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DISCUSSION ON THE SHORT-TERM AND IMPENDING EARTHQUAKE PREDICTION BY THE MODULATION MODEL

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Abstract

In the time near to earthquake occurrence, a source region and its neighbor region are in unstable state.In this case, some weak external factors, such as tidal forces, atmospheric pressure or magnetic storms, may modulate the processes in these regions and the precursors produced by these processes.If we find some precursors synchronized with some external factors, we should pay a special attention to possibility of earthquake occurrence.In previous paper, we stated many of examples of our country to demonstrate the modulation model.In this paper, we present some examples quoted from foreign countries to demonstrate the model. It should be pointed out that the external factors may possibly cause aseismic slip and false precursors.

Introduction

The short-term and the impending earthquake prediction is the most important one among earthquake prediction with various terms.This problem has been approached in two ways; the first is based on instrumentally recorded precursors, the second has considered the trigger effect of external factors on earthquake occurrence.In general, the precursor and the trigger effects were usually regarded as independent each other. It is our view that external factors may not only trigger earthquakes but may also influence precursors, so that both precursor and trigger effect are dependent upon each other (Guo, Qin, 1980). We proposed the following model.

Just prior to the occurrence of an earthquake, the processes in source region and its neighborhood change to an unstable state.In this case some weak external factors, such as tidal forces, atmospheric pressure, or magnetic storms may influence the processes in the source region and its neighborhood. That is the processes are modulated by these external factors. Therefore the precursors appearing in the source region and its neighborhood are formed by the processes and the modulation. During the time that the external factors act on the source region and its neighbourhood, the processes are excited and the precursors are more remarkable in amplitude, more concentrated in time and more varied. Then some fluctuation phenomena of precursor synchronized with external factors may appear. We may judge the possibility of earthquake occurrence based on this synchronization.

Physical mechanism of modulation

According to the combination model of earthquake preparation (kuo, et al, 1973), an earthquake source is composed of a stress accumulation element and some stress adjustment elements which are located in the neighborhood of the former. In the stress accmulation element, the shear strength of the medium or the static frictional limit on fault plane is high; the adjustment element, however, contrasts with the stress accumulation element, having a strength much lower than the stress accumulation element. Under action of regional tectonic stress, special in the time near to earthquake occurrence, the stress adjustment element may produce creep slipping, plastic deformation and flow, thereby transfering stress into the extremes of the accumulation element, thereby initiating an earthquake. When an earthquake is occurring, fracture in the accumulation element propagate rapidly, stopping only when it again meets the adjustment element. The kinds of adjustment elements are varied and may include creeping faults, plastic regions having high temperature, regions rich in fluid, junction regions of geologic faults, regions composed of broken stone and so on. We may postulate an earthquake source according to the combination model shown in Fig 1. In the simplest example, the adjustment element is a creep fault that is located on both ends of an accumulation element, as shown in Fig 2.

According to this model, instablities will appear in the accumulation element and the neighboring adjustment elements just prior to the occurrence of an earthquake. Instablity in an adjustment element, such as creep slipping, plastic deformation and flow, appears earlier than instability in the accumulation element. This precursors observed in the adjustment element appear earlier than precursors observed in the accumulation lement,

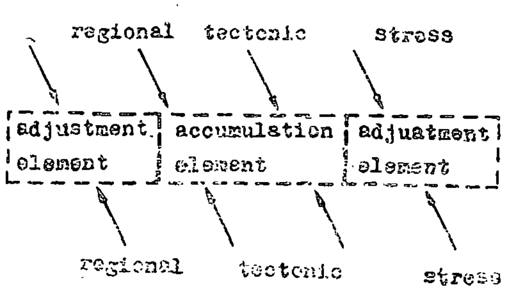

Fig. 1 Scheme of earthquake source according to the combination model

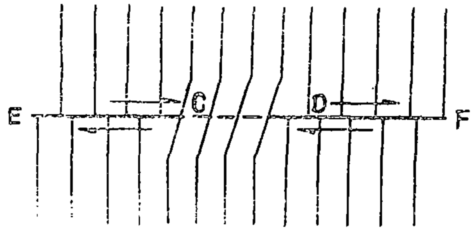

Fig. 2 The simplest combination model CD—Stick-slip fault as accumulation element
EC, DF—Creep fault as adjustment element

