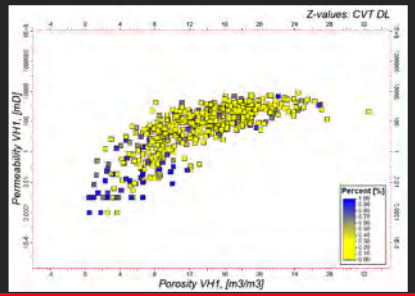


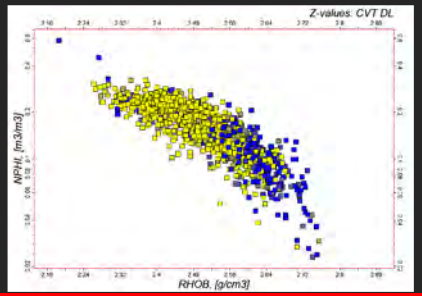


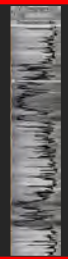
Match core depth using CVT logs

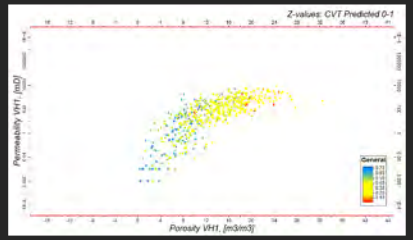
Methodology: CVT evaluation

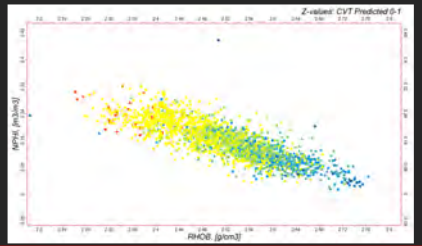
CVT´s vs NPHI/RHOB and conventional analysis

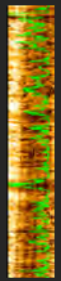


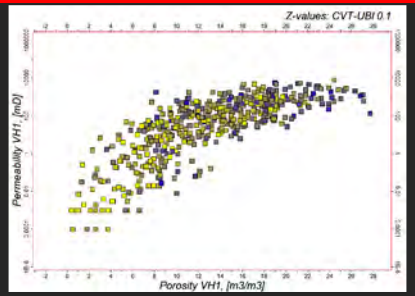


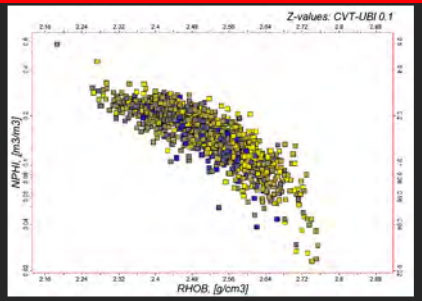












Methodology: Inferring CVT-log from core to reservoir

Extending CVT-tomo to an Entire Well → CVT-Predicted-tomo

Collect Tomography pictures

↓ CVT tomography

Collection of logs (core interval)

Regression →

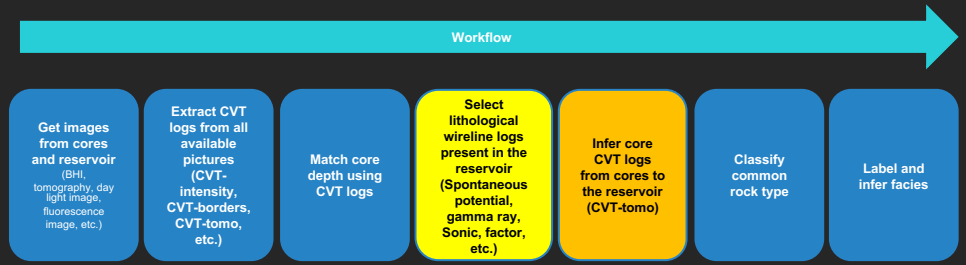
Fit model

Infer model →

Infer CVT-TOMO for the rest of the well

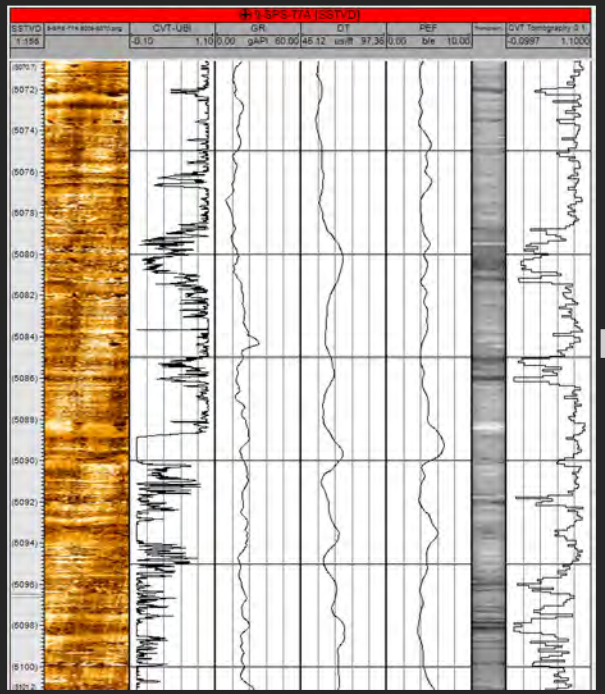
↑ Defined by expert

Select representative logs (PEF, GR)



Methodology: Inferring CVT-log from core to reservoir

Example

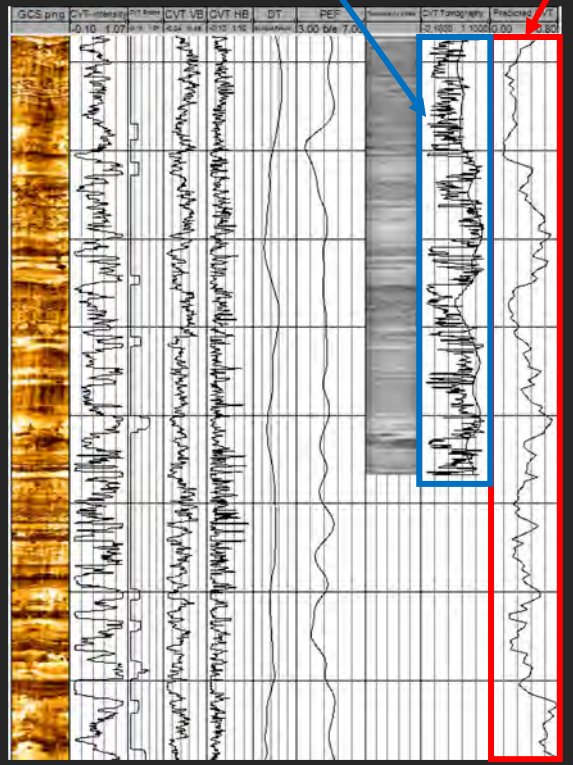


CVT and CVT Predicted

4 CVT UBI
GR
Pef
DT

Supervised method based on CVT Tomography

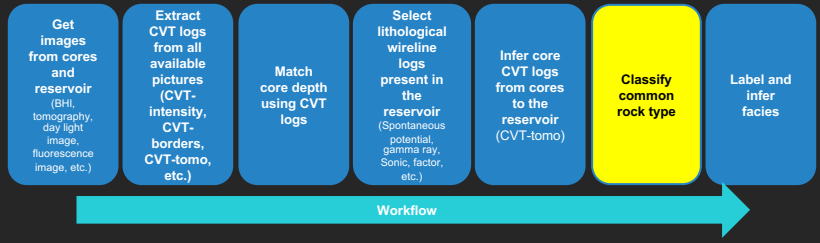
Infer core CVT logs from cores to the reservoir (CVT-tomo)

