Upper-Scale Structural Evaluation of the Forearc Weak Suture Zone and the Pacific Plate Interface

— An Analysis Based on Precursor Data (No.1778) —

Author

Yoshikazu Hiraoka

Affiliation

Independent Researcher, Nishinomiya, Japan

Contact

hiraoka.yoshikazu@nifty.com

ORCID

https://orcid.org/0009-0006-9470-3373

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Abstract

This study reinterprets precursor data (No.1778) published by the Yatsugatake South Base Observatory using the framework of seismology and tectonics, in order to evaluate the upper-scale structural potential of the forearc weak suture zone and the Pacific Plate interface beneath the Kanto Basin. The precursor data are not used for earthquake prediction; instead, they are treated as aggregate indicators of crustal stress release and incorporated as input parameters for structural modeling. Thirteen magnitude-equivalent values reported in the official bulletin were converted into rupture length and rupture area using empirical scaling laws (Matsuda, 1975; Wells & Coppersmith, 1994). The total rupture area reaches approximately 5.6×10^4 km², corresponding to a moment magnitude of Mw 8.7. Although the forearc weak suture zone alone cannot account for such a rupture area, a composite rupture model involving both the suture zone and the low-angle Pacific Plate interface provides a structurally plausible scenario. This study does not aim to predict any specific earthquake. Rather, it evaluates the structural upper limits implied by precursor-derived aggregate quantities and examines the tectonic conditions under which large-scale rupture could theoretically occur.

Keywords

Forearc weak suture zone; Pacific Plate; precursor anomaly; FM radio propagation; Matsuda scaling; Wells & Coppersmith; Kanto Fragment; low-angle subduction; rupture area; tectonic structural modeling

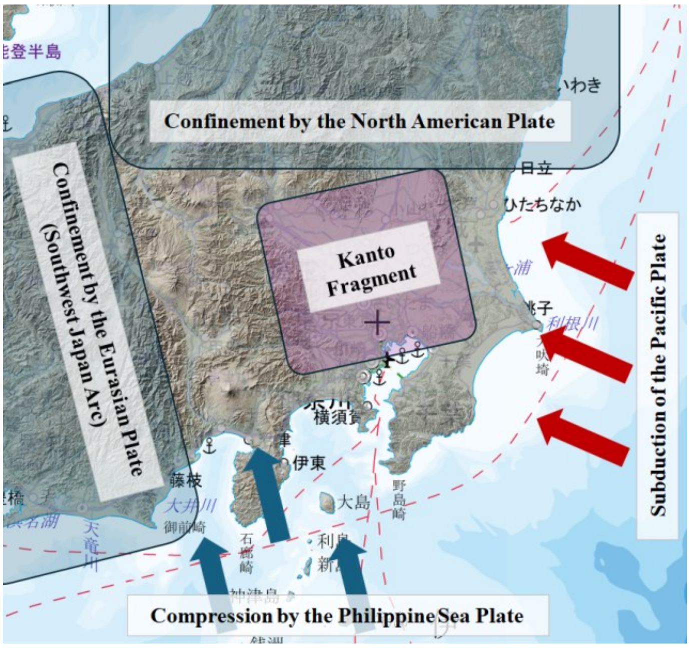
1. Introduction

This study aims to reinterpret precursor anomaly data (No.1778) published by the Yatsugatake South Base Observatory using seismological and tectonic perspectives, and to evaluate the structural upper-scale potential of the forearc weak suture zone and the Pacific Plate interface beneath the Kanto Basin. The precursor data are not intended for predicting specific earthquakes; instead, they are positioned as aggregate indicators of crustal stress release and used as input parameters for structural modeling.

The target region is the forearc weak suture zone located above the subducting Pacific Plate beneath the Kanto Basin. In a previous study (Hiraoka, 2026), the author suggested that the Japanese arc may contain an unstitched forearc segment with accretionary characteristics. The region forms an active plate boundary beneath an urban area, with a subduction angle lower than that of typical inland active faults. These geometric features are essential for evaluating the potential for large-scale rupture.

This paper is intended for specialists in seismology, crustal structure, precursor anomaly analysis, and urban disaster mitigation, and is written as a technical document focusing on structural causality rather than general explanation.

