From GEMINI Help Describing the KHAN Module

GEMINI
Geo-Engineering Modeling through INternet Informatics
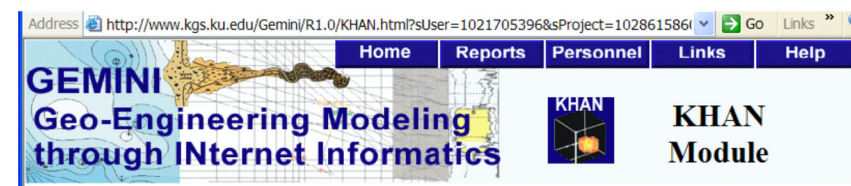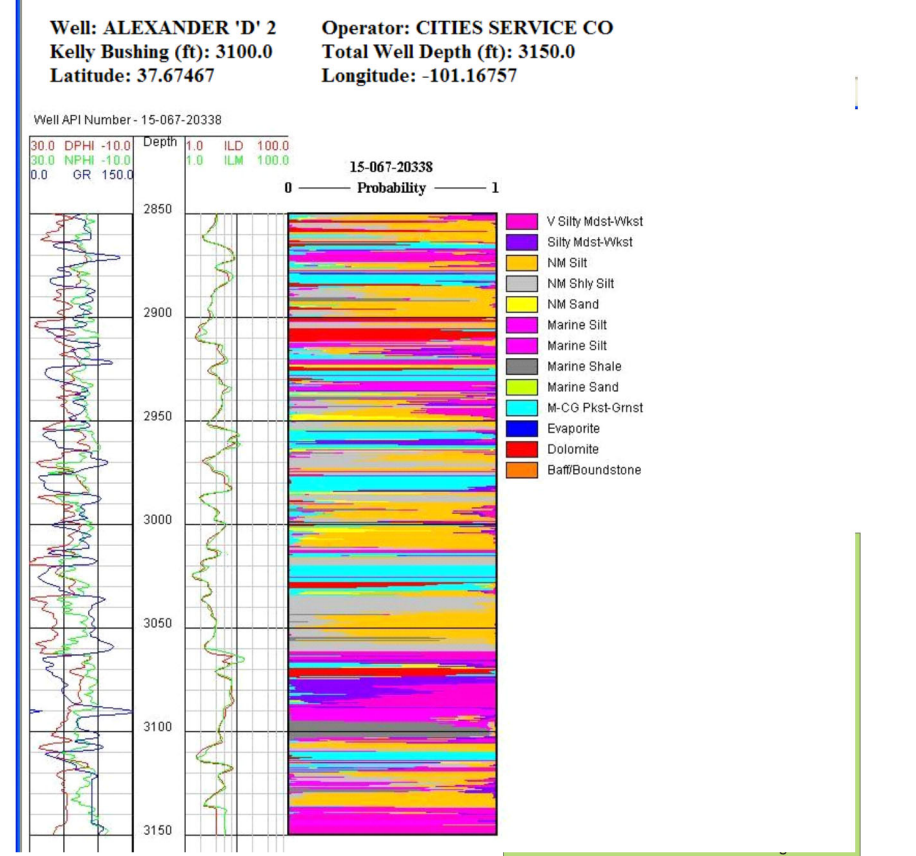
KHAN Module

KHAN is being designed to conduct statistical modeling (continuous variable prediction, discriminant analysis, and clustering) of large databases to derive meaningful patterns including assessing pay in multiple LAS files. The module will accomplish data mining via statistical analysis of databases. The process will be automated and semi-automated, the later to accomplish revealing meaningful patterns in large volumes of data in a reasonable amount of time. The predecessor of KHAN, KIPLING, demonstrated the ability to predict descrete and continuous variables such as lithofacies and permeability using wireline logs (http://www.kgs.ukans.edu/software/Kipling/Kipling1.html). KHAN fits in the family of applications that include classical and localized regression, smoothing splines and kernel functions, neural networks, and CMAC (Cerebellar Model Arithmetic Computer). Hagens and Doeveton (1991) adapted the CMAC algorithm for use in representing a general function of multiple variables and applied the algorithm to mapping of a geological surface. The software developed for this work was a predecessor to the Kipling software.