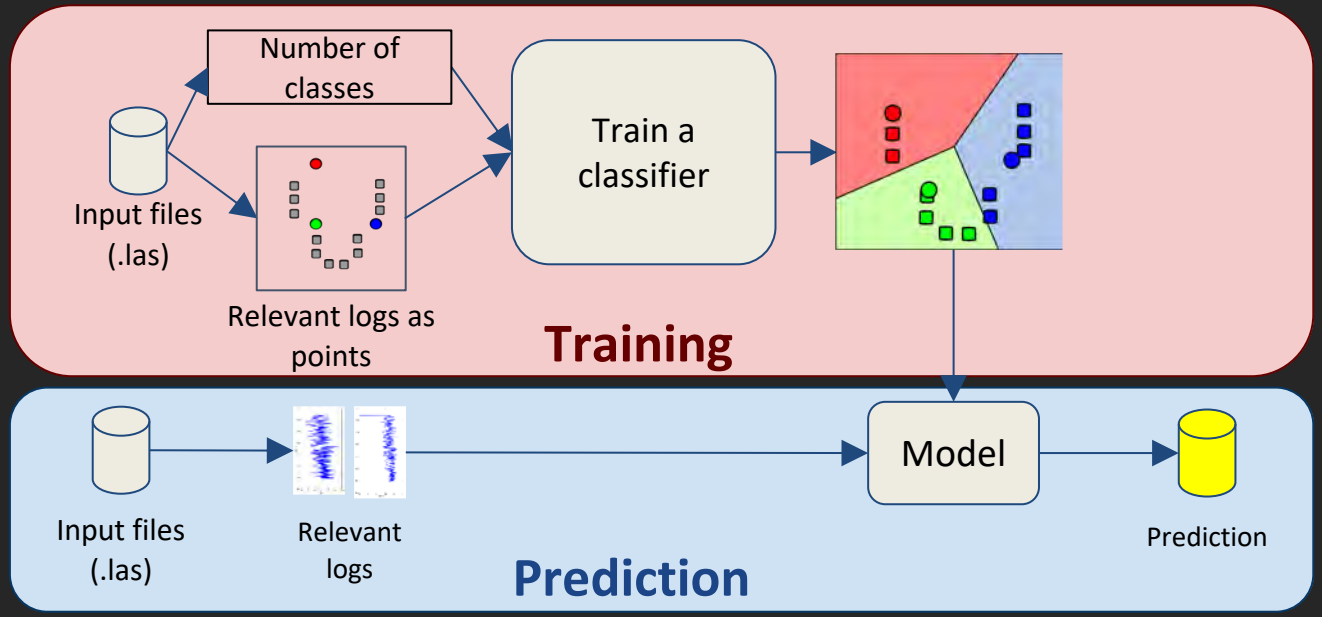


Methodology: Classifying Litho type (or rock type)

Litho type
evaluation from CVT results

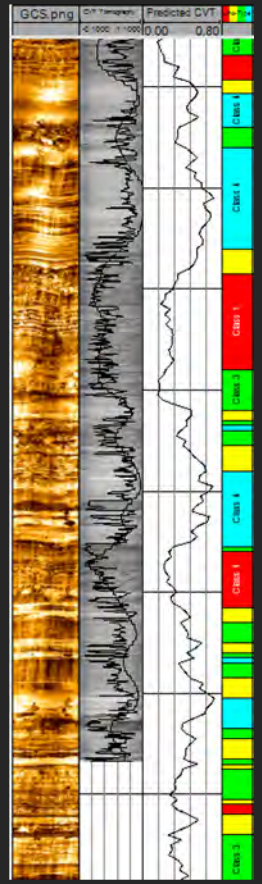
Unsupervised classification of litho types



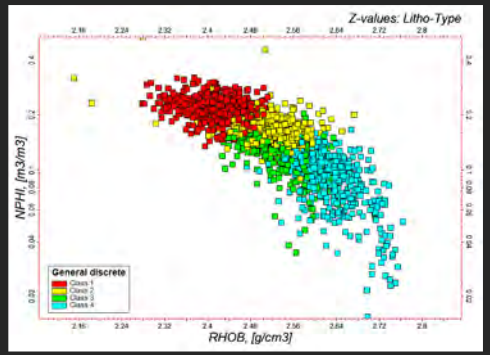


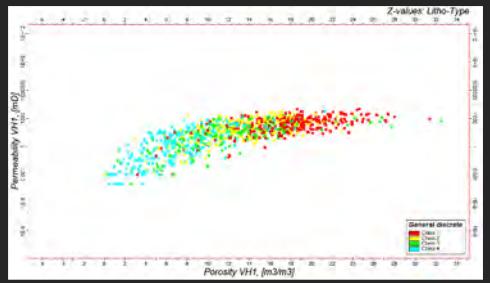
Classify common rock types

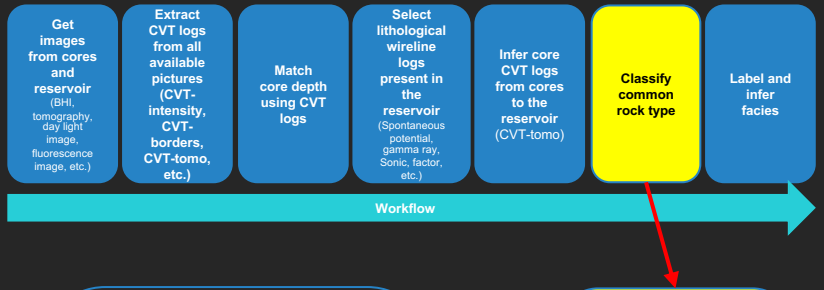
Methodology: Litho type



Novel **litho type** evaluation form CVT results







4 classes unsupervised

Features used:

