VLF/LF EM emissions as the main precursor of earthquakes and their searching possibilities for Georgian s/a region

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Georgia is seismic active country and searching of earthquakes problem is vital for us.

The receiver of VLF/LF electromagnetic emissions is installed in Georgia in this year. By the installation of receiver Georgia is already included in the very important experimental working and it is a great step not only for our country but for the neighbor territory and the whole Caucasus too.

Our scientific group, based on electrodynamics, has created the theoretical model of generation of electromagnetic emissions detected before earthquake (Kachakhidze, M.K., Kachakhidze,N.,K., Kaladze,T.D. A model of the generation of electromagnetic emissions detected prior to earthquakes. Physics and Chemistry of the Earth 85–86 2015, 78–81).

Analyses of the theoretical model enables us to make the following conclusion: VLF/LF electromagnetic emissions brings to earth surface rich information about earthquakes preparation process. Therefore electromagnetic emissions should be considered as the “main precursor” or simply, as the “precursor” of earthquake.

Besides by our theoretical model we have explained possible physical mechanisms of the geophysical phenomena in the lithosphere-atmosphere- ionosphere coupling system which accompany earthquake preparation process and reveal themselves several months, weeks or days prior to earthquakes (M.Kachakhidze, N. Kachakhidze, T. Kaladze. EXPLANATION OF LITHOSPHERE-ATMOSPHERE-IONOSPHERE COUPLING SYSTEM ANOMALOUS GEOPHYSICAL PHENOMENA ON THE BASIS OF THE MODEL OF GENERATION OF ELECTROMAGNETIC EMISSIONS DETECTED BEFORE EARTHQUAKE. GESJ: Physics 2015, No.2(14), p.66-75).

In our opinion these phenomena might be considered as “earthquake indicators”.

We offer earthquake prediction methodology which determines simultaneously location, time and magnitude of expected earthquake. The Methodology is based on avalanche model of fault formation (Mjachkin, V.I., W.F. Brace, G.A. Sobolev and J.H. Dieterich. Two models for earthquake forerunners, Pageoph., Basel. 1975, vol. 113) and abovementioned theoretical model of generation of electromagnetic emissions where is formulated the following relation

$$\omega = k\frac{c}{l} \quad (1)$$

where ω is main frequency of electromagnetic emissions, l is the linear dimension of the emitted body (that is fault length in the focus) c – is the velocity of the light.

k - is the coefficient, which depends on the particularities of the geological environment.

During large earthquake preparation period the first stage of fault formation may go on for a several months or years. At this stage chaotic formation of microcracks without any orientation takes place. This stage is reversible. It means that during of this stage not only microcracks can be formed but can be also“locked”.Cracks created at this stage are small (up to several hundred meters order). If we recall that process has chaotic character we should wait for weak foreshocks throughout the whole seismogenic area.

We may consider this kind foreshocks like regional foreshocks.

Because of process reversibility and cracks small sizes, according to our model, the first stage of fault formation should be expressed by discontinuous MHz electromagnetic emissions. Such emissions really are fixed in case of earthquakes in nature.

The second stage of the avalanche model of fault formation is the irreversible formation process of already somewhat oriented microcracks. Because the process irreversibility and cracks still small sizes, this process should be expressed by already continuous MHz frequencies. According to the avalanche model this process takes place about 10-14 days before earthquakes.

By the developing of this stage cracks gradual increasing takes place at the expense of their uniting. According to formula (1), it results in gradual decrease of frequencies. When the cracks size reaches kilometer order, it refers to the transition of MHz to kHz frequencies.

At the third stage of the avalanche model the relatively big size faults use to unite into one - the main fault. This process should correspond to gradual fall of frequencies in kHz.

From the other side fault length increasing refers to the increase of a magnitude of the incoming earthquake by Ulomov's (Ulomov, V. I.. Ordering of geostructure and seismicity in seismoactive regions. Seismisity and seismic zoning of Northern Eurasia, Moscow, 1993,Vol. 1, 27–31) formula

$$lgl=0.6M_s-2.5 \quad (2)$$

where l is numerical value of the length in km. This formula is just for inland earthquakes with magnitude $M_s \geq 5.0$.

