An automated procedure for the detailed analysis of geophysical well logs

Andrés Alcolea[1], Jens K. Becker[2], Paul Marschall[2]

[1]HydroGeoModels, [2]Nagra

Introduction

Facies interfaces are often located by interpreting combinations of well logs (e.g., natural and spectral gamma with caliper).

Standard practice in well logging:

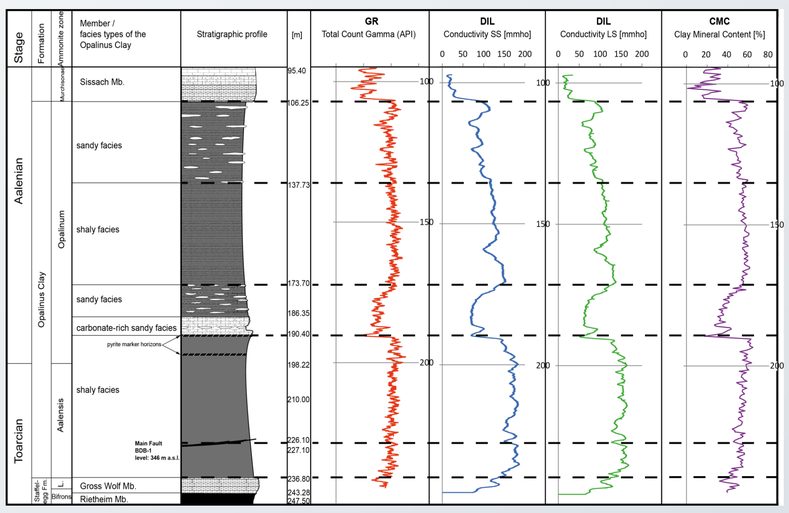
- Log analysis long after completion ⇒ loss of "first hand" information
- Slow ⇒ lack of feedback for on-site decisions.
- Subjective ⇒ not traceable
- Combination of thin layers in one single notably thicker layer ⇒ potential water conductive features or preferential migration paths missed

Objectives

Develop a workflow for automated interpretation of well logs:

- parameter based and objective ⇒ reproducible and traceable
- quick ⇒ feedback for on-site decisions
- accurate as the signal resolution

- **Outputs**:
  - ✓ location of interfaces and evaluation of uncertainty
  - ✓ identification of lithology
  - ✓ distribution of shale volume along the borehole
  - ✓ geostatistical inference of hydraulic properties, i.e., porosity and hydraulic conductivity

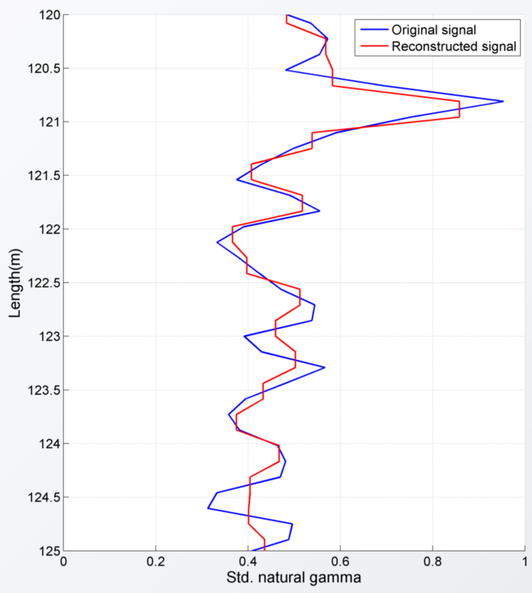


Traditional well logging.
Composite of well logs and facies interpretation.
Borehole BDB-1.

The figure displays, from left to right, a simplified stratigraphic profile, total gamma count (API), short spaced conductivity SS (mmho), long spaced conductivity LS (mmho) and clay mineral content (%). (modified from Reisdorf et al., 2016).

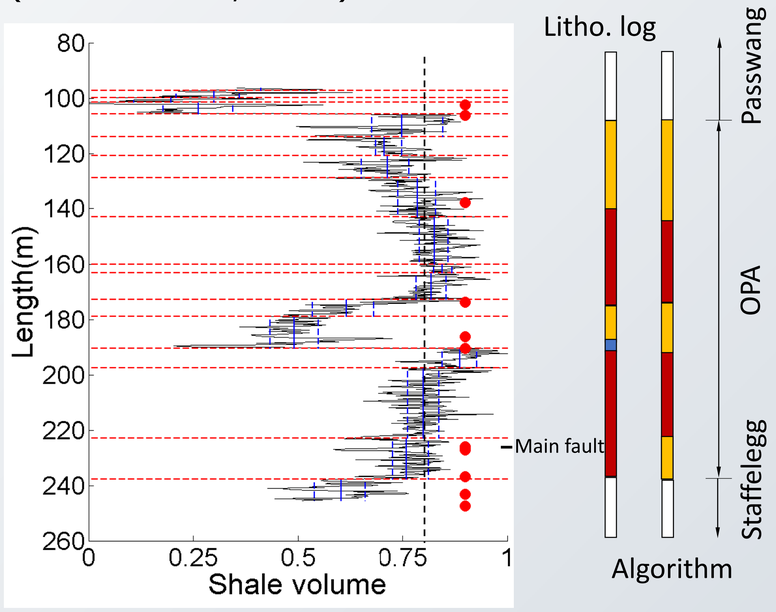
Methodology

Step 1: simplified equivalent signals (Lanning & Johnson, 1983).



