OBSERVATION AND EXPERIMENT ON SEISMO-ELECTROMAGNETIC WAVES IN CHINA

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Abstract

Two observatoies were built up in Beijing Baijiatan and Longfang of Hebei Province to record the Seismo-Electromagnetic waves (SEM) before earthquakes on 1985. The waves received can be divided into five ranges according to their frequency bands: 0.1-20Hz; 15KHz; 1.65MHz; 0.5-5KHz; 120-160KHz. By many years' observation it has been found that unusual radio emission was sometimes recorded in most stations within the epicentral distance of 200Km one to ten days before an earthquake of magnetude greater than 4.0.

We have collected the data concerning the whole process for the earthquakes of magnitude 6.1 on 18th of October 1989 in Daton, Shanxi province.

We have taken part in the experiment on fractures of rocks in the field to study the mechanism of producing SEM pulses on the impending stage before an earthquake and to clarify whether the SEM emission can be generated during the fractures in rocks.

(1) Introduction

Great attention has been drawn to the SEM waves after the large Tangshan earthquake of 1976. Some stations have been established for observation of SEM waves at dangerous areas of earthquakes in China. They expect precursory signals of SEM waves to appear before large earthquakes with magnitude of 6.0 to 7.0Ms at dangerous areas.

Since Tangshan earthquake of 1976 our research group was established for observation of SEM waves with frequebcy 5 bands on May of 1985 in order to study on the dominant SEM waves components before earthquakes. Between 1985 and 1990 we decorded 85 samples of earthquakes by this method.

One of the most prominent abnormal SEM waves was recorded before the 6.1 magnitude earthquake on 18th, October 1989 in Daton, Shanxi Province for six years. The depth of focus was approximately 10Km, the epicenter was located in Danton, Shanxi Province and the distance between the Beijing Baijiatan station and the epicentral distance of 200Km. We also collected the data obtained from synchronous observations at 10 stations within the epicentral distance of 200-300Km and studied the characteristics of the signal with time. Our work benefits the research on the mechanism of SEM from the body of the seismic source.

Fracture experiment on the rocks conducted three times in the field proved that the fracture of large scale of rocks produce EM waves, the antenna at the earth's surface is capable to receide the EM waves generated from fracture of underground rocks.

(2) Observation system and capability of predicting an earthquake

There are two sites at Beijing Baijiatan and Longfang of Hebei Province within distance of 70Km. Two sites are synchronouns recording SEM waves with frequency 5 bands since May, 1985.

The instrument for observation and frequency bands shown as table 1.

Table.1

No	F bands	Instrument for observation	observed physical parameters	sensitivity	arrangement for antenna
1	0.1-20Hz	GC-IA magneto-induction probe	magnetic	10 nT	E-W S-N 2m below the earth surface
2	15KHz	RR-7 interference meter	electric field	1 μv	2m in length whip-like vertical
3	1.65 MHz	RR-2 interference meter	E	1 μv	2m in length whip-like vertical
4	o.5-5KHz	seismo- EM meter	E	0.5mV/m	2m in lenth whip-like vertical
5.	120-160KHz	seismo- EM meter	E	0.5mV/m	2m in lenth whip-like vertical

The capability of predicting an earthquake in terms of the SEM waves' abnormaly before its occurrence. We studied the data obtained at wto sites (May, 1985- Dec, 1990) and analyzed data for statistics. The criterion for celecting the correspoding earthquakes has been shown in table.2.

Table.2

Epicentral distance Km	Magnitude (Ms)
< 200	> 4
< 500	> 5
< 1000	> 6
> 1000	> 7

There are 4 features:

1. The anomaly of SEM waves was observable at most station within the epicentral distance of 200Km, one to ten days before an earthquake of magnitude greater than 4.0.

2. The SEM signals for an impending earthquake were observed synchronously at two stations within the distance of 70Km although sometimes were not.

3. Not all the 5 frequency bands synchronouse received anomal of SEM waves before same earthquake. Sometimes signals were observed at only one or two frequency bands, and sometimes at all 5 bands.

4. Sometimes very large signals of anomaly did not correspond to an occurrence of earthquake (within the epicentral distance of 200Kmand with magnitude greater than 4.0) but an earthquake of magnitude greater than 7.0 occurred beyong the epicentral distance of 1000-2000Km. No anomalous SEM waves have been observed during the occurrence of an earthquake.

