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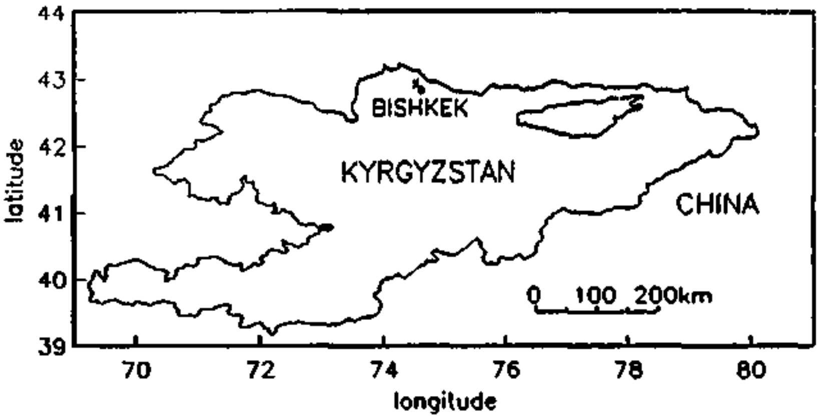

Fig. 1. The point of ETF registration (shown by x).

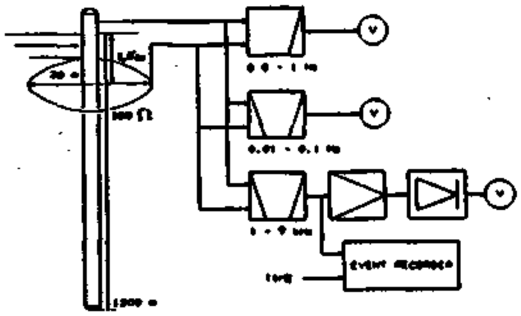

Fig.2. Block diagram of RIF registration,

device is shown in Fig.2. The system consists of 2 electrode:
1) the first is in the hole with 1200 m depth;
2) the second is located at 1.5 *m* depth around the 'note with circle-diameter 20 m and the resistance between the electrodes 100 Ohm.
AH the data are recorded on 3-channel recorder in real time and with time interval of 0.5 sec.

The setting of recording ranges has been made according to the register apparatus. For the first channel (1 Hz) recording range is (-1.0//1.0 V) with zero-mounting on 1,0 V X'center of recording tape); for the second channel (0.01-0.1 Hz) it is (-50//50 V) with zero-mounting on +0.0 mV (center of recording tape); for. the third channel (1-9 kHz) it *is* (0.0//200 mV) with zero-mounting on 0.0 (nearest edge of recording tape). In the record the time correction relative to the first channel is; for the second channel - (+4 min); for the third channel - (+7 min).

3. Results

With the help of identification and systematic classification, we had tried to find the distinctive peculiarities of artificial and natural phenomena, which had been displayed in ETF records on 3 frequency ranges.

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STUDY OF REGULARITIES IN MEASURING THE VERTICAL COMPONENT OF EARTH'S ELECTROTELLURIC FIELD FOR FINDING EARTHQUAKE PRECURSORS

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Abstract. The results of the measurements of vertical component of electrotelluric field during the period from the end of 1991 to the beginning of 1995 are given. The analysis of obtained data shows that electrokinetical effect in connection with the preparatory process of earthquakes with magnitude greater than 3.8 (M>=3.8) and within the distance 300 km from the observation station can be singled out and quantitatively described.

1. Introduction

The experimental results, which have been accumulated to date on the world forecasting ranges, testify about a possibility of using the horizontal component of electrotelluric field (RTF) for earhtquake (EQ) prediction (Sobolev, 1975; Vorotsos and Alexopoulos, 1987; Kinoshita et al.. 1989; Toktosopiev et al., 1993). The investigation of possibility for discovery of electrokinetical effect caused by the changes in strained conditions of earth's crust before earthquakes, due to the changes of electrotelluric potential, has been carried out by Gershenzon et al, (1989). On the basis of calculations they put the natural and very common assumptions about the beginning and development of inhomogeneous mechanical properties in the strain crust during EQ preparation. It was enough for drawing of space-timing picture of superfluous pore liquid pressure distribution near Earth's surface. As the result, it was shown that pressure gradient in horizontal plane was not large and led to comparatively weak electrokinetical effects. But in vertical plane, when pore liquid is easily connected with the surface, the large vertical gradient of pressure appears near the surface with comparatively quick changes of volumetric deformation, therefore, we can have the considerable value of electric field. As the result, there are two methods of ETF measuring for finding EQ precursors:

1) for horizontal (traditional) disposition of electrodes with consideration of crust's inhomogeneities;
2) for vertical disposition of electrodes, one is above, and another is below the water-carrying stratum in homogeneous environment.

