Breaking Peroxy Bonds in H₂O Ice Doped with H₂O₂ to Create Positive Hole Charge Carriers
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Abstract
The electric conductivity of rocks in the Earth’s crust increases when they are stressed such as before major earthquakes. The increase is due to peroxy defects, which — when broken — release positive-hole charge carriers. Water ice doped with hydrogen peroxide represents a model system, where this process can be studied. Blocks of pure H₂O ice and H₂O₂-doped H₂O ices, frozen first at −20 °C and then cooled to −80 °C, will be stressed at one end with a piezoelectric transducer (pzt) to activate positive hole currents flowing down the stress gradient. Pure H₂O ice should produce no such currents. Stressing H₂O₂-doped H₂O ices, however, should lead to a 100-1000 times increase currents. These stress-activated currents are carried by defect electrons, generated by the break-up of the peroxy bonds of H₂O₂ molecules embedded in the ice structure. These defect electrons are associated with the oxygen anion sub-lattice and known as positive holes. H₂O₂–doped H₂O ices represent analogs to igneous or metamorphic rocks, which naturally contain peroxy defects, typically O₃Si-OO-SiO₃, and also produce positive hole currents when subjected to stress. These positive hole currents are crucial to understand pre-earthquake phenomena.

Methods

By using purified water doped with H₂O₂, we hope to create the simplest peroxy bond possible. We are attempting this to validate the process in which igneous or metamorphic rocks will generate positive charge carriers when subjected to extreme stress [Freund, 2002; Freund et al., 2006]. Most igneous and metamorphic rocks will contain other impurities that may contribute to these charge carriers, but by using purified water ice doped with hydrogen peroxide we hope to eliminate any possibilities and have nothing but pure peroxy bonds. Instead of mechanical stress applied by a hydraulic press, stress will be applied with a piezoelectric transducer (pzt) by way of 20-40 kHz ultrasonic waves (Figure 1). We expect the currents to be in the pico- or nanoampere range. We’ll also conduct conductivity experiments by applying a voltage to the ice during ultrasound activation of the positive hole charge carriers.

Results

We hope to demonstrate the generation of stress-activated hole currents in H₂O₂-doped H₂O ices, capable of flowing out of the stressed sub-volume. This will provide insight into the nature of similar hole currents that are observed upon stressing igneous or high-grade metamorphic rocks. We hope to confirm that the outflow currents generated by stressing rocks are due to the break-up of peroxy defects and the formation of mobile positive hole charge carriers, h⁺. The advantage of H₂O ices is that, by doping them with H₂O₂, we can introduce at will the progenitors of the positive hole charge carriers.

References