Geophysical Research Abstracts
Vol. 14, EGU2012-5733, 2012
EGU General Assembly 2012

Vp/Vs Ratio: Dispersion and Anisotropy Effects in Cracked Rocks

X.-q. Wang (1,2), A Schubnel (2), J Fortin (2), Y Gueguen (2), and H.-q. Ge (1)

(1) Institute of Geophysics, China Earthquake Administration, 5 Minzudaxue South Road Haidian,10081 Beijing China, (2) Laboratoire de Geologie,Ecole Normale Superieure,CNRS,UMR 8538,24 Rue Lhomond,75005 Paris France

Rocks may contain variable amount of cracks depending on tectonic stresses and geological settings. Crack density, geometry and orientation influence elastic wave velocities and the development of elastic anisotropy. When rocks are fluid saturated, the frequency dispersion of P and S waves should be considered. In this study, we investigate two different models: the first one consists of a randomly oriented cracked medium; the second one of a horizontally aligned cracked medium. In both cases, we investigate how the crack density and the crack orientation geometry influence the (apparent) Vp/Vs ratio at high (MHz – laboratory case) and low (less than KHz – field case) frequencies.

The first model of randomly orientated cracks results obviously in zero anisotropy. The HF elastic moduli are derived from a non-interactive effective medium theory (EMT). LF saturated moduli are obtained using the HF dry moduli and substituting them into the extended Biot-Gassman equations. At high frequency, our results show that the Vp/Vs ratio ranges from 1.6 to 1.8 in the dry case, and from 1.6 to 2.1 in the saturated case, in good agreement with experimental data obtained on Westerly granite, Carrara marble and a low porosity (4%) Fontainebleau sandstone. A maximum Vp/Vs ratio of 2.1 is obtained for rocks with a crack density of 0.5 and crack aspect ratio of 10^{-4}. The Vp/Vs ratio dispersion only varies from -5% to 0, which means the frequency regime has only little influence on the Vp/Vs ratio variations.

The second model, consisting in horizontally aligned cracks, results in a maximum anisotropy, but no dispersion. In this case, Thomsen's parameters are used to characterize anisotropy. We show that fluid effects on anisotropy are mainly important for low crack aspect ratio and high crack density, in good agreement with Guéguen and Sarout (2011). Considering now an apparent Vp/Vs ratio as a function of the ray angle relative to the crack fabric (varying from 0 to 90°), we demonstrate that both Vp/Sv and Vp/Sh can easily vary from 1.2 to 3.5. Maximum apparent Vp/Vs ratios ($>$2.5) are obtained for large crack densities ($>$0.25) and low aspect ratios ($<10^{-3}$) and for wave propagating along the crack fabric (for both Sv and Sh waves) or perpendicular to the crack fabric (for Sv waves only).

From the above results, we conclude that crack anisotropy has a larger influence than the crack density on the apparent Vp/Vs ratio. These are important observations, from which we argue the possibility that high Vp/Vs ratio ($>$2.2) as recently imaged by seismic tomography in subduction zones might in fact not correspond to high pore fluid pressures zones, but rather to artefact of raypath sampling in zones presenting important crack anisotropy or mineral fabric (Bezacier et al. 2010). These results might prove to be useful for geophysicists to interpret seismic data in terms of fluid and rock interactions.