Probably, the first investigations in ETF vertical component measurement for EQ prediction and volcanic activity have been carried out in Japan (Fujinawa and Takahashi, 1990). According to our agreement in science-technical cooperation, in Kyrgyzstan the analogous measuring system, produced by "TOA Electronic LTD" and "NF Electronic Instruments", was mounted.

2, Measuring system

Beginning from November 1991 in Kyrgyzstan (Fig.1) the continuous measuring of ETF vertical component has been organized for discovering earthquake precursors.

The system has 3 recording channels, every one from which has its own frequency range: DC-1 Hz, 0.01-0.1 Hz, and 1-9 kHz. Block diagram of the

a) Artificial perturbations

Por singling out of perturbations, which were caused by hunan activity (observation station is in Bishkek), me have used records of daily (notion for 3 channels fro» Monday to Priday (otherwise the working days, Fig.3(a» and daily notion for Saturday, Sunday, and holidays (otherwise the unworking days, Fig. 3(b)). In comparison of these records the perturbations (so-called "packets"), which are displayed on 0.01-0.1 Hz and 1 Hz ranges and have a definite period and amplitude in tine interval fro» 07.00 to 16.30 local time (LT), are singled out.

b) Geomagnetic activity

For singling out of geomagnetic perturbations, the magnetograms of vertical coiponent of geomagnetic field at the nearest stations were used. Figures 4(a,b) show the examples of ETP perturbations caused by geomagnetic activity (magnetic storms). As the rule, perturbations have the characteristic peculiarities on tine and magnitude of geomagnetic activity, which are displayed on 0.01-0.1 Hz and 1 Hz ranges. The arrival of the first impulse of geomagnetic perturbations is reflected in mV-increase on 0.01-0.1 Hz and 1 Hz ranges.

c) Thunderstorm activity and whistling atmospherics (whistlers)

Figure 5(a) shows the example of storm influence in 3 frequency ranges. At the moment, when all these ranges, given in definite measuring limits, cannot register input signals exceeding limits, the protective system begins to work

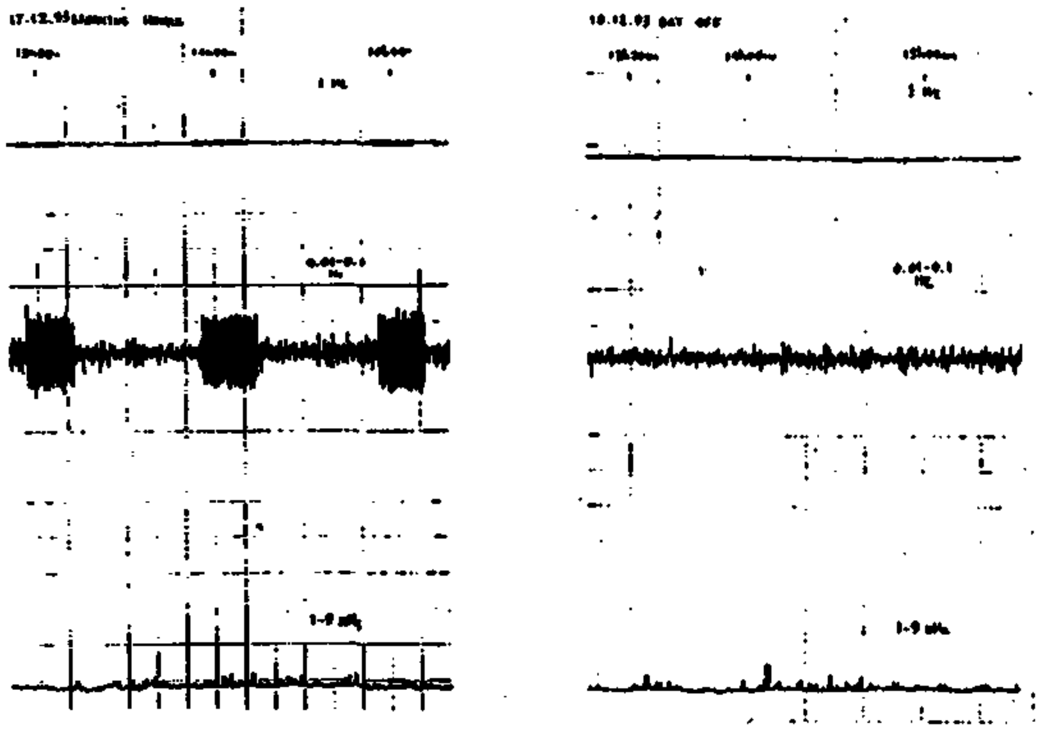
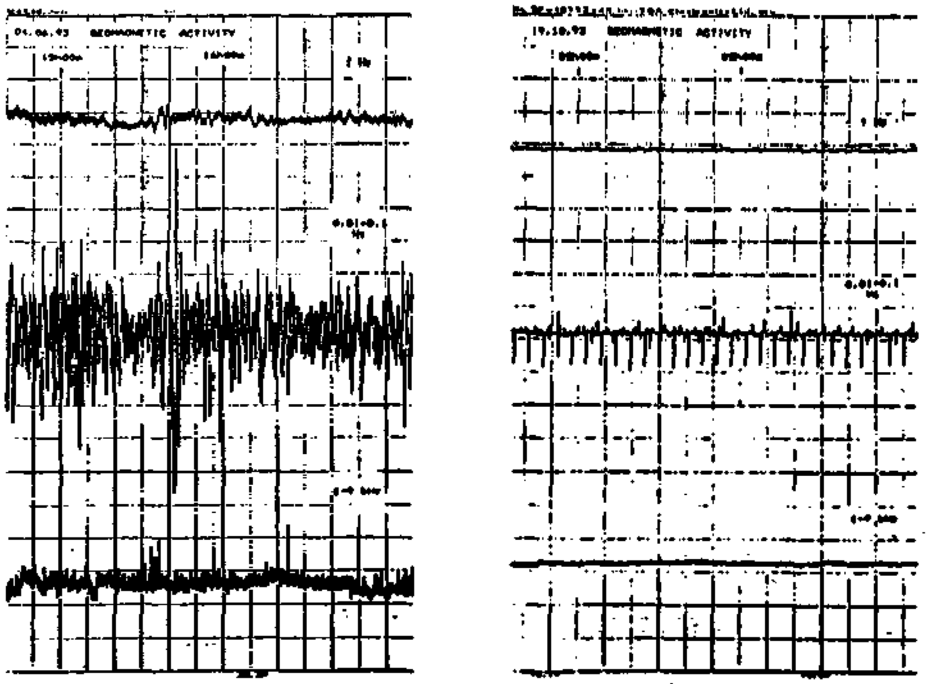