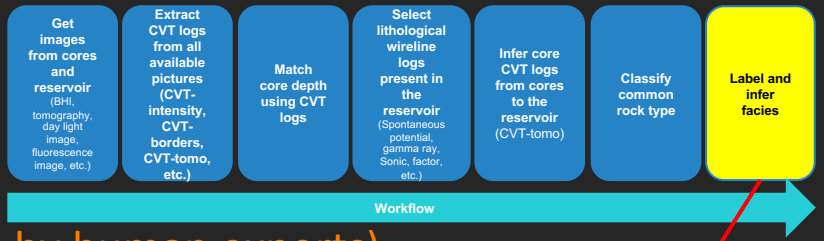
- CVT-tomo-pred
- RHOB
- NPHI

Classify common rock types

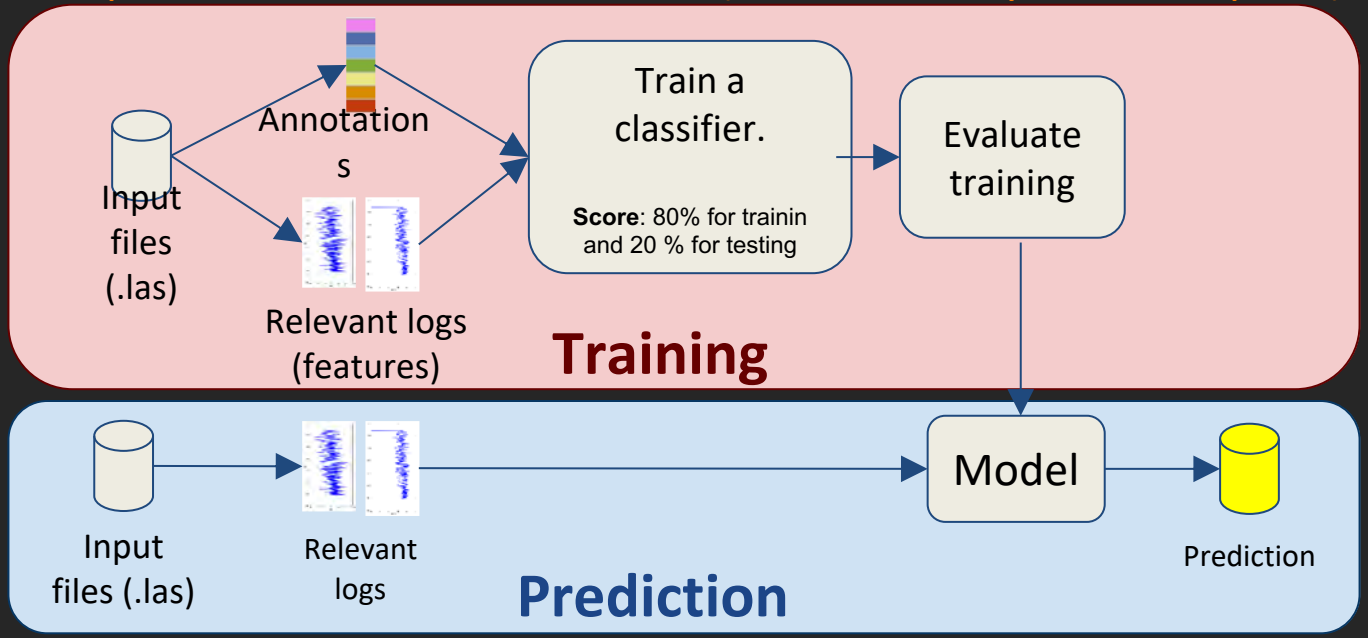
Methodology: Predicting Facies

CAYROS group

Facies for model



Supervised classification of facies (annotations by human experts)



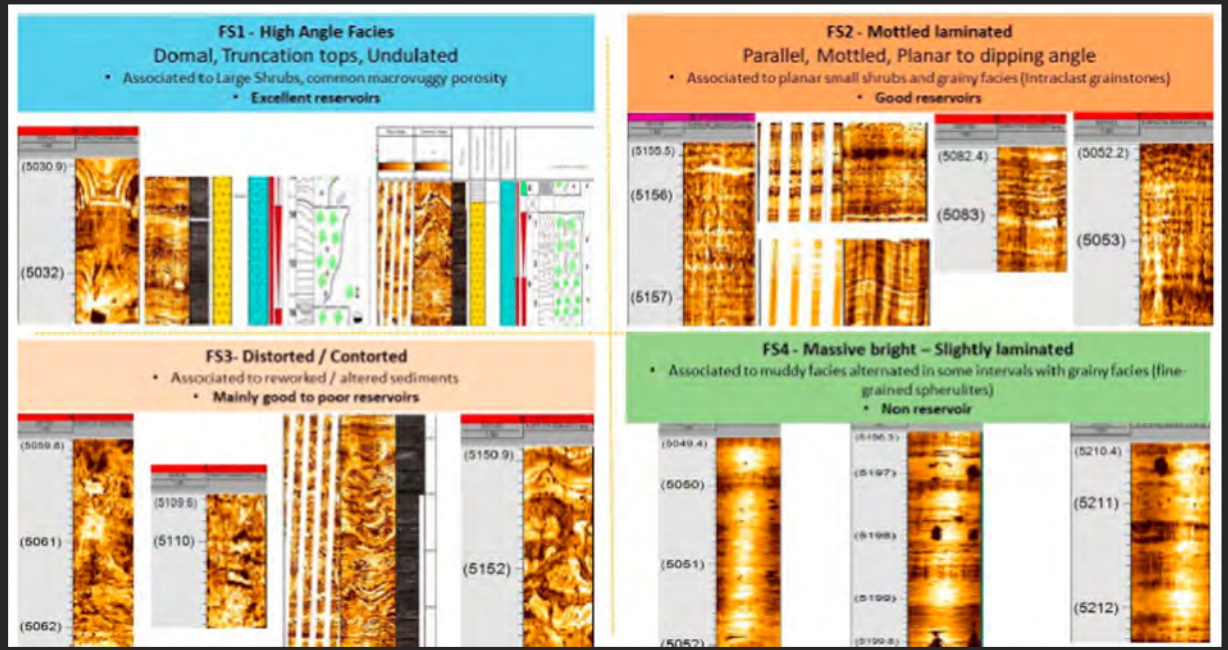
Methodology: Predicting Facies

Label and infer facies

Get images from cores and reservoir (BHI, tomography, day light image, fluorescence image, etc.) → Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.) → Match core depth using CVT logs → Select lithological wireline logs present in the reservoir (Spontaneous potential, gamma ray, Sonic, factor, etc.) → Infer core CVT logs from cores to the reservoir (CVT-tomo) → Classify common rock type → Label and infer facies

