

# Volumetric Rock Model (VRM)

@wikipedia

The rock volume  $\Omega_r$  is split into three major components: pore volume  $\Omega_e$ , **shale** volume  $\Omega_{sh}$  and rock matrix  $\Omega_m$ :

$$(1) \quad \Omega_r = \Omega_e + \Omega_{sh} + \Omega_m$$

The usual practice is to use relative volumes:

$$(2) \quad \phi_e = \frac{\Omega_e}{\Omega_r}, \quad V_{sh} = \frac{\Omega_{sh}}{\Omega_r}, \quad V_m = \frac{\Omega_m}{\Omega_r}$$

which are measured in V/V units (or fracs) and honor the following constraint:

$$(3) \quad \phi_e + V_{sh} + V_m = 1$$

The relative pore volume  $\phi_e$  is also called **effective porosity (PHIE)** and contains **free** and **connate fluids** (water, oil, gas).

It corresponds to air porosity of the dried laboratory cores:  $\phi_e = V_{\text{air core}}$ .

The relative **shale** volume  $V_{sh}$  is called **shaliness** and contains three major components: **silt**  $V_{\text{silt}}$ , **clay**  $V_c$  and **clay bound water**  $V_{\text{cbw}}$ :

$$(4) \quad V_{sh} = V_{\text{silt}} + V_c + V_{\text{cbw}}$$

The log name is **VSH**.

The **clay bound water**  $V_{\text{cbw}}$  is usually measured as the fraction of shale volume:

$$(5) \quad V_{\text{cbw}} = s_{\text{cbw}} \cdot V_{sh}$$

where  $s_{\text{cbw}}$  is called **bulk volume water of shale (BVWSH)**.

The **total porosity** is defined as the sum of **effective porosity**  $\phi_e$  and **clay bound water**  $V_{\text{cbw}}$ :

$$(6) \quad \phi_t = \phi_e + V_{\text{cbw}} = \phi_e + s_{\text{cbw}} V_{sh}$$

The log name is **PHIT**.

The term **total porosity** is more of a misnomer as it actually does not represent a pore volume for free flow as the **clay bound water** is essential part of the rock solids.

Nevertheless, the **total porosity** property has been adopted by petrophysics as a part of interpretation workflow where the intermediate value of **total porosity** from various sensors leads not only to **effective porosity** but also to **lithofacies analysis**.

The **effective porosity** is not a final measure of the volume available for flow.

It includes the [unconnected pores](#) which do not contribute to flow:

$$(7) \quad \phi_e = \phi_{\text{connected}} + \phi_{\text{closed}}$$

Besides the [connected effective pore volume](#)  $\phi_{\text{open}}$  includes the connate fluids which may be not flowing in the practical range of subsurface temperatures, pressure gradients and sweeping agents:

$$(8) \quad \phi_{\text{connected}} = \phi_{\text{free}} + \phi_{\text{connate}}$$

Finally, the pore volume available for flow is represented by the following formula:

$$(9) \quad \phi_{\text{flow}} = \phi_e \cdot (1 - s_{\text{connate}})$$

where

$s_{\text{connate}} = \frac{\phi_{\text{connate}}}{\phi_{\text{open}}}$	a fraction of pore volume, occupied by connate fluid (usually water or oil) and estimated in laboratory <a href="#">Special Core Analysis (SCAL)</a>
---	--

As one may expect the  $\phi_{\text{flow}}$  value has the most linear correlation with [permeability](#).