

Forecasting M6+ ‘Significant’ Earthquakes (II): Global Electric Circuit Hypothesis

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Abstract: The reliability of certain pre-seismic factors in forecasting future earthquakes requires a mechanistic explanation. Electric currents in the mantle and crust, and their interactions with Earth’s global electric circuit and geomagnetic system, indicate the potential for uniformly forced movements of earth over large areas at various depths, and offer a possible characterization of deep earthquakes (Blot echoes). A mechanism involving current-driven movement of material is hypothesized as a reaction / relaxation by induced mechanical stress, destabilizing dynamic piezoelectric potential existing in crystallite rock under constant magnetic and gravitational pressure.

1. INTRODUCTION

Deep earthquakes have long-posed a conundrum for geologists. The way we traditionally think of brittle rocks and tectonic plates shifting, cracking, slipping and thrusting is not so convenient for describing action, or causation of action, deep within the mantle. If significant electrical fluctuations can occur at significant depths, a mechanism complementary to those already in existence for deep earthquakes is implied, and aids in characterizing the movements below.

The earthquake forecasting model presented in part I utilizes terrestrial signals to hypothesize the locations where the global electric circuit (GEC) has the highest chance of affecting the crust. It is well understood that fair weather currents from ionosphere downward (high pressure) oppose the upward currents associated with low pressure and lightning storms (ex. positive streamers, terrestrial gamma flashes, sprites). Whether by induction or by direct current flow, the GEC may find fault lines and ride subducted crust down into the mantle, perhaps as deep as the transition zone.

Earth’s crust varies in thickness, extending down as much as 75-100 km deep. Guided by surface magnetism and crustal composition, the GEC and geomagnetic system have numerous means of accessing the mantle, including through highly active fault zones, which are cracks (openings) in the crust, and through the subducted crust itself. In addition to most fault zones having low resistivity (high conductivity) contents, where water can more easily descend through cracks in the earth’s crust, subduction zones direct telluric currents down into the mantle, where more than 50% of the material is water-rich olivine (Mg^{+2}, Fe^{+2}) $2SiO_4$ and its polymorphs.

Olivine conductivity under mantle conditions has been inferred from satellite data (Velimsky, Martinec and Everett, 2006) and has been repeatedly demonstrated in a laboratory setting (Constable, 2006; Wang, 2006; Xu et al., 1998; Duba, 1974; Duba, 1972; Kobayashi and Maruyama, 1971). Other contributions to mantle conductivity include a poloidal current system driven by earth’s core (Roberts and Lows, 1961), wadsleyite and ringwoodite, which are upwards of two orders of magnitude more conductive than olivine below the low-velocity zone (Xu et al., 1998), and iron monoxide, which makes up a significant portion of the mantle (Ohta et al., 2012). Layers of aligned olivine crystals exist near the surface and at the low-velocity zone 200-300 km deep, connected by convective channels (Lin et al., 2016) that may contain and

transport water and other conductive material. Recently, Zhan suggested that all deep earthquakes nucleate within olivine (Zhan, 2017), and evidence of metastable olivine wedges exists in many active subduction zones.

2. CURRENT, WATER AND OLIVINE

If the GEC and geomagnetic system reaches and affects the currents in the mantle, the mechanism for deep earthquake ruptures might include the movement of water and olivine. Current passes directly through some materials, and will seek low-resistance zones (fault systems) in areas where the crust resists the current.

