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A search on earthquake based on regional stored energy oscillation model

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ABSTRACT

Earthquakes still post a great threat to human beings. As the information technology and science advance, the study of earthquakes has also made great progress. Yet from the long-term prospect, the study of earthquake still faces many difficulties. The research of earthquakes based on regional stored energy oscillation model, to some extent, plays an important role in the earthquake prediction.

KEYWORDS

Regional; Stored energy oscillation; Earthquake studies; Regional stored energy.

INTRODUCTION

In terms of seismic structure, China is a country with frequent earthquakes. Therefore, earthquake prediction remains a difficult yet important task for us. As science and technology develop, people have realized that most natural systems are nonlinear systems and linear systems are just either similar to nonlinear systems or simplified from nonlinear systems. The preparation of earthquakes is undoubtedly very complicated. Therefore, it necessary and important to employ regional stored energy oscillation model to study and predict earthquakes.

INTRODUCTION OF REGIONAL STORED ENERGY OSCILLATION MODEL

The preparation and development of an earthquake is very complicated and the precursors and irregularities occurred in such process are also nonlinear. For example, the distribution of earthquakes is not even. The frequency, irregularities and the time of occurrence are also nonlinear, not in a certain pattern. In other words, the irregularities, despite the scopes, and the evolvement on time and space are closely connected with geological structure. Therefore, the nature of earthquake is uneven medium coming across stress, also the nonlinear storage and evolvement of energy in a certain region. According to modern physics, it can be observed that the nonlinear storage of energy is similar to the precursors of an earthquake. Therefore, simulating and predicting an earthquake by employing nonlinear storage of energy (which is simulating an earthquake with regional stored energy oscillation model) is crucial in providing evidence for earthquake prediction.

THE SIGNIFICANCE OF APPLICATION OF EMPLOYING REGIONAL STORED ENERGY OSCILLATION MODEL IN EARTHQUAKE STUDIES

In predicting the earthquake

Since 1980s, the global scientific community has been post with 10 most difficult questions and one of them is earthquake studies. As one of the most difficult questions, is has been addressed with continuous efforts. Although great progress has been achieved, the difficulties and obstacles still remained. Earthquake studies require long time and hard work. Therefore, due to regional stored energy oscillation model's usefulness in the simulation of earthquakes, is has been widely applied in earthquake prediction.

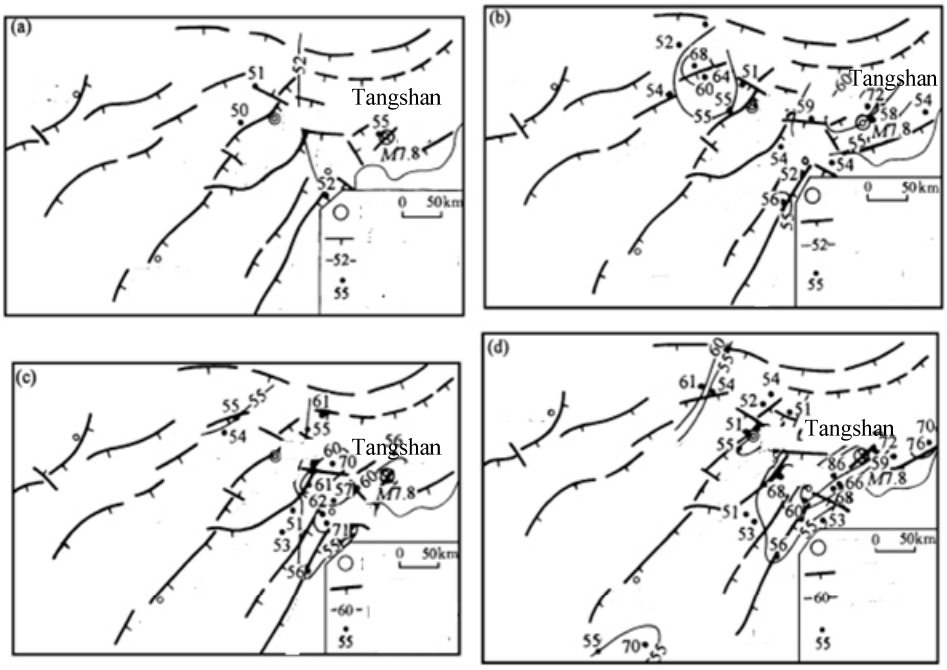
In improving the methods of predicting earthquake

Since the earthquake is caused by a number of fault planes, which belongs to regional stored energy oscillation system, the prediction of earthquakes may not be precise as expected. For the structure belongs to the same level system, the difference in regularities will cause predictions vary in time. If the structure gets more even, the range of time and space for earthquake prediction gets broader. This model is suitable for the prediction of long-time earthquakes. It's also useful in improving methods of earthquake prediction and therefore finds more effective methods to predict earthquakes.

