high frequencies. The attenuation reaches zero. However, in the squirt or local flow, there is a modified solid that includes the soft pores, and the modified frame has rock porosity corresponding to stiff pores. Therefore, squirt flow describes the interaction between the matrix and the fluid inside the pores in the rock.

Dvorkin *et al.*, (1995) extended the squirt flow mechanism by Mavko and Jizba (1991) to estimate velocity dispersion and inverse quality factors for low and high frequencies employing the complex bulk elastic modulus of the saturated rock (K_r) that is given by:

$$K_r = \frac{K_\mathrm{m}}{1 - \alpha_\mathrm{m} dP/d\sigma}, \quad (1)$$

Where K_m is the bulk modulus of the modified solid, $\alpha_\mathrm{m}=1-K_\mathrm{m}/K_\mathrm{ms}$, K_ms is the bulk modulus of the saturated modified solid, and $dP/d\sigma$ is the ratio between pore pressure and hydrostatic confining stress (Appendix A).

The complex shear modulus of the modified solid (μ_m) is given by:

$$\mu_m = \left[\frac{1}{\mu_{dry}} - \frac{4}{15}\left(\frac{1}{K_\mathrm{dry}} - \frac{1}{K_\mathrm{md}}\right)\right]^{-1}, \quad (2)$$

where μ_{dry} and K_{dry} are the dry shear modulus and the dry bulk modulus, respectively. K_md is the dry bulk modulus modified (See Appendix A).

The complex compressional modulus (M_m) is calculated from:

$$M_m = K_r + {}^4/_3\, \mu_m \quad (3)$$

The compressional (V_P) and shear wave (V_S) velocities consider the real part of M_m and μ_m, correspondingly:

$$V_P = \sqrt{\frac{Re(M_m)}{\rho_{sat}}}, \quad V_S = \sqrt{\frac{Re(\mu_m)}{\rho_{sat}}}, \quad (4)$$

where ρ_{sat} is the saturated density.

The inverse quality factors of P-wave (Q_P^{-1}) and S-wave (Q_S^{-1}) are the ratio of the real and the imaginary part of M_m and μ_m, respectively. The Q_P^{-1} and Q_S^{-1} are given by:

$$Q_\mathrm{P}^{-1} = \left|\frac{\mathrm{Im}(M_m)}{Re(M_m)}\right|, \quad Q_\mathrm{S}^{-1} = \left|\frac{\mathrm{Im}(\mu_m)}{Re(\mu_m)}\right| \quad (5)$$

Dvorkin *et al.*, (1995) introduced the *Z* parameter which is the ratio of characteristic squirt flow length (*R*) and the diffusivity of the soft pore (k):

$$, \quad Z = \sqrt{\frac{R^2}{\mathrm{k}}}, \quad (6)$$

R is a parameter that represents the radial flow of fluid inside pores with grains (Murphy *et al.*, 1986), not depending on the frequency. Finding *Z* is matching the measured velocities with predicted velocities by the squirt flow model. Figure 1 presents the squirt flow mechanism due to the elastic wave propagation from a sonic tool in a well.

2.2 Methodology

The proposed methodology consists of four stages (Figure 2). The first stage is the petrophysical evaluation, where properties such as total porosity (PHIT), effective porosity (PHIE), water saturation (S_w), hydraulic permeability, and mineralogy are estimated from density (RHOB), neutron (NPHI), resistivity, and sonic well logs.

The second stage is the rock physics modeling, which comprises two steps; bringing the interval to be examined to a common fluid denominator and finding a model that matches and explains well log data through velocity-porosity relationship (Dvorkin *et al.*, 2014). The squirt flow model requires the effective dry rock elastic moduli (K_dry) obtained from the static rock physics modeling.

The third stage is the inversion for obtaining *Z*, dispersion of velocities and inverse quality factors (Q_P^{-1}, Q_S^{-1}). Here, the simulated annealing approach was used for solving the objective function given by:

where $V_\mathrm{P\text{-}log}$ and $V_\mathrm{S\text{-}log}$ are the measured P- and S-wave velocities from well logs. $V_\mathrm{P\text{-}ult}$ and $V_\mathrm{S\text{-}ult}$ are the P- and S-wave velocities estimated from core velocities. V_P (0.5 MHz,10 KHz) and V_S(0.5 MHz,10 KHz) are the predicted P- and S-wave velocities by the squirt model at these frequencies. w_i, where subscript i=1-4 indicates the weighting factors to velocities, respectively.

The fourth stage corresponds to establish the correlation between the hydraulic permeability with the *Z* parameter and attenuations in terms of inverse quality factors. This correlation