The influence of external factors, such as tidal forces, atmospheric pressure and magnetic storms, on processes in the source region and its neighborhood can be classified as follows:

1. Mechanical effect According to Fig. 2, tidal forces and atmospheric pressure act on the source region and concentrate stress in the tip of the creeping fault, thereby causing the accumulation element to approach failure. When a fault is strike-slip, the intermediate principal stress axis is directed vertically. Variations of atmospheric pressure may influence the magnitude of the intermediate principal stress and the shear strength of the medium (Mogi, 1967, 1971). Owing to inhomogeneity of crustal structure and relief of the ground, tidal forces and atmospheric pressure will enhance the shear stress and the tensile stress on fault plane for dip-slip ior strike-slip earthquake in some cases. The above mentioned effect may nfluence the instability of the source region. Because high tidal forces and atmospheric pressure act intermittently on the source region, the modulation of instability in the source region is intermittent also.

2. Stress-chemical corrosion In general, some fluids, such as water, exist in the adjustment element and contain some chemical substances that may cause corrosion in the tip of the crack around which there are stress concentrations, thereby causing extension of the crack. Tidal forces and atmospheric pressure can urge fluids to migrate to the tip of the crack. Because these external factors act intermittently upon the fluid, the extension of crack is intermittent also (Guo, et al, 1982).

Under the influence of a magnetic storm, some ions in the fluid may migrate into the tip of the crack, causing corrosion increasing the instability.

3. Magnetic effect In the rock around the tip of crack there are small

ferromagnetic grains that experience magnetostriction during magnetic storms. This magnetostriction may influence the extension of cracks and thus modulate the failure process.

4.Magnetic-caloric effect Immediately before an earthquake, the temperature on a fault plane is increased by preceding slip. In this case, the fault plane possibly becomes a thin layer with higher temperature.The geo current induced by magnetic storms is concentrated in this layer, further increasing the temperature and thus the instability of the source region. In this manner, magnetic storm may modulate the processes in a source region and its adjustment element.

Examples of modulation

As stated above, external factors not only modulate the accumulation element, but also modulate the adjustment element or adjustment field. This means that precursors modulated by external factors may appear in epicentral area (accumulation element) as well as its periphery.If the adjustment element is large, then precursors may appear far from the epicenter. we only take the tidal modulation as an example as follows。

We present some obvious examples of precursors and creeps in the Soveit Union, Japan and America that may demonstrate the above mentioned modulation model.

(1)The Jan. 14, 1978 Izu-Oshima-Kinhai earthquake (M= 7)

This earhquake is a famous one in Japan for recent years. On Jan. 9 , a sudden change of radon was observed in the station which is located in the middle of the Izu-peninsula (Na-

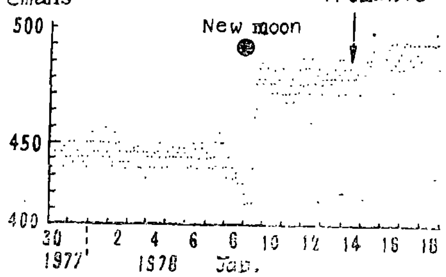

Fig. 3 Relation of a sudden change of radon with a Izu—Oshima—kinhai earthquake

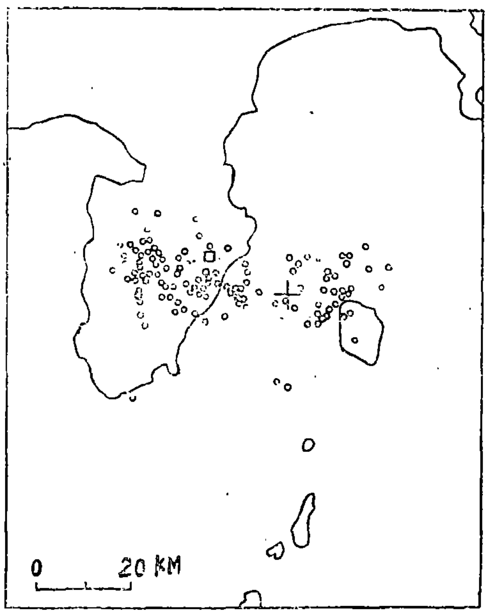

Fig. 4 Radon station, epicentre of mainshock and its distribution of afftershock of Izu—Oshima—Kinhai earthquake

