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Research Article

ELECTROMAGNETIC WAVES CAUSED BY TECTONIC EARTH MOVEMENT

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ABSTRACT

Prior to large earthquakes the Earth sends out transient signals, sometimes strong, more often subtle and fleeting. These signals may consist of local magnetic field variations, electromagnetic emissions over a wide range of frequencies, a variety of atmospheric and ionospheric phenomena. Great uncertainty exists as to the nature of the processes that could produce such signals, both inside the Earth's crust and at the surface..When rocks are stressed, peroxy links break, releasing electronic charge carriers, h_, known as positive holes. The positive holes are highly mobile and can flow out of the stressed subvolume. The situation is similar to that in a battery. The h_ outflow is possible when the battery circuit closes. The h_ outflow constitutes an electric current, which generates magnetic field variations and low frequency EM emissions. The study of chemical processes based on a model equation for electromagnetic waves is presented.

Keywords: Electromagnetic waves; pre earthquake; tectonic.

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1. INTRODUCTION

A method studied for predicting earthquakes through changes in crust electrical parameters. These parameters are including the impedance and the electrical potential of shifts and pressure the layers of the earth that produce electromagnetic waves. Through the calculation of the wave equation and offer an initial model to compute the surface potential and profile of a fault can be intensity an earthquake predicted from the fault. Parallel study changes in the frequency range of ULF and VLF electric and magnetic fields and other studies show that the use of electromagnetic methods alongside electrical methods provides better results in predicting earthquakes.

2. CALCULATION OF MOMENT MAGNITUDE AND DEFINITION EARTHQUAKE INTENSITY

All from 1980 earthquake was introduced a way to introduce for measurement earthquake that is called seismic moment M_0 (seismic moment). Seismic moment depends on the size fault area (A) and average level of fault Δu. Therefore:

$$M_0 \sim A \Delta u \qquad (1)$$

And to be more precise the product of three factors determined measuring an earthquake.

$$M_0 = « \times A \times \Delta u \qquad (2)$$

= μStiffness dyn/cm^2,A= Area of broken cm^2 ,Δu = Average slip cm^2, μ is the shear modulus for shallow earthquakes $3-5 \times 10^{11} dyn/cm^2$.

Since numbers of seismic moment are very large. A new measure is defined as the moment magnitude:

$$M_w = \frac{\log M_0}{1.5} - 10.73 \qquad (3)$$

2.1. Calculating the potential

Arrangement of the flow electrodes were placed with greater distance compared to potential electrodes. Have the form of:

$$r_1 = (L-x) - \ell, r_2 = (L+x) + \ell \quad , \quad r_3 = (L-x) + \ell, r_4 = (L+x) - \ell \qquad (4)$$

If the smallest distance between the electrodes flow and potential electrodes. Be much larger from The distance between the two electrode potentials (Coefficient 10 or more) from equation (3-33), we have:

$$\circ_a = \frac{2\text{®}\Delta V}{I}\frac{1}{\left[\left\{\frac{1}{(L-x)-\ell}-\frac{1}{(L+x)+\ell}\right\}-\left\{\frac{1}{(L-x)+\ell}-\frac{1}{(L+x)-\ell}\right\}\right]} \quad (5)$$

Because 1 in conclusion have after Simplify:(L-x)≫because is

$$\circ_a = \frac{\text{®}}{2\ell}\frac{(L^2-x^2)^2}{(L^2+x^2)}\left(\frac{\Delta V}{I}\right) \quad (6)$$

This arrangement often be used symmetrically.