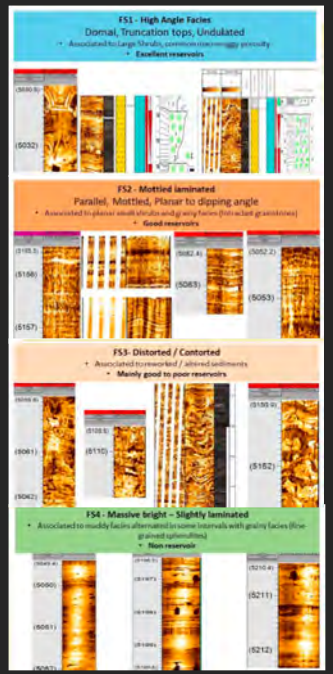
Workflow

Facies example



Methodology: Predicting Facies

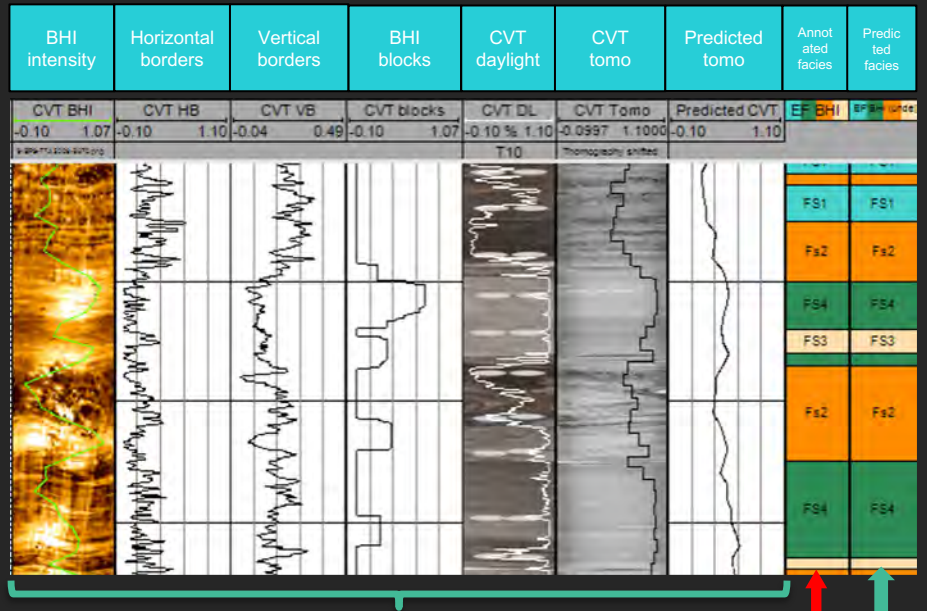
Cored well example



Label and infer facies

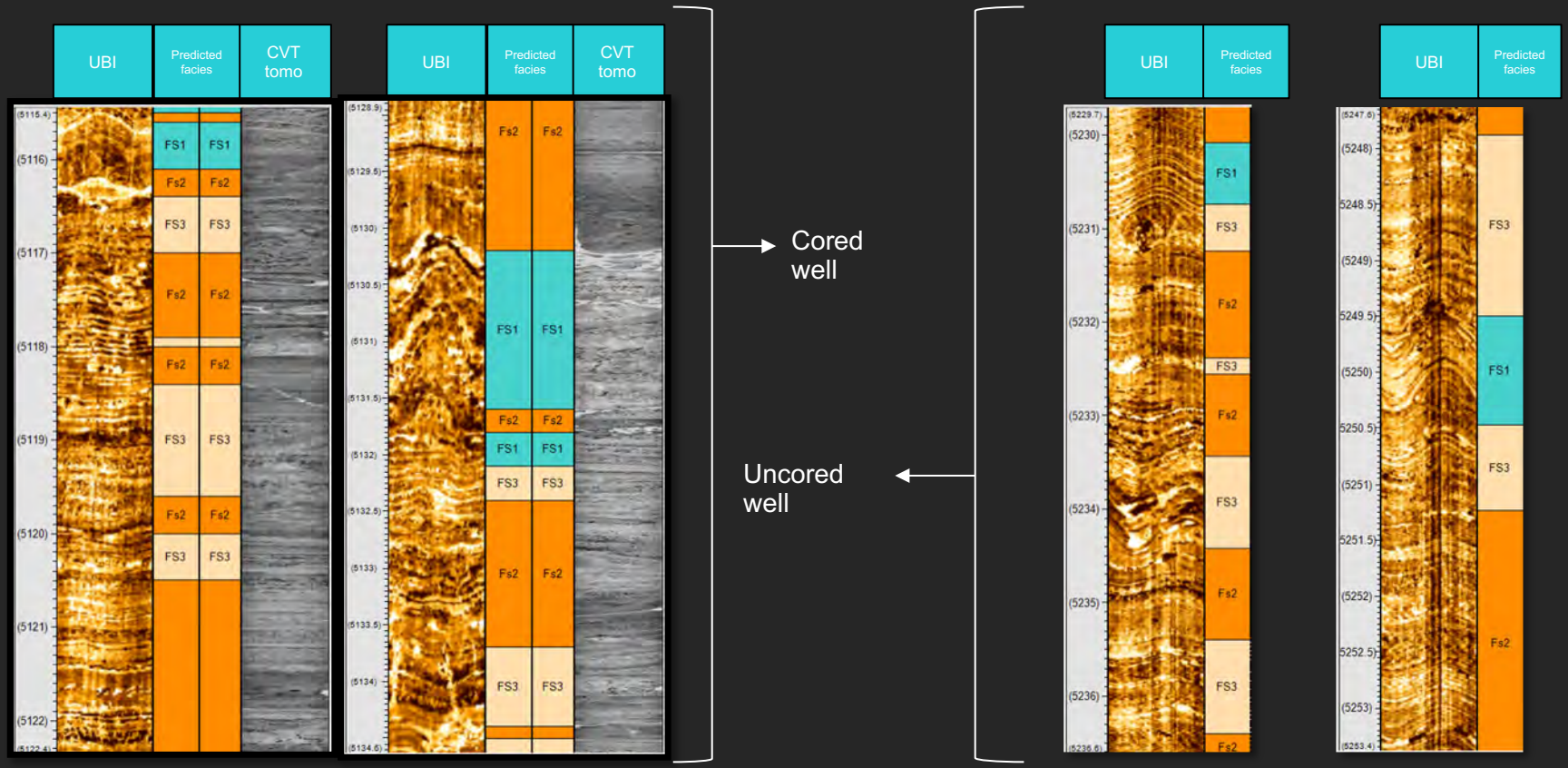
Get images from cores and reservoir (BHI, tomography, day light image, fluorescence image, etc.) → Extract CVT logs from all available pictures (CVT-intensity, CVT-borders, CVT-tomo, etc.) → Match core depth using CVT logs → Select lithological wireline logs present in the reservoir (Spontaneous potential, gamma ray, Sonic, factor, etc.) → Infer core CVT logs from cores to the reservoir (CVT-tomo) → Classify common rock type → Label and infer facies