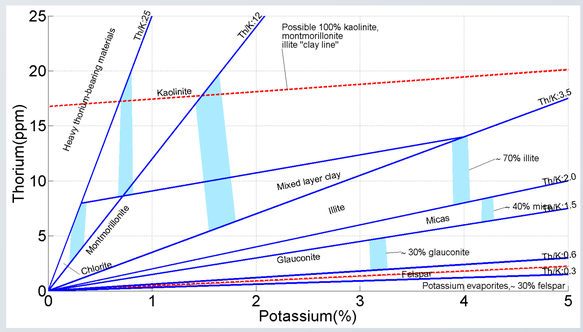
Original and reconstructed natural gamma signals.
Borehole BDB-1.

Step 2: automatic location of interfaces (Alcolea et al., 2015).



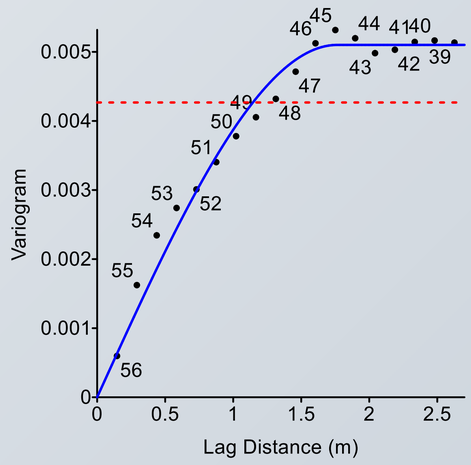
Located interfaces and calculated shale volume.

Step 3: lithology from shale volume and spectral gamma.



Th/K diagram. Identified facies borehole BDB-1.

Step 4: geostatistical inference.

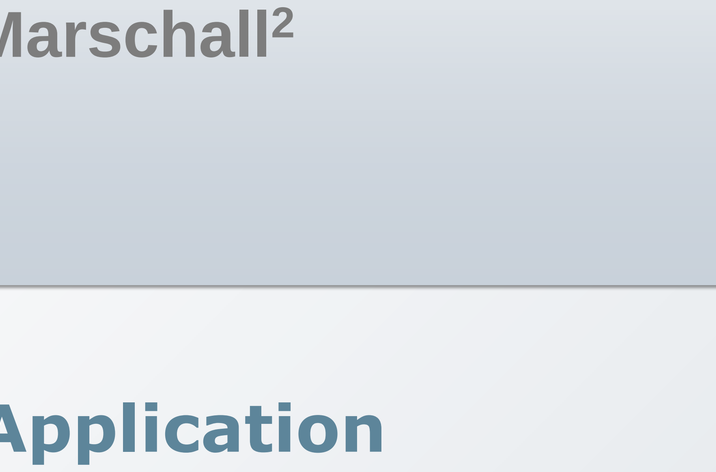


Variogram of shale volume. Facies 5, borehole BDB-1.

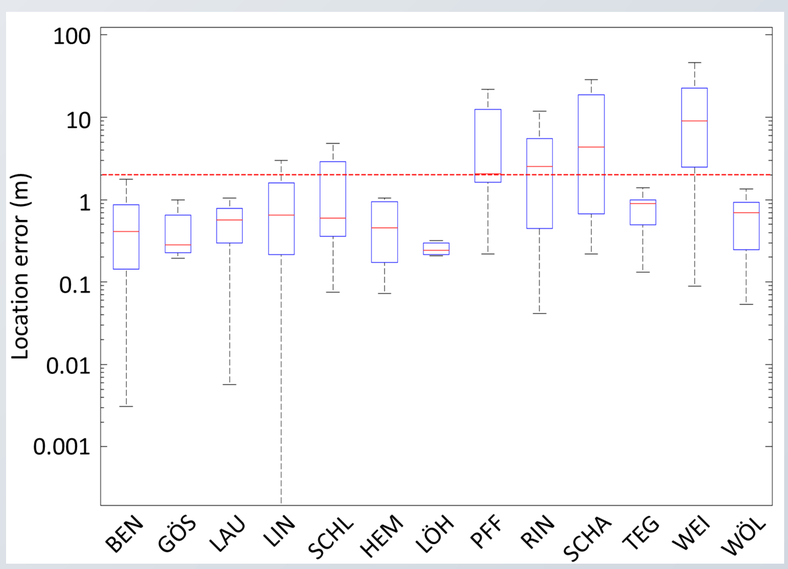
Application

13 boreholes in Northern Switzerland

Location of boreholes.



Location error of identified facies in borehole Benken.



Location error of identified facies in all boreholes.

Good accuracy
Large number of identified interfaces
Objective and traceable

Alcolea A., Becker J. K., Nussbaum Ch., 2015. VA Experiment: Interpretation of well logs from BDB-1, BVA-1 and BDS-4 boreholes; TN 2015-100.

Lanning E. N., Johnson D.M., 1983. Automated identification of rock boundaries: An application of the Walsh transform to geophysical well-log analysis. Geophysics v. 48, pp. 197-205.

Reisdorf, A.G., Hostettler, B., Jaeggi, D., Deplazes, G., Bläsi, H., Morard, A., Feist-Burkhardt, S., Waltschew, A., Dietze, V., Menkveld-Gfeller, U., 2016: Litho- and biostratigraphy of the 250m deep Mont Terri BDB-1 boreholre through the Opalinus Clay and bounding formations, St.-Ursanne, Switzerland. Technical Report 2016-02, Mont Terri Project.

Dr. Andrés Alcolea, HydroGeoModels
andres.alcolea@hydrogeomodels.ch
Dr. Jens Karl Becker, Nagra
jens.becker@nagra.ch
Dr. Paul Marschall, Nagra
paul.marschall@nagra.ch

HGM
HydroGeoModels

nagra.