A general application for KHAN is to predict "electrofacies", discrete geometric units that ideally are correlatable and correspond to significant, rationale geologic rock bodies. In other words, the petrophysical classification resulting from this "electrofacies" analysis might be based on a "training set" consisting of petrofacies (lithofacies+pore types) or generic stratigraphic units such as flooding units, condensed sections, and paleosols. Moreover, the user may want to distinguish rock that is hydrocarbon pay. Systematic classification of pay in a field, region, or basin could be used to process new LAS files for hydrocarbon show in a quantitative manner. Systematizing pay at the field level could help develop the reservoirs by helping identify priority areas and intervals.

Dialogs will lead the user through specifying training variables and defining model parameters. Predictions will be made and the model will be matched to the dataset variables. Plot will be generated of the predicted electrofacies probabilities such as that shown below.
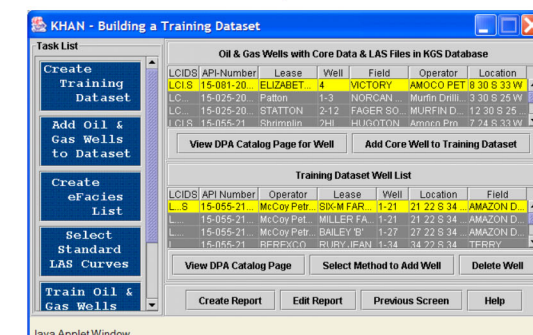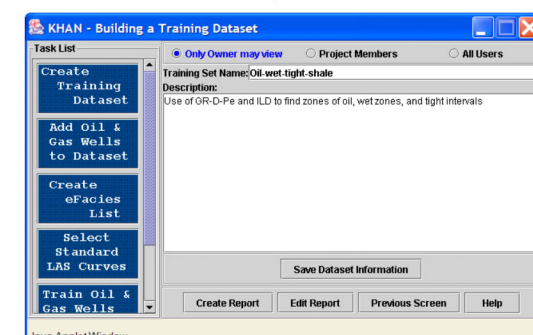
Well: ALEXANDER 'D' 2   **Operator: CITIES SERVICE CO**
Kelly Bushing (ft): 3100.0   Total Well Depth (ft): 3150.0
Latitude: 37.67467   Longitude: -101.16757

Survey, Open-file Report, no. 2003-30 (Available online: http://www.kgs.ku.edu/PRS/publication/2003/ofr2003-30/index.html)

