SYNERGETIC EFFECT OF ABNORMAL BEHAVIOR OF ANIMALS BEFORE EARTHQUAKES

Wu Zhongliang

(Institute of Geophysics, SSB, Beijing, 100081)

ABSTRACT

The synergetic effect of abnormal behavior of animals before earthquakes is discussed in this paper. The result of a simple model based on the interaction between animals can explain the statistical data. It was also pointed out that the system of animal colony reacts to the stimuli of environment in a nonlinear way, which leads to more complexity in the application of this phenomena in earthquake prediction.

Key Words: Abnormal behavior of animals, synergetic effect, earthquake prediction

INTRODUCTION

The abnormal behavior of animals before earthquakes had been regarded as one of the most important precursors of destructive earthquakes (IBAC, 1977; Andriese, 1979). The results of many field investigations and experiments show that such abnormal behavior is associated with the physical or chemical precursors such as microseismicity, the emanation of gas and the change of electromagnetic field (Buskirk, et al. 1981; Jiang, 1980, 1981; Deshpande, 1987). A problem which has been neither mentioned nor resolved is , in which way the animals affect each other in their abnormal behavior. And such a problem is inevitable as we consider the utilization of this phenomena in earthquake prediction, because generally the animals live in colony and bound to interact with each other, especially in the case of anomaly. In fact, before many earthquakes, most of the events of abnormal animal behavior are in the form of social reaction (see, e. g. Chen, et al. 1979, in Fig. 1). And their interaction with others, of their own or different species, played an important role in the formation of the abnormal behavior which precedes earthquakes.

SYNERGETIC EFFECT OF ABNORMAL BEHAVIOR OF ANIMALS BEFORE EARTHQUAKES

Considering a simple model, let us assume that in the sense of average the sensitivity of all species of animals is at the same level, and there exists an interaction between different individual animals. Within time interval Δt the probability of the induction of another event of abnormal behavior by a previous events is $\Lambda\,\Delta t + 0(\Delta t)$, and thus a new event of abnormal behavior should be induced by N previous abnormal events with probability $\Lambda\, N\Delta t + 0(\Delta t)$. Therefore at time $t + \Delta t$ the probability of the occurrence of N abnormal events is

$$P_N(t+\Delta t) = P_{N-1}(t) \wedge (N-1)\Delta t + P_N(t)(1 - \wedge N\Delta t) \quad (1)$$

As $\Delta t \to 0$, equation (1) becomes

$$\frac{dP_N(t)}{dt} = -\wedge N(t)P_N(t) + \wedge (N(t)-1)P_{N-1}(t) \quad (2)$$

with the solution

$$P_N(t) = \binom{N-1}{i-1} e^{-\wedge t}(1 - e^{-\wedge t})^{N-i} \quad . \quad (3)$$

where i is the number of abnormal events at t=0, and thus

$$E\{N(t)\} = \sum_{j=i}^{\infty} jP_j(t) = ie^{\wedge t} \quad . \quad (4)$$

From Fig. 2 and Fig. 3 it may be seen that equation (4) can explain the trends of variation of the statistical data on the temporal scale of day and hour. With the concept of synergetic effect we can understand why the occurrence of abnormal behavior of animals does not synchronize with other physical and chemical precursors causing the animal reaction and why in average the event number of the abnormal behavior varies in the way of exponental increase. Considering the limited number of animals, the difference in sensitivity between different species and the background noise, more detailed models may be developed to fit the statistical data. However, it is more important that the synergetic effect dominates the temporal evolution of the abnormal behavior of animals.

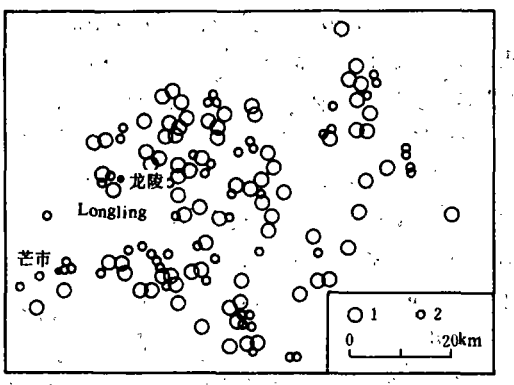

Fig. 1 Spatial distribution of abnormal behavior of animals before the Longling earthquake, Yunnan on May 29, 1976 (from Chen, et al.,1979).
1. for abnormal behavior of colony
2. for abnormal behavior of individual animal

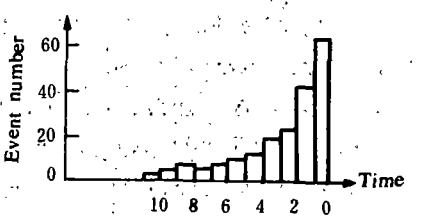

Fig. 2 Average temporal distribution of event number of abnormal animal behavior before earthquakes (from Jiang, 1980), the time unit is hour

The system of the animal colony reacts to the physical and chemical stimuli in a nonlinear way. In this process two dominant factors are the intensity of the environment stimuli F and the strength of the interaction within the colony B. The status of the reaction may be described by the parameter $\wedge$ in equation (4) with a positive $\wedge$ represents the state of abnormal behavior and a

negative one represents the normal. As a qualitative description the simplest form of the system reaction may be expressed as a cusp system as shown in Fig. 4, in which we see three kinds of paths of the variation of parameters which corresponds to the three cases we are familiar in the practice of earthquake prediction: (1) abnormal animal behavior precedes earthquake; (2) earthquake without abnormal behavior of animals; and (3) abnormal behavior of animals without earthquakes.