$$\circ_a = \frac{\text{®}L^2}{2\ell}\left(\frac{\Delta V}{I}\right) \quad (7)$$

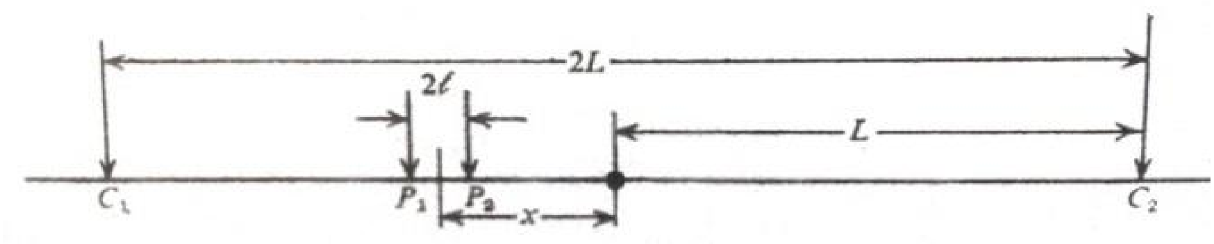

Fig.1. View of the Schlumberger array

Potential electrodes are fixed in speculation deep. While the distance between the electrodes flow spread symmetrically toward center of the arrangement. When L is large it may be necessary that l also increase till potential be measurable.

2.2. Calculate the electric field

According to Maxwell's equations:

$$\nabla \times E = -\frac{\partial B}{\partial t} \quad (8)$$

$$\nabla \times H = J + \frac{\partial D}{\partial t} \quad (9)$$

As a result:

$$\nabla \times \nabla \times E = -\frac{\partial}{\partial t}(\text{«}_0 J + \text{«}_0 \frac{\partial D}{\partial t}) \quad (10)$$

Where D is the displacement current density.

$$\Rightarrow -\nabla^2 E + \nabla(\nabla . E) = -\text{«}_0 \frac{\partial J}{\partial t} - \text{«}_0 \frac{\partial^2 D}{\partial t^2} \quad (11)$$

P is the polarization current density.

$$\Rightarrow -\nabla^2 E + \frac{\nabla °_f}{£} = -«_0 \frac{\partial J}{\partial t} - «_0 \frac{\partial^2}{\partial t^2}(£_0 E + P) \tag{13}$$

$$-\nabla^2 E + \frac{\nabla °_f}{£} = -«_0 \frac{\partial J}{\partial t} - £_0 «_0 \frac{\partial^2 E}{\partial t^2} - «_0 \frac{\partial^2 P}{\partial t^2} \tag{14}$$

arranging the above equation:withWe have

$$\Rightarrow -\nabla^2 E + £_0 «_0 \frac{\partial^2 E}{\partial t^2} = -\frac{\nabla °_f}{£} - «_0 \frac{\partial J_f}{\partial t} - «_0 \frac{\partial^2 P}{\partial t^2} \tag{15}$$

Given that: $J_f = ± E$

$$\Rightarrow \nabla^2 E - £_0 «_0 \frac{\partial^2 E}{\partial t^2} + ± «_0 \frac{\partial E}{\partial t} = -\frac{\nabla °_f}{£} - «_0 \frac{\partial^2 P}{\partial t^2} \tag{16}$$

By considering the following equations:

$$£_r = \frac{£}{£_0},\ £ = £_0 + ¡,\ P = P(E),\ P = ¡ E \tag{17}$$

Fore the must nuture deelecteric is between 1 and -1 , k>1 , χ>=0.$£_r$

For conductors k ∞ is assumed.

$$\Rightarrow \frac{\partial^2 P}{\partial t^2} = ¡ \frac{\partial^2 E}{\partial t^2} \tag{18}$$

With insertion of in relation (16):

$$\Rightarrow \nabla^2 E - (£_0 «_0 - «_0 ¡) \frac{\partial^2 E}{\partial t^2} + ± «_0 \frac{\partial E}{\partial t} = -\frac{\nabla °_f}{£} \tag{19}$$

Due to depending on Space and time the expected in flat wave we can expec field as follows fore the field E:

$$E(r,t) = \hat{E} e^{-i(µ t - k.r)} \tag{20}$$

In which $\hat{E}$ is vectore constant amplitude flat wave. By derivative From function as $\hat{E} e^{-iµ t}$ ratio to time we see that for function in this specific case operator $\frac{\partial}{\partial t}$ is equivalent to multiplying in symbol $-iµ$ and For function as $\hat{E} e^{ik.r}$ operator $\vec{\nabla}$ is equivalent to ik .