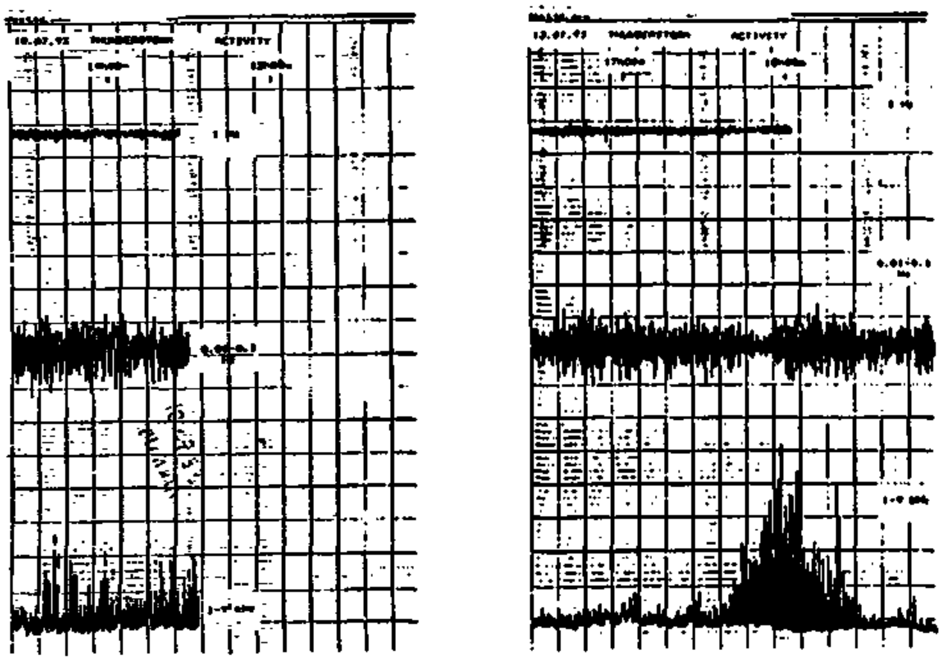
Fig.3(a). Record of daily motion on working day.

Fig.3(b). Record of daily motion on unworking day.



