

Supplementary Material for: Experimental insights into factors influencing Vp/Vs ratios at the Nevado del Ruiz Volcano, Colombia

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Aguilera Bustos & Adam (2023) should be cited if this material is used independently of the article.

KT model [Kuster and Toksöz 1974] estimates the effective bulk K_{KT} and shear μ_{KT} moduli as a sum of volumetric contributions of the different inclusion geometries:

$$(K_{KT} - K_m) \frac{K_m + \frac{4}{3}\mu_m}{K_{KT} + \mu_m} = \sum_{i=1}^N x_i (K_i - K_m) P^{mi} \quad (1)$$

$$(\mu_{KT} - \mu_m) \frac{\mu_m + \frac{4}{3}\zeta_m}{\mu_{KT} + \zeta_m} = \sum_{i=1}^N x_i (\mu_i - \mu_m) Q^{mi} \quad (2)$$

where $\zeta_m = \frac{\mu_m}{6} \left(\frac{9K_m + 8\mu_m}{K_m + 2\mu_m} \right)$; K_m and μ_m are the bulk and shear moduli of the minerals, respectively. K_i and μ_i are the bulk and shear moduli of the inclusions, respectively; x_i is the volume fraction of each inclusion type multiplied by the porosity; and the coefficients P^{mi} and Q^{mi} are coefficients that include the type of inclusion shapes. For penny-shaped cracks and spheres, these coefficients are given by [Walsh 1969; Kuster and Toksöz 1974; Berryman 1995]:

$$P^{mi}(\text{spheres}) = \frac{K_m + \frac{4}{3}\mu_m}{K_i + \frac{4}{3}\mu_m} \quad (3)$$

$$Q^{mi}(\text{spheres}) = \frac{\mu_m + \zeta_m}{\mu_i + \zeta_m} \quad (4)$$

$$P^{mi}(\text{penny}) = \frac{K_m + \frac{4}{3}\mu_i}{K_i + \frac{4}{3}\mu_i + \pi\alpha\beta_m} \quad (5)$$

$$Q^{mi}(\text{penny}) = \frac{1}{5} \left(1 + \frac{8\mu_m}{4\mu_i + \pi\alpha(\mu_m + 2\beta_m)} + 2 \frac{K_i + \frac{2}{3}(\mu_i + \mu_m)}{K_i + \frac{4}{3}\mu_i + \pi\alpha\beta_m} \right) \quad (6)$$

where $\beta_m = \mu_m \left(\frac{3K_m + \mu_m}{3K_m + 4\mu_m} \right)$ and α is the aspect ratio of the pennies. This model is based on isolated and idealized pore

shapes by the assumption of no fluid flow between inclusions (pores or cracks) so it can model the rock elastic properties at high frequencies (ultrasonic). It also assumes randomly distributed, isolated and in small volumes inclusions. The inclusion sizes are smaller than the wavelength. We simply calculate V_p and V_p/V_s by:

$$V_P = \sqrt{\frac{K_{KT} + 4/3\mu_{KT}}{\rho}} \quad (7)$$

$$V_P/V_S = \sqrt{\frac{K_{KT}}{\mu_{KT}} + \frac{4}{3}} \quad (8)$$

where $\rho = (1 - \phi)K_m + \phi$, K_i is the bulk density and ϕ is the total rock porosity.

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