Result of analyzed data (Beijing Baijiatan station) for statistics was shown in table.3 and table.4.

Table.3

EQ / SEM	Occurred (118)	NO
abnormality (85)	72%	20%
NO	28%	

Table. 4

ΔT / bands	3	5	10
2	51 %	60 %	72 %
3	34 %	41 %	51 %
4	25 %	34 %	38 %
5	14 %	20 %	24 %

ΔT: days of appeared abnormals of before earthquakes

The table.3 shows that in 20% of the casea no corresponding earthquake was associated with the appearance of the abnormal SEM waves and that in 28% of the casec no anomaly of SEM waves was associated with the actual earthquakes.

(3) Analysis of the SEM anomaly before the 6.1 magnitude earthquake of 18th October, 1989 in Danton, Shanxi Province

We collected the data obtained from synchronous observations at 10 sites within the epicentral distance of 200-300Km. Fig.1 shows the distribution of observation sites. Fig.2 and Fig.3 show the abnormal signals observed at 10 sites before the earthquake.

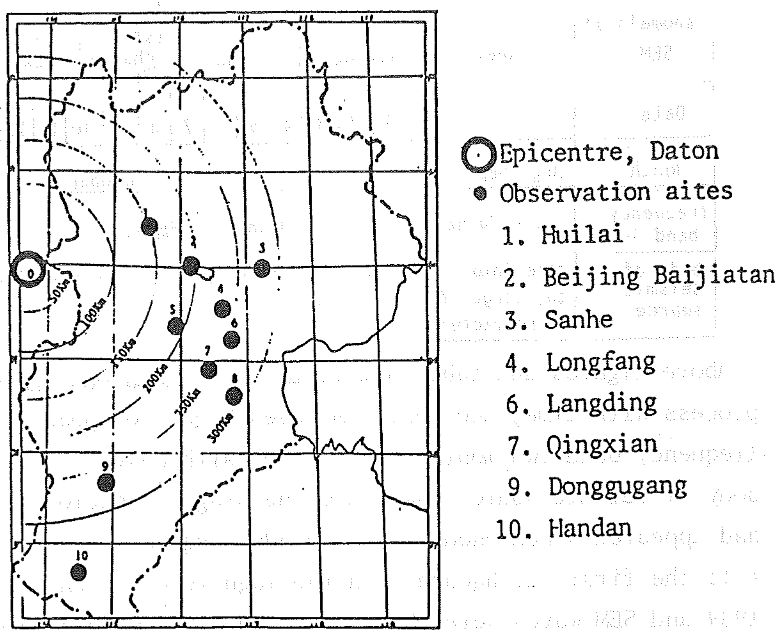

Fig.1 The distribution of observation sites

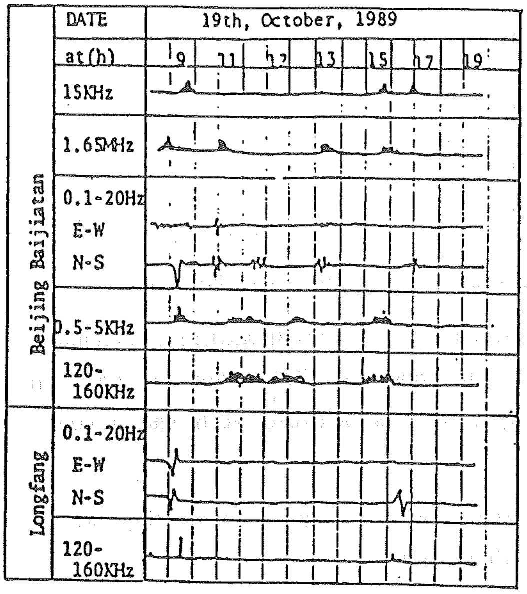

Fig. 2 The abnormal signals observed within 5 frequency bands at two stations on the 9th of October