THE EVOLUTION CHARACTERISTICS OF PRECURSORS OF AN EARTHQUAKE

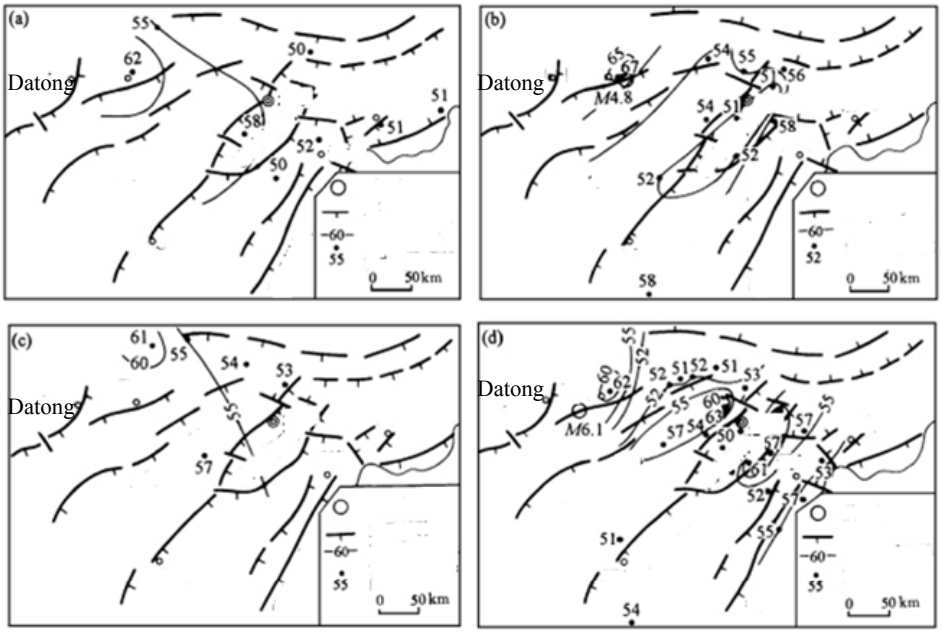
TABLE 1: The special evolvement characteristics of the precursor μ

Tangshan 7.8 magnitude	One year to the earthquake	few irregularities	small area with irregularities and no highly intense areas
	Six months to the earthquake	frequent irregularities	large area with irregularities and no highly intense areas
	One month – half a month to the earthquake	irregularities became less frequent	the area with irregularities became smaller and highly intense area occurred in the block edge and inner areas of Tangshan
	less than 30 days to the earthquake	irregularities became more frequent	the area with irregularities became larger and highly intense area occurred in the block edge and inner areas of Tangshan
Datong 6.1 magnitude	Six months to the earthquake	few irregularities	small area with irregularities and highly intense area occurred in the block edge and inner areas
	Two months – Six months to the earthquake	frequent irregularities	large area with irregularities and highly intense area occurred in the block edge and inner areas
	One month – two months to the earthquake	irregularities became less frequent	the area with irregularities became smaller and no highly intense areas
	less than 30 days to the earthquake	irregularities became more frequent	the area with irregularities became larger and no highly intense areas



(a) ΔT>13;(b)6<ΔT<13;(c)3<ΔT<6;(d) ΔT≤3
ΔT refers to the period of earthquake's occurrence

Figure 1: The earthquake precursor diagram of 7.8-magnitude Tangshan earthquake



(a) ΔT>24;(b)13<ΔT<24;(c)3<ΔT<13;(d) ΔT≤3
ΔT refers to the period of earthquake's occurrence

Figure 2: The earthquake precursor diagram of 6.1-magnitude Datong earthquake

An earthquake is a process of pushing force occurred on geological structure and caused energy to store and release. Such process will cause physical and chemical changes occur on hypocenter and its surrounding areas, such as the changes of ground water's position and terrains, and the chemical change of water quality. The precursors of an earthquake include various irregularities and characteristic of clues of a coming earthquake. The special evolvement characteristics of the precursor μ is shown as TABLE 1.

With the differences in time, the precursors and characteristics of earthquakes are also different. According to TABLE 1, Figure 1 and Figure 2, the characteristics of precursors can be divided into dynamic and static precursors.

