GSWA Petrophysical Logs 2026

Explanatory Notes

To be used in conjunction with the petrophysical logs released as part of the WA CO2 Storage Atlas.

[Last updated: 12 June 2026]

Petrophysical interpretation methodology

Interactive Petrophysics (IP) well log analysis software, developed by Geoactive, was used to calculate clay volume, porosity, water saturation, and interval summations. No additional environmental corrections have been applied to the data collated from WAPIMS. It is acknowledged that some well log data may lack full environmental correction, which can reduce the accuracy of the interpreted values. Where available, routine core analysis data were used to calibrate variable grain density and porosity. Only wells with a minimum log dataset of gamma ray (GR), resistivity (RES), density (DENS) and neutron (NEUT) were selected for petrophysical interpretation. Bad hole conditions have been identified by a kill flag (KILLFLAG). No interpreted results are reported over these intervals.

A full listing of all interpretation parameters used in each interval of each well is available in Officer Basin Petrophysical Logs Parameters.xlsx and Perth Basin Petrophysical Logs Parameters.xlsx. Most parameters are used to initialize the porosity and saturation calculation and do not reflect the actual values used in calculations. Petrophysical interpretation results and the intermediate values used to calculate these results are downloadable.

Gamma ray rescaling

Final GR curves were often a composite of data acquired from behind casing and open-hole data. Because GR data from behind casing is typically subdued, it was adjusted by multiplying it by a factor necessary to match the GR range observed in open-hole conditions. After correcting each well to open-hole equivalents, GR data were rescaled. This rescaling ensures that GR values are displayed within the range of 0 to 150 API units, except in cases where the GR response indicated potential hot sands. These high GR spikes may still exceed display limits and wrap the well log display GR track. It is important to note that this rescaling process is purely cosmetic and does not normalize the GR response. The resulting GR curve is named GR_{NORM}.

Volume of shale

Volume of shale is calculated as an intermediate curve to help refine the final volume of clay. Shale volume contains clay minerals and shale sized matrix grains whereas clay volume is just clay minerals.

A crossplot solution for the density-neutron-derived volume of shale is obtained by defining a straight line between the matrix point and the fluid point for each interpreted interval, along with a 100% shale point. The DENS and NEUT well logs along with these three points serve as inputs to the equation cited below (Equation 1). The matrix and fluid points do not necessarily need to represent 0% and 100% fluid, respectively; rather, it is

the distance between the matrix–fluid line and the shale point that governs the calculation. Data points that lie along the matrix–fluid line are assigned 0% VSH, increasing to 100% VSH at the shale point.

$$VSH_{ND} = \frac{(\mathrm{DENS}_{fluid} - DENS_{matrix}) \times (NEUT - NEUT_{matrix}) - (\mathrm{DENS} - DENS_{matrix}) \times (\mathrm{NEUT}_{fluid} - NEUT_{matrix})}{(\mathrm{DENS}_{fluid} - DENS_{matrix}) \times (NEUT_{shale} - NEUT_{matrix}) - (\mathrm{DENS}_{shale} - DENS_{matrix}) \times (\mathrm{NEUT}_{fluid} - NEUT_{matrix})}$$

Equation 1: Neutron density volume of shale

A gamma ray volume of shale (VSH_{GR}) has been derived graphically for each interpreted interval by defining a clean GR value and 100% shale GR value (Equation 2). These values have been solved to replicate the VSH_{DN}. It is necessary to determine VSH_{GR} because gamma ray (GR) well log data is generally of higher quality than the neutron (NEUT) and density (DENS) log data.

Consequently, VSH_{GR} is typically used as the starting point for the iterative solution of porosity and water saturation.

$$VSH_{GR} = \frac{GR - GR_{clean}}{GR_{shale} - GR_{clean}}$$

Equation 2: Gamma ray volume of shale

The final volume of clay is an output of the iterative solution of porosity and water saturation, reported as the volume of wet clay (VWCL), which includes dry clay and clay bound water, consistent with effective porosity and volume of dry clay (VDCL), which includes just the volume of dry clay and is consistent with total porosity. Neither of these clay volumes are equivalent to the VSH starting point, but the shape of the final volume of clay curves should replicate VSH_{ND} as the final porosity volumes are generally derived from neutron density porosity.

Porosity

IP calculates effective volumes, which are then corrected to total volumes. The rock volume as a function of total porosity is represented by the curves: VOL_SAND, VOL_LST, VOL_DOL, VOL_SPM, VDCL, and PHIT. A second suite of curves showing rock volume relative to effective porosity includes VOL_SAND, VOL_LST, VOL_DOL, VOL_SPM, VWCL, and PHIE. Additional curves, VCOAL, VSALT, VANHY and KILLFLAG, identify intervals where the interpretation has been deliberately nulled to avoid spurious results (Figure 1).