Figure 1. Conceptual diagram of the forearc weak suture zone



The forearc region beneath the Kanto area is structurally confined by the North American Plate (to the northeast) and the Eurasian Plate (Southwest Japan Arc, to the west), compressed from the south by the Philippine Sea Plate, and overridden by the rapidly subducting Pacific Plate from the east. The Kanto Fragment lies atop the upper surface of the subducting Pacific Plate, tilting westward. Plate boundaries and angles shown here are schematic.

Base map: Geospatial Information Authority of Japan (Digital Japan Web Map), modified by the author.

2. Overview of the Kushida Method and Its Use in This Study

The precursor data used in this study are based on electromagnetic anomaly observations conducted by the Yatsugatake South Base Observatory (director: Y. Kushida). The Kushida Method detects anomalous FM radio propagation, interpreted as signals reflecting changes in crustal stress or rupture preparation processes.

Among the observed anomalies, the PBF-type anomaly is associated with magnitude-equivalent values derived empirically from its duration and characteristics. These values differ from seismological moment magnitude (Mw), but serve as indicators of aggregate crustal stress release. In this study, magnitude-equivalent values are converted into rupture length and rupture area using empirical scaling laws.

Importantly, this study does not treat precursor anomalies as earthquake predictions. The values are used solely as input parameters for structural modeling.

According to the official bulletin "Report No.471," precursor No.1778 consists of 13 magnitude-equivalent subevents:

- Mj 7.5 × 1
- Mj 7.6 × 2
- Mj 7.7 × 2
- Mj 7.8 × 2
- Mj 7.9 × 3
- Mj 8.0 × 3

These values are interpreted as aggregate rupture potential equivalent to multiple Mj 7–8 class events. They are integrated using scaling laws to evaluate the structural upper limits of possible rupture.

The precursor anomalies detected by the Kushida Method are hypothesized to arise from electric potentials generated by micro-failures of asperities. These potentials are thought to modify the state of the ionosphere through a mechanism analogous to a capacitor, thereby influencing the reflection and scattering of FM radio waves. Consequently, the occurrence of numerous subevents in precursor No.1778 can be interpreted as the result of cascading micro-failures of multiple asperities distributed across a wide, low-angle fault plane, providing a coherent explanation for the observed anomaly sequence.

3. Precursor Data and Magnitude-Equivalent Values

The No.1778 precursor anomaly includes multiple magnitude-equivalent values published by the Yatsugatake South Base Observatory (2026). In this study, these values are not treated as indicators of individual earthquake magnitudes. Instead, they are interpreted as aggregate quantities equivalent to multiple M7–8 class events, and are used as input parameters for rupture scaling analysis.

3.1 Nature of the Precursor Data

The precursor anomalies do not indicate the timing or certainty of earthquake occurrence. They are interpreted as signals reflecting broad crustal stress changes. In this study, the aggregate precursor quantity is treated as equivalent to multiple Mj 7–8 class events and integrated using scaling laws.

3.2 Rupture Length Scaling (Matsuda, 1975)

Magnitude-equivalent values are converted into rupture length using Matsuda's empirical relationship. Summing the rupture lengths yields several hundred kilometers, corresponding to M 9.7 if interpreted as a single event. This represents an upper-bound linear rupture estimate and may overestimate total rupture area.

3.3 Rupture Area Scaling (Wells & Coppersmith, 1994)

Using rupture area scaling, the total area reaches approximately 5.6×10^4 km², corresponding to Mw 8.7. This is a more physically grounded estimate, incorporating rupture width and slip.

3.4 Interpretation of Aggregate Quantity

Two models are considered:

- Distributed rupture model: multiple M7–8 events
- Single composite rupture model: forearc weak suture zone + Pacific Plate interface

The latter is evaluated in subsequent chapters.

4. Scaling Analysis: Upper-Bound Rupture Potential

This chapter evaluates the rupture potential implied by the No.1778 precursor data by converting magnitude-equivalent values into rupture length and rupture area. These results do not predict any specific earthquake; rather, they provide an upper-bound estimate of rupture scale that could theoretically occur within the regional tectonic framework.