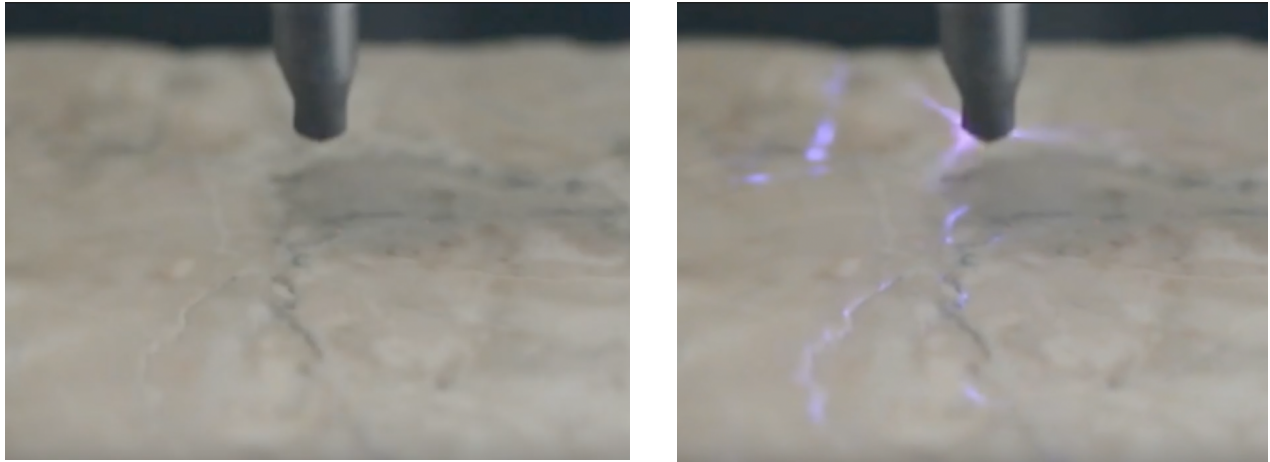


Figure 1: Demonstration of direct current from above seeking the path of least resistance through cracked rock. When the current is turned on, the cracks are illuminated due to the current seeking those low-resistance points.

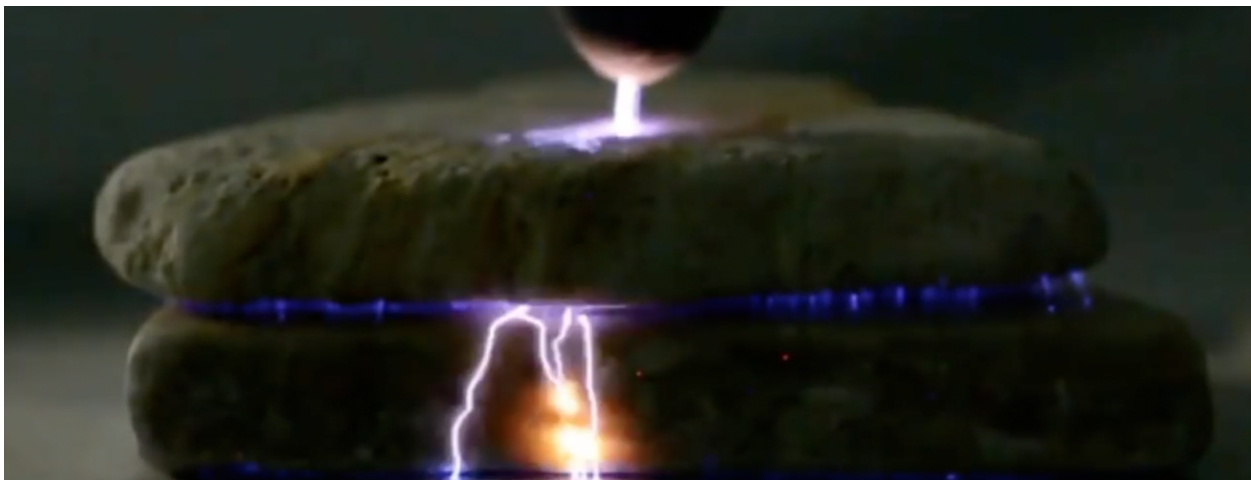


Figure 2: Sandstone on top of quartz, direct current from above. Sandstone has low resistivity compared to quartz, and allows the current to pass, whereas the quartz does not allow the passage of current as easily, directing on a path of lesser resistance around the crystal.

More water exists in the mantle than in earth's entire oceans (Schmandt et al, 2014; Thompson, 1992).
Current attracts, is attracted to, and can move water.

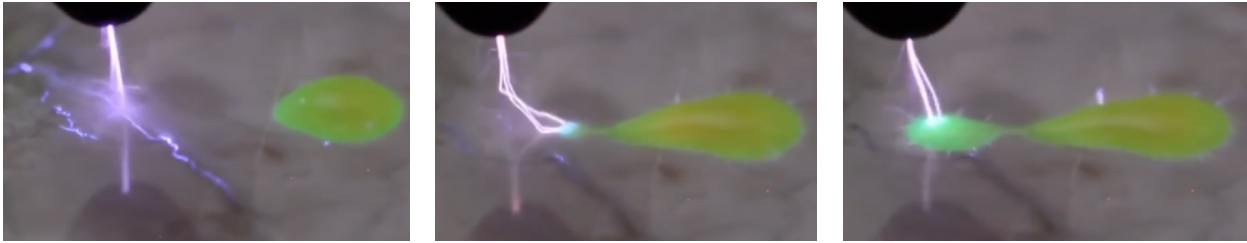


Figure 3: Direct current from above discharged directly above crack (expected path of least resistance, confirmed in left image) near water (with Pyranine for ease of visualization). Current and water are attracted in the center image. Water is pulled to the original current pathway through the crack.