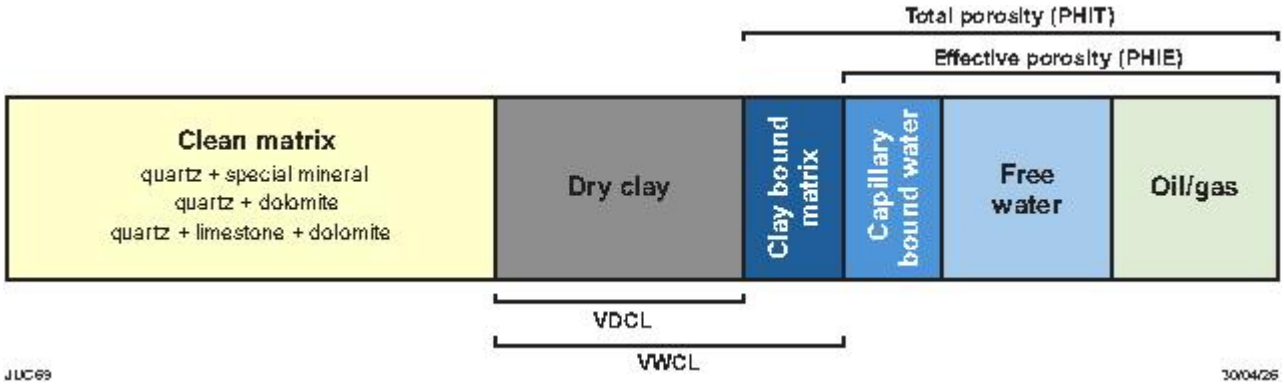


Figure 1: Petrophysical interpretation of rock matrix, clay volume and pore fluid distribution

Porosity has been determined using neutron-density data wherever possible. IP simultaneously solves for ϕ_N and ϕ_D porosity using Equations 3 and 4.

$$\Phi = \frac{\Phi_{neut} - VCL \times NEUT_{clay} + NEUT_{matrix} + Exfact + NEUT_{salinity}}{SXO + (1 - SXO) \times NEUT_{hyHI}}$$

Equation 3: Effective neutron porosity

$$\Phi = \frac{\rho_{matrix} - \rho_{bulk} - VCL \times (\rho_{matrix} - \rho_{clay})}{\rho_{matrix} - \rho_{fluid} \times SXO - \rho_{hyapp} \times (1 - SXO)}$$

Equation 4: Effective density porosity

Interactive Petrophysics (IP) begins with the assumption that water saturation (Sw) is equal to 1 and initializes using user-defined input values and then iteratively solves for porosity and water saturation. The process continues until the change in porosity and water saturation between successive iterations is less than 0.001, indicating convergence (Equation 5). Convergence is primarily obtained by varying the volumes of minerals from the nominated 2-mineral model chosen for each interval, including sand/limestone/dolomite, quartz/dolomite, or quartz/special-mineral combinations. If sand/limestone/dolomite is the nominated 2-mineral model it will vary volumes of sand and limestone for the condition $\phi_N < \phi_D$ and between limestone and dolomite when $\phi_N > \phi_D$. Away from carbonate intervals the 2-mineral model uses quartz and a special mineral with the mineral properties of pyrite. Importantly, special mineral volume is considered a composite of minerals denser than quartz is not considered to represent pyrite mineral volume.

$$\Phi = \Phi_{DENS1} + \frac{\Phi_{NEUT1} - \Phi_{DENS1}}{1 - (\Phi_{NEUT1} - \Phi_{NEUT2})/(\Phi_{DENS1} - \Phi_{DENS2})}$$

Equation 5: Neutron – density crossplot effective porosity solution

IP supports multiple variable inputs in the porosity and saturation equations. In this interpretation, all available variable options were enabled. These parameters are solved in a defined order: first, flushed zone saturation; then hydrocarbon density; followed by matrix density; and finally, volume of clay.

The variable invaded zone saturation option allows saturation in the invaded zone to be calculated directly from neutron-density data. This approach was found to yield more consistent results given the wide variety of resistivity inputs in the well log dataset.

For each of the remaining variables, the calculation begins with the initial input value and progressively solves toward a final value at each depth, constrained between preset minimum and maximum limits.