4.1 Rupture Length Scaling (Matsuda, 1975)

Using Matsuda's empirical relationship, the magnitude-equivalent values (M 7.5–8.0) reported by the Yatsugatake South Base Observatory (2026) are converted into rupture lengths. Summing these lengths yields a total rupture extent exceeding several hundred kilometers. When reconverted into magnitude, this corresponds to approximately M 9.7. Although this estimate may overstate the true rupture potential due to its linear nature, it indicates that the precursor quantity represents a very large cumulative rupture length.

4.2 Rupture Area Scaling (Wells & Coppersmith, 1994)

Applying rupture area scaling yields a total rupture area of 5.6×10^4 km², corresponding to Mw 8.7. This estimate incorporates rupture width and slip, making it more appropriate for evaluating large-scale rupture scenarios. The precursor quantity is therefore consistent with an upper-bound rupture area of Mw 8.7.

4.3 Interpretation: Distributed vs. Composite Rupture

Two structural interpretations are possible:

- Distributed rupture:
  Multiple M 7.5–8.0 events occurring independently within the forearc weak suture zone.
- Composite rupture:
  A single large rupture involving both the forearc weak suture zone and the Pacific Plate interface.

The composite rupture model is structurally plausible if the two domains are mechanically connected. This possibility is examined in the next chapter.

5. Tectonic Model: Geometry of the Forearc Weak Suture Zone and the Pacific Plate

This chapter examines the tectonic geometry beneath the Kanto Basin, focusing on the forearc weak suture zone and the subducting Pacific Plate. The structural configuration determines whether a composite rupture involving both domains is feasible.

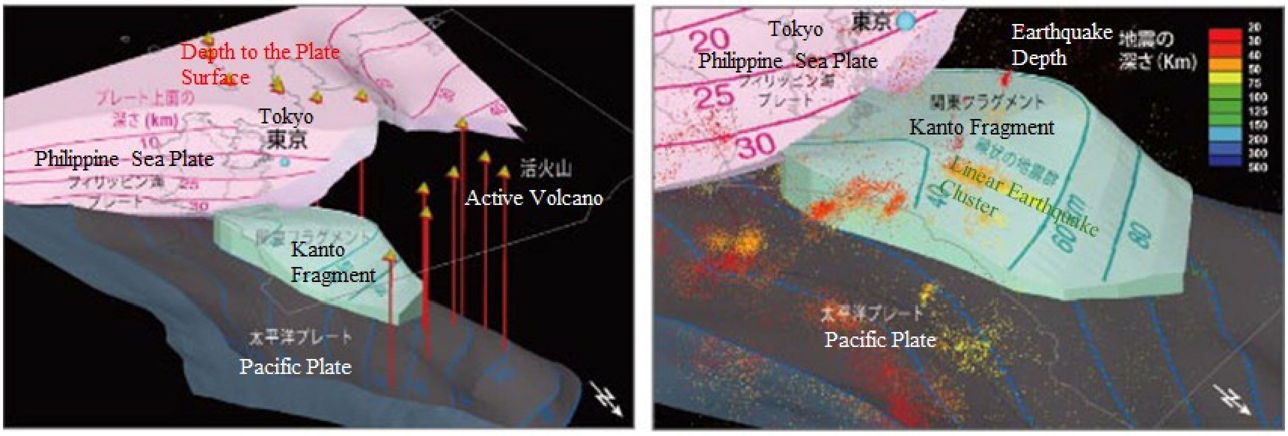
5.1 Subduction Angle of the Pacific Plate Beneath the Kanto Basin (30–40°)

Seismicity, depth distribution, and tomographic studies (e.g., Ishida, 1992; Kita et al., 2010; Nakajima & Hasegawa, 2006) indicate that the Pacific Plate subducts at an angle of approximately 30–40° beneath the Kanto Basin. This angle is:

- lower than typical inland active faults (45–60°), and
- higher than ultra-low-angle megathrusts (10–20°) discussed in recent studies.

This geometry allows the plate interface to extend continuously over a large area, providing favorable conditions for large-scale rupture.

Figure 2. Geometric relationship among the Pacific Plate, the Philippine Sea Plate, and the Kanto Fragment



Oblique view of the Kanto Basin from the northeast. The Pacific Plate subducts westward beneath the region, and the detached Kanto Fragment rests on its upper surface while also tilting westward. From the south, the Philippine Sea Plate subducts and exerts compressional stress on both the Kanto Fragment and the overriding crust.
Source: AIST (National Institute of Advanced Industrial Science and Technology), “A fragment of the plate hidden beneath the metropolitan area and earthquake generation,” Figure 3, modified by the author.

