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PHYSICS

On the Negatively Charged Layer of the Earth's Electric Field

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Abstract—Based on the hydridic Earth model, we propose a hydridic model of the Earth's electric field. The model predicts that the negative electrode of the Earth's capacitor is located under the Earth's crust and the Earth's fluids carry a positive charge. We have observed an excess of positive charge in the Earth's crust down to kilometer depths. The model explains the unitary variation of the fair-weather atmospheric electric field strength, the change in atmospheric electric field strength and the precipitation of high-energy electrons during earthquakes.

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An excess of positively charged air ions is known to be observed in underground rooms with poor ventilation. This fact is surprising, because a negatively charged layer, which is the negative electrode of the Earth's electric field capacitor, is expected to be detected. Where is the negative electrode of the Earth's capacitor located?

In this paper we propose a new model of the Earth's electric field named the hydridic Earth electricity (HEE) model, because it is a corollary of the hydridic Earth model [1, 2].

The hydridic Earth model predicts the Earth's elemental composition. The outer core and mantle of the Earth must consist of metal hydrides and metals, respectively. The temperature of the Earth's core in the hydridic Earth model oscillates and periodically rises due to the radiogenic release of heat in the Earth. When the hydride decay temperature is reached, free hydrogen appears on the surface of the Earth's core, which begins to diffuse upward into the metallic mantle, into a region with a lower hydrogen concentration. At high temperature the hydrogen dissolved in metals loses the electron and, subsequently, there exist only separate free protons and electrons diffusing in the metal separately. The proton mobility increases with rising temperature of the medium. As a result of this property, the upward-propagating hot protons form narrow hot jets [1, 2], transferring the temperature of hot lower layers upward. Below we will call these protons hot. The protons and electrons that reached the crust-mantle boundary behave differently. The electrons do not pass into the crust, which is an insulator for them, while the hot protons have a probability to pass into the crust and to continue their motion upward. The bulk of the positive charge passes to the atmosphere in rift zones in the form of hot positively charged hydrogen-containing gases. This is the current of the Earth's capacitor charge that reaches high altitudes predominantly above hot rift zones. The electrons propagating in the metallic mantle form the negative electrode of the Earth's capacitor on the mantle surface under the crust. In the HEE model the separation of charges occurs under the Earth's crust.

The ionization of the atmosphere by cosmic rays generates everywhere a constantly flowing discharge current of the Earth's capacitor. O_2^+ and NO^+ air ions are produced in the atmosphere, which are hydrated when interacting with atmospheric moisture. Subsequently, the reaction occurs inside these hydrated ions. Its essence is that the positively charged ions of oxygen and nitrogen oxide take the electron away from water hydrogen to form hydrated cations of hydroxonium [4]:

$$O_2^+(H_2O)_n \rightarrow H_3O^+(OH)(H_2O)_{n-2} + O_2,$$

$$NO^+(H_2O)_n \rightarrow H_3O^+(H_2O)_{n-2} + HNO_2.$$

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In the absence of ascending airflows the hydroxonium cations reach the ocean surface or the wet soil under the action of the Earth's electric field. Not the hydroxonium cation itself but the positive charge diffuses in the water. This phenomenon is described by the Grotthuss mechanism, which has been studied well and explains the high water conductivity for positive charge. Some oxides that form the basis for perovskites also have a high proton conductivity. Thus, the discharge current of the Earth's capacitor reaches the negative electrode of the Earth's capacitor.

We come to the idea that the Earth's crust is filled with positive charge due to the upward motion of hot protons as narrow jets through the crust and the ubiquitous downward motion of thermal discharge protons of the Earth's capacitor. Some of these protons spend a long time in the crust and form a volume charge screening the charge of the negative electrode of the Earth's capacitor. This unexpected prediction of the HEE model explains the excess of positively charged air ions in underground rooms with poor ventilation. To make sure that this prediction is reliable, we studied the density of air ions in unventilated underground rooms by measuring it with a Sapfir-3M air ion counter. To obtain reliable measurement results under conditions of enhanced underground room humidity, we heated the aspirator chamber of the counter by a fan, if necessary, to keep the insulator surfaces of the aspirator chamber in a constant state. An air ion density of several hundred ions per cubic centimeter is usually observed in the near-surface air, while in underground laboratories with poor or switched-off ventilation we observed an increase in the density of air ions of both signs from thousands to tens of thousands of ions per cubic centimeter. An excess of positively charged air ions from several thousand to tens of thousands of ions per cubic centimeter was always observed in this case. Such a picture was observed at all depths from several meters to a kilometer. To interpret the number of positive air ions in closed underground rooms, we use two sources of ions: first, the radioactivity of rocks, in this case, equal numbers of positive and negative ions are produced; second, the protons of the volume charge in the crust whose existence was predicted by the HEE model. To interpret the number of negative air ions, we use only one source of ions, the radioactivity of rocks. The density of negative air ions turned out to be proportional to the radon density in the air of underground rooms, which we also measured. This suggests that the radioactivity of the surrounding rocks is the source of negative air ions in underground rooms. Thus, we experimentally recorded an excess of positive charge in the crust predicted by the HEE model.