□——Radon station
+——Epicentre of mainshock
○——aftershock

kamura et al, 1980). This sudden change of radon is shown in Fig. 3 The radon station is 25km from epicentre of the main shock, and its location are within the area of after shocks which occured during the period from 14 Jan. to 28 Feb.as shown in Fig. 4.

It is interested that the day, Jan. 9, coincided with a new moon, as shown in Fig. 3. According to the modulation model, the synchronization means that the area around the radon station is unstable, we should pay a special attention to the earthquake.

(2) The Izu—Hanto—Toho—Oki earthquake of June 29, 1980

This earthquake(M=6.7) is near to the Jan.14, 1978, earthquake above.

The foreshocks that occured four days before the main—shock coincided with high tidal force as shown in Fig. 5.

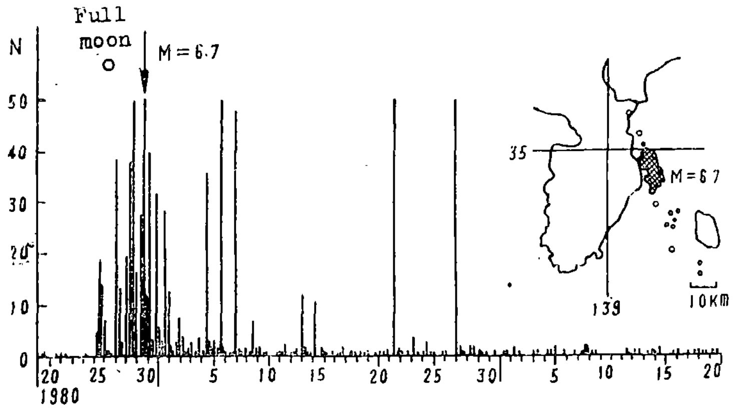

Fig. 5 The Izu—Hanto—Toho—Oki earthquake of June 29, 1980 and related seismicity (after 防灾セ)

(3) In the book wrote by Asada et al (1978), there are four typical examples of sudden changes of strains.Two among them coincided with full moon or new moon, and 8—6 hours later,the earthquakes took place, as shown in Fig. 6 and Fig. 7.

(4) In the middle Asia, The Soviet Union, two days before the Alay earthquake (M= 7) a sudden anomaly, ΔF, of the magnitic field amplitude difference between the Adijan station and the Taskent station appeared (Fig. 8). The epicentre of the earthquake is near to the Andijan and about 250km from Taskent.

(5) The Feb. 7, 1972 Garm earthquake (M=4.7) 3—to 4 days before this earthquake, sudden change in radon concentration was observed in the Obi—Garm hydrochemical station (Mirzoev, et al, 1974), located 130 km from the epicenter.It is interesting that the radon increasing day was coincided with a new moon, as shown in Fig. 9.

