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Self-Generated Electric Currents from Igneous Rocks under Stress

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Introduction Igneous rocks, when stressed, convert mechanical energy into electrical energy. The reason is that, during application of stress, electrical charge carriers are activated. These charge carriers are defect electrons in the O 2p-dominated valence band of oxides and silicates, also known as positive holes or p-holes for short. Normally, p-holes lie dormant as positive hole pairs (PHP), equivalent in silicates to peroxy links, O_3X-OO-YO_3 with X,Y=Si,Al etc.[1]

Experimental When we apply stress to the central portion of 30x30x1 cm^3 rock tiles, a p-hole current flows out of the stressed rock volume (7 cm^3) to the edge of the tile. The current is self-generated: it flows without externally applied voltage. When we increase stress rapidly (1 sec) from 0 to 50 MPa, we measure peak currents of $>$5, 700, and 2000 pA/cm^3 from dry granite, anorthosite, and gabbro respectively. When we hold the stress constant at 50 MPa, the currents decay fast at first to levels of $\approx$3, 300 and 1000 pA/cm^3 respectively, then more slowly with a half-life of the order of 10-20 hrs.

When we apply 80 MPa to one end of a 120 cm long block of granite (cross section of 10x15 cm^2), we measure a p-hole current of up to 10 nA flowing out of 1000 cm^3 stressed rock (the "source volume") down the length of the granite block to a Cu electrode at the far end of the block and through an ammeter to ground. An outflow of p-holes from the "source volume" is equivalent to an inflow of electrons from the unstressed rock. To close the electric circuit we attach a Cu electrode to the stressed rock connecting it to ground via a second ammeter. We measure an electron current of up to –10 nA flowing out of the "source volume" to ground.

Discussion We are faced here with stress-induced currents. Such currents can be expected to be activated when rocks in the mid-crust are subjected to ever increasing stresses that will eventually lead to an earthquake. In the case of medium to large earthquakes the rock volumes under directional stress are in the order of tens to hundreds of thousands of cubic kilometers.

On the basis of our laboratory experiments we envision large electrical currents that could be generated and flow out of such "source volumes" deep in the Earth's crust. In fact we envision two currents, p-holes and electrons, flowing in opposite directions. If such currents exist, we can expect them to be coupled via their self-generated electric fields and subject to oscillations[2]. When powerful currents running deep in the ground begin to oscillate, they should emit electromagnetic radiation that may be powerful enough to be recorded at the Earth's surface.

Conclusion We may have discovered the basic physical process responsible for a wide range of pre-earthquake electromagnetic (EM) phenomena: stress-activation of p-hole currents. In the past attempts to explain pre-earthquake EM phenomena have mostly centered on piezoelectricity[3] or streaming potentials[4].

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