KHAN Module in GEMINI – Step-by-Step

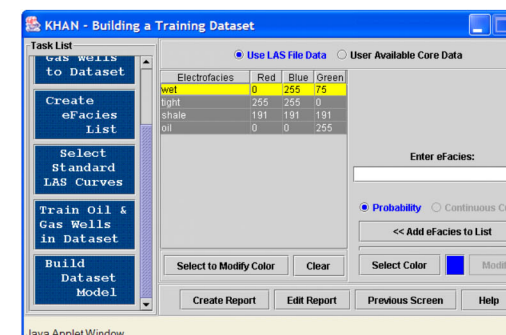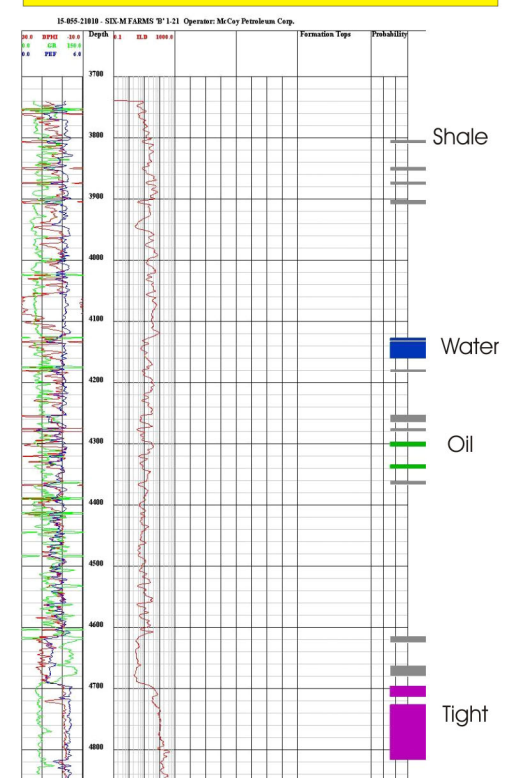Opening dialog in GEMINI Used to access KHAN Module
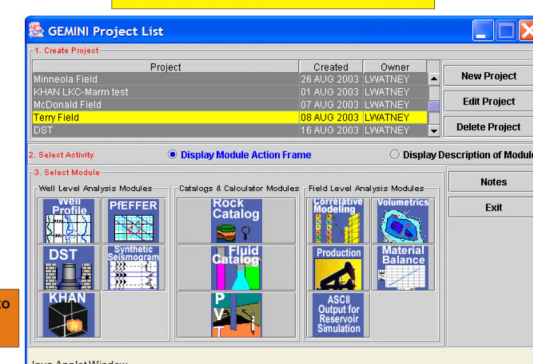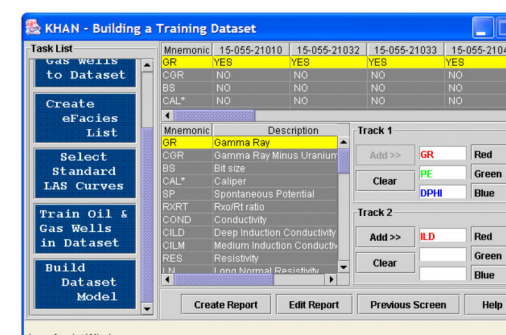
Button to Launch KHAN

Review wells selected for training set

Review logging tools used in classification

Review electrofacies

Intervals selected and classified as oil, water, shale, and tight. DST and perforations used to define oil and water zones.
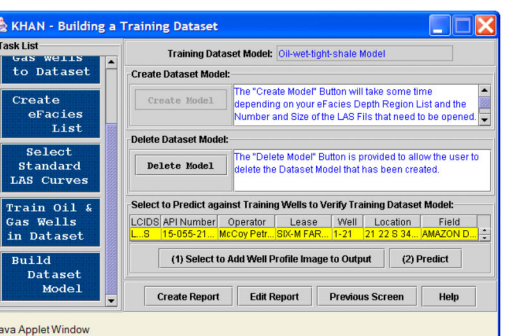
Shale
Water
Oil
Tight

KHAN
Training Dataset Oil-wet-tight-shale

Training summary output as web page.

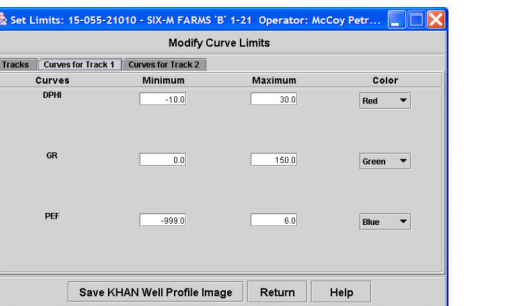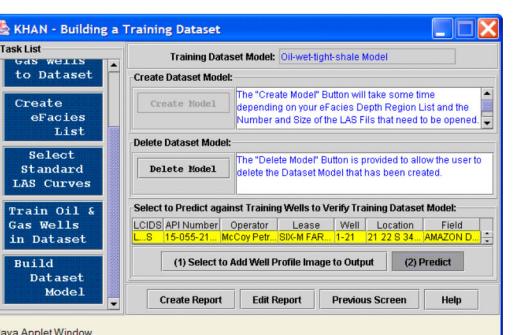## Prediction Phase