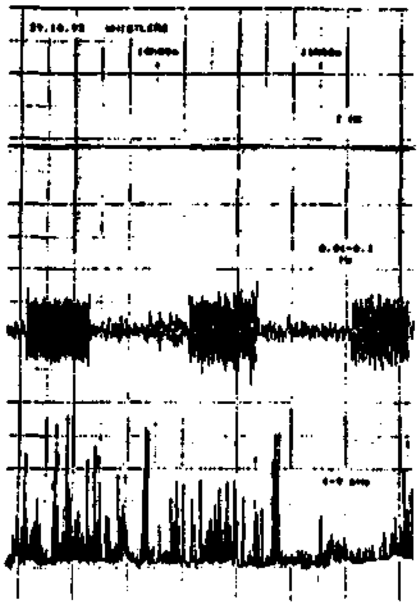
(a) (b)

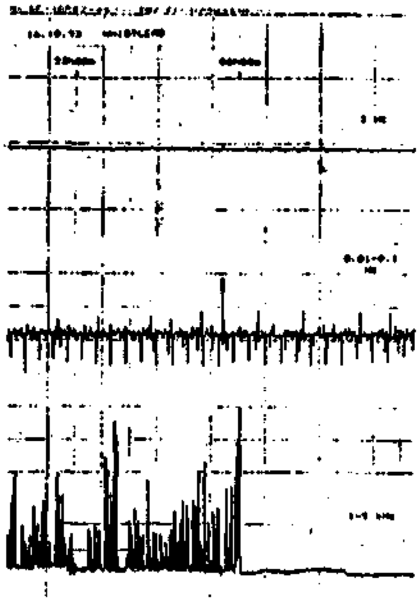
Fig.4. Examples of ETF perturbations caused by geomagnetic activity (magnetic storms).



(a) (b)

Fig,5, Influence of thunderstorm activity.





(a) (b)

Fig.6. Influence of whistlers on the background of magnetic storm,

and ranges are restarted. It should be noted that during ston activity as displayed at all ETF recording ranges at the sane tine (there is only amplitude difference), the protective system works selectively (Fig.S(b)).

As a rule the whistler's influences do not lead to the start of protective system and are displayed only at 1-9 kHz range. According to existing notions, the appearance of whistlers is defined by meteorological conditions. That is an explanation of daily variation of whistler appearance, which is defined by the daily variation of ionospheric parameters. Figures 6(a) and 6(b) show the influence of whistler on 3 frequency ranges.

3.1. Precursor signal and quantitative appreciation

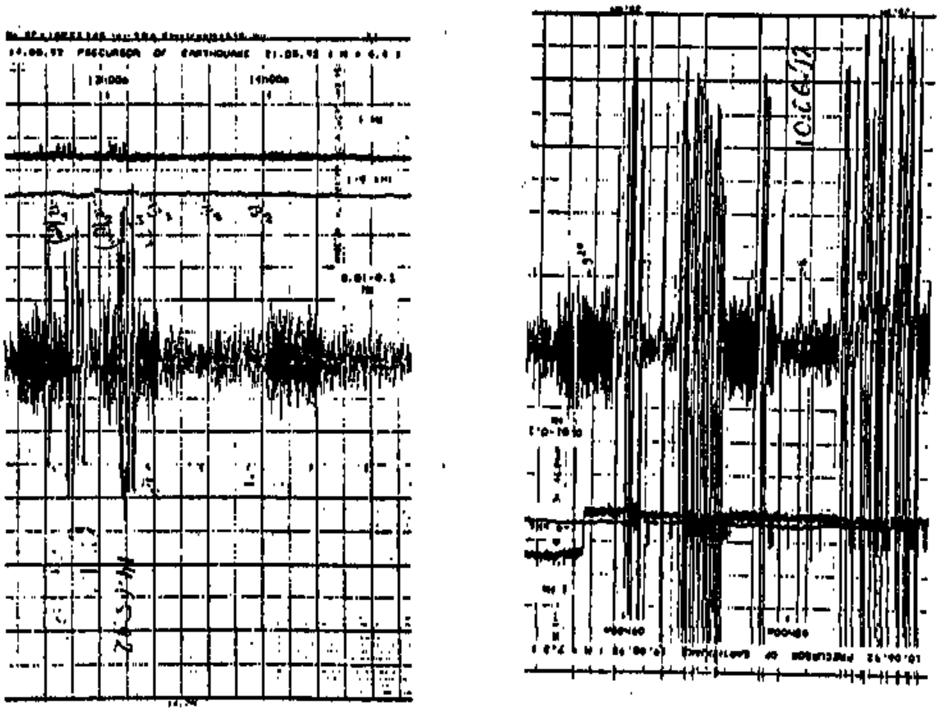
Figures 7(a-f) show examples of precursor signals (PS) for those EQ which are shown on Table 1. As can be seen from these pictures, the 0.01-0.1 Hz and 1 Hz ranges have been worked synchronously. Therefore, we had made the quantitative appreciation of PS-amplitude in mV on these ranges (items 7 and 8 of Table 1).

