Sonic Porosity

The sonic porosity is usually abbreviated **SPHI** or **PHIS** on log panels and denoted as ϕ_s in equations.

The key measurement is the p-wave velocity $V_{p\,log}$ from sonic tool readings.

The key model parameter is rock matrix sonic velocity $V_{p\,m}$ which is calibrated for each facies individually and can be can be assessed as vertical axis cut-off on $V_{p\,log}$ cross-plot against the core-data porosity ϕ_{air}.

The model also accounts for saturating rock fluids with p-wave velocity $V_{p\,f}$ value.

In overbalance drilling across permeable rocks the saturating fluid is usually mud filtrate.

In underbalance drilling this the saturating fluid is identified from resistivity logs.

WGG Equation (Wyllie)

The **WGG** sonic porosity ϕ_s equation is :

(1) $$\frac{1}{V_{p\,log}} = \frac{1-\phi_s\,C_p}{V_{p\,m}} + \frac{\phi_s\,C_p}{V_{p\,f}}$$

where C_p is compaction factor, accounting for the shaliness specifics and calculated as:

(2) $$C_p = \frac{V_{shc}}{V_{sh}}$$

where

V_{sh} – p-wave velocity for adjacent shales,

V_{shc} – p-wave velocity reference value for tight shales (usually 0.003 ft/s).

GGG Equation (Gardner, Gardner, Gregory)

The **GGG** sonic porosity ϕ_s equation is :

(3) $$\frac{1}{V_{p\,log}^{1/4}} = \frac{(1-\phi_s)}{V_{p\,m}^{1/4}} + \frac{\phi_s}{V_{p\,f}^{1/4}}$$

The above equation is based on the Gardner correlation for sonic density:

(4) $$\rho_s = 171 \cdot V_{p\,m}^{1/4}$$

where ρ_s is measured in $\left[\frac{\text{m}^3}{\text{kg}}\right]$ and $V_{p\,m}$ is measured in $\left[\frac{\text{m}}{\mu\text{s}}\right]$

and mass balance equation:

(5) $$\rho_s = (1 - \phi_s)\rho_m + \phi_s \rho_f$$

RHG Equation (Raymer, Hunt, Gardner)

The **RHG** sonic porosity ϕ_s equation is :

(6) $$V_{p\,log} = (1 - \phi_s)^2 V_{p\,m} + \phi_s V_{p\,f}$$

and only valid for $\phi_s < 0.37$.