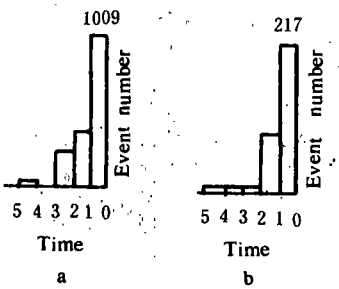

Fig. 3 Temporal distribution of event number of abnormal animal behavior before earthquakes (from Jiang, 1980), the time unit is day
a. Haicheng earthquake, Liaoning on Feb. 4, 1975
b. Longling earthquake, Yunnan on May 29, 1976

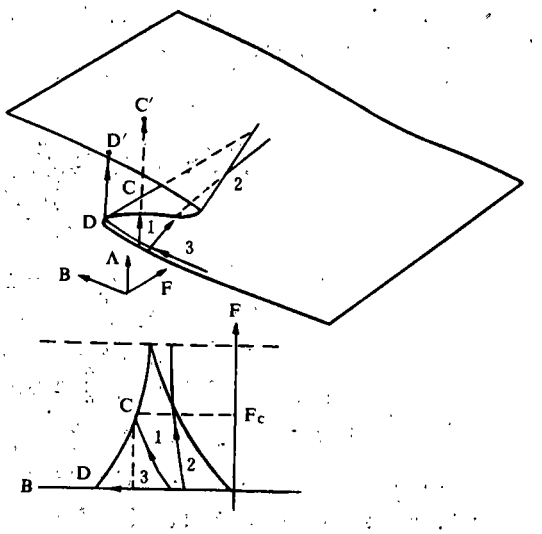

Fig. 4 Relation between the parameters and its variation paths

DISCUSSION

The earliest western reference to the discovery of the relation between abnormal animal behavior and earthquakes was found in Italy as early as 1887, whilst hundreds of years ago Chinese had found the same phenomena. Many writings on earthquake prediction (e. g. Rikitake, 1976) mentioned abnormal animal behavior as one of the precursors to be considered as elements for prediction. And it was the abnormal animal behavior before the Haicheng, Liaoning, China earthquake of 1975 that helped the government to persuade the residents to leave their houses in the winter days before the catastrophe. It was pointed out that the minute physical or chemical variations before earthquakes are perceived by the animals which naturaly react according to their specific anatomy, physiology, psychology and behavioural patterns. To some extent the animals amplified the physical and chemical precursors. And in the same sense we may say that the colony of animals amplified the animal reaction for the second time. And the second amplification plays a more important role in the distortion of information of the on- coming earthquake, which can not be ignored in the study of earthquake prediction.

REFERENCES

[1] Andriesc, P. D. (ed), EHRP Conference II: Abnormal animal behavior prior to earthquakes, 1979.
[2] Buskirk, R. E, C. Frohlich and G. V. Latham, Unusual animal behavior before earthquakes: A review of possible senso-

ry mechanisms, Rev. of Geophysics and Spacephysics, 19, 247—270, 1981.
〔3〕 Chen, L. and W. Zhao (eds), The 1976 Longling Earthquake, Seismological Press, 1979.
〔4〕 Deshpande, B. G., Earthquakes, Animals and Man, Indian National Science Academy, 1987.
〔5〕 Institute of Biophysics, Academia Sinica, Animals and Earthquakes, Seismological Press, 1977.
〔6〕 Jiang, J., Animal abnormal behavior is an earthquake short- term precursor, Acta Seismologica Sinica, 2, 304—313, 1980.
〔7〕 Jiang, J., A study of the relation between acoustic emission and animal unusual behavior prior to earthquakes, Acta Seismologica Sinica, 3, 429—439, 1981.
〔8〕 Rikitake, T., Earthquake Prediction, Elsevier, 1976.

地震前动物异常行为的协同效应

吴忠良

（国家地震局地球物理研究所）

摘 要

本文研究了动物群体中乃至一个特定地区的整个生态系统中动物个体之间的相互作用，讨论了地震前动物异常行为的协同效应。在最简单的情况下，描述这种协同效应的方程具有生态学中的种群动力学方程的形式。作为这种协同效应的一个结果，地震前动物异常起数的平均值具有指数增长的形式，这与实际资料是相符的。用外界环境变化和动物群体对外界刺激反应两个因素作为控制参量的简单的非线性模型，可以定性地解释震前动物异常行为的复杂性。因此，在用动物异常进行临震预报时，必须考虑动物群体的作用及由协同效应导致的复杂性。

关键词：动物异常行为 地震 协同效应

（上接96页）

DISCUSSION ON THE FORMULA OF MEAN SQUARE ERROR OF MOSCLOSURES FOR TRILATERATION NETWORKS

Jiang Zaisen , Zhu Yiqing

(Second Crustal Deformation Monitoring Center, SSB, Xi'an, China)