Identification of Minerals and Rock types from Well Log Data

Arpita Roy and Rima Chatterjee
Dept. of Applied Geophysics, Indian School of Mines, Dhanbad, India
rima_c_99@yaho.com

Abstract:

It is now a relatively established procedure, with recent advances in logging technology, to be able to generate a comprehensive, continuous measurement of major element chemistry in the subsurface. Concurrent with these advances, strategies have been developed which transform elemental data, derived from nuclear logging measurements, into a set of mineral modes that accurately represent the mineralogy of a rock. Resulting mineralogy logs are potentially valuable on their own, especially for creating a geological model in the absence of (or to enhance) core measurements. Mineralogy logs can also be used for the determination of other petrophysically useful formation descriptors, such that in wells where core recovery is poor they can help to extend evaluation across poorly defined zones. With good acquisition, derived mineralogy may be used effectively for inter-well correlation and for the determination of enhanced estimates of matrix density and porosity.

Introduction:

It concerns identification and quantification in terms of volumes, of main minerals that are found in sedimentary rocks and rocks which are non-sedimentary in nature. Mineralogy and lithology are the fundamental signatures of a deposition or in general the genesis and diagenesis of rocks, and have seminal implications on arriving at the geological processes responsible for the formation of the rocks. On a more mundane front, mineralogy and lithology allow for a conceptualized modeling of the pore fabric and thereby, the transport properties, voidage etc of rocks in a cost effective manner, since continuous coring is not possible. The transport properties, expressed as permeability from the perspective of mineralogy, as well as from the perspective of texture as a expressed by pore size and throat distributions can be probed through magnetic resonance and high resolution imaging.

For the identification and quantification of the main minerals in sedimentary and non sedimentary rocks the principal tools are the different cross plots and least square error optimization based inverse modeling of the rocks to effect quantification of the main constituent minerals that are differentiated by logs (Ellis, 1987, Hertzog et al., 1989 and Jeremy, 1995). The inversion results are used to understand the lithology, texture and transport properties. To this end, the mineral volumes would be used to generate permeability estimates, with a calibration from NMR based permeability.

Methodology:

The work flow's first step is to depth match the input data, and cross plot the data as Density vs Neutron porosity, PEF vs potassium and thorium concentration vs potassium weight fraction. Elemental capture spectrometry allows generation of an inversion which is automated and available as a product, as quartz, mica, feldspar, carbonates, pyrites, gadolinium and samarium outputs, which help clarify the mineralogy as well as aid in the quantification of mineral presence, component wise. Elemental capture spectrometry data is also inverted into alkali oxides weight percentage, which is instrumental in generating the Total Alkali Silica (TAS) Diagram and thereby identify rock types, in case of non sedimentary rocks.

The second step would be to build a mineralogical model and use the same for inverting the log response data sets into mineral volumes. To this end the standard logs of density neutron gamma ray photo electric factor would be used. In case of non sedimentary rocks, the elemental capture spectrometry tool used would be integrated with other inputs to generate the volumetric inversion results.

In the inverse modeling process referred to above, log responses are forward modeled in accordance with standard tool response equations. The forward model is compared with the actual log measurements. Automatically the volumes are adjusted for reducing the error, one component volume adjusted at a time. The process continues as an automatic process and ends with a solution vector that leads to minimum squared error, where error is defined as difference between theoretical and actual log response. The squared errors are added using pre fixed weight factors with suitable normalizations already applied, to result in squared error, which is the cost function, whose being minimum is the necessary and sufficient condition for a valid solution vector.

The mineral volumes are used to arrive at permeability and to validate the same from NMR based permeability where available.

Conclusions:

The study involves the identification and quantification of the main minerals in sedimentary and non sedimentary rocks. The principal tools for these are the different cross plots and least square error optimization based inverse modeling of the rocks to effect quantification of the main constituent minerals that are differentiated by logs. The mineral volumes have been used to generate permeability estimates, with a calibration from NMR based permeability where MNR data is available.

References:

- Ellis, D. V. (1987) *Well Logging for Earth Scientists,* Elsevier, New York, 532 pp
- Hertzog, R., Colson, L., Seeman, B., O'Brian, M., Scott, H., McKeon, D., Grau, J. A., Ellis, D., Schweitzer, J. and Herron, M. M. (1989) Geochemical logging with spectrometry tools, *SPE Formation Evaluation,* 4. 153- 162.

- Jeremy L., Peter H. and Mike L. (*1995*) Reservoir characterization from downhole Mineralogy, *Marine and Petroleum Geology*, 12(3), 233-246.