The 3-stage earthquake generation process observed during 3 months before the 2011 Tohoku earthquake

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1 Introduction
Various phenomena were observed before the 2011 Tohoku earthquake. As for the broad band seismic network; F-net, its availability degraded. The 1st degradation occurred from December 22, 2010 to January 18, 2011, then 2nd one occurred from February 16 to March 2, after the part of the first degradation recovered to normal status. The main shock occurred on March 11, after the part of the second degradation returned to normal again.

Remarkable improvement of such measuring instrument as GNSS in recent years gives useful information about movement of crusts. So, seismic activities and measuring results of GNSS etc. are added to further check the degraded situation of the F-net.

2 Analysis
It seems that the period of approximately 3 months before the earthquake was consisted of 3 stages indicated below.

First stage
Analysis: Accumulation of strain in the continental plate reached maximum limit in the Tohoku and Chubu regions. Possibly as a result of such situation, the wide area in Japan showed vibration or slip. Then the Pacific ocean plate stopped its advancement. Since such movements are on several day-basis, this slipping is the one like Creep. They occurred in the area far from the epicenter, the epicenter have not been formed at this moment.

Second stage
Period: Middle of February to early March
Analysis: As a result of the first stage, restless increase of stresses by the Pacific ocean plate can not be accepted any more. Then, small breakage was formed near the initial rupture point of the earthquake.

Third stage
Period: Several days before to the day of the main shock on March 11.
Analysis: Slipping of the continental plate started, and it reached the main shock.

Observed phenomenon:
On March 8, eastward movement was recorded by GNSS.
The Sanriku-oki earthquake (M7.3) occurred on March 9. The earthquakes with magnitude of 6 followed.
On March 11, The main shock of the Tohoku earthquake occurred.

Keywords: 2011Tohoku earthquake, F-net, GNSS
### 東北地方の動き
**Move of Tohoku area**

<table>
<thead>
<tr>
<th>2010/Dec</th>
<th>2011/Jan</th>
<th>/Feb</th>
<th>/Mar 3/11</th>
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<tbody>
<tr>
<td>東北地方の動き</td>
<td>X (西へ移動)</td>
<td>X (新潟県)</td>
<td>X (東へ移動)</td>
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<tr>
<td>地震・火山活動</td>
<td>父島近海</td>
<td>板東下</td>
<td>喫火</td>
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<td>(EQ and Volcano)</td>
<td>地震 M7.4</td>
<td>地震 M5</td>
<td>地震 M5</td>
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<td>GPS (広域の動き)</td>
<td>X</td>
<td>X</td>
<td>X (震央南方)</td>
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<td>F-net (欠測)</td>
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### 解釈 (Analysis)

1. **第一段階 (1st stage):** 陸側プレートの広域で震央の断層帯に到達。陆側プレートは彈性を失い粘性で動きを示した。
2. **第二段階 (2nd stage):** 陸側プレートと太平洋プレートの境界に部分的な破壊を生じた。
3. **第三段階 (3rd stage):** 部分的な破壊領域が広域の破壊 (本震) に発展した。

**図1. 2011年東北地方太平洋沖地震発生までの3段階の過程**

*Fig1. 3 stage process before the 2011 Tohoku earthquake*