Automatic interpretation of geophysical well logs

Andrés Alcolea*, Jens Karl Becker**

*HydroGeoModels, Tösstalstrasse 23, CH-8400 Winterthur
(andres.alcolea@hydrogeomodels.ch)
**Nagra, Hardstrasse 73, CH-5430 Wettingen

Facies interfaces are often located by interpreting combinations of well logs (e.g., natural and spectral gamma with caliper). Generally, this interpretation is made long after the logs were collected. This often leads to a loss of “first hand” information, as collected on-site. In addition, well log interpretation is usually slow and tedious, what hinders on-site decisions. To make things worse, (1) the standard interpretation is subjective and based on subtle “manipulations” of the raw data that are hardly traceable in the long run, and (2), small lithological changes (e.g., in clay content) or intercalated thin layers presenting different lithologies are often combined in one single (notably thicker) stratigraphic unit. Yet, such thin layers may be clearly visible in geophysical logs and are important (e.g., as preferential flow paths for contaminant migration or as water conducting features). Therefore, an automated, parameter based (and thus traceable) quick look of the lithology after log completion represents a valuable tool to help with on-site decisions (e.g., depth of the different lithological sub-units). To that end, an interpretation workflow and corresponding algorithm has been developed.

The algorithm consists of two main parts, i.e., the identification of facies and corresponding interfaces and the inference of hydrogeological properties (hydraulic conductivity and porosity). First, the algorithm uses a set of Walsh functions which enhances transitions in signal levels and weighs/combines information from all available well logs (e.g. caliper, density, natural and spectral gamma, neutron, etc.) to select a set of interfaces between facies. Identified facies can be as thin as the log accuracy (usually centimetre). In a second step, the algorithm identifies the lithology of the inferred facies using the Schlumberger standard diagram correlating Thorium to Potassium contents, provided that spectral gamma was measured. Third, the distribution of shale volume is inferred from the gamma log. Fourth, an estimate of the distribution of effective porosity along the borehole is obtained if the total porosity is known. Such distribution can also be correlated to that of hydraulic conductivity through empirical laws after some calibration process. The variability of the estimated (per facies) hydraulic properties, allows the deterministic estimation of variograms and other higher order statistics that are the starting point of the necessary posterior geostatistical (either deterministic or stochastic) modelling exercises.

This work presents the methodology and its application to a set of 16 boreholes in Mont Terri and northern Switzerland (Figures 1 and 2).

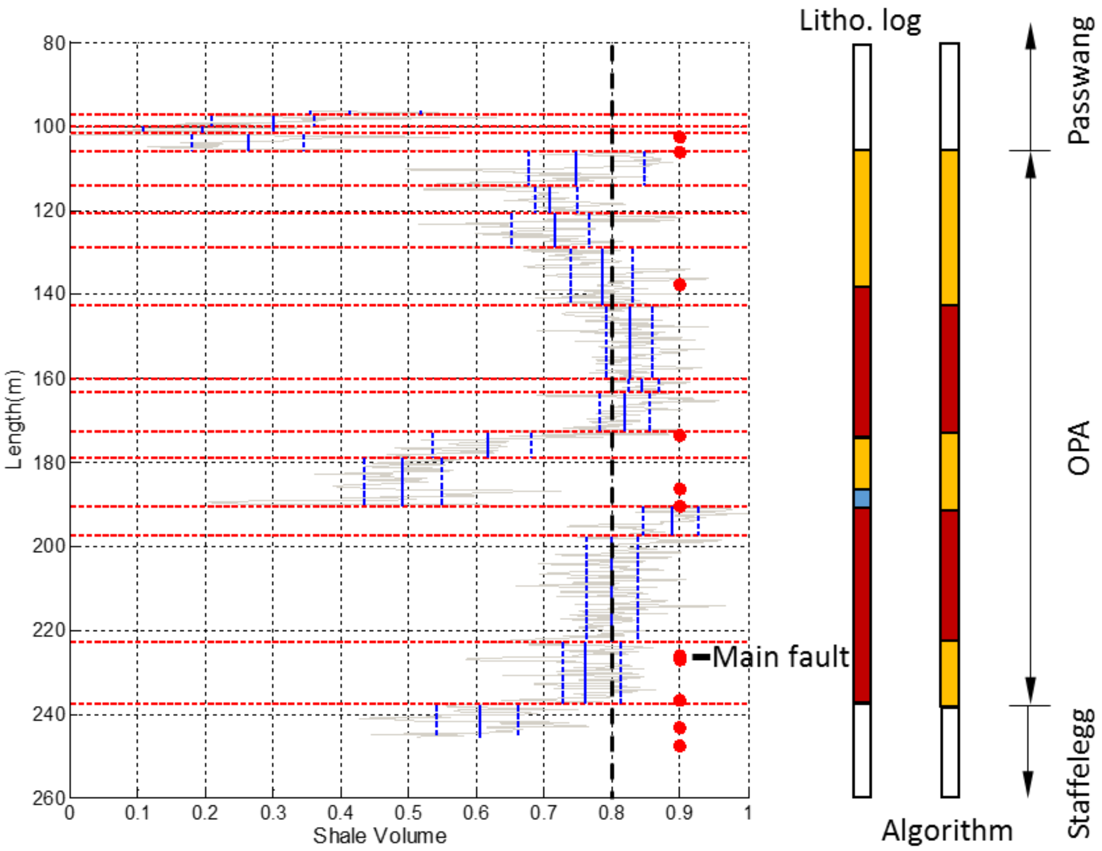

Figure 1. Identified facies mineralogy in borehole BDB-1 (Mont Terri). Orange, brown and blue rectangles on the right depict sandy, shaly and carbonate-rich sandy facies respectively. Red dots depict the facies interfaces from the manually interpreted lithostratigraphic logs, dashed red lines indicate the facies interfaces picked by the algorithm.

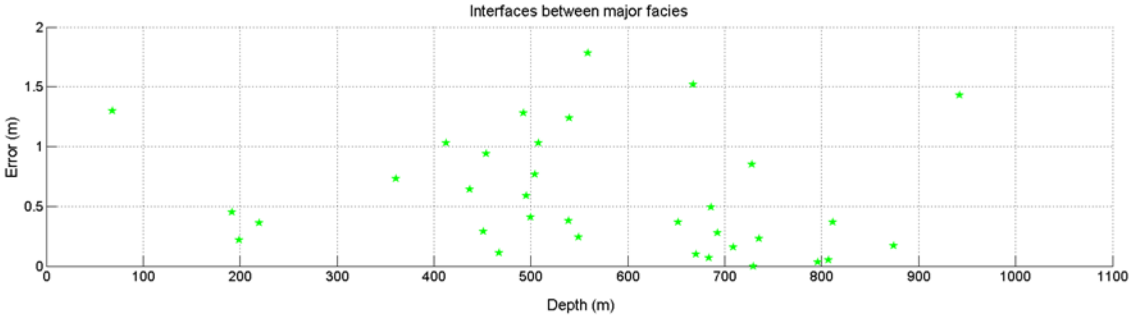

Figure 2. Identification errors of observed interfaces in Benken borehole.