Workflow



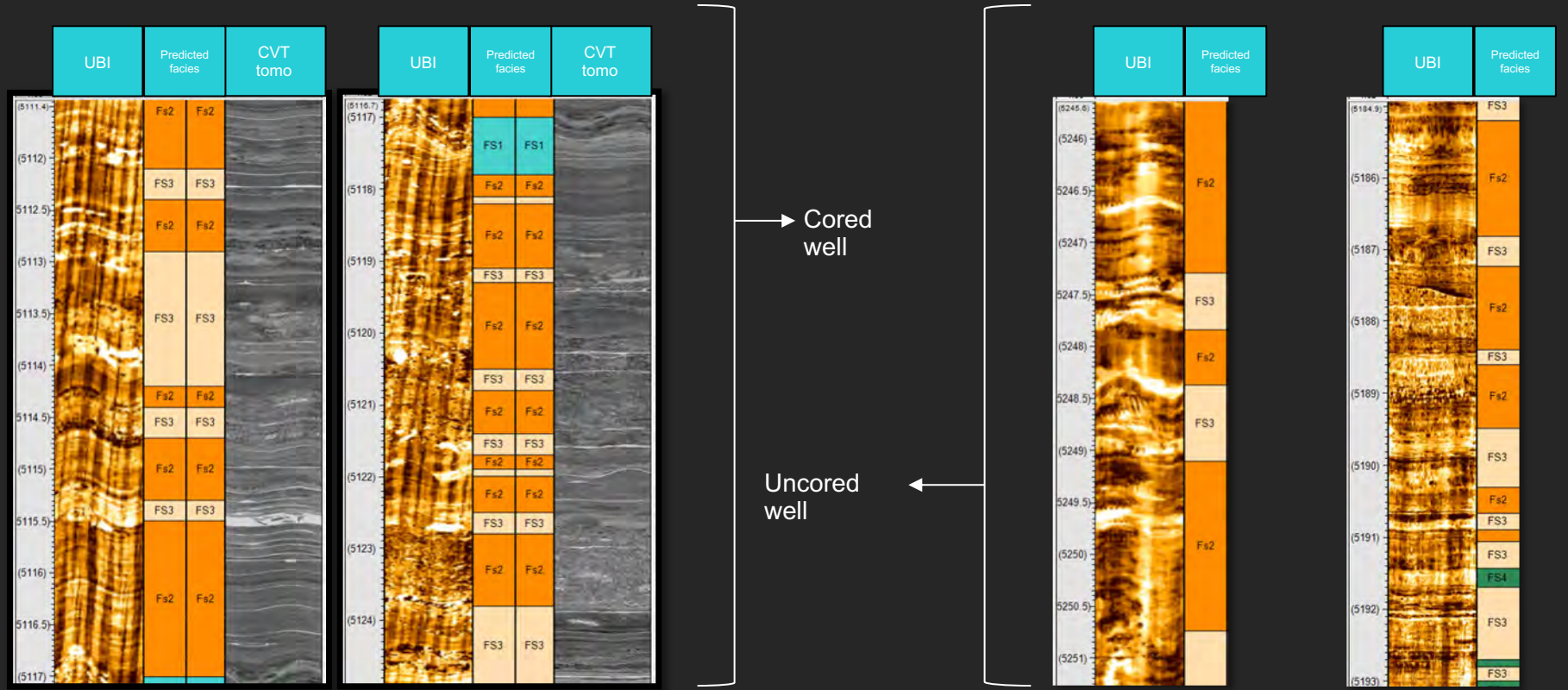
Results

Some examples



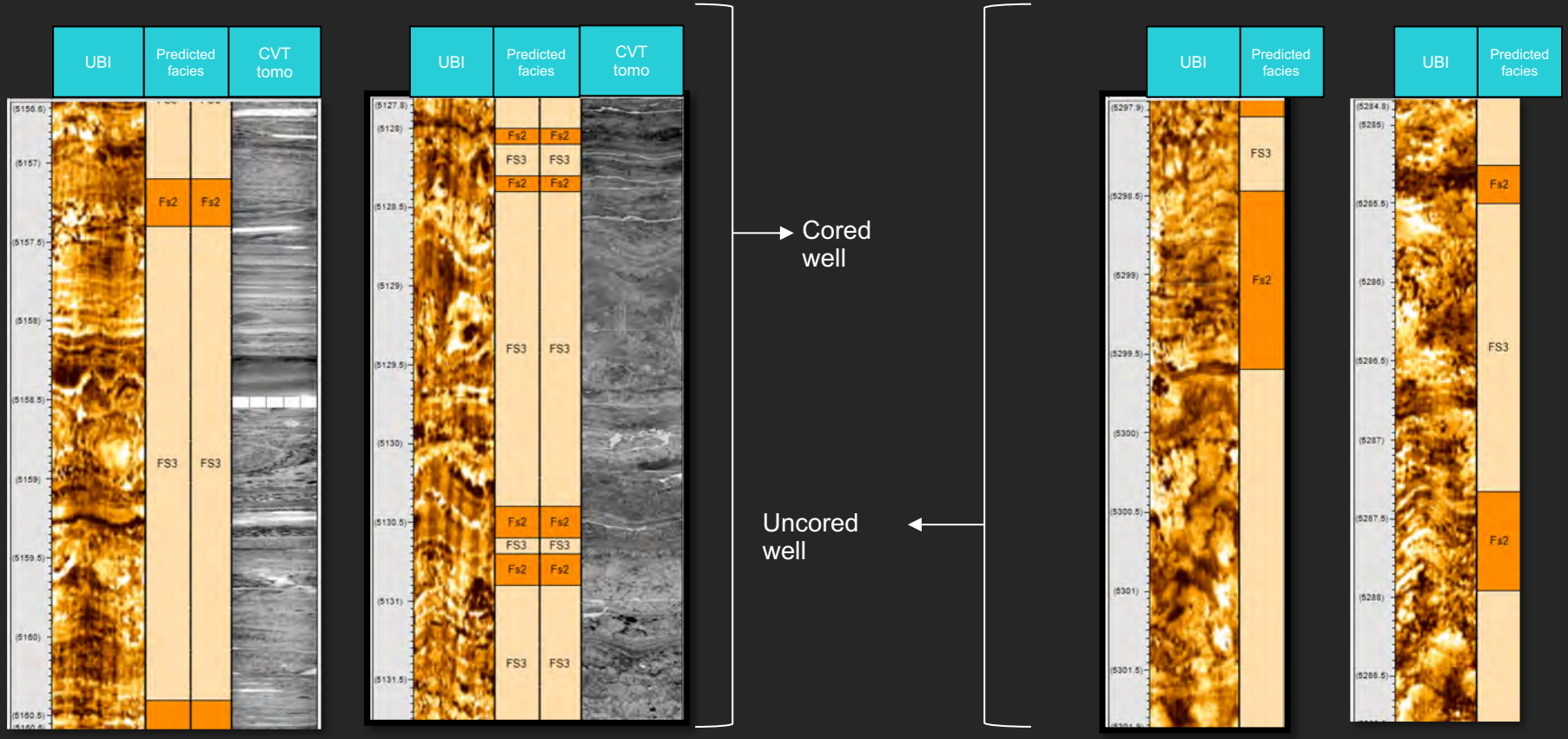
Results

Some examples



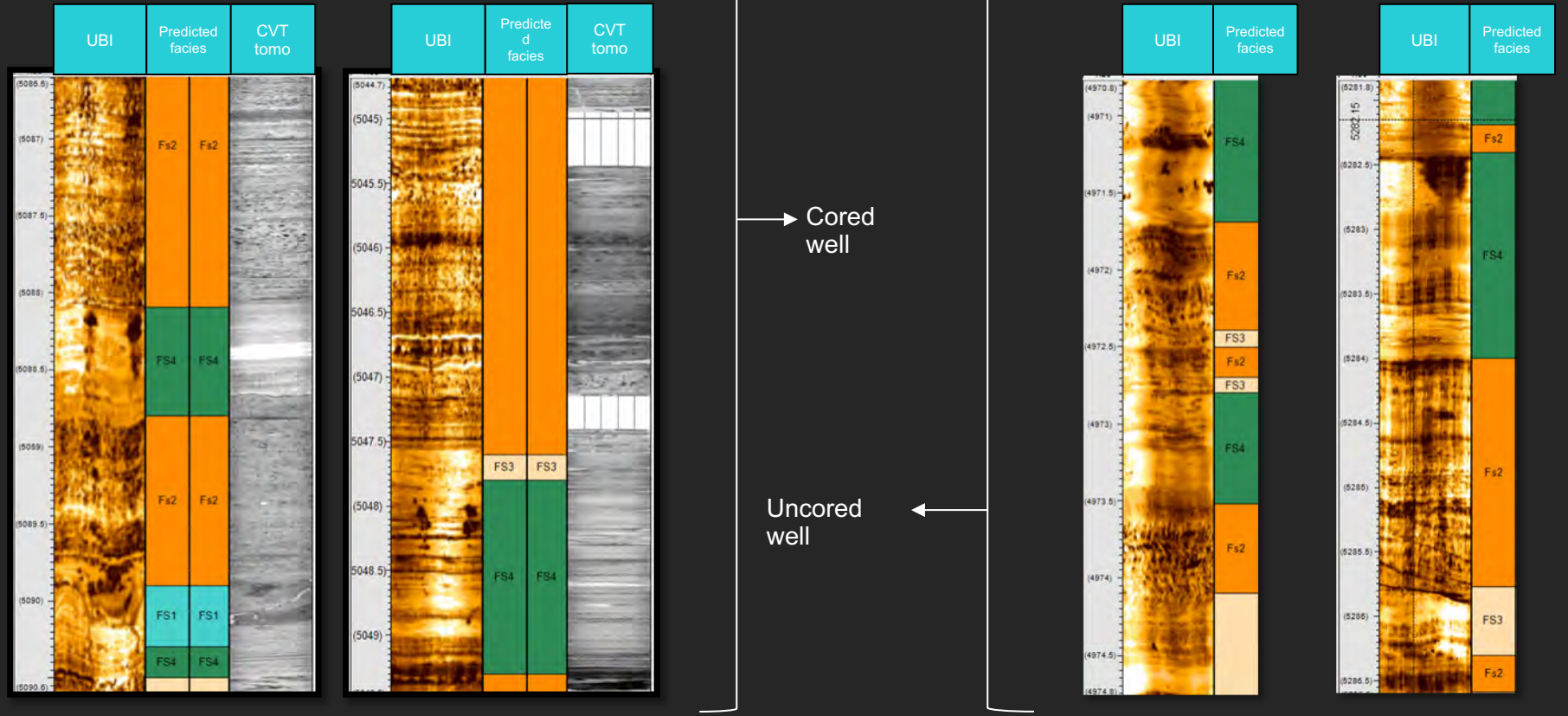
Results

Some examples



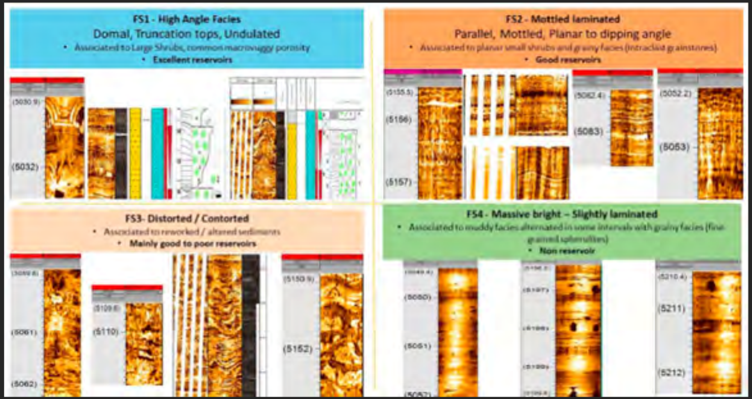
Results

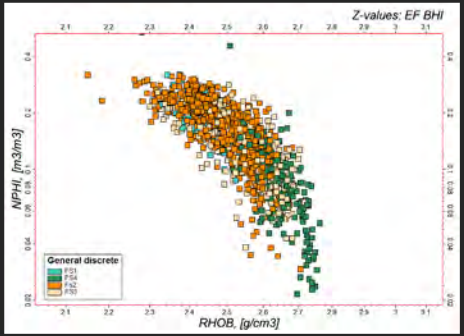
Some examples

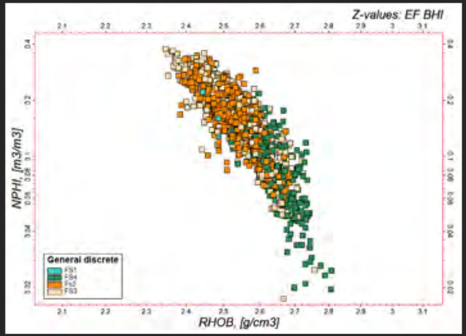


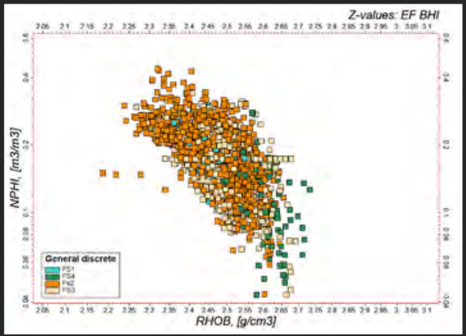
Results

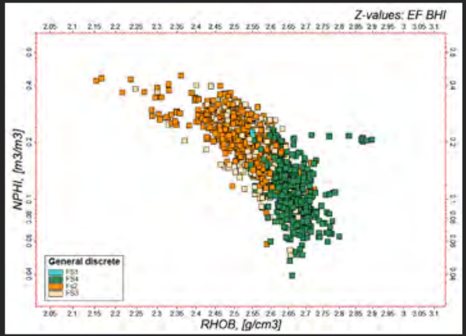
Electrofacies vs RHOB/NPHI

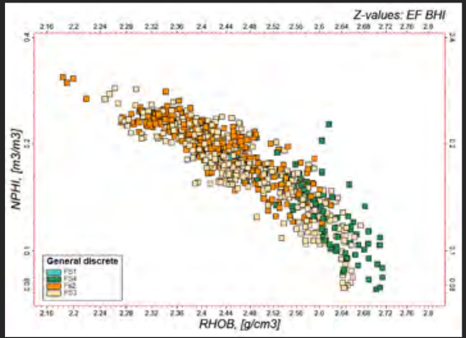