The first arrival of PS-impulse on 0.01-0.1 Hz range is displayed in IRV-decrease and the similar decrease is observed at 1 Hz range, too. Therefore, the PS calculation on 0.01-0.1 Hz range was made in negative meanings of amplitude and all output data were averaged. For 1 Hz range in PS-amplitude calculation, we considered the trend character of year motion (Fig. 8), which was concluded in mV-minimui in summer (July-August) and mV-maxiraura in winter (December-February), and that is why we have taken the average meaning of daily motion (without PS-anplitude) for that PS-time, as a background meaning, and according to it, the PS-amplitude has been selected. After that all the data have been averaged.

Table 1. Precursor signals.

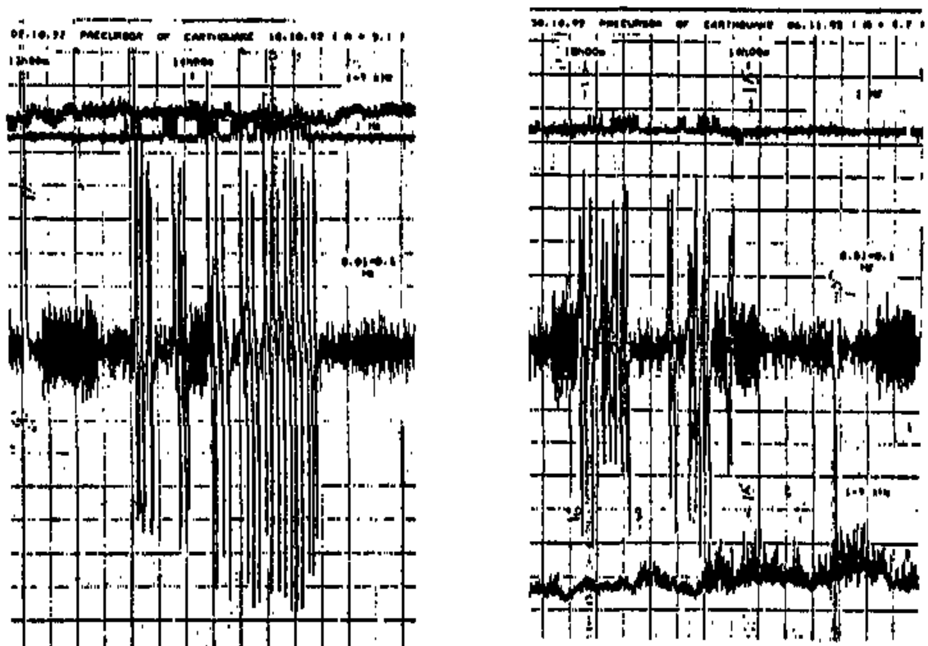
1 - EQ date; 2 - EQ coordinates; 3 - distance(R); 4 - magnitude(M);
5,6 - date and time (LT=UT+5h) of precursor signal's displaying(PS);
7 - amplitude (Л1) of PS on 0.01-0.1 Hz range;
8 - amplitude (A2) of PS on 1 Hz range;
9 - day's quantity before EQ