5.2 Structural Characteristics of the Forearc Weak Suture Zone

The forearc weak suture zone exhibits multiple indicators of structural weakness, including velocity discontinuities, concentrated seismicity, and crustal boundaries. Although located beneath an urban region, it may connect structurally to the Pacific Plate interface. The suture zone alone can generate M7–8 class events, but its rupture potential increases significantly if it participates in a composite rupture with the plate interface.

5.3 Consistency with Low-Angle Megathrust Models

Recent studies (Ide et al., 2026) suggest that low-angle megathrusts can accumulate stress and generate large slip. Although the Pacific Plate beneath the Kanto Basin is not ultra-low-angle, its relatively low angle allows stress to accumulate in both the plate interface and the forearc domain. If the forearc weak suture zone connects mechanically to the plate interface, it may act as the “forearc expression” of a larger rupture. This configuration is consistent with an *M*w 8.7 composite rupture model.

6. Conditions for Composite Rupture and Structural Feasibility

This chapter evaluates whether the forearc weak suture zone and the Pacific Plate interface could jointly produce a rupture of *M*w 8.7.

6.1 Limitations of the Forearc Weak Suture Zone Alone

The estimated rupture area of the forearc weak suture zone is on the order of several tens of thousands of square kilometers. This corresponds to an upper limit of *M*w 8.0–8.3. Therefore, the suture zone alone cannot account for an *M*w 8.7 rupture.

6.2 Expansion of Rupture Area Through Low-Angle Plate Interface Participation

If the low-angle Pacific Plate interface participates in the rupture, the total rupture area increases by a factor of several times. This expanded area is consistent with the *M*w 8.7 estimate derived from precursor scaling.

6.3 Consistency with Precursor Aggregate Quantity

The total precursor-derived rupture area (5.6×10^4 km^2) cannot be explained by the forearc weak suture zone alone. However, it aligns with a composite rupture model involving both the suture zone and the Pacific Plate interface.

7. Considerations for Social Interpretation and Data Handling

This chapter addresses potential misunderstandings when discussing large-scale rupture scenarios.

7.1 Handling of Precursor Data

Precursor data are not predictive indicators. They are used solely as structural input values. To prevent misinterpretation, the precursor quantity is treated as an upper-bound scenario rather than a forecast.

7.2 Communicating Structural Possibility

The Mw 8–8.7 range represents a structural upper limit, not a prediction. The discussion focuses on theoretical feasibility, not on whether such an event will occur.

7.3 Avoiding Misinterpretation

Statements implying certainty or inevitability of large earthquakes must be avoided. This study is a technical evaluation of structural models, not a hazard warning.

8. Conclusions

This study converted precursor anomaly data (No.1778) into rupture length and rupture area using empirical scaling laws and compared the results with tectonic structures beneath the Kanto Basin. The findings suggest:

- The precursor aggregate quantity is consistent with an upper-bound rupture area equivalent to *M*w 8.7.
- The forearc weak suture zone alone cannot produce such a rupture, but a composite rupture involving the

Pacific Plate interface is structurally plausible.

- The Pacific Plate beneath the Kanto Basin forms an active plate boundary beneath an urban region, providing geometric conditions favorable for large-scale rupture.
- This study does not predict earthquakes; it evaluates structural upper limits implied by precursor-derived quantities.

Future work includes 3D structural modeling, stress field analysis, and integrated evaluation of precursor anomalies. An additional unresolved question is whether the same asperity can undergo multiple micro-failure episodes. This issue remains open and represents a topic for future investigation. However, it does not fundamentally affect the upper-bound scaling evaluation presented in this study.

Data Availability Statement

All data referenced in this study are available from the sources listed in the References. No new data or code were generated for this research.

Conflict of Interest Statement

The author declares no conflicts of interest related to this study.

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Author Contributions

The author conceived the study, conducted the analysis, and wrote the manuscript.

AI Usage Statement

AI tools were used to assist in literature search and stylistic adjustments for academic writing. Machine translation tools were used in a supplementary manner for translation, but all conceptual content is original to the author, who assumes full responsibility for its accuracy.

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