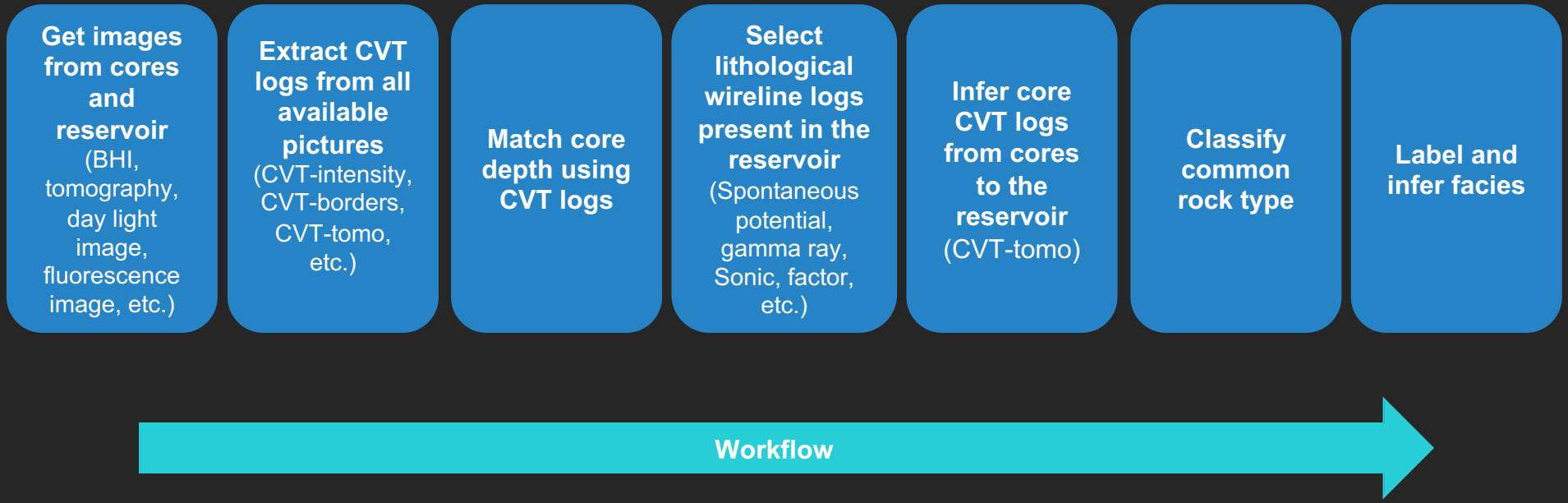
Conclusions

Conclusions

- A systematic and quantitative methodology was presented
- Proposed steps were:
  - Extract quantitative CVT logs from all available pictures.
  - Match core depth using CVT logs.
  - Select wireline logs present in the reservoir.
  - Infer core CVT logs from cores to the reservoir.
  - Classify common rock characteristics such as litho type and facies.
- Results in cored and uncored wells were presented.
- Huge **positive impact** is possible appling **this Workflow** to oil and gas reservoirs.