Select well for prediction
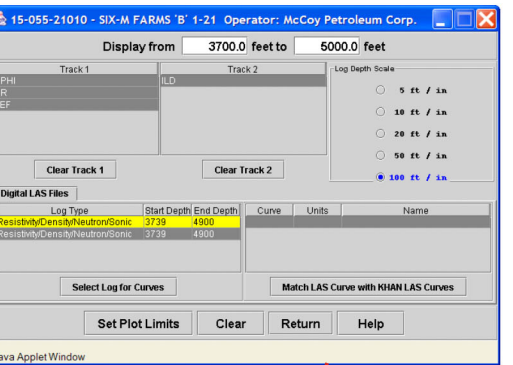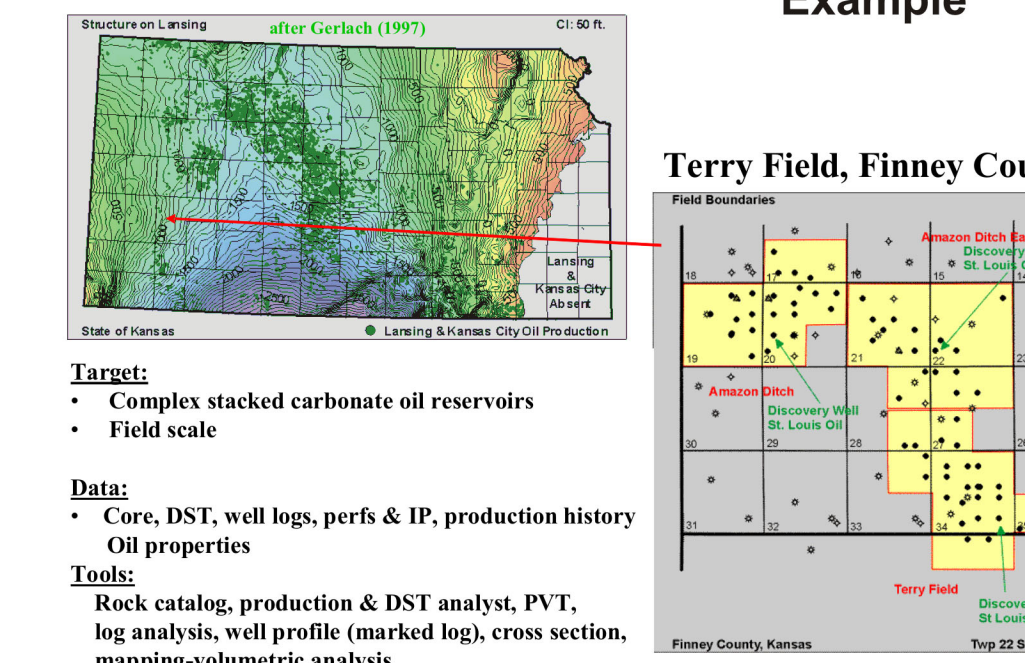
Select interval to predict pay and match logs.

Modify curve limits on output log.