N	1	'I	3	A	5	6	7	8	9
	EQ date	EQ coord'mates	R km	И	PS date	PS time	Л1 mV	Л2 mV	Q
1	21. 05. 92	41' 00" 72' 28"	260	4. 4	14.05.92	12h30m-13!il0m	-20	-40	8
2	19. 08. 92	42* 04" 73' 38"	120	7. 3	06. 06.92	13h20ra-13h50m	-50	-150	75
					10.06.92	071i 00m-09h 00 m	-50	-90	71
					14.06.92	08h40m-10h00m	-50	-90	67
						12hl0m-12h30m	-50	-100	
						13h50m-14lil0m	-50	-100	
					18.0G.92	10h40m-12h00m	-50	-90	63
						13h20m-13h40m	-40	-80	
					19.06.92	07h50m-08h50m	-50	-100	62
						12h20m-14h00m	-50	-90	
					22.06.92	07h20m-08h40tn	-50	-100	59
						Uh20m-15h20ra	-50	-100	
3	18. 10. 92	42' 11" 73' 13"	135	5. 1	02.10.92	13h40m-14h50m	-40	-50	17
					03.10.92	12ti20m-12h4Om	-30	-50	16
					06.10.92	12h40m-13h00m	-30	-50	13
4	06. 11. 92	4 Г 06" 72' 12"	275	4. 7	30.10.92	15h00m-16ti00m	-20	-40	7
5	24. 12. 92	42' 20" 72' 13"	220	5. 0	03.11.92	14h30m-151i00m	-25	-50	52
					06.11.82	12h20m-13h00m	-30	-50	49
					U.11.92	10h20m-10h40m	-40	-50	44
						I2hl0n-12h20n	-25	-50	
						13hl0m-13hZOm	-30	-50	
					17.11.92	OOhOOnr-OShlOm	-40	-70	38
						12hl0m-12h30m	-30	-60	
					18.11.92	10lil0m-10h30m	-30	-50	37
						14hl0m-15h3Om	-30	-50	
					20.11.92	08h30m-09h40m	-40	-60	35
						12h30m-14h20m	-40	-60	
					23.11.92	08hl0m-08h30m	-40	-60	32
						09h30m-10h00m	-40	-70	
						12h00m-12U30m	-40	-60	
					01.12.92	12h00m-12hl0n	-30	-50	24
						12h40m-13h00m	-30	-50	
					07.12.92	08hl0m-10hl0m	-30	-50	18
						13hl0m-15hO0m	-30	-50	
					08.12.92	10h20m-101t30m	-25	-50	17
						12h00m-12h20m	-30	-50	
					09.12.92	07h40m-09h00m	-35	-50	16
					11.12.92	Hh20m-Hh40m	-35	-60	14
					17.12.92	12h20m-14h30m	-40	-70	8
6	27.01.. u	40' 42" 72' 42"	285	3. 8	21.01.94	12h00m-12ia0m	-10	-20	G



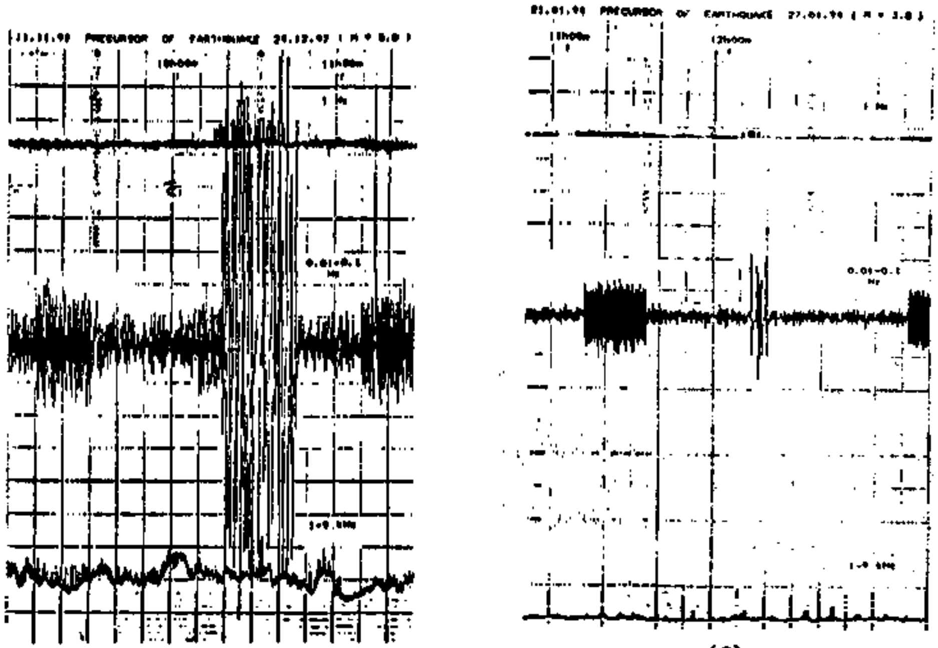
(a) <b>

Fig. 7. (a) ETF-change before 21.,05.92 Щ with MM. 4 and
(b) 19.08.92 EQ with M=7.3



(c) (d)

Fig. 7. (c) ETF-change before 18.10.92 EQ with H=5.1 and
(d) 06.11.92 EQ with M=4.7,



(e) (f)

Fig.7. (e) BTF-change beFore 24.12.92 EQ with И=5.0 and
(f) 27.01.94 EQ with H=3.8.

