Core-to-Log Integration and Calibration
(The Elastic Properties of Rocks?)

Barry Setterfield
LPS
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Core to Log Integration and Calibration (The elastic properties of rocks?)

- Measurements derived from core material are taken as definitive because they have been measured under standard laboratory conditions on rock samples derived from the reservoir.
- Log measurements are seen as having greater uncertainty in consequence of the tools, means and environment by which they are acquired.
- Industry has long sought to reconcile log derived measurements with those derived from cores. The subject is fraught with assumptions and uncertainty.
  - Firstly, there is the process of integration of the two measurements by depth matching the core and plug samples to the logs.
  - Secondly, there is the process of calibration of the log measurements using the core plug measurements.
- A review of the basic principles and techniques is presented, along with some of the uncertainties, assumptions and errors.
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Check Core

• Cored interval vs Recovery. Less than 100%? Where did it go?
• Lithology: clastic, carbonate, thin beds, massive beds, vugs etc?
• Is the core the right way up? Are coloured ‘tramlines’/arrows correct? Is the ‘Top’ the top and is the ‘Bottom' the bottom?
• Is the core accurately re-constructed?
• Are the core pieces in correct sequence? Do sedimentary features agree with this?
• Are there any missing pieces or gaps?
• When core is measured it is often assumed that lost material is from base. Is this the case?
• Do the core plug (H & V) depths agree with the plug hole depths in the core?
• Do the core photo’s match the core?
• Do core and core photo’s match image logs?
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Check Logs

• Are logs on-depth with each other?
• Does logger’s last casing shoe match Driller’s? Is there a depth discrepancy? How does this match initial core to log depth offset prior to shifting
• Are log responses correct? e.g. 57 us/ft in casing
• Are logs within tolerance? Check QC tails.
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Factors affecting depth matching

• Acquired using floating installation? Then was there a tidal correction between cores and/or between logging runs?
• Stump from previous core? At the top of the next core?
• Core barrel jams – signs of wear or erosion of core material?
• Loss of core material e.g. souvenirs?
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• Which curves to choose to match? e.g. Gamma Ray, Bulk Density, Porosity, Sw, Image Logs. Look for the Log curves with the most variable features.

• Single Core, block shift whole core? Block shift sections of cored interval? Depth shift individual plugs - dubious?

• Multiple Back-to-Back Cores. Block shift cores individually? Block shift sections of cored intervals? Depth shift individual plugs - dubious?

• Do not Stretch-Squeeze depth shift!
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First step is to create depth plots
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Then crossplots of the core data against the various log data

‘To some observers, the $y$-on-$x$ line-fit initially is awkward and less central than some other line-fits. The reduced-major-axis (RMA) line-fit, for example, follows the intuitive middle ground along the major axis of the data cloud (see Fig. 3). The "structural" line-fits estimate the relationship that would be observed if both the $y$ and $x$ variables were error-free. The RMA line provides this relationship for the particular case when $y$ and $x$ have equal fractional errors. These structural line-fits are not generally used in practice because, for their future use, they apply to error-free $x$-input data, not the real measured data. The RMA slope is defined by the ratio of the standard deviations (SDs) of $y$ and $x$ together with the sign of $r$. The $y$-on-$x$ slope is equal to the RMA slope multiplied by the correlation coefficient $r$. ‘

Woodhouse, R. 2003
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‘The initial impression of y-on-x does not weaken its status as the method with the lowest overall residual error in the required y estimates. When viewed from any position on the x-axis, the y-on-x line is central within the y-data values near that x-position (see Fig. 4). Providing average y-estimates from measured x-data is the main feature of y-on-x lines; however, the y-variance of the calibration data is not preserved by y-on-x predictions and the extremes of the y-range are averaged. The RMA line-fit does honour the y-variance; but if y and x are only moderately correlated, high porosity values are overestimated and low porosity values are underestimated (see Fig. 5). The depths of the RMA-predicted high and low y-values will not be at the same depths as the core high and low values. ‘

Woodhouse, R. 2003
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Factors to Consider

- Errors in ‘Y’?
- Errors in ‘X’?
- ‘Y’ Dependent Variable
- ‘X’ Independent Variable
- $y$-on-$x$ method assumes that the $y$ and $x$ measurements apply to the same rock sample
- Cores are not always regularly sampled
- To fix Zero Intercept or not? e.g. with average grain density
- Calibration lines should be determined for a single population
- There are circumstances when line-fits such as RMA should be considered e.g. carbonates
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Factors to Consider Cont..

• Orientation of Core and plugs relative to logging tool sensor orientation
• Plotting Horizontal or Vertical Plugs?
• Temperature change in bringing core to surface
• Change in wettability from virgin state
• Stress relief during recovery process i.e. unloading, de-gassing
• Damage during plugging, cleaning and drying processes
• Formation heterogeneity
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Plotting Porosity and Permeability

It is recognised that excellent porosity-permeability relationships can be obtained once the conventional core data are grouped according to their rock types.

- Flow Zone Indices (FZI)
- Reservoir Quality Indices (RQI)
- Hydraulic Units
References and Acknowledgements

- [http://petrowiki.org/Porosity_for_resource_in_place_calculations](http://petrowiki.org/Porosity_for_resource_in_place_calculations)
- SPWLA for use of PetroWiki material