An excess of positive charge can give rise to positively charged hydrogen-containing gases at depths of ~10 km and, as a sequence, to numerous pores and cracks at these depths. The latter is observed in ultradeep boreholes. The rapid rise of these charged gases to the Earth's surface can accompany an earthquake and can even be its cause, because the gas pressure in pores will drop in this case. We can also imagine that discharge of the Earth's capacitor occasionally leads to an electric discharge at great depths. This underground discharge can also accompany an earthquake and can even be its cause.

Let us introduce the concept of an effective charge on the Earth's surface as the difference between the number of electrons under the crust and the volume positive charge in the crust, which exceeds significantly the charge in the ionosphere. This effective electric charge determines the atmospheric electric field strength. The observed phenomenon of an increase in the atmospheric electric field strength during earthquakes becomes clear, because a decrease in the excess of positive charge in the Earth's crust in the case of a rapid rise of the charged gases to the surface leads to an increase in the effective negative charge on the Earth's surface. The increase in the atmospheric electric field strength before an earthquake is determined by the rate of ejection of charged fluids into the atmosphere in the earthquake region, while the return of the field strength to normal values is determined by the filling of the Earth's crust with positive charge. The latter process is slow and can last up to several days. In the case of an underground discharge, we may expect a decrease in the atmospheric electric field in the earthquake region.

The precipitation of high-energy electrons from the Earth's magnetic belts in the earthquake region can also be explained, because the density of the positive charge at high altitudes will rapidly follow the density of the effective negative charge on the Earth's surface. The strongest earthquake occurred on March 11, 2011, in Japan, whose hypocenter was at a depth of 32 km, was accompanied by an increase in the electron concentration in the ionosphere several days before the earthquake.

In our HEE model we introduce a new source of charge for the Earth's capacitor: the hot positively charged hydrogen-containing gases escaping into the atmosphere that reach high altitudes mainly in the afternoon, when the air warms up. This process differs from the ubiquitous downward motion of the thermal protons of the Earth's capacitor discharge current, because the hot positively charged hydrogen-containing gases escape into the atmosphere in large quantities and reduce the effective electric charge in the region of their escape; therefore, the Earth's atmospheric electric field does not entrain the ions of these fluids downward. It should be noted that the charge and discharge processes of the Earth's capacitor proceed continuously, and the competition between them must determine the unitary variation of the fair-weather atmospheric electric field strength [3]. In rift zones, where there is an excess of positive ions in the HEE model compared to other zones, we should observe an increase in the fair-weather field strength in the afternoon. This increase will rapidly manifest itself at all points of the globe due to the high conductivity in the ionosphere [3]. Thus, in the HEE model under consideration the main contribution to the variability of the fair-weather electric field strength is made by the rift zones located along meridians: Arabian-Indian, Mid-Atlantic, and East Pacific. The increase in the fair-weather electric field strength begins when the air in the Arabian-Indian rift zone begins to warm up sufficiently. This occurs at local time from 14 h, which corresponds to Greenwich Mean Time (GMT) of 9.5 h. The charge excess above the discharge ends when the air warming ends in the East Pacific rift zone. This occurs at 18 h local time, which corresponds to 24 h GMT. The increase in the unitary variation of the fair-weather electric field strength is observed precisely from 10 to 24 h GMT.

Thus, the presented HEE model predicts the presence of a significant negative charge under the Earth's crust and the presence of a significant positive volume charge in the crust. The HEE model also predicts that the hydrogen-containing gases escaping from the Earth's crust into the atmosphere carry a positive charge.

The model allows the excess of positive charge in the Earth's crust, the unitary variation of the fair-weather electric field strength the change in the atmospheric electric field strength, and the precipitation of high-energy electrons during earthquakes to be explained from a unified standpoint. This success of the HEE model is a significant argument for the validity of the hydridic Earth model, because the HEE model is its corollary.

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