Prediction

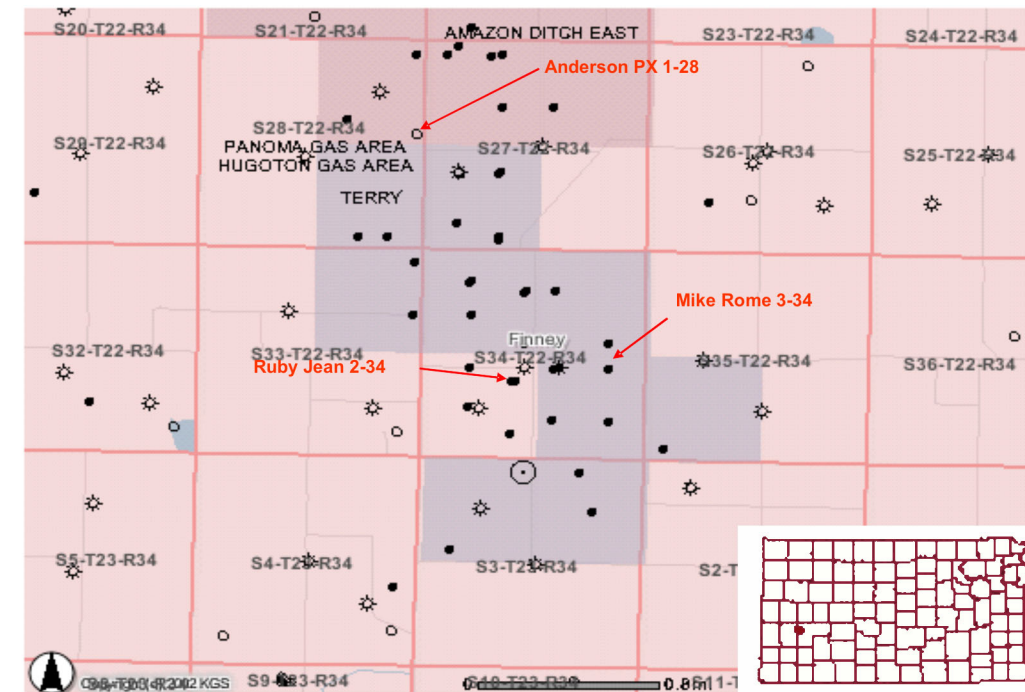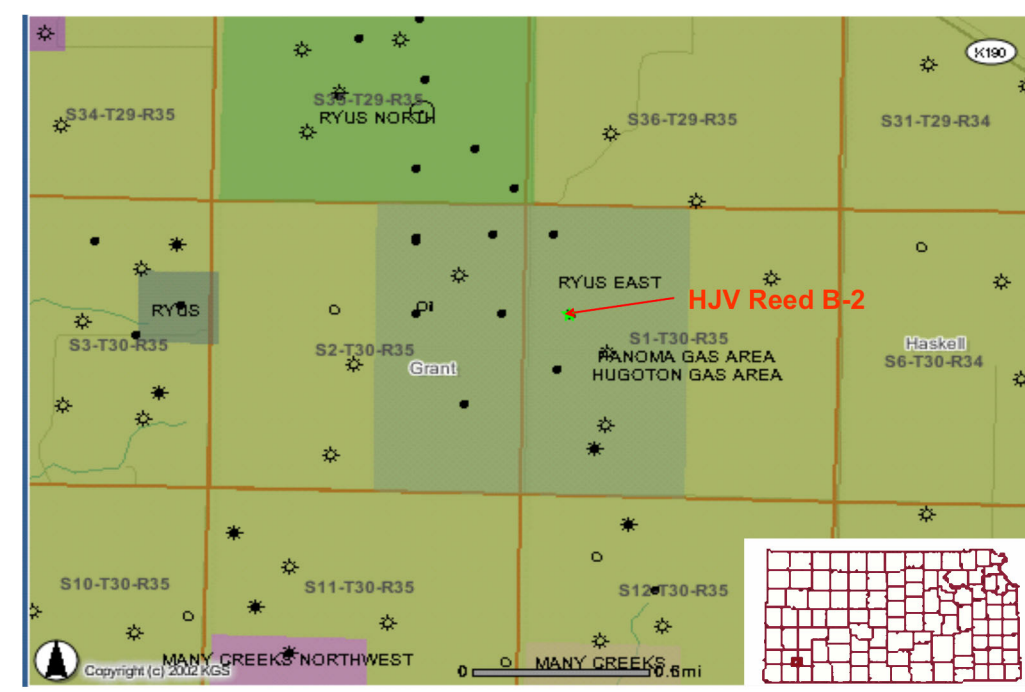## Example

