

Formation Acoustic Log @model

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 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 :

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

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

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

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 :

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

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

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

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

and mass balance equation:

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

RHG Equation (Raymer, Hunt, Gardner)

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

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

and only valid for $\phi_s < 0.37$.