DISCUSSION ON SOME OF THE PRACTIZATION INDICES FOR IMMINENT PREDICTION OF MEGASEISMS

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Abstract

In the paper, we statistically analyze the sudden impending earthquake anomalies and obvious trend anomalies of all kinds of precursors of 11 great earthquakes (Bohai Ms7. 4, Luhuo Ms7. 9, Yongshan Ms7. 1, Haicheng Ms7. 3, Longling Ms7. 4, Tangshan Ms7. 8, Songpan Ms7. 2, Daofu Ms6. 9, Wuqia Ms7. 4, Lancang Ms7. 6, Gonghe Ms7. 0)in Chinese continent from 1969 to 1990 by synthesizing many stages and phenomena. Then we study the whole characters and physical explaination of sudden anomalies before the megaseisms, summarize the evolutionary law of time, space and intensity(or frequence)of each precursory anomaly, the distributing law of the item-and-frequency of the sudden impending earthquake anomalies with time (the interval from sudden changes to earthquake occurrence) and the constitutional and synchronous laws of these anomalies, and discuss the comprehensive methods distinguishing imminent anomalies of megaseisms, the synthetic indices of imminent prediction and the effectively temporal prediction.

Key Words: Sudden impending earthquake anomaly; Whole characteristics; Imminent prediction indices

The Comprehensive Predicting Indices of Sudden Impending Earthquake Anomalies for Megaseisms in Chinese Continent

In the research of the imminent anomalies of a great earthquake and the forecasting indices, it is needed first to study the reliability of each single precursor or the way to judge each single anomaly, the ability corresponding to earthquake and the frequency distribution from the sudden changes of anomaly to the burst. On the whole, the monitoring and prediction ability of each single method is still very weak. On the one hand, there are anomalies but no earthquake or there are earthquakes but no anomalies, i. e, there exists uncertainty between earthquakes and anomalies. On the other hand, because of the varied pattern of anomalies, the nonuniformity in spatial and temporal distributions[1,2], it is difficult to predict earthquakes by means of a few anomalies from a single precursor. In order to search for some forecasting indices, we have tried to analyse some earthquake examples in different districts, but the results show a bad recurrence. This is because the nonuniformity of rock's physical properties and structures, different actions of focal stress field and regional stress field make all kinds of effects reflected by the earth's surface different from each other.

In this paper we analyse the evolutionary nature of many precursors in time, space and in-

tensity, especially the colonial nature that the precursors tend to concentrate in space and synchronize in time. On this basis, some "personally" scattered precursors may be distinguished.

The Evolutionary Nature of Precursor anomalies in Time, Place and Intensity for 11 Great Earthquakes

(1) About one year before the burst, the medium term and long term trend anomalies were mainly from deformation (ground tilt, triangulation, levelling survey, strain, etc.), secondly from geochemistry (hydrochemistry, radon, etc), geoelectricity, stress and geomagnetism as well as some earthquake-deficient periods. At least one of the three methods-earth deformation, geochemistry, geoelectricity showed long-term or mid-term anomalies before each earthquake.

(2) About half year before the earthquakes, the mid-term or short-term trend anomalies were mainly from earth deformation, geochemistry, secondly from stress, geoelectricity, geomagnetism and gravity accompanied with earthquake-deficient phenomena or precursory swarm.

From (1) and (2) combined with seismic activity, it can be judged whether there will be any Ms 7.0 earthquakes, and it is also possible to estimate the magnitude according to the continued time of trend anomalies. Meanwhile it's likely to pick out the condition that there are anomalies but no earthquake, because the anomalies are characterized by belt-shaped distribution and no obvious trend background anomaly.

(3) About three months before earthquake, the short-term anomalies were mainly from earth deformation and geochemistry, secondly from geoelectricity, ground-water(water level, temperature, discharge), fore-shock activity or precursory swarm, stress, geomagnetism. At least one of earth deformation stations and at least two of the other stations showed obvious short-term anomalies before each great earthquake. Small earthquakes become more active or unusually calm around earthquake region. In epicentral area and near it, small shocks obviously became more active or suddenly quiet. Then moderate shocks or swarm activity occurred in the gap. 6 of 11 great earthquakes had obvious foreshock activity, thus the ratio of anomaly occurrence is 55%. The short-term anomalies were more obvious and concentrative than the medium term ones. 60—70% anomalies occurred within a 200km range from epicenter.

(4) The signs of transition from medium term anomalies to short term anomalies: there are relatively synchronous turns, acceleration, larger wave motion or disappearence on the background of some trend anomalies; short-term and imminent anomalies occur at many stations, their degrees and frequencies obviously increase, their occurrence time basically synchronizes (the difference between their initial times is less than a month) and their places are relatively concentrative (the radii of the anomaly areas are less than 200km); the frequency and intensity of foreshock activity obviously increase or suddenly become quiet, or precursory swarms occur, etc.

