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Earthquake Prediction Research Based on the TRIZ Philosophy

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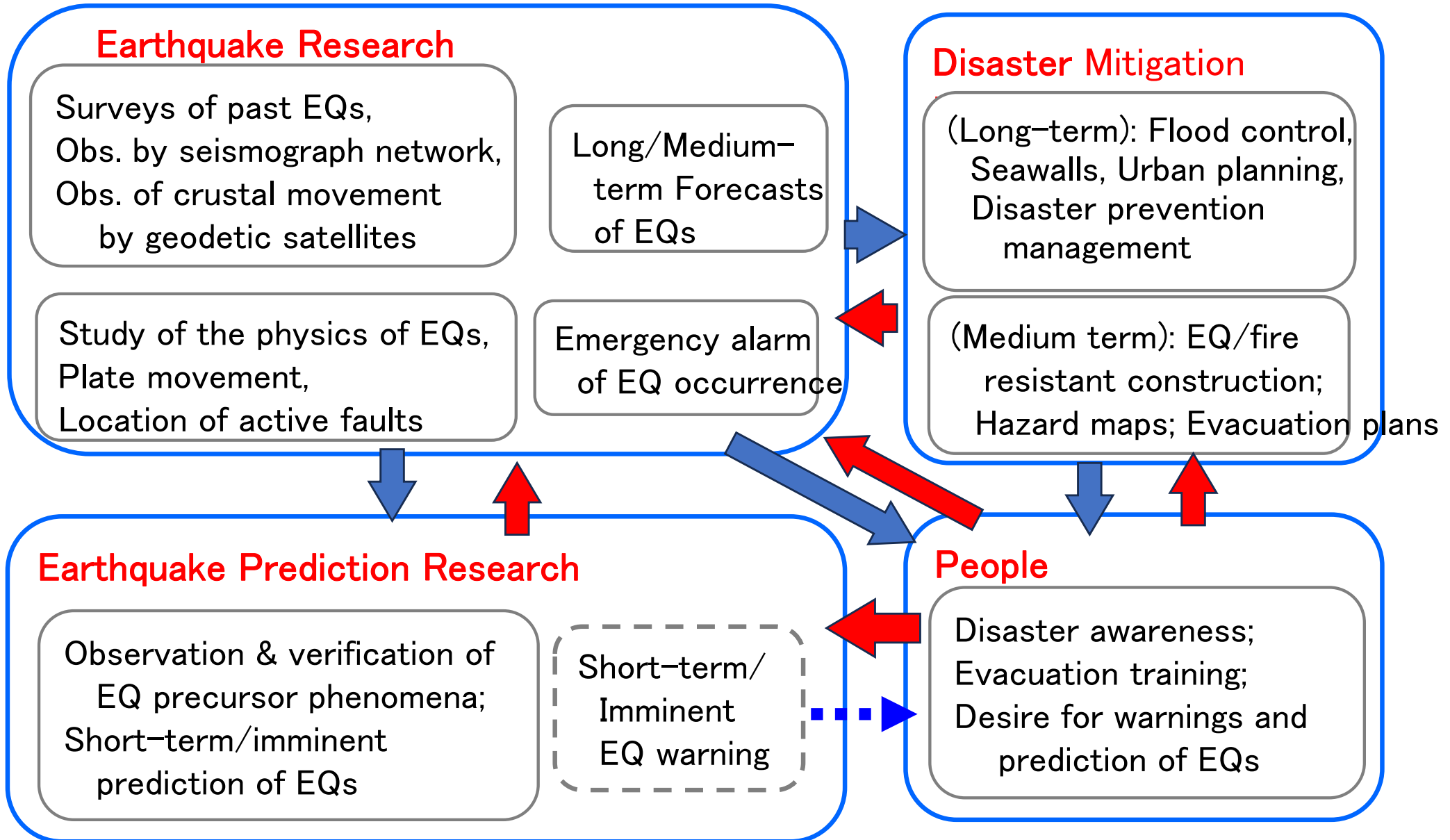
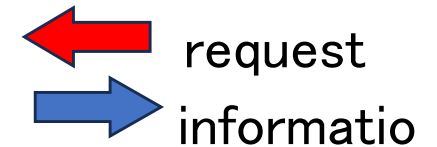


Hanshin-Awaji Great Earthquake Disaster
Jan. 17, 1995. M 6.7 (Photo: Jiji com.)