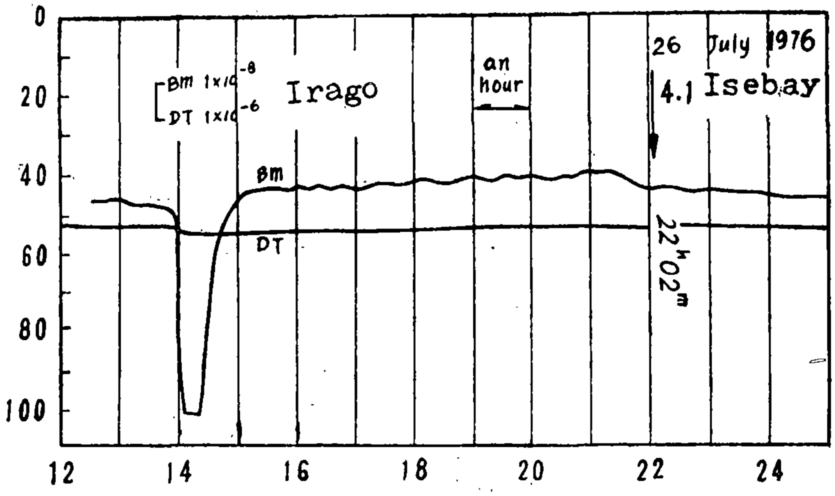

Fig. 6 Correlation between the full moon and the sudden change of strain (after Asada)

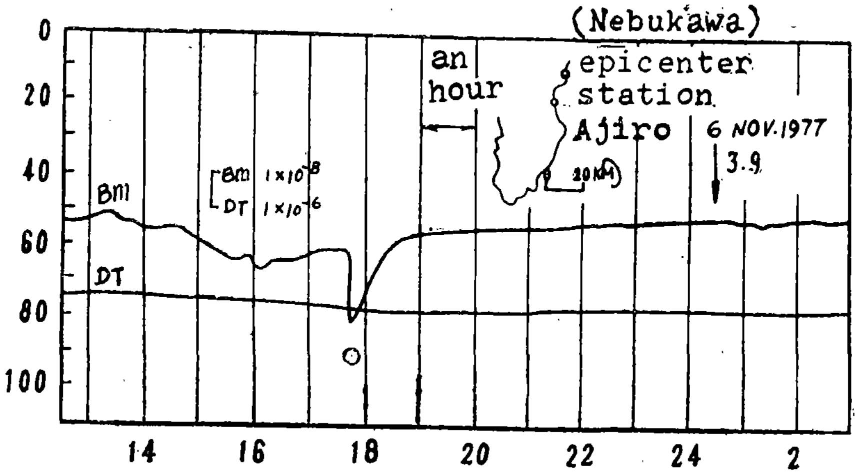

Fig. 7 Correlation between the full moon and the sudden change of strain (after Asada 1978)

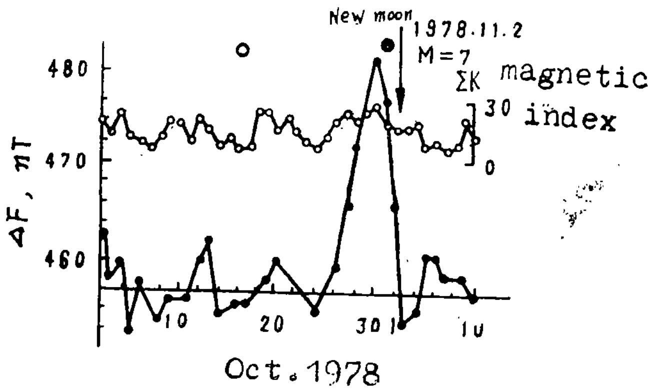

Fig. 8 Varition of the difference of magnetic field on Andijan and Taskent with time (after V.A Shapiro et al.1980)