The Indices of Short-term, Especially Impending Earthquake Prediction

The earthquake prediction should include the estimations of time, space, magnitude and probability of earthquake occurrence. In the paper, indices of comprehensive prediction of great earthquakes are discussed based on the data checked repeatedly.

(1) There are obvious trend background anomalies, which are observed by at least one of earth deformation stations, one of geochemistry or groundwater stations and one of geoelectricity, strain, geomagnetism stations, i.e. at least 3 stations and many measuring points.

(2) Before the strong earthquakes, the basic imminent precursors (earth deformation or/and foreshock activity) would certainly appear, the probability of earth deformation anomaly occurrence is 100% , that of foreshock activity anomaly 55% . In addition, the probability of groundwater anomaly occurrence is 91% , that of geochemistry 82% . In the paper, by analyzing 11 earthquake examples, it is found that atmospheric pressure or temperature often suddenly decreases or increases immediately before earthquakes, probability of the anomalies is 91%. Occurrence of more than 2 of the 4 cases mentioned above, at least one of which is basic imminent precursor, is preconditions for imminent prediction. The disturbance of non-seismic anomalies can be removed based on index 1. If other interferential anomalies are roughly removed, the ratio of anomalies corresponding to earthquakes, i.e. the number of earthquakes having anomalies /the number of predicted earthquakes, is 82%.

(3) The anomaly "crowd" basically synchronous in time and relatively concentrative in space is the sufficient condition for imminent prediction. According to statistics, the intervals from sudden impending earthquake changes of all precursors to earthquake occurrences are : 4—16 days (earth deformation), 3—17 days (atmospheric pressure), 6—19 days (geochemistry), 1—9 days (groundwater), 16—30 days (geomagnetism), 3—9 days (gravity), 3—16 days (geoelectricity) and 1—15 days (stress). Based on (2) and (3) mentioned above, the probability of earthquake occurrence within 20 days is more than 60% (Fig • 1).

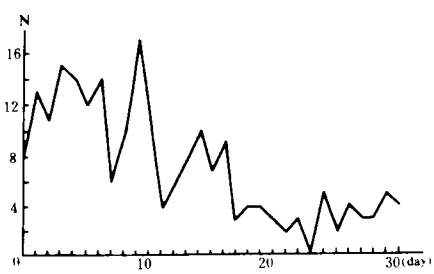

Fig. 1

(4)Small earthquakes become from active to quiet, the frequency and intensity of sudden changes of some precursors are increased, their time is synchronous and space is concentrative, for example, water levels fall or go up suddenly, radon sharp changes continuously many times, the measuring value curve of single component of tilt diverts or its vector diagram ties, strain

step with order $> 10^{-7}$ and stress measuring value with varied range $>20-100$Kpa appear, atmospheric pressure suddenly falls more than 10mb, the measuring values of geoelectrical resistivity quickly decrease or turn to the opposite direction, the daily changes of geomagnetism become distortional or electromagnetic disturbance, macroscopic anomalies appear in succession, etc., these are all imminent anomalies. In this case, it can be predicted that an earthquake will occur within 10 days. The sudden anomalies within 10 days before the earthquake make up 40% of all imminent anomalies. Of course, before a small number of great earthquakes (Tangshan earthquake, Songpan earthquake), sometimes there are more anomalies, sometimes less, capriciously. We statistically analyzed the dates of 300 $M\geqslant 6$ earthquakes in Chinese continent since 1900, the results show that the superior distribution of these dates is not remarkable. Based on the catastrophism theory, the root cause of earthquake occurrence is the unstability of structure, that is, earthquake is an expression of self-organization in fault evolution system.

(5) The prediction of magnitude for $Ms>7.0$ earthquakes

The magnitude M is calculated by using the experiential formula $\mathrm{Log}\ T=a+bM$ (or $\mathrm{LogRT}=a+bM$), in which T is days of trend anomalies and R is the range of anomalies (epicentral distance). Analyzing near 100 moderate-strong earthquakes, it is found that the amplitude of sudden anomalies had no obvious relation to magnitude. Mr. Guo Zengjian put forward an empirical formula $M=3.3+2.1\mathrm{Log}L$, in which L is length of the causative fault. Maximum magnitude (M_{max}) can be calculated by susing the following

$$M_{max}=0.574M_f+0.755\mathrm{Log}t+1.814\ ^{*}.$$

in which M_f is magnitude of maximum foreshock and t is time after the foreshock occurrence.