East Japan Great Earthquake Disaster
Mar. 11, 2011. M 9.1 (Photo: Asahi)

Positioning of Earthquake Prediction Research:



Study of EQs (conventional seismology)

Investigation of past earthquakes

Faults, Sediments, Paleoseismology

Observation by seismograph network

With a network of high-sensitivity seismographs;
With a network of strong-motion seismographs;
Analysis of seismic waves → Real-time analysis
→ Analysis (epicenter area, magnitude, seismic process,

Observation of crustal movement by geodetic satellites

Longitudinal measurement of relative movement
at multiple locations; Accumulation of stress

Study of the physics of earthquakes

Plate boundaries, Tectonic structure,
Plate movement;
Location and historical events of active faults;
Assessment of stress accumulation
Study of EQ processes (hypothetical)

Emergency alarm of EQ occurrence

Epicenter, magnitude,
Seismic intensity forecast,
Tsunami Warning

Effective for emergency evacuation
(Sometimes too late to evacuate.)

Long/medium-term forecast of EQs

Probabilistic forecasting:
Damage simulation (Hazard Map)

Short-term/imminent prediction
is "impossible".

(Seismological Society of Japan (SSJ)
and the Government evade
EQ prediction research)

Limitations of
mechanistic
observation

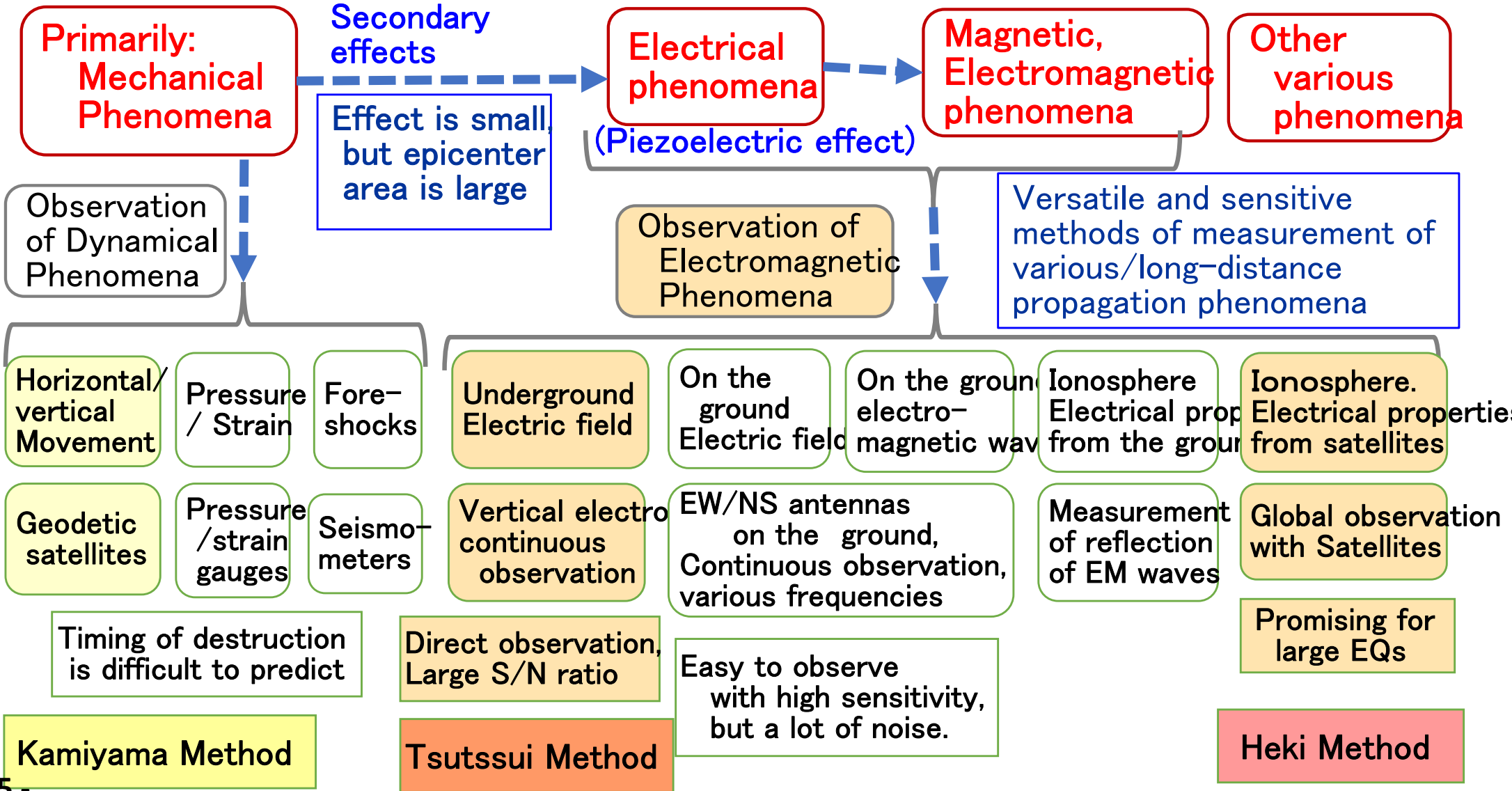
Expected Stages of Earthquake Prediction (EQP) Research