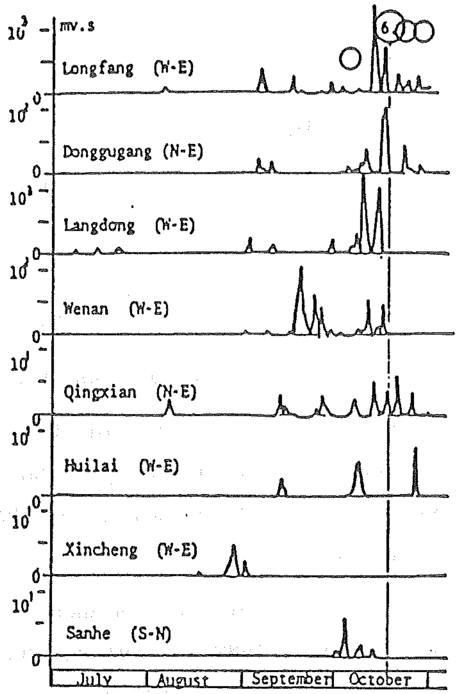

Fig.3 The synchronous record from stations at network of Hebei Province (DC-20Hz)

Table.5

anomals of SEM	week	strong			no				step change		week						strong			no
Date		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Month	Aug- Sep	October																		
frequency band	0.1- 2o Hz	0.1hz - 1.65MHz																		QE
body of seismic source	come into the stage of microfracture	come into the large scale of microfracture																		6.1 Ms 6.4 6.3 (Ml)

Above figures and table.5 tell us that anomalous SEM waves on change process with time, and that SEM waves began to appear in ultra-low frequency band two months before the earthquakes. It was shown that the body of seismic source came into the stage of microfracture. The anomaly had appeared synchronously in 5 bands frequency after the 1th of October till the first earthquake with the magnitude 6.1 on the 18th of October 1989 and SEM waves were observed at 10 sites within epicentral distance of between 200-300Km. This indicates that the body of seismic source had came into higher stage of microfractures. On the whole, the anomalous SEM waves before earthquakes of magnitude 6 have larger amplitudes, wider radiation extent and earlier appearance than before those earthquakes of magnitude 5.

(4) Fracture experiment on the rocks in the field

We have taken part in the experiment of fractures in rocks using a man-made explosion in order to study the mechanism of producing EM pulses on the impending stage before an earthquake and thus to clarify whether the EM emission can be generated during the fractures in rocks.

Explosion was made with 500 tOns (NTN) in granitic caves in Apr., 1981. We observed the EM pulses during the fracture process in the granitic hill. It can seen from Fig.4 that series of EM signals were received by the antenna 600m away from the explosion source at 119.3ms after the explosion and the duration of the EM signals was about 522ms. The dominant EM components were of 292-3700Hz according the spectrum analysis the signals recorded by magnetic type. Those EM signals were neither due to the vibration of the madium around the receiver since the arrival time of seismic waves, 130ms, as shown in Fig.4 was about 10.7ms later than that of the EM signal, nor due to the explosion isself since the EM emission from the explosion should have a short duration (5-20ms) and extremely high frequency (a few hundreds-a fwe thousands 10^9 Hz) which might be easily absorbed by the rocks above the caves and is also far beyond the dominants frequency bands of EM signals we received. It was seen from the high speed films for the explosion that the upper layer the exploded cave started to move upwards at about 100ms by shock waves and was blown up at 600ms. The time interval from 100 to 600ms is thought as the fracture process of the cave which coincides with the apperrance of EM signals. Therefore we think that the EM signals we received were due to the fracture of the mountain rocks.

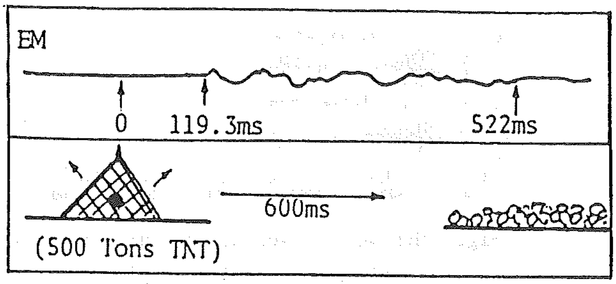

Fig.4 The EM accompanied with fracture of the mountain rocks

The observation were also made of two underground nuclear explosion in 1983 and 1984 in order to reveal whether the EM waves from the fracture of underground rocks can be detected by an antenna at earth's surface or not