Therefore we have for operator $\frac{\partial^2}{\partial t^2}$ $-µ^2$ and fore ∇^2 we have $-k^2$:

$$-k^2 E - (£_0 «_0 - «_0 ¡)(-µ^2) E - ± «_0 (-iµ) E = ik \frac{°_f}{£} \tag{21}$$

The volume density is equal fore positive charge and negative charge. Therefore:

$$°_e = °_h,\ °_f = °_e + °_h \Rightarrow °_f = 0 \tag{22}$$

$$-k^2 + «_0(£_0 - ¡)µ^2 + iµ«_0± = 0 \tag{23}$$

$$\Rightarrow k^2 = «_0(£_0 - ¡)µ^2 + iµ«_0± \tag{24}$$

We sort the equation:

$$k^2 = «_0(£_0 - ¡)µ^2(1 + i\frac{±}{(£_0 - ¡)µ}) \tag{25}$$

$$\Rightarrow k = µ\left[«_0(£_0 - ¡)\right]^{1/2}(1 + i\frac{±}{(£_0 - ¡)µ})^{1/2} \tag{26}$$

Since k is complex wave number: $k = \sim + i$, We rsanym both sides to the power of 2:

$$k^2 = (\sim + i\ )^2 = \sim^2 - \ ^2 + 2i\sim \tag{27}$$

by placing equal amounts k^2:We have,

$$\begin{cases} \mathrm{Re}: \sim^2 - \ ^2 = «_0(£_0 - ¡)µ^2 \\ \mathrm{Im}: 2\sim\ = \frac{±}{(£_0 - ¡)µ}«_0(£_0 - ¡)µ^2 = ±µ«_0 \end{cases} \tag{28}$$

$$= \frac{±µ«_0}{2\sim} \tag{29}$$

By placing in real part of equation (28):

$$\sim^2 - \frac{±^2µ^2«_0^2}{4\sim^2} = «_0(£_0 - ¡)µ^2 \tag{30}$$

$$\Rightarrow 4\sim^2 - 4µ^2«_0(£_0 - ¡)\sim^2 - ±^2µ^2«_0^2 = 0 \tag{31}$$

By applying change variable have $\sim^2 = X$:

$$4X^2 - 4µ^2«_0(£_0 - ¡)X^2 - ±^2µ^2«_0^2 = 0 \tag{32}$$

obtained by solving the equation In terms of X:we

$$X = \frac{4µ^2«_0(£_0 - ¡) ± 4µ«_0\sqrt{µ^2(£_0 - ¡)^2 - ±^2}}{8} = \sim^2 \tag{33}$$

$$\Rightarrow £_0 - ¡ = £_0 - £ + £_0 = 2£_0 - £ \quad ¡ = £ - £_0 \tag{34}$$

$$\Rightarrow X = \frac{4µ^2(2£_0 - £)«_0 ± 4µ«_0\sqrt{µ^2(2£_0 - £)^2 - ±^2}}{8} = \sim^2 \tag{35}$$

$$X = \frac{µ^2}{c^2} - \frac{1}{2}\frac{µ^2}{v^2} ± \frac{1}{2}µ«_0\sqrt{µ^2(2£_0 - £)^2 - ±^2} \tag{36}$$

That $c^2 = \frac{1}{£_0«_0}, v^2 = \frac{1}{£«_0}$. In this particular case, we take wave propagation in the air: Means $v = c$. In case of publication in the fog, dust, $£, n$ environment must be determined. Then we can write $± \simeq 0, £_0 = £$ we have with fixing the relationship in equation (33):

$$X = \frac{µ^2}{c^2} - \frac{1}{2}\frac{µ^2}{c^2} ± \frac{1}{2}µ^2«_0£_0 = \frac{µ^2}{c^2} - \frac{1}{2}\frac{µ^2}{c^2} ± \frac{1}{2}\frac{µ^2}{c^2} \tag{37}$$

$$\Rightarrow X = \frac{\mu^2}{c^2}, X = 0 \quad (38)$$

$$\Rightarrow \sim = \left[\frac{\mu^2}{c^2}\right]^{1/2} = \frac{\mu}{c} \quad و \quad = 0 \quad (39)$$

$$k = \sim + i \quad = \frac{\mu}{c} \quad (40)$$

$$E = E_m \exp\left[-i(\mu t - \frac{\mu}{c}.r)\right] \quad (41)$$

$$\Rightarrow E = E_m \exp\left[-i\mu(t - \frac{1}{c}.r)\right] \quad (42)$$

By knowing $H = \frac{E}{¦}$ as a result:

$$H = \frac{E}{¦} = \frac{E_m \exp(- \quad .r)\exp[-i(\mu t - \sim .r)]}{¦} \quad (43)$$

