Abstract

Precursors of various disciplines to the 1944 Tonankai earthquake of magnitude 7.9 are collected on the basis of existing literature, postcard inquiry and so on. Precursors amounting to 347 in total number are obtained. Only 66 of them can be used for the statistics of precursor time. In addition to geoscientific data for such as crustal movement, and seismicity, data for rumbling, anomalous animal behavior, fireball appearance, change in ground water and the like are obtained. It is brought out that the precursors to the Tonankai earthquake appeared most frequently for a period 10~1 days and next frequently for a period 1~0.1 days before the earthquake.

The mode of precursor appearance thus brought out may be useful for guessing how possible precursors to the soon-to-occur Tokai earthquake would occur.

1. Introduction

In order to carry out earthquake prediction observation in the earthquake-threatened Tokai area, Japan, most effectively, it is highly desirable to know how earthquake precursors appeared before large earthquakes that occurred in the past. If the mode of precursor appearance can be inferred to some extent for great earthquakes in the past, we may have some idea about how precursors would appear before a similar earthquake in the future on the condition that the physical mechanism of earthquake occurrence is approximately the same for these earthquakes.

The 1944 Tonankai earthquake, of which the magnitude was once determined as 8.0 and recently revised as 7.9 by Japan Meteorological Agency (JMA), occurred toward the end of the World War II when Japan was in a state of confusion. No accurate estimate of victims, which amounted to around 1,000, could be performed under such a confused circumstances immediately before the surrender of Japan. On top of such tumultuous circumstances, the military censorship for news media was so strict that no real damage could be publicized. Under the circumstances, information about the Tonankai earthquake was so limited that it is even called a “phantom earthquake.”

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In spite of the expected difficulties owing to the scarcity of data under the circumstances mentioned in the above, the Association for the Development of Earthquake Prediction (1982, 1983) undertook to collect precursor data for the Tonankai earthquake as many as possible because the pattern of precursor appearance in the case of this earthquake is thought to play an important role in guessing possible pattern of precursor appearance for the Tokai earthquake suspected to occur in the near future.

2. Sources of data

Precursor data for the Tonankai earthquake are taken from the following four sources:

(i) Existing literature
(ii) Seismic data by Central Meteorological Observatory (now JMA)
(iii) Inquiries by return post cards
(iv) Inquiries mainly made by volunteers at high and middle schools in Shizuoka Prefecture

(1) Existing literature

Every report on the Tonankai earthquake was under strict military control, so that no thorough investigation of various features of the earthquake could be made. Under the circumstances, very few reports on the earthquake were published soon after the earthquake. Some of them were classified as top secret.

(2) Seismic data

The numbers of felt and unfelt earthquakes at a number of weather stations in Central Japan are examined for the period during 1938—1945 on the basis of the table published by JMA and the original records at the Owase and Tsu weather stations.

The most outstanding feature revealed by the seismic data is the point that a large number of unfelt earthquakes having an S-P time of 2—3s were observed at Owase for a period during August—September, 1944. Such an activity cannot be observed at the neighbouring stations, say Shionomisaki and Tsu. The locations of these and other neighbouring stations are...
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shown in Fig. 1. It is therefore certain that a swarm activity of small earthquakes occurred nearby the Owase station which is the only station that registered the activity.

(3) Return post card inquiry

In view of the scarcity of precursor data found in existing literature, the Association for the Development of Earthquake Prediction (1983) undertook an inquiry survey by return post card. Inquiry post cards, of which the postal fare was prepaid, were sent to 2,000 people, who were middle school students at the time of the Tonankai earthquake, picking up their names from membership lists of alumni associations. Most of them were forced to work at factories or farms under the military control at the time of the earthquake. It is requested on the card to reply to the following questions:

1. Did you observe any anomalous phenomenon precursory to the Tonankai earthquake?
2. If yes, please answer the following.
   (a) When?
   (b) Where?
   (c) What kind of phenomenon?
   (d) How much, how long, to what extent ... etc.?
   (e) Is it experienced by yourself, or is it secondhand information?

610 people kindly replied to the questions. This amounts to about 30% of the inquired people. Some of the respondents replied with comments by their relatives and friends, so that the total number of respondents certainly exceeds 30% of the inquired people.

The number of people who recognized or noticed something unusual before the Tonankai earthquake amounts to 102. Among them, there are some people who pointed out more than one anomaly, so that there are 131 replies in total.

(4) Volunteer inquiries in Shizuoka Prefecture

A number of high and middle schools as well as a branch office of the prefectural office made inquiry survey about the Tonankai earthquake when the fear of coming Tokai earthquake was stressed in the later half of the 1970's. These inquiries were mostly concerned with general aspects of the Tonankai earthquake, so that they did not particularly put much stress on precursors. Among 5,692 sheets of inquiry, only 207 reply sheets contain some precursor-like phenomena. Only 6% of the precursor data can provide reliable precursor times.