(6) The prediction of earthquake location

The future epicenters most likely are in the regions where macroscopic and microscopic anomalies relatively concentrate or foreshocks are active or structures are active and in the zones where anomalies finally concentrate or intensify. The danger areas divided by medium term and long term earthquake prediction can be used as important references for determining the future earthquake locations. In addition, individual measuring points can reflect the direction of earthquakes.

The prediction of aftershocks also is an important real problem. In fact, there are the dual main earthquakes, strong earthquake swarms, strong aftershocks, strong aftershocks during main earthquake's later period, strong earthquakes occurring within short term, earthquakes concerned with each other, etc. At present, the earthquake types are determined mainly based on seismic sequence characters and the trend suggestions are made by using experiential methods after the main shock. The actual earthquake examples show that after the first obvious earthquake some precursory anomalies basically finish, but sometimes continuously develop or

* State Seismological Bureau. Final Report of the Grade a Procedings of the Applied Studies on Comprehensive Earthquake Prediction. 1984

undulate, or new or larger anomalies appear, this indicates that there are distructive strong aftershocks later. From this case, the differences between seismic effects and new precursory anomalies can be studied and then the anomaly marks of strong aftershocks are discussed. Mr. Wang Chengmin proposed that some obvious precursors after an earthquake might be the dynamic indicator of stress transfering from the preceding shock area to the next one. In addition, the dominant region of each type of historical earthquake sequence and the relation of earthquake sequence, maximum magnitude to regional structure characters, scale of active fault, assemblage form of active tectonics and gap of faults can be studied by using seismogeological method. Therefore, it is possible to comprehensively judge the tendency after a main shock by combining seismometry, short-term and imminent precursor, and seismogeology.

Method and Program for Imminent Prediction of Large Earthquakes

To predict a great earthquake in an area, more than 8 kinds of precursory methods (at least 3 kinds in the 4 kinds, earth deformation, ground fluid, atmospherical pressure and seismometry) and more than 40 measuring points must be arranged within the effective monitoring area whose radius is 300km (from the epicenter), while the average density of measuring points is more than 2 every 3000km^2 within the area where anomalies relatively concentrate. This is the base for monitoring prediction, or else it is difficult to obtain the impending earthquake criterion indices.

The impending earthquake prediction is the key, but long-term, mid-term and short-term predictions are the bases, The earthquake source is inferred based on the seismic regime dynamics within a large area and imminent prediction is inferred by analyzing the whole process of anomaly development. The serious problem in analyses of long-and-mid-term trend anomalies is that anomaly volume is little but its time long. Therefore, the "anomaly" easily is drowned in the undulatory variations of background values or the interferences. Of course, some trend anomalies are very obvious. The marks of transition from short-term to imminent anomalies (trend anomalies quicken, transfer or renew and sudden anomalies appear in large amount) are easily observed. Thus, the key of effectively predicting great earthquakes is correct judgment of impending earthquake anomalies.

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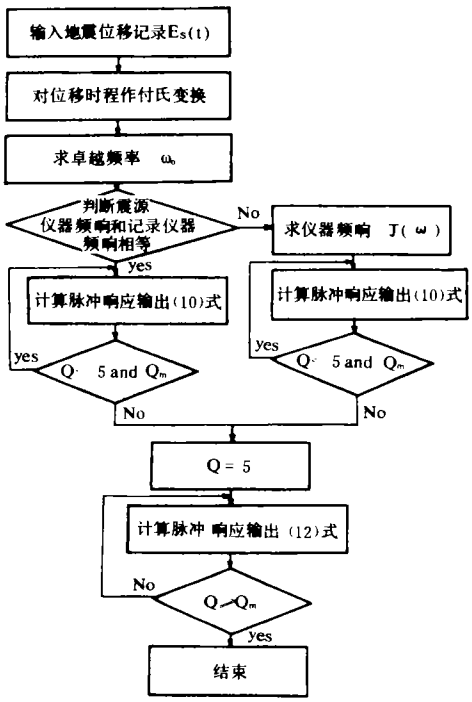

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IN-SITU MEASUREMENT OF SOIL Q-VALUE

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大震临震预报的某些实用化指标探讨

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摘　要

本文对我国大陆 1969 年至 1990 年所发生 11 次大震(唐山、炉霍、松潘、海城、渤海、龙陵、永善、澜沧、乌恰、道孚、共和)的各种前兆临震突变异常和趋势性背景异常运用多阶段综合、多现象综合的方法进行统计分析。研究临震突发性异常的总体特征及其物理解释，归纳各种前兆异常分阶段发展的时、空、强(频)演变规律，临震突变日距发震日的时间分布规律，临震突发性异常组合性与同步性规律，探讨大震临震异常综合判断方法、临震预报综合指标和有效性时间预报。