Conclusions

Workflow

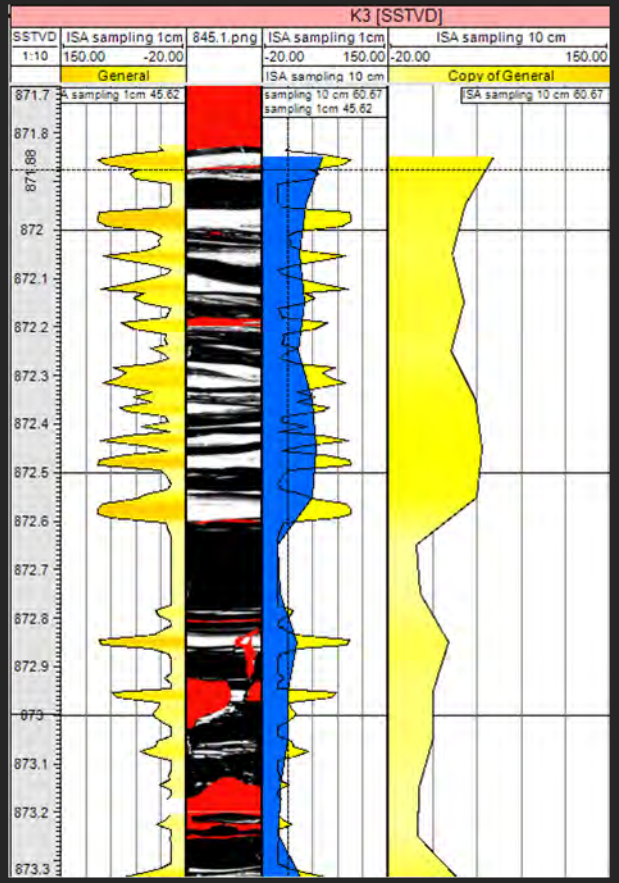


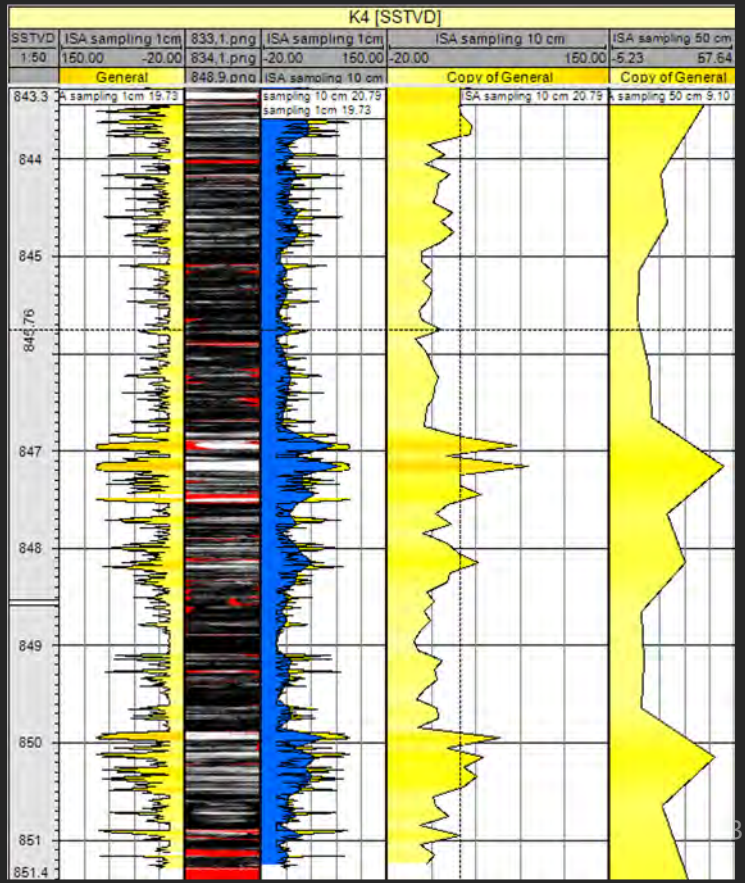
Other applications of CVT

Sandstone net to gross in hetherolothic reservoirs

Original images

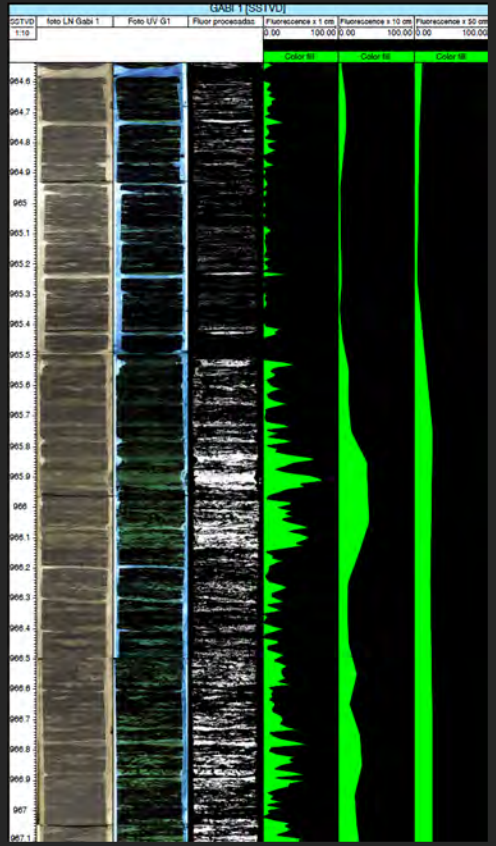
Input for algorithm

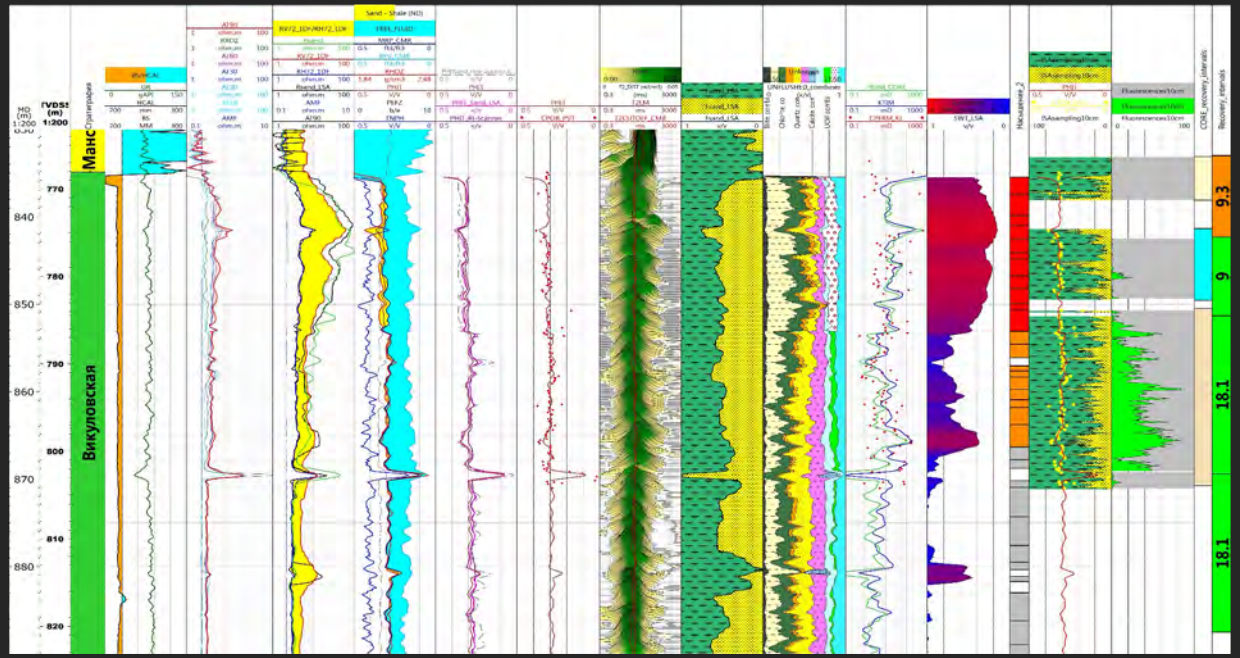




Other applications of CVT

Fluorescence (oil impregnation) O-W and G-O contacts





CVT obtaining quantitative data from images

CAYROS group

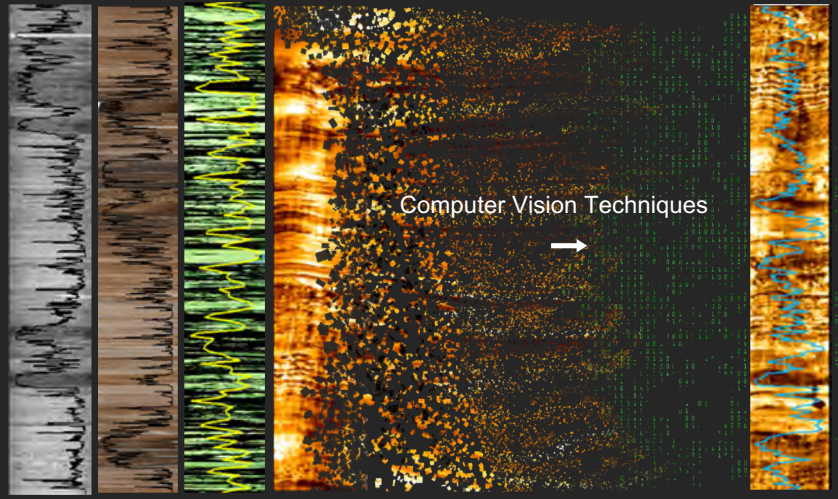
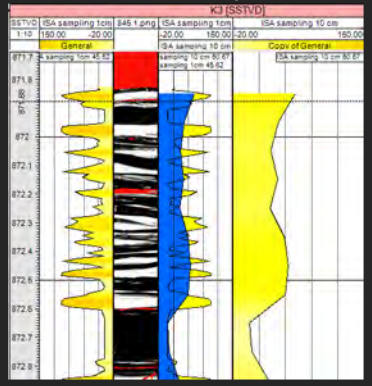


IMAGE BASED
new set of logs

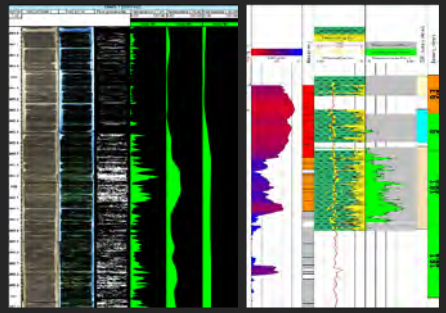
- Intensity
- Color bands
- Morphologic features (borders, blocks, etc)

CVT logs are useful for:

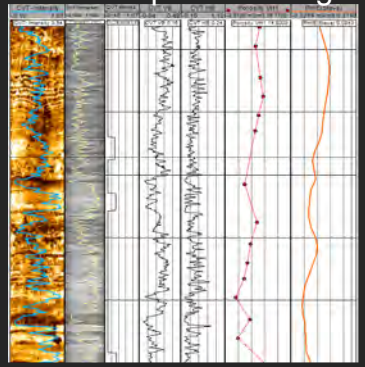
1. Net to gross in heterolithic deposits



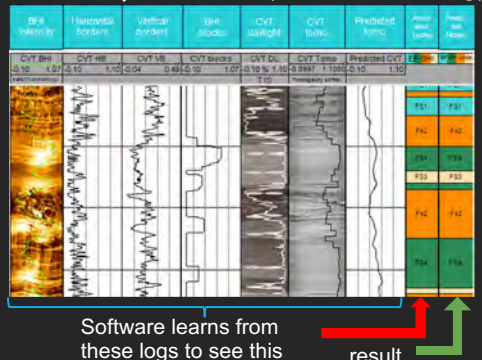
2. Fluorescence analysis (definition of fluid contacts)

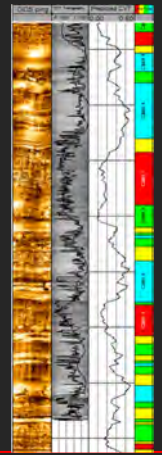


3. Core depth matching

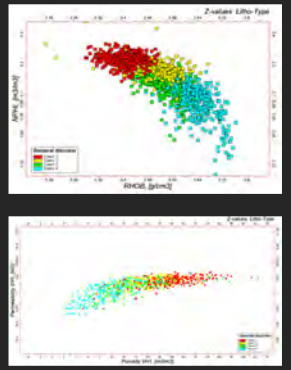


