Volumetric Rock Model (VRM)

@wikipedia

The rock volume Ω_r is split into three major components: pore volume Ω_e, shale volume Ω_{sh} and rock martix Ω_m :

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

The usual practice is to use relative volumes:

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

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

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

The relative pore volume ϕ_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_{silt} , clay V_c and clay bound water V_{cbw} :

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

The log name is **VSH**.

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

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

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

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

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

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) $$\phi_e = \phi_{\rm connected} + \phi_{\rm closed}$$

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

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

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

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

where

$s_{\rm connate} = \dfrac{\phi_{\rm connate}}{\phi_{\rm open}}$	a fraction of pore volume, occupied by connate fluid (usually water or oil) and estimated in laboratory Special Core Analysis (SCAL)

As one may expect the $\phi_{\rm flow}$ value has the most linear correlation with permeability.