(1) dynamic precursors. Before an earthquake, the precursors are gradually becoming increasing frequent as a whole. However, they come in a nonlinear system. Sometimes precursors occur, sometimes not. Sometimes contour lines appear more frequent, sometimes less. The space range of irregularities sometimes becomes broad, sometimes narrow. But judging from the whole trend, they also share a common feature: the precursors of epicenter are always frequent as a whole.

(2) static precursors. The precursors occurring before an earthquake are always in an irregular pattern. The shape of their contour lines is basically similar to the shape of geological structure's lines. The precursors may occur with different frequency, and the distribution of the frequency may be affected by the bumps and dents of geological structure, which causes the differences in prediction drawings. It shows that the preparation and development of earthquakes are complicated. However, all these various characteristics have one shared feature: the highly intense precursors always surround the epicenter.

THE TYPES OF REGIONAL STORED ENERGY OSCILLATION MODEL

The block model

The block model refers to the visual simulation of an earthquake by using spring-block to impose force on several faults. This model is used to simulating the process of an earthquake. During the preparation and development of an earthquake, the stress value of all parts can be worked out with a linear differential equation. If the stress value of a part is larger than the static friction, the block will move in this part and the stress will be released. Meanwhile, readjust all the stress values within the system and make them the initial values and calculate the stress values of all parts based on the changes over the time. The simulation based on this model demonstrates that the time and space of earthquakes have a certain pattern, which plays an important role in sorting out the patterns of the earthquake and also is useful in promoting earthquake prediction.

The cellular automata model

The cellular automata model is drawn from the theory of dissipative system's self organization and its main function is to simulate some features of the alignment occurring in the process of the earthquake. This model divides a space into numerous cellular with a certain pattern and each one is imposed with fixed discretization data to show the physical situation of this part. In terms of time, it's also discrete. During this period, each part of cellular will evolve into something new and replace the old ones. The rules employed in such process are regional rules, which mean, for the part in the next period, each part of cellular decides the values of its present time. This model is able to simulate the characteristics and details of the earthquakes.

Other models

Apart from the block model and the cellular automata model, regional stored energy oscillation includes other models, such as planar network system model. It's made of several nonlinear parts. By detecting seismic activities with planar network system, it simulates the fault planes which have mutual affects on each other. Planar network system model fully considers the coupling occurred in faults. However, due to the differential equations this model needs for application, it requires substantial, complicated calculation, but it restrains the wide application of planar network system model.

THE CALCULATION BASED ON REGIONAL STORED ENERGY OSCILLATION MODEL

The conclusion based on regional stored energy oscillation

With current technology, it's difficult to directly calculate the stress value of the structure or its stored energy value. Therefore, the nonlinear energy storage occurring in modern physics can be employed to simulate the situation of energy storing of certain geological structure. The specific methods are employed to change the block model: 1. to demonstrate unevenness of geological structure with location function of its part into different stratigraphic data; 2. to demonstrate the nonlinear features of certain structural activities by employing elastic coefficient. After changing the model, the focus shifted to the study of energy storage, transfer and evolvement. Based on this model, the equation of activities among the blocks will be created. When discretization was created, it comes to the calculation of the differential equation and get E~f (v^2), which is the stored energy a point gets in different periods.

The mass of the block is supposed to be m_i, the elastic system between two blocks K_c, the non-elastic system between two blocks K_{cn}, the friction of the block and lower bottom $F(x_i)$, the displacement x_i caused by block "i" has to fit the mechanical differential equation:

$$v_i \geqq K_{ci}\left(x_{i-1}-2x_i+x_{i+1}\right)+K_{cni}\left(x_{i-1}-2x_i+x_{i+1}\right)^n-K_{pi}x_i-F\left(v_i\right)$$

Suppose n=4, Kc=40, 46, 50; Kcn=20, 24, 30; Kp=1, 4, 8; time "t" will be calculated from 0 to 730, and the results are shown in Figure 3 and Figure 4.

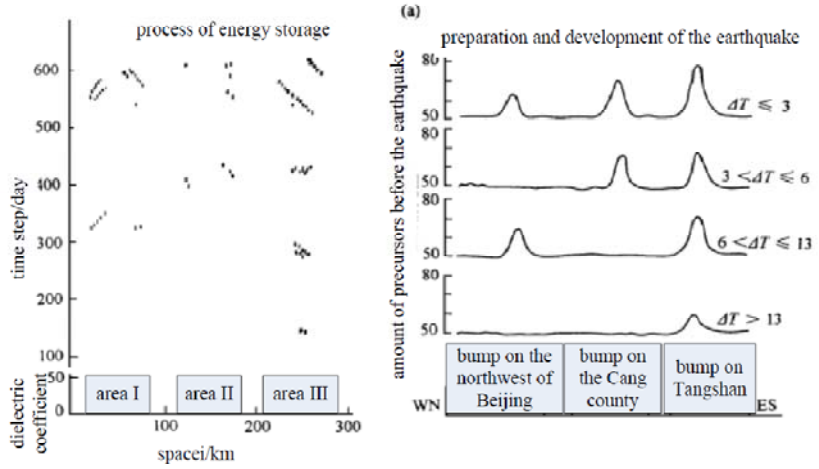


Figure 3: The comparison of the evolvement of precursors before the earthquake and the process of regional stored energy oscillation model - the 7.8 magnitude Tangshan earthquake