4. Facies prediction (Machine learning)





5. Rock types



Cayros Group Corp
840 6 Ave SW. Suite 300
Calgary AB T2P 3E5
Ph. +1 (403) 691-1092
info@cayrosgroup.com
CANADA

Cayros Group LLC
5100 Westheimer Road
Suite 200.
Houston, Texas 77056
Ph. +1 (281) 973-2879
Info.usa@cayrosgroup.com
USA

Cayros Group SAS
Calle 93 No. 11A-28
Oficina 601.
Bogotá, Cund. 110221
Ph. +57 (1) 508-6926
Info.colombia@cayrosgroup.com
COLOMBIA

Grupo Inversionista Cayros S de RL de CV
Park Plaza
Av. Javier Barros Sierra #540
Col. Lomas de Santa Fe
México City 01210
Ph. +52 (55) 8525-5585

Av. Isla de Tris No. 1
Plaza Carmen Center. Local 7PA
Colonia Aeropuerto
Ciudad del Carmen, 24119
Ph. +52(938)111-3833

Info.mexico@cayrosgroup.com
MEXICO

Cayros Group INC
1st Floor, Hastings House
Balmoral Gap.
Hastings, Christ Church. BB14034
Info.barbados@cayrosgroup.com
BARBADOS

GCS Geological Services
Cayros Partner
Florencio Molina Campos 150
Bahia Blanca, B8002CYD, Buenos Aires
Info@gcsargentina.com
ARGENTINA