Figure 4: Direct current through sandstone (top), water with Pyranine, and quartz (bottom). The attractive force of the current pulls the water along the current against gravity, pushing up on the sandstone.

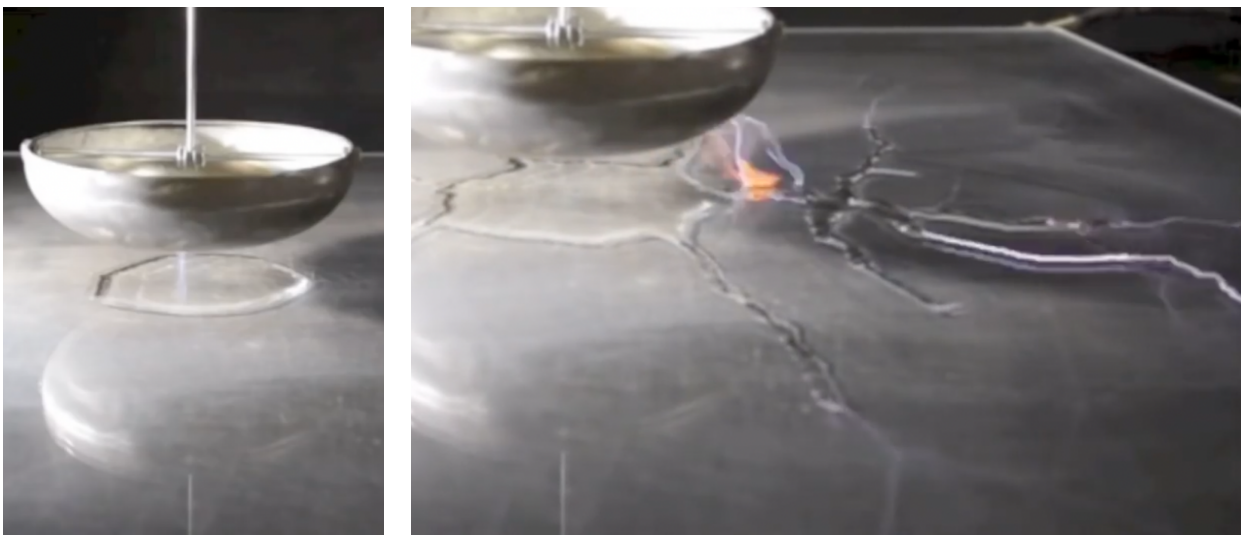


Figure 5: Direct current discharged into water will carry the water with the current.

Olivine presents slight movement upon charging, and significant movement upon discharging.

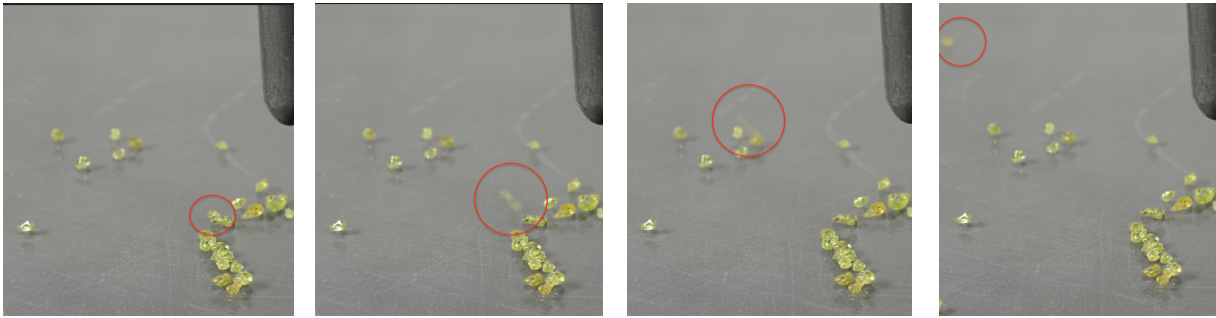


Figure 6: Olivine crystals beginning to discharge after slow charging for 60 seconds with 70kV at 1 amp. In order left to right, the sequence above shows an example of discharge movement. The crystal that discharges is seen in the red circles.