3. Data

(1) Data from existing literature

A fair number of data clearly indicate that Pt. Omaezaki had been subsiding before
the earthquake, that the subsidence slowed down ten to several years before the earthquake and that the land there tended to upheave several days prior to the earthquake occurrence with an enormous acceleration several hours before the earthquake occurrence. It is fortunate that the transient crustal movement immediately before the occurrence of a great earthquake was monitored by a levelling survey which was going on over the deformed area by coincidence. Fig. 2 shows the precursory upheaval of a levelling bench-mark near Kakegawa as estimated by Mogi (1982).

It is extremely interesting that the bubble of a levelling apparatus swayed side to side, so that no measurement could be performed a few minutes before the earthquake occurrence as reported by Koshiyama (1976). The reported ground instability is supported by other observations brought to light by the return post card inquiry which will be presented in the following clause.

Most reports on rumbling suggest that the rumbling took place almost at the same time of earthquake occurrence. This is quite a contrast to the reports on rumbling and detonation for the Ansei Tokai earthquake (Association for the Development of Earthquake Prediction, 1982) for which rumblings had been heard since about 100 days prior to the main shock.

(2) Data from post card inquiry

As stated in the last section, the return post card inquiry provided the most reliable data set. Among crustal movement and earthquake data, we have a number of reports that suggest that the ground became unstable several minutes prior to the earthquake occurrence. The ground seems likely to have tended to sway with a period of several seconds. Such a view matches with the report which describes the sway of the bubble of a levelling apparatus several minutes prior to the earthquake occurrence.

Reports on rumblings and foreshocks are relatively few for the Tonankai earthquake although we have some.

It appears to the author that the reports on anomalous animal behaviour as described in a number of reports are typical for animal precursors to a large earthquake.

It is not quite clear whether or not earthquake light is a phenomenon preceeding
an earthquake. It is interesting, however, that two reports, which are independent from one another, describe appearance of a fire ball fairly clearly. In view of the fact that many fire balls were observed prior to the Songpan-Pingwu earthquakes (M=7.2, 6.7, 7.2, 1976) in Sichuan Province, China (Rikitake, 1982), it cannot be ruled out that the reported fire ball might have something to do with the earthquake occurrence.

Not many reports on underground water are available. Fig. 3 shows the spots where the precursor-like phenomena obtained by the post card inquiry are observed.

(3) Volunteer inquiries in Shizuoka Prefecture

These inquiries are mainly concerned with the earthquake damage rather than the premonitory effect, so that extremely small number of data can be used for inferring precursor time.
There is one instance that strange rumblings were heard a few times a day since 4—5 days before the earthquake. Several reports on foreshocks are collected. The precursor times range from several months to a few minutes. The data for anomalous animal behaviour include crows, pheasants and eels. A few reports on fireballs are available although no precursor time is known.

It is interesting to note that a report from Kakegawa indicates that noises were received by a radio set before the earthquake. The reporter wrote that the earthquake occurrence was predicted because of radio noise.

4. Characteristics and statistics of precursors

The numbers of data precursory to the Tonankai earthquake are summarized as given in Table 1. The total number of data amounts to 347. It is possible, however, to estimate the approximate precursor time only for 66 instances.

It is difficult to evaluate the accuracy of these precursory data. In the following statistics of precursor time, it is presumed that the data are all correct because there is no other way of analyzing the data.

(1) Characteristics of precursors

(a) The ground around Pt. Omaezaki had been subsiding before the Tonankai earthquake. The subsidence slowed down about 10 yr before the earthquake, and it appears that the land there tended to upheave several years prior to the earthquake. The land uplift seems likely to have been accelerated several hours before the earthquake occurrence.

(b) A swarm of unfelt earthquakes, that lasted about two months, occurred near Owase, Mie Prefecture since about 100 days prior to the main shock.

(c) Most of rumblings occurred at the same instant of main shock occurrence. However, a number of reports indicate that rumblings were occurring several days prior to the occurrence of the main shock.

Table 1. The numbers of precursors to the Tonankai earthquake for various disciplines

