

3D VELOCITY DISTRIBUTION OF P AND S WAVES IN ROCKS BY MEANS OF ULTRASONIC AND NEUTRON DIFFRACTION STUDY

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The knowledge of 3D velocity distribution of P- and S-waves in rocks is very important parameter for interpretation and understanding the nature of seismic anisotropy observed in the earth's crust and upper mantle. A new high-pressure measuring head was designed and constructed to enable ultrasonic sounding of spherical rock samples in 132 independent directions under up to 60 MPa of acting hydrostatic pressure by means of simultaneous longitudinal and transversal sounding. New measuring system enables ultrasonic sounding of spherical rock samples by using a pair of P-wave sensors and two pairs of perpendicularly polarized S-wave sensors (T_V and T_H) see Fig.1. Shear wave sensors polarization is oriented according to rotation axis of the sample. Special shear wave gel was used to transfer shear waves between the sample and sensors under acting hydrostatic pressure. An isotropic glass sphere was used to check and calibrate the new measuring setup [1]. A spherical sample of a biotite gneiss from the Outokumpu scientific drill hole was used for testing measurement. There is shown that both, P- and S-wave velocities, can be measured simultaneously up to 70 MPa, respectively. We report data of the 3D velocity distribution of P- and S-waves measured for the first time on a sample sphere of biotite gneiss. We rely, in particular, on the directional dependence of compressional and shear wave propagation and their relationship to the crystallographic (CPO) and shape preferred orientation (SPO) of major rock-forming minerals. The 3D seismic measurements revealed a strong foliation-related directional dependence (anisotropy) of P- and S-wave velocities. Ultrasonic measurements were compared with 3D velocity calculations based on neutron diffraction measurements of crystallographic preferred orientation (CPO) of major minerals. Comparison of 3-D velocity distribution (P, S1, S2 and S1-S2) determined by two completely different methods ultrasonic sounding and neutron diffraction is shown in Figure 2. Measurements showed that the intrinsic bulk anisotropy is basically caused by the CPO of biotite constituting about 23 vol.% of the rock [2].

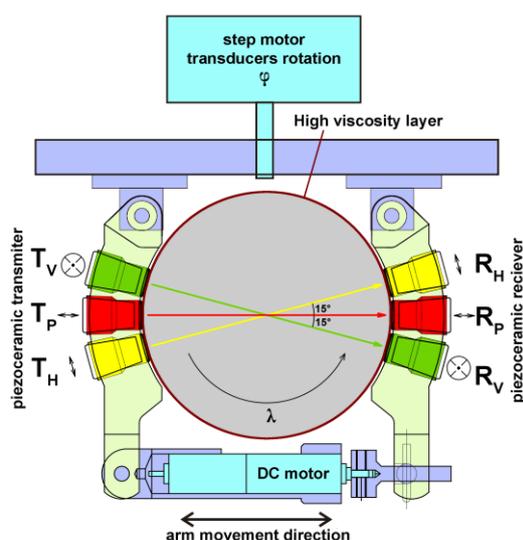


Figure 1: Measuring arrangement of spherical sample by P and S waves under high confining stress.

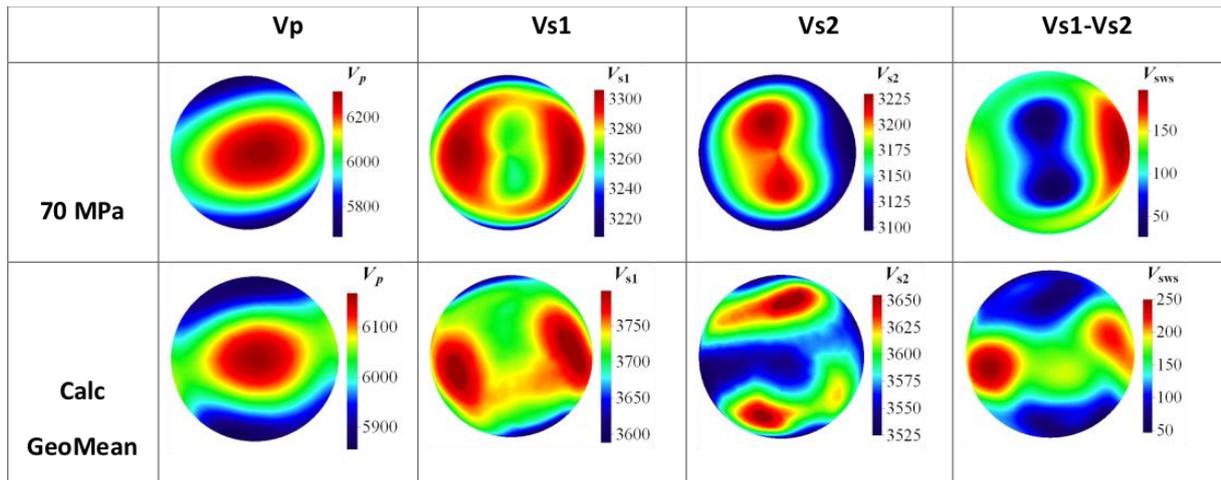


Figure 2: 3-D distribution of P, S1, S2 and S1-S2 velocities. Upper row - 3-D distribution determined by ultrasonic at 70 MPa, Lower row – 3-D distribution determined by neutron diffraction.

References

- [1] T. Lokajíček and T. Svitek: Laboratory approach to the study of elastic anisotropy in spheres by simultaneous longitudinal and transverse sounding under confining pressure, *Ultrasonics*, 56 (2015), 294-302
- [2] T. Lokajíček, H. Kern, T. Svitek and T. Ivankina: 3D velocity distribution of P- and S-waves in a biotite gneiss, measured in oil as the pressure medium: Comparison with velocity measurements in a multi-anvil pressure apparatus and with texture-based calculated data, *Phys. Earth Planet. Inter.*, 231 (2014), 1–15