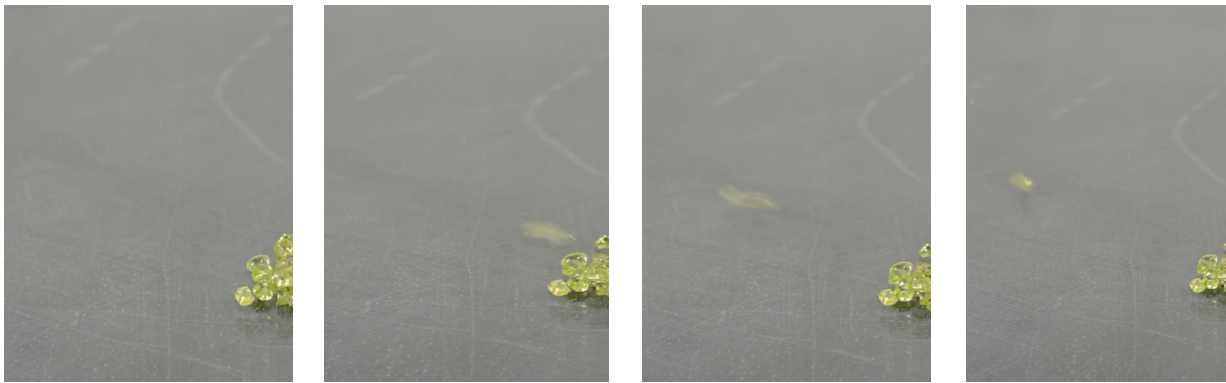


Figure 7: Olivine crystals beginning to discharge after slow charging for 60 seconds. In order from left to right, the sequence above shows an example of discharge movement as an olivine crystal leaves the pile on the right.

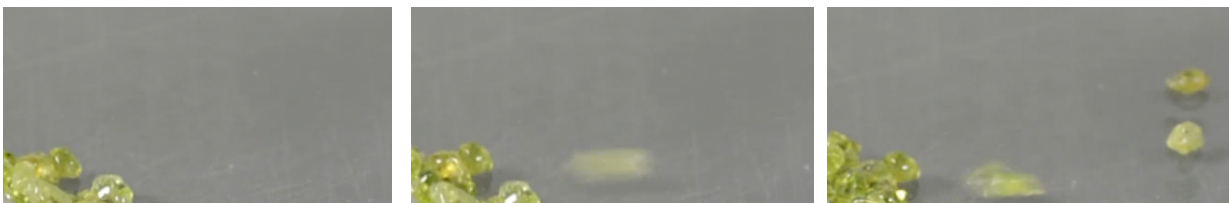


Figure 8: Olivine crystals beginning to discharge after slow charging for 60 seconds. In order from left to right, the sequence shows an example of rapid discharge movement as three olivine crystals migrate to the right, one by one.

3. DISCUSSION

Water is more volatile, and olivine is more conductive, at mantle conditions than they are at atmospheric pressure and room temperature in the lab. If there are significant fluctuations in the mantle currents, then water and olivine might react with large-scale translocation of earth.

Many of the mechanisms capable of producing telluric currents, which might reach the mantle via subduction zones and other faults, were identified by Helman (Helman, 2013), and are applicable to this hypothesis. Geomagnetically induced currents and the vertical ion/electron component of the GEC (from the planetary system, space weather and galactic cosmic rays) have already been acknowledged, but there are other possible sources of electromagnetic/static fluctuations (electrokinetic effects of fluid flow in porous rock, geomagnetic jerks that produce currents in the mantle, magnetohydrodynamic effects), charge transmission (exoelectron emission due to rock and crystal deformation, thermoelectric effects), and domain rearrangement (piezoelectric and pyroelectric effect) which could be enhanced or triggered by the GEC. In the mantle or the crust, a large release or flow of electrons could, during short periods of stress relaxation, cause localized translocations of water and geologic materials. Only one of these mechanisms is required for current-driven translocation of material, and all are possible.

The electromagnetokinetic phenomenon (Kolin, 1953) may also be relevant at the large scales involved in seismic ruptures, as electrically neutral particles will be forced perpendicular to an electric current *and* the corresponding magnetic field. This indicates that the entire area affected by a direct current flow can be forced, even the neutral material. The electromagnetokinetic principle has been used to control position of materials in aluminum melts, understand capillary flows, separate biological particles, and is almost always applied in fluid environments (like the atmosphere and mantle). The name ‘electromagnetokinetic’ has largely been replaced, and is commonly referred-to as electromagnetophoresis, or in describing electromagnetic buoyancy, when used in various biological and industrial applications. When applied to the crust and the mantle, it offers a complimentary mechanism to those previously mentioned for large-scale movement along low-resistivity fault zones resulting from current.

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