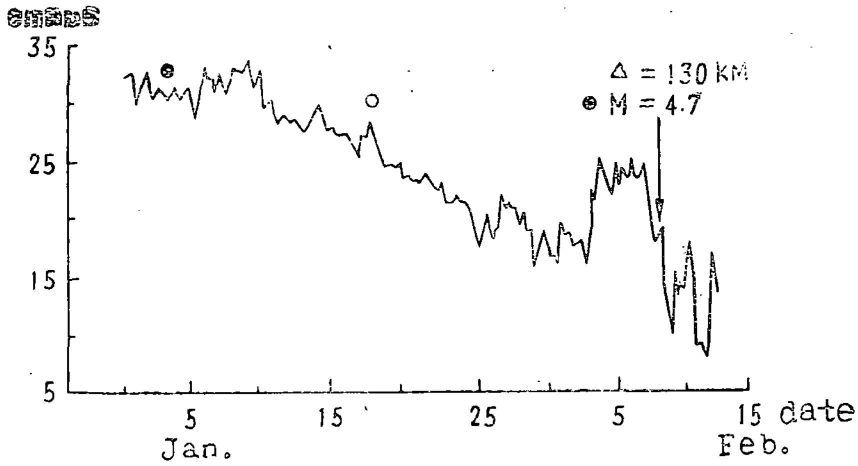

Fig. 9 Correlation between sudden change of radon and lunar phase

(6) The Nov.28, 1974 Thanksgiving earthquake On Oct.31, 27 days before the earthquake, a sudden magnetic anomaly was observed in station which is 11 km from epicenter in Hollister, this day is within the period of high tidal force, as shown in Fig.10.

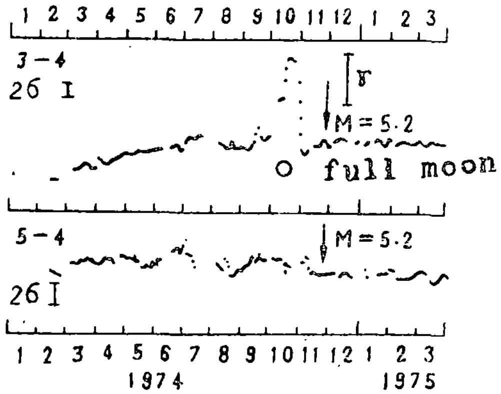

Fig.10. Magnetic anomaly before the Thanksgiving earthquake of 1974 (after Asada)

Disscusion

According to our previous paper, the modulation effect of external factors on precursors may be classified follows:

1.Modulation of source region This modulation is responsible for precursory processes in the accumulation element (epicentral area) .

2.Modulation of the adjustment region This modulation is responsible for precursory processes in the adjustment elements which are far from the epicentral area.

3.Aseismic modulation If a precursor coincides with external factors and there is no earthquake to follow it, then we call this an aseismic modulation, for example, Johnson et al (1974) presented three creep events in California. In their paper, among them two events coincided with ftll moon, as shown in Fig.11—12.In the Soviet Union, there were some hydrochemical anomalies in the Middle Asia region, which coincided with high tidal force, we take a change of radium as an example in Fig. 13.

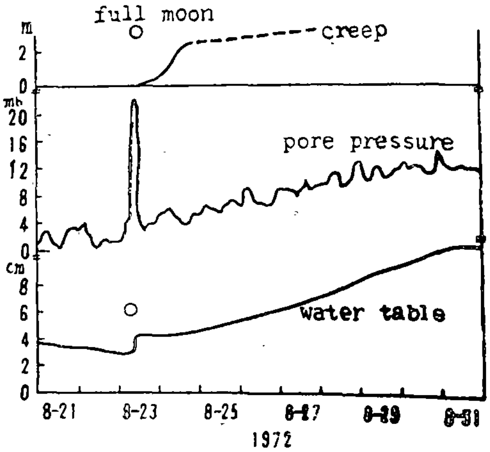

Fig.11 Correlation between full moon and Aseismic anomalies

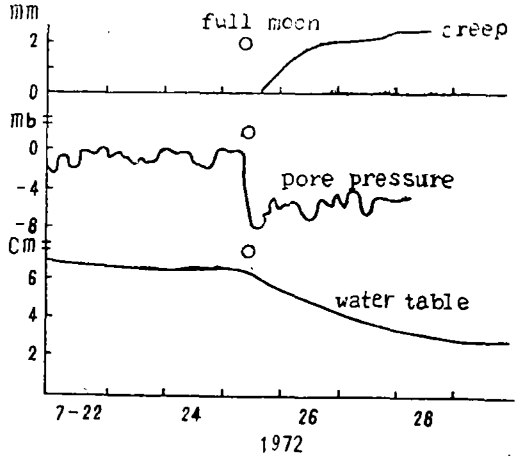

Fig.12 Calculated pore—pressure change, observed water—level change and fault creep event on Aug.23,1972

