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Influence of confining and pore fluid pressures on velocity and conductivity of water-saturated rock

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Pore fluid pressure in seismogenic zones can play a key role in the occurrence of an earthquake (e.g., Sibson, 2009). Its evaluation via seismic velocities and electrical conductivity can lead to a good understanding of seismic activities. It is essential to understand how seismic velocities and electrical conductivity reflect the pore fluid pressure. We have conducted measurements of elastic wave velocity and electrical conductivity of a water-saturated rock for various confining and pore fluid pressures.

Measurements have been made using a 200 MPa hydrostatic pressure vessel, in which the confining and pore fluid pressures can be separately controlled (Watanabe et al., 2008). Conductivity measurement requires the electrical isolation between water in a rock sample and the metal work of the pressure vessel. A plastic (PEEK) endpiece was specially designed to get electrical isolation between water in a sample and the metal work. The endpiece has a built-in plastic (DURACON) piston, which passes the pressure of oil from an external pump to the pressure of water in a sample. A good linear relationship between the oil and water pressures has been confirmed. The friction of the piston causes only 2-3% difference between oil and water pressures.

Berea sandstone was used for its high porosity (19.1%) and permeability (3x10^{-13} m^2). Cylindrical samples have dimension of 25 mm in diameter and 30 mm in length. Their axes are perpendicular to the sedimentation bed. The grain size is 100-200 micrometer. A dry sample has Vp=3.2-3.3 km/s and Vs=1.9-2.0 km/s in the direction perpendicular to the axis, and Vp=3.0-3.1 km/s and Vs=1.9 km/s in the direction parallel to the axis. Velocities are slightly lower in the direction perpendicular to the sedimentation bed. A water-saturated sample has Vp=3.5 km/s and Vs=2.1 km/s in the direction perpendicular to the axis. A significant increase in Vp is caused by water saturation. When the pore fluid pressure is kept constant, Vp and Vs increase with increasing confining pressure. When the confining pressure is kept constant Vp and Vs decrease with increasing pore fluid pressure. The effective confining pressure is defined by the difference between the confining and pore fluid pressures. The change in Vp and Vs shows a good correlation with the effective confining pressure. Vp and Vs increases with increasing effective confining pressure. Only a small increase is observed when the effective confining pressure is higher than 60 MPa. Similar results on Berea sandstone have been already reported by Christensen and Wang (1985). We will also report the results of electrical conductivity.

Keywords: elastic wave velocity, electrical conductivity, confining pressure, pore fluid pressure, water-saturated rock