Terry Field, Finney County

Target:
- Complex stacked carbonate oil reservoirs
- Field scale

Data:
- Core, DST, well logs, perfs & IP, production history
- Oil properties

Tools:
- Rock catalog, production & DST analyst, PVT, log analysis, well profile (marked log), cross section, mapping-volumetric analysis,
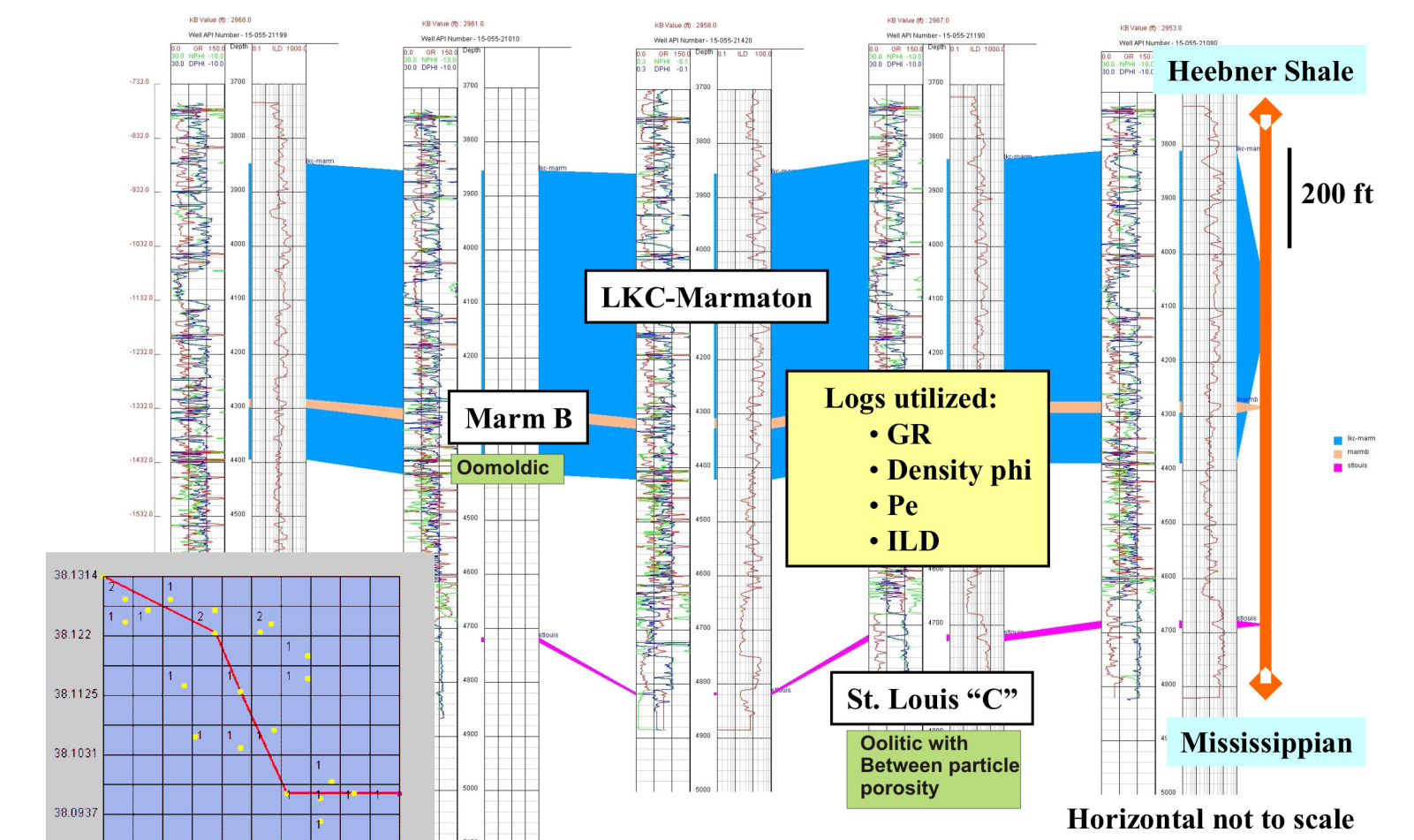- KHAN (Kansas Hydrocarbon Association Navigator)