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Total data</th>
<th>Data for which approximate precursor time is estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crustal movement</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Rumbling</td>
<td>208</td>
<td>10</td>
</tr>
<tr>
<td>Earthquake</td>
<td>46</td>
<td>13</td>
</tr>
<tr>
<td>Anomalous animal behaviour</td>
<td>34</td>
<td>20</td>
</tr>
<tr>
<td>Earthquake light and fire ball</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Underground water</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Anomalous sea condition</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>347</strong></td>
<td><strong>66</strong></td>
</tr>
</tbody>
</table>
days prior to the earthquake. In contrast to the Ansei Tokai earthquake, no
rumblings preceding the main shock more than several months are reported
for the Tonankai earthquake.
(d) There are a number of reports that strongly support the fact that the ground
became unstable several minutes preceding the main shock. They are as follows;
(i) The bubble of a levelling apparatus swayed side to side, so that no
measurement could be performed.
(ii) A machine tool stand for determining the center of a metal rod mounted
on a lathe became unstable at a factory.
(iii) A chain hanging beside an electric furnace started to make sound
because of slow swaying at an aircraft factory just before the earth-
quake occurrence.
(iv) Centering for an object attached to a lathe was impossible at an air-
plane factory.
(v) It was difficult to cut a duralumin plate along a straight line with
scissors at a factory.
(vi) A young man lying on the ground in an air-raid shelter felt some
sway as if someone stamps on top of the shelter. This is a report
from an air-plane factory destroyed by the earthquake.
(vii) Middle school students, who were working in a factory, suddenly felt
dizzy. While they were talking each other about the strange feeling,
the great shock took place.

Most of the above reports were reported by people who were handling
precise instruments and machine tools. It seems highly likely that the ground
began to sway with a period of a few seconds immediately prior to the main
shock occurrence.
(e) Precursor times are identified for the anomalous animal behaviour
amounting to 20 in number. As for the species involved, we have
mosquito, rat, mantis, grasshopper, leech, catfish, dog, crow, chicken,
peasant, horse, ... etc.
(f) Among the reports on earthquake light and fire ball, there are two
independent reports on a fire ball appearance.
(g) The seismicity in a broad area around the epicenter of coming earth-
quake became high revealing a so-called “doughnut phenomenon”,
while the epicentral area was forming a seismic gap. During the 20-
year period, the activity of deep-focus earthquakes in the Chubu and
Kinki districts was high.

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(2) Statistics of precursor time

In order to make statistical studies on precursor times which range from a few minutes to several years, precursor time $T$ is measured in units of day and the frequencies of $\log_{10} T$ for each range having an interval of 1.0 are counted. Fig. 4 is the histogram of frequency distribution of logarithmic precursor time for the total data. The shaded columns in the figure indicate the geoscientific data.

Looking at the figure, we observe that the peaks of precursor time appear for $\log_{10} T = 0 \sim 1$ and $-1 \sim 0$. It may also be said that the frequency distribution of animal, light and geoscientific precursors are more or less the same. Namely, the precursors to the Tonankai earthquake appeared most frequently for a period $10 \sim 1$ days before the earthquake, and they appeared next frequently for a period $1 \sim 0.1$ days before the earthquake.

According to Weibull distribution analyses, the mean precursor times are estimated as 0.73, 0.50 and 1.0 days for the total, animal and geoscientific data. It may be said that there are no conspicuous differences in the precursor time between the three data sets.

5. Concluding remarks—Possible appearance of precursors anticipated for the earthquake suspected to occur in the Tokai area in the near future—

One of the main purposes of collecting and analyzing precursors to the Tonankai earthquakes is certainly to guess the possible mode of precursor appearance in the case of the soon-to-occur great earthquake in the Tokai area. As the physical mechanism of occurrence of the suspected earthquake may be approximately the same as those of
the great earthquakes in the past, there is good reason to presume that the precursors, if any, would occur in a fashion similar to those for the past earthquake.

It is therefore intended here to describe the possible mode of precursor occurrence for the hypothetical great earthquake expected to occur in the Tokai area on the assumption that the pattern of precursor appearance in the cases of the Ansei Tokai and Tonankai earthquake would repeat.

Summarizing what were stated in this paper along with the study on the precursors to the Ansei Tokai earthquake, a likely precursor appearance may be as follows;

(1) **About 20 yr before the earthquake**: Seismicity in the Kinki, Chubu and Kanto areas becomes high. Moderately large earthquakes including magnitude 6~7 ones tend to frequently occur.

(2) **About 10 yr before**: The ground subsidence at Pt. Omaezaki slows down and the ground tends to upheave several years before the earthquake.

(3) **Several months before**: Rumblings are heard in Mie, Aichi and Shizuoka Prefectures.

(3) **About 100 days before**: Swarm activities of small earthquakes occur nearby the epicentral area.

(4) **About 10 days before**: Number of precursory effects including anomalous animal behaviour increases. Fire balls may be observed. The precursors are observed over a wide area from Izu to Kii Peninsulas. The land uplift at Pt. Omaezaki is accelerated.

(6) **Several hours before**: The land uplift at Pt. Omaezaki is more accelerated.

(7) **Several minutes before**: The ground becomes unstable and begins to sway.

(8) **A few seconds before or at the same time**: Terrific rumblings occur.

What are written in the above are of course fictitious. But the author believes that the probability of observing premonitory effects of roughly similar kind would be high, should the anticipated earthquake occur in the Tokai area.

**References**