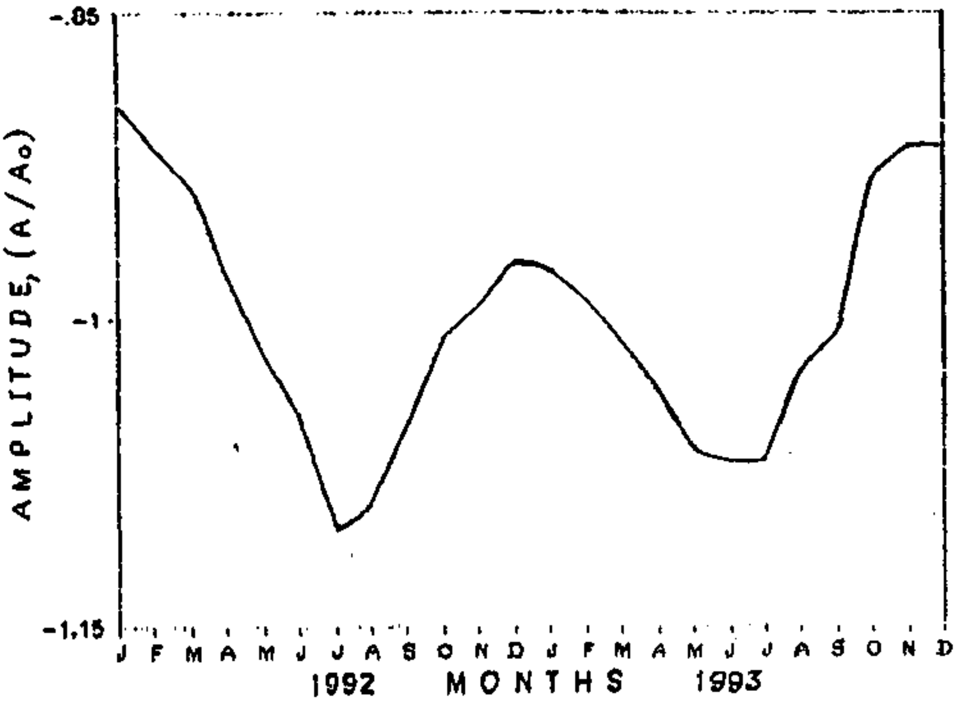


Fig.8. Trend character of year motion of ETF.

Table 2. Results.

N	Events	Displaying on ranges 0.01-0.1 Hz	1 Hz	1-9 kHz
1	Artificial perturbations	yes	yes	no
2	Geomagnetic activity	yes	yes	no
3	Thunderstorm activity	yes	yes	yes
4	Whistlers	no	no	yes
5	Precursor signal (PS)	yes	yes	no

4. Discussion and conclusions

Registration and analysis of vertical component changes of Earth's ETF permit us to make the conclusion that recorded artificial and natural events have their own characteristic peculiarities on 3 frequency ranges (Table 2) and can be selected with the help of this method of data processing.

As for geomagnetic storm activities and whistlers, it is very difficult to explain the correlation of these events with EQ, because all the data, which we have, do not permit us to answer "is this anomaly the consequence of process beginning on zone of EQ preparation" (Gokhberg et at., 1985; Hayakawa et al., 1993; Finkelstein et al., 1973).

As for PS, the practice of forecasting researches have shown that with data processing the possibility of experiment in real time (IT) is extended essentially, because the time anomaly of observed field can be interpreted as PS, whereas the time of PS displaying in LT.

Figure 0 shows the item 7 from Table 1 (PS-displaying during 24 hours of LT) and the quantity of its appearance for this variational row.

We can explain the time of PS appearance (ad hoc, 07h00ra < LT < lGhOOre) by the nature of PS-displaying, using this method of ETF measurements. It is a common knowledge that the solar wind leads to appearance of inulti-frequency ionizing radiation with high power on the earth poles. This radiation is dispersed in unpoling fields and on that moment, when dispersion vertical current of the Earth is in permissible limit, the reflection of the ground and underground anomalies can be measured (Helms, 1985).

The permissible limit, ad hoc, is defined by the time of EQ precursor's displaying, which is fixed at 1-9 kHz range, which is expressed by the transition from night maximum to day minimum and. from day minimum to night maximum (Fig.10) (so-called "effect of sunrise and sunset"). Here we must note

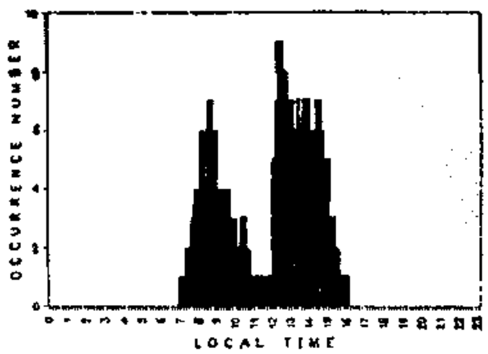


Fig.9. PS-displaying during 24 hours and its occurrence number.

that every day corresponds with its transition time.