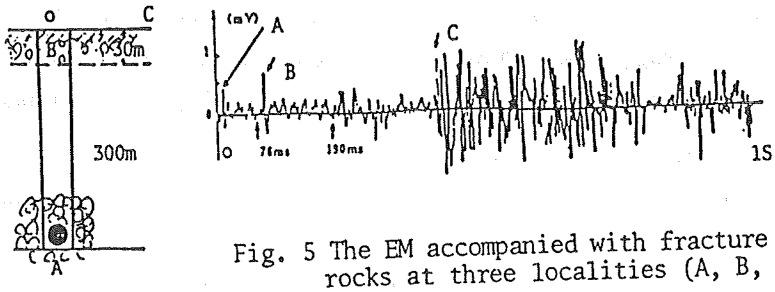

Fig. 5 The EM accompanied with fracture in rocks at three localities (A, B, C)

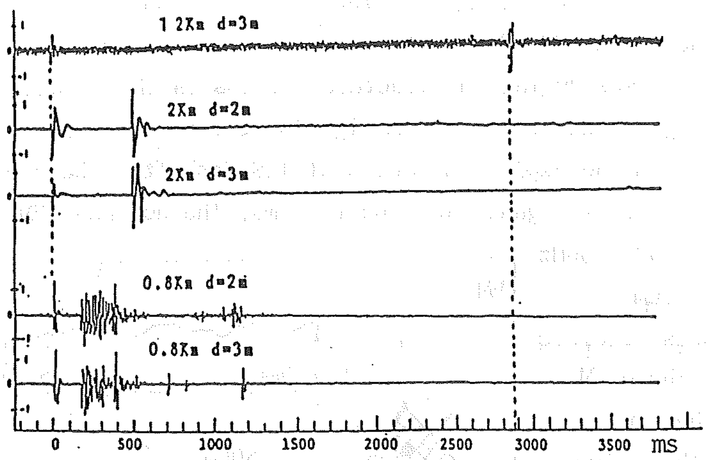

Fig.6 The EM received at the three stations after underground nuclear explosion (0.8Km, 2Km, 12Km)

and to find the spectrum of the EM signals from the fracture of large scale of rocks.

Result of the measurement for the 1983 explosion is shown in Fig.5. Three groups of EM signals were received after underground nuclear explosion (A, B and C); A: at the seismic source, B: at the earth's surface above the source, and C: at the observation site 960m away from the source. The fracture in rocks at B with thickness about 30m and a radius of 500m was due to stronger shock waves from the seismic source which arrived at earth's surface and produced reflecting waves. The fracture in rocks at C was due to seismic waves arrived. The EM emission is dominant at frequencies of 200 -7000Hz.

Three observation sites were shosen 0.8, 2.0 and 12.6Km away from the source , where the same instruments and antenna as the previous ones were established before the second experiment in 1984. Consequently, the EM waves associated with the fracture process in rocks were observed (Fig.6). It is shown from the experiment that firstly, the fracture of large scale of rocks produces EM waves and secondly, the antenna at the earth's surface is capably to receive the EM waves generated from the fracture of underground rocks and thirdly, the frequency bands for those EM waves aer fairly wide and the lower frequency bands are dominated by the components of 200Hz to a fwe KHz.

An enlightenment was given from experiments that the observation sites should be set up close to an active fault so that the EM waves from the fault can be received as long as the fault acts.

(5) Discussion

After many years' observation and study we are convincing that the anomaly of SEM waves can be observed before an impending earthquake. This information may be useful means to make an impending prediction although it may not be valid for all the cases. However, the SEM signals anomaly, as a method for earthquake prediction, needs further intensive observation and experimental work. There are some problems to be solved: 1. Not all the 5 frequency bands simultaneously received anomalous SEM before an earthquake. Sometimes only one or two frequency bands, and sometimes all the 5 bands received signals. Why is appeared this phenomena? 2. Why don't we receive anomalous SEM during the occurrece of an earthquake? We made experiments of rocks fracture. Most and strong signals of EM were received at primary crack of rocks. If recorded SEM waves propagates from a region of impending earthquake so this signals is stronger at occurring earthquake. 3. Why don't all the stations with the same antennas and the same recorders synchronously receive anomalous SEM waves before some earthquakes in China, in Japan and in Greece. I suppose that this signals is not directly propagating from earthquakes focus to absérvation sites at earth's surface. 4. How do signals of SEM propagate to observation sites at earth's surface from earthquake focus?

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