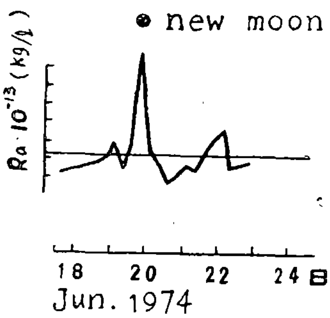

Fig.13 Correlation between new moon and Ra anomalies on the Alamaging fault

4.False modulation This modulation is that the external factor directly modulate the objects which appear some false precursors. It should be pointed out, in some time false precursor may be coincidental with earthquake occurence.Because, on the one hand, the external factor may directly produce false precursors, on the other hand, the external factor have some things to do with earthquake occurrence.

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由调制模式讨论短临预报

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摘　要

在接近地震发生前，震源区和它的邻近地区处于不稳定状态。在这种情况下，一些微弱外因，如引潮力，大气压力或磁暴可以调制这些地区向发震发展的过程以及由这些过程所引起的前兆，在我们以前的文章中曾论述过这个问题。外因对前兆的调制效应可以分为以下几种类型：

1.过源调制　这种调制是外因对应力积累单元（震中区）的不稳定过程的调制并相应引起前兆。

2.过场调制　过场调制是外因对震源外围调整区的不稳定性进行调制，并相应引起前兆。

3.非震调制　即外因对地壳内非地震的不稳定性进行调制，并相应引起某些观测项目的突变异常。例如某些蠕滑事件可以被外因调制，但不一定有地震发生。

4.虚假调制　这种调制是外因直接调制某种对象并引起假前兆。例如气候的突然变化引起动物异常等。值得指出的是，有时假前兆还可能与地震发生同步。这是因为外因一方面可以直接引起假前兆，另一方面对地震发生也有触发作用。

在以前的文章中，我们介绍过许多我国的例子以证明调制模式。本文列举国外一些比较典型的震例以进一步证明调制模式对短临预报的普遍适用性。在国外的震例中，其中日本的震例有4个。它们是1978年元月14日伊豆半岛与大岛之间发生的7.0级地震。在这次地震前5天，距震中20公里的氡气观测站观测到了氡气的突然变化，此日为朔日；1980年6月29日伊豆半岛东方海中发生6.7级地震，在震前4天前前震突然频繁活动，此前震开始活动日接近望日；1976年7月26日日本伊势湾4.1级地震，该震虽不大，但地震前8小时在震中附近的伊良湖形变站记到临震当天的形变暴，此日为朔日。1977年11月6日，日本根府川3.9级地震，离震中10多公里的网代形变站在地震前6小时观测到形变暴，此日为望日。苏联的震例有二个，第一个例子是1978年11月2日苏联中亚阿莱地方发生7级地震，震前两天安集延和塔什干地磁台磁场差值ΔF突然异常，此日为朔日。第二个例子是1972年2月7日加尔姆4.7级地震，这次地震前3—4天在离震中130公里的氡气站上观测到突然异常，此日为朔日。美国的一个震例是著名的感恩节地震，该震发生在1974年11月28日，震级为5.2。10月31日，即震前27天霍利斯特地磁台阵中有两个台的地磁场差值出现突变，此日恰好为望日。

上述两台在震中西南10公里左右。由于固体潮资料是已知的，便于对比，所以文中对比的外因皆为固体潮。其它磁暴与大气压力变化调制的例子将在以后讨论。

以上震例说明，在临近地震前震源以及外围地区已处于不稳定状态，因而此时外因能调制震源过程，激励震源变动，使之发生较大的前兆变化。因此突然的前兆变化与外因同步可视为地震即将来临的标志。此外文中还列举了美国加里福尼亚圣安德烈斯断层蠕滑加速与固体潮高潮同步的例子以及苏联中亚地镭区的突然变化与固体潮高潮同步的例子。因此应当指出，外因也可能引起非震滑动和假前兆。