Of course, cracks association into one fault will use definite part of tectonic energy and will result in its decrease.

In such situation which by the avalanche model of fault formation can last from several hours up to 2 days, main fault is already formed but earthquake does not occur yet, since the rest accumulated tectonic stress is not sufficient to overcome the limit of strength of geological environment. Of course, later, at the approach of critical value of tectonic stress, the balanced state in the system will be deranged and the earthquake will occur.

The system, which is waiting for further (additional) "portion" of tectonic stress, is in the so-called "stupor" condition. It means that cracks formation is not going on in focus anymore, and respectively, electromagnetic emissions would not take place. This theoretical imagination is proved by experiments.

The moment of interruption of emissions is urgent for determination of expected earthquake time of occurring. Up to emissions interruption, by the final value of the main frequency we can determine the fault length in the focus area or we can determine magnitude of the expected earthquake by formula (2).

According to our theoretical model the epicenter area will be approximately limited to the territory where the earth surface will have positive potential towards atmosphere. This theoretical conclusion is proved in cases of earthquakes in nature.

We would like to remind that at the present time it is no reliable criterion, which can distinguish large foreshock from main shock in advance. This task can be solved by theoretical model of generation of electromagnetic emissions during earthquake preparation period in case of process monitoring.

If after the any shock electromagnetic emissions still continues to exist and the frequency value still tend to decrease, it means that the process of fault formation is not completed yet and we have to wait for the more and larger shock in future.

We should expect the frequencies growing after the main earthquake which will refer to the fact that we should not expect the larger than the occurred earthquake but we have to wait for a series of aftershocks.

The present report offers general, that is, "classical" picture of earthquake preparation and its realization (foreshock – main earthquake – aftershock).

Finally, based on two (1) and (2) formulas we may create the scale of dependence of incoming earthquake magnitude (even by the one/tenth accuracy) on the final, main frequency of electromagnetic emissions fixed immediately before the earthquake (Table I).

Thus, in case of monitoring of electromagnetic emissions, this methodology enables us step by step to follow the process of earthquake preparation and make prognostic conclusions by definite precision.

Table I

M_s	L (km)	ω (kHz)
5	3,16-3,38	94,87-88,66
5,1	3,39-3,89	88,536-77,218
5,2	3,89-4,46	77,112-67,254
5,3	4,47-5,12	67,162-58,576
5,4	5,13-5,88	58,495-51,018
5,5	5,89-6,75	50,947-44,435
5,6	6,76-7,75	44,373-38,701
5,7	7,76-8,9	38,647-33,707
5,8	8,91-10,2	33,661-29,358
5,9	10,2-11,7	29,317-25,569
6	11,7-13,5	25,534-22,27
6,1	13,5-15,5	22,239-19,396
6,2	15,5-17,8	19,37-16,894
6,3	17,8-20,4	16,87-14,714
6,4	20,4-23,4	14,693-12,815
6,5	23,4-26,9	12,797-11,161
6,6	26,9-30,9	11,146-9,7212
6,7	30,9-35,4	9,7078-8,4668
6,8	35,5-40,7	8,4551-7,3743
6,9	40,7-46,7	7,3641-6,4228
7	46,8-53,6	6,4139-5,594
7,1	53,7-61,6	5,5863-4,8722
7,2	61,7-70,7	4,8654-4,2435
7,3	70,8-81,2	4,2376-3,6959
7,4	81,3-93,2	3,6908-3,219
7,5	93,3-107	3,2146-2,8036
7,6	107-123	2,7998-2,4419
7,7	123-141	2,4385-2,1268
7,8	141-162	2,1238-1,8523
7,9	162-186	1,8498-1,6111
8	186-214	1,6089-1,4032
8,1	214-245	1,4013-1,2221
8,2	246-282	1,2205-1,0644
8,3	324-324	1,063-0,9271
8,4	324-372	0,9258-0,8075
8,5	372-427	0,8063-0,7033
8,6	427-490	0,7023-0,6125
8,7	490-562	0,6117-0,5335
8,8	563-646	0,5327-0,4646
8,9	647-741	0,464-0,4047
9	742-1585	0,4041-0,189