Stage	Tasks & Activities	Status in Japan
(0) Preparatory	Search for various candidates of precursor phenomena ; Try and develop observation methods/instruments.	various trials
(1) Single site observation	Observe a candidate phenomena at a single site; Develop the observation method/instrument ; Examine the correlation with (some types of) EQs.	Novel methods by Tsutsui, by Kamiyama
(2) Multiple sites observation	Form a research project by multiple groups/sites; Observe the phenomenon at multiple sites in parallel ; Confirm the correlation with (some types of) EQs.	Proposal of a research project
(3) Country-wide deployment	Country-wide network of observation sites and groups; Observe and analyze many cases of EQs, and try to predict EQs; Establish a method to predict EQs (where, when, how large) .	
(4) Integrate multiple methods	Integrate different complementary methods for EQ prediction; Construct a technical system of analyzing/predicting EQs; Demonstrate the usefulness of predicting damaging EQs.	
(5) Official operation of warning	Get the understanding by academia, society, and government; Official operation of warning system of EQ prediction; Practice and improve it further; Deploy the system in the world.	Hopefully in 20 years !

Candidates of EQ precursor phenomena and their observation methods

EQs = Rupture phenomenon caused by moving pressure between plates/faults

Energy accumulation:
from thousands to tens years
Destruction: from minutes to seconds