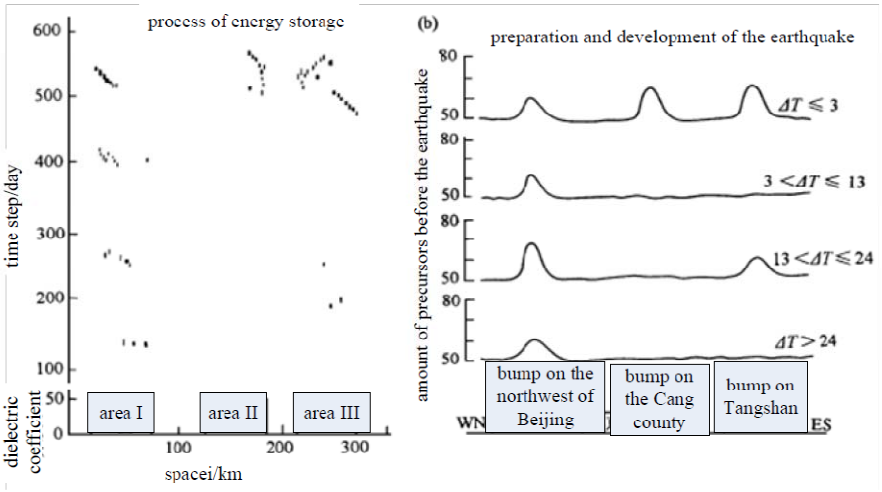


Figure 4: The comparison of the evolvement of precursors before the earthquake and the process of regional stored energy oscillation model - the 6.1 magnitude Datong earthquake

According to the calculations of the values, if the parameters of the structural formation are even, there will be no irregularities or nonlinear features when the block was moving, therefore no energy restores in a certain region. In other words, if the medium was even, and the shape of the formation is linear during the movement, there will be no energy storage in any points and therefore no earthquakes occur.

If the medium is even, yet irregularities or nonlinear features occur in the movement, with pushing force or the effect of initial activity, there will be energy storage in a certain region. But during such period, the calmness will remain for a long time and the locations of energy storage will not be specified. In such conditions, the phenomenon similar to the earthquake will appear, but the real earthquake won't occur.

Since energy storage changes with time, the drawing of precursors is very complicated. Besides, the process of energy storage is nonlinear, there might be a small storage of energy before the large one comes, or sometimes it comes to large energy storage. It also indicates the situations of precursors of earthquakes, some having more irregularities, some having less.

The comparison of the evolvement of strong earthquakes' precursors and the process of regional stored energy oscillation model

According to Figure 1, 2, 3 and 4, judging from the comparison of the process of energy storage and the situation of precursors occurring on epicenter, the intensity of precursors come from low to high, while the points of energy storage show otherwise. The time gaps in such activities are shown in a nonlinear pattern instead of a regular pattern. According to the diagrams, there is obviously a connection between the precursors of the epicenter and the nonlinear energy storage. It shows the differences between the epicenter and non-epicenter, which provides evidence to predict the areas of earthquakes.

By comparing Figure 1 and Figure 2, it can be observed that there is a pattern of precursor irregularities in the epicenter occurring before and after an earthquake: the precursors will expand, then contract, and expand again. Judging from diagram 3, energy storage starts from the epicenter, then stores in the areas with high- parameter medium. Meanwhile, the pattern of expand-contract-expand will occur again. Therefore, the evolvement of precursors before a severe earthquake and energy storage share common features. However, since the results vary with the change in time, it can be observed that the precursors of an earthquake are connected with the complicated energy storage in earth's crust.

CONCLUSION

As information technology develops, the official departments and relative departments have achieved great progress in earthquake prediction and people also have increasingly gained knowledge about the earthquake and its activities. The studies and predictions of earthquakes based on regional stored energy oscillation enable the data and information to be reorganized and sorted out, so as to build and improve more reliable methods to predict earthquakes.

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