Example Training Well from Terry Field Pay Model: Ruby Jean 2-34
Pay Prediction: M. Rome 3-34 & Anderson PX 1-28

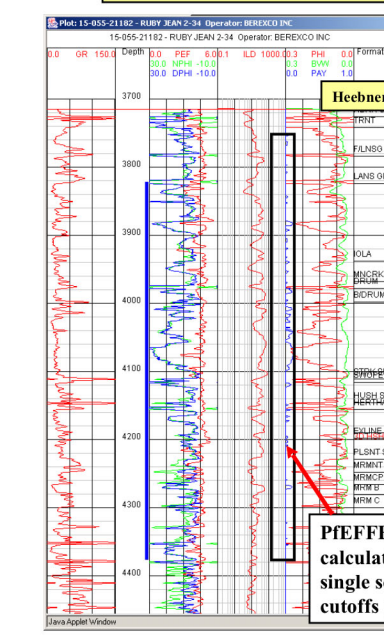**Pay Prediction Well:** HJV Reed B-2 in Ryus East Field, 40 mi south of training area

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Northwest-Southeast Structural Cross Section Across Terry Field Showing Training and Prediction Intervals for KHAN Example

Heebner Shale
200 ft
LKC-Marmaton
Marm B
Oomoldic
Logs utilized:
- GR
- Density phi
- Pe
- ILD
St. Louis "C"
Oolitic with Between particle porosity
Mississippian
Horizontal not to scale

Cross section index in Terry Field

Well Profile showing portion of 700 ft interval for training and prediction

Heebner Shale

Training KHAN to recognize:
--Oil, Wet, Tight, Shale

entire LKC-Marmaton
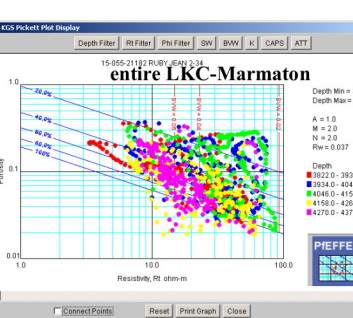
Generally not possible to accurately analyze pay from a long depth interval at one time in a conventional top down approach unless make assumptions about constant parameters.

Single Archie parameters are not necessarily valid for larger intervals.

PFEFFER Pay calculation using single set of cutoffs (blue curve)

Reservoirs with varying:
- Lithology (although not in this example)
- Pore geometry
- Pore type
- Archie m, n
- Log cutoffs

Rhomaa-Umaa X-plot & Lithology Plot
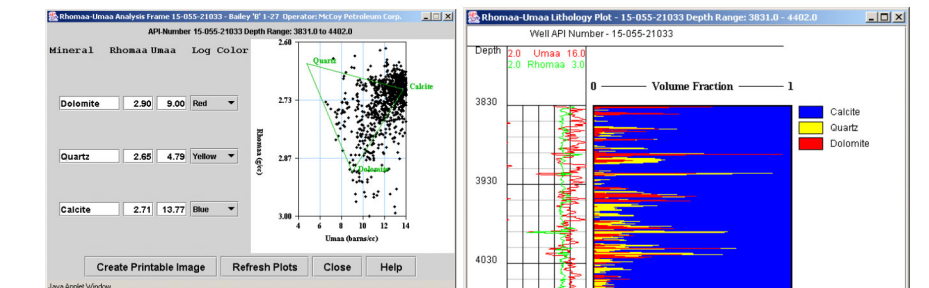
KHAN example also implicitly includes composition...

KHAN incorporates other petrophysical parameters besides porosity and resistivity as appropriate including composition to encompass lithofacies.