Calculate the time variation of the electric field **(**$\frac{dE}{dt}$**)**: Since we dont have free charge density then:

$$\frac{°_f}{£_0} = 0 \quad (44)$$

And we have the Laplace equation :

$$\nabla^2 V = 0 \quad (45)$$

The potential is function $\ddot{}$:

$$\Rightarrow \frac{1}{r}\frac{\partial^2 V}{\partial \ddot{}^2} = 0 \quad (46)$$

By integration solution that is obtained as follows:

$$\Rightarrow V = A\,\ddot{} + B \quad (47)$$

With apply boundary conditions that here $\ddot{} = 0$, $V = 0$ and for $\ddot{} = \sim$ $V = \Delta V$, abtianed:

$$\left.\begin{array}{l} 0 = A(0) + B \\ \Delta V = A(\sim) + B \end{array}\right\} \Rightarrow A = \frac{\Delta V}{\sim}, B = 0 \quad (49)$$

By substituting these values into the equation of potential:

$$\Rightarrow V(\ddot{}) = \frac{\Delta V}{\sim}\ddot{} \quad (50)$$

$$\Rightarrow \Delta V = -\int E.dl \Rightarrow dV = -E.dl \quad (51)$$

So finally we can write:

$$E = -\nabla V = -\frac{1}{r}\frac{¢}{¢\ddot{}}(\Delta V \frac{\ddot{}}{\sim})\hat{\ddot{}} = -\frac{\Delta \ddot{}}{r\sim}\hat{} \quad (52)$$

And then the differential of E we have:

$$\Rightarrow \frac{dE}{dt} = -\frac{1}{r\sim}\frac{d(\Delta V)}{dt} \quad (53)$$

We know $D = £_0 E + P = £E$ so :

$$\frac{dD}{dt} = -\frac{£}{r\sim}\frac{d(\Delta V)}{dt} \quad (54)$$

But after displacements of layers and electromagnetic wave propagation, what we recorded by electromagnetic record,.is in fact, the frequency ν or we can say that ω here we can say that: $\frac{d\,|E\,|}{dt} = \mu$ Means we with recorded frequency same Time variation field record and also simultaneously record ΔV in a time interval can be time variation ΔV means $\frac{d(\Delta V)}{dt}$ achieved. Now using these two parameters and considering the known dip angle of the fault studied (~) we can use the above equation and r is means distance from the fault to obtain. To obtain r and knowing that part of the surface along the fault which usually changes ℓ , can be calculated area of broken A. Now, according to equation (3) $M_0 = « \times A \times \Delta u$. We can calculate the seismic moment M0. Course in this equation μ or difficult environments for our specific and predetermined. Also Δu or moderate slip can also be based on past statistics calculated for each fault. This way calculation of seismic moment can be a magnitude earthquake in the equation (3-9) as mentioned earlier Means $M_w = \frac{\log M_0}{1.5} - 10.73$ obtained.

3. CONCLUSION

In this work a method for predicting earthquakes offered based on the record the frequency electromagnetic waves before the earthquake which usually before the quake will be sent, that this method, the recording wave frequency and changes in the electrical potential of around the fault, using data about the fault: length foult, fault dip angle, average size of fault displacement in previous earthquakes, possible earthquake intensity is predictable.

4. REFERENCES

[1] Telford, W.M, Geldart, L.P, Sheriff, R.E, *Applied Geophysics*, Cambridge University Press, (1991), 522-536.

[2] Lay,T, Wallace ,T.C, *Modern Global Seismology* , Academic Press ,

London(1995),379-383

[3] Freund, Friedemann, *Pre-earthquake signals: Underlying physical processes*, Journal of Asian Earth Sciences, Vol. **41** (2011) 383–400.

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