The resulting effective porosity is converted to total porosity by adding the volume of clay bound water back in via the calculation of volume of wet clay times total clay porosity where the total clay porosity has been calculated via Equation 6.

$$\Phi_{total\ clay} = \frac{(\rho_{dryclay} - \rho_{wetclay})}{(\rho_{dryclay} - \rho_{fluid})}$$

Equation 6: Total clay porosity

Effective porosity curves derived from neutron, density, sonic, neutron-density, and neutron-sonic logs—namely PHIE_NEUT, PHIE_DENS, PHIE_SON PHIE_ND and PHIE_NS —are also available. These intermediate curves allow for a quick assessment of well log data quality. When these curves align the well log data and porosity interpretation parameters are likely of good quality. Offsets in one or more curves typically indicate poor-quality log data or poor fitting porosity interpretation parameters.

Saturation

Total water saturation was calculated using the Archie equation (Archie, 1952). A single water resistivity was estimated from the Pickett Plot (Pickett, 1973) for each interpretation interval in each well. The Pickett Plot was filtered to show effective porosities above 10% and volume of wet clay less than 30% when solving for formation water resistivity. The saturation exponent, *n*, was kept constant at 2 and a variable *m* exponent was calculated from the Shell formula (Equation 7) (Winsauer and Shearin, 1952), after initializing with an m exponent derived from the Pickett Plot for each interpreted interval. The initial m exponent has been used in the graphical solution of formation water resistivity in each interpreted interval.

$$\boldsymbol{m = 1.87 + \frac{0.018}{\Phi_e}}$$

Equation 7: Shell formula variable m

If coal, salt or anhydrite logic have been selected then an output curve equal to 1 will be created for VCOAL, VSALT or VANHY if the density, neutron and/or sonic values meet the required thresholds. In this circumstance all porosity outputs are set to 0.0 and water saturation outputs are set to 1.0.

Interval Summations

The net flag (NET) denotes where the volume of wet clay is less than 30% and the effective porosity is greater than 10%. These cut-offs reflect intervals with effective storage capacity but do not reflect effective hydraulic capacity. No minimum thickness has been applied.

Mnemonics

DEPTH	.m	: Depth
BVW	.v/v	: Bulk volume water (Phie x Sw)
BVWT	.v/v	: Bulk volume water total (Phit x Swt)
GDENS	.g/c3	: Equivalent core grain density
GR_NORM	.api	: Gamma Ray rescaled from 0 to 150
KILLFLAG	.	: Badhole
M_VAR	.	: Variable m exponent
NET	.	: Net reservoir
PHIE	.v/v	: Effective porosity
PHIE_DEN	.v/v	: Effective porosity from density
PHIE_ND	.v/v	: Effective porosity from density neutron
PHIE_NEUT	.v/v	: Effective porosity from neutron
PHIE_NS	.v/v	: Effective porosity neutron sonic
PHIE_SON	.v/v	: Effective porosity from sonic
PHIT	.v/v	: Total porosity
RHOFL	.g/c3	: Fluid density
RHOHY	.g/c3	: Hydrocarbon density
RHOMA	.g/c3	: Matrix density
SWE	.v/v	: Effective water saturation
SWT	.v/v	: Total water saturation
TEMP	.degC	: Formation temperature
VANHY	. v/v	: Volume of anhydrite
VCOAL	.v/v	: Volume of coal
VDCL	.v/v	: Volume of dry clay
VOL_DOL	.v/v	: Volume of dolomite
VOL_LST	.v/v	: Volume of limestone
VOL_SPM	.v/v	: Volume of special mineral
VOL_SAND	.v/v	: Volume of quartz

VSALT	.v/v	: Volume of salt
VSH_GR	.v/v	: Gammaray volume of shale
VSH_ND	.v/v	: Neutron density volume of shale
VWCL	.v/v	: Volume of wet clay
AZI	.deg	: Borehole azimuth
INC	.deg	: Borehole inclination
TVD	.m	: True vertical depth
TVDSS	.m	: True vertical depth subsea
YLOC	.m	: Y Coordinate
XLOC	.m	: X Coordinate
NORTHING	.m	: Borehole Northing
EASTING	.m	: Borehole Easting

References

Archie, GE 1952, Classification of carbonate reservoir rocks and petrophysical considerations: AAPG Bulletin, v. 36, no. 2, p. 218–298.

Pickett, GR 1973, Pattern recognition as a means of formation evaluation: The Log Analyst, v. 14, no. 4, p. 3–11, https://onepetro.org/petrophysics/article-abstract/171683/Pattern-Recognition-As-A- Means-Of-Formation?redirectedFrom=fulltext.

Winsauer, WO and Shearin, HM 1952, Resistivity of brine-saturated sands in relation to pore geometry: AAPG Bulletin, v. 36, p. 253–277, doi:10.1306/3D9343F4-16B1-11D7-8645000102C1865D.

Contact

For further information contact: petdata@dmpe.wa.gov.au