The reflection of by-surface and underground anomalies is fixed on 0.01-0.1 Hz and 1 Hz ranges. Coming fros that, the 1 9 kHz range is not subject to the influence of geomagnetic activity (magnetic storms) and ionizing radiation, which were caused by solar wind, dispersing from earth poles to unpole fields, it permits to explain the daily motion oГ this range, if we take into consideration the influence of solar wind on all structures of power lines of Earth's geomagnetic field on day and night sides.

After that, from Table 1 (items 6 and 7), we distinguish 2 types of EQ, which are characterized by day's quantity during which PS is displayed. The earthquakes of the first type are EQ N 1,4,6 - not more than 1 day (as the rule). Here we must say that for EQ of first type the sources are identified with motion on existing fault planes, and for Щ of second type with appearance of new faults. Thus, coining from existing EQ types, it is possible to predict the place, which is defined by geological conditions.

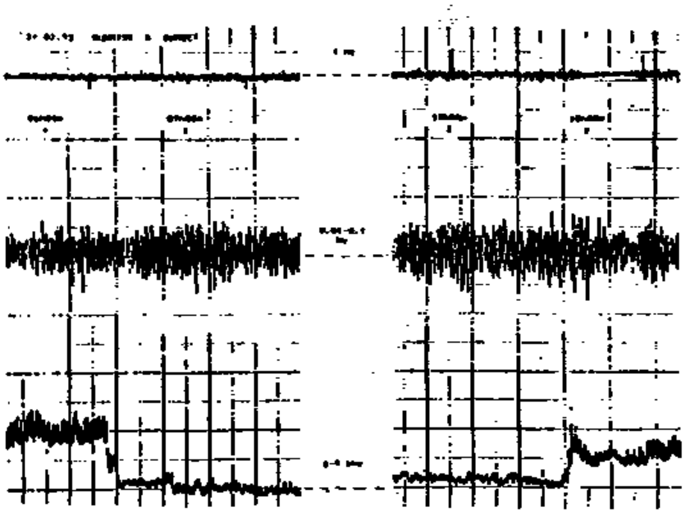
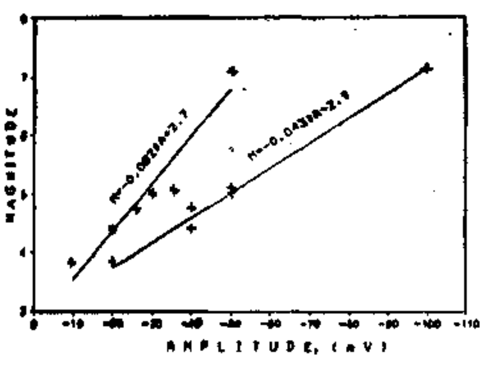


Fig.10. Effects of sunrise and sunset on ETF-variation.



Fig,11- Dependence between KQ magnitude (Ю and amplitude (Л) of PS.

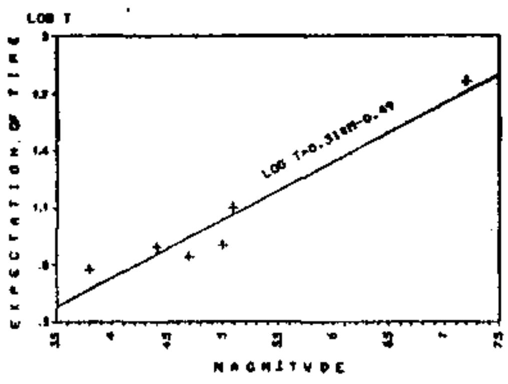


Fig.12. Correlation of EQ waiting time (T) and magnitude (H).

Dependence between EQ magnitude (M) and amplitude (A) of PS was built without distinguishing on EQ types (Fig, 11). The first equation is for 0.01-0.1 Hz range and the second is for 1 Hz range:

1) K = -0.82 * Л + 2.7;

2) H = -0.43 * A + 2.9.

Item 10 of Table 1 shows the day's quantity before EQ, beginning from the day of anomaly appearance. Figure 12 shows the correlation of waiting time (T) ("lull") be fore EQ and i ts magn i tude (Ю. Th i s dependence has been bu i 11 without distinguishing on EQ types (we must say only that, the day's quantity before EQ has been calculated from appearance of the last anomaly). This correlation we had written as the following eauation:

Log T = 0.31 * И - 0.49,

Thus, if we have the network of measuring stations for vertical component of ETF, then it is possible to put the task of short-term prediction of place, power and time of future earthquakes.

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