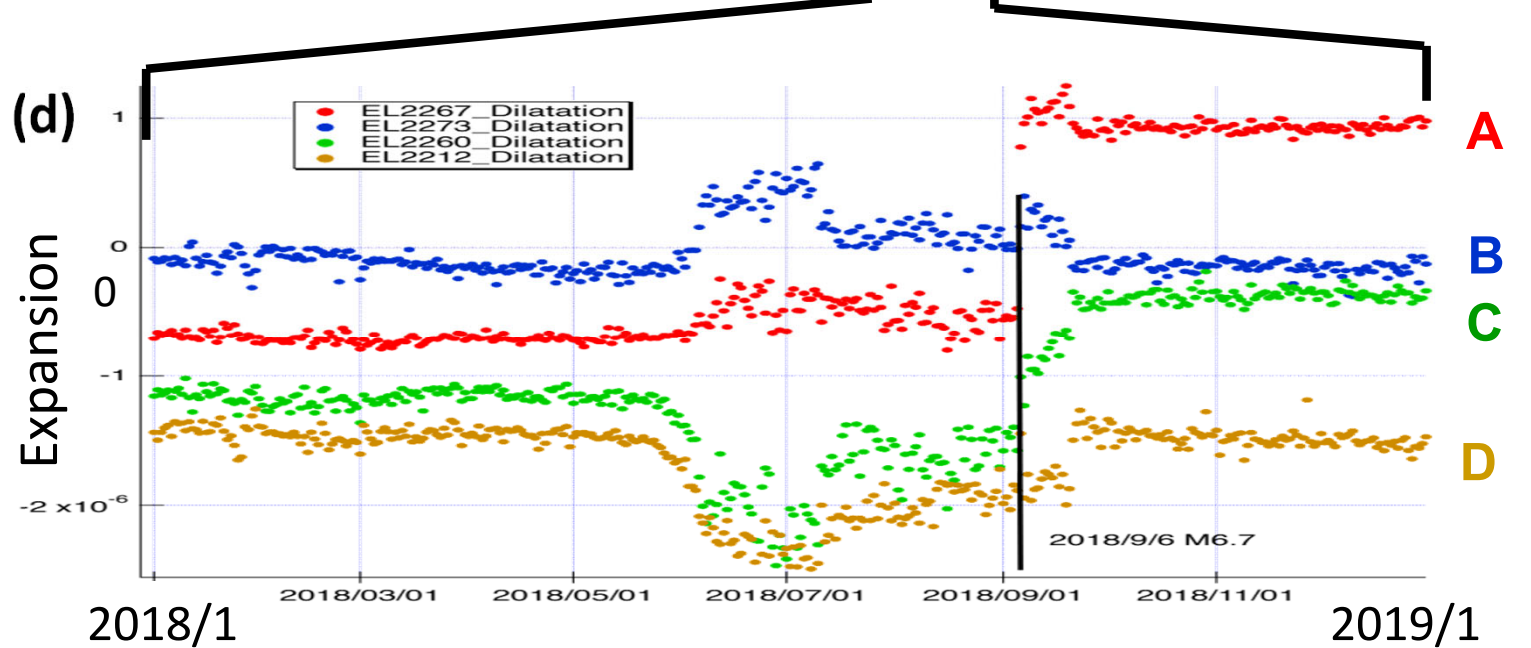
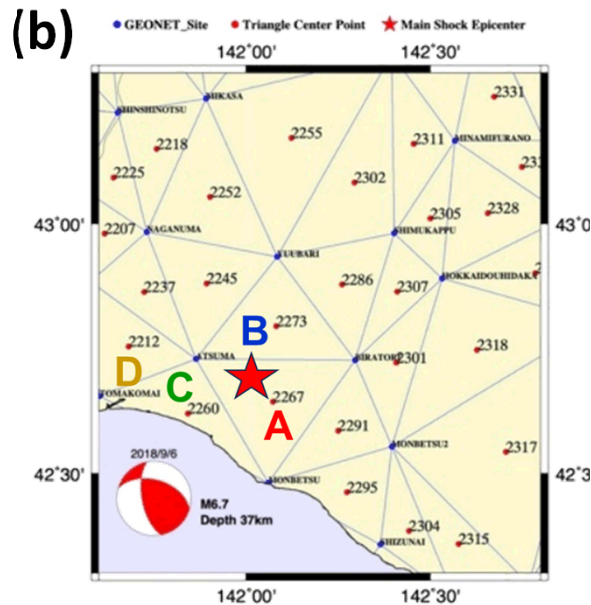
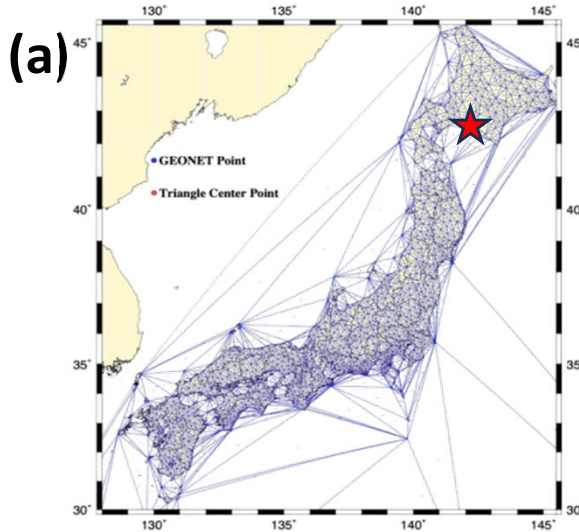
Requirements of Precursors for Short-term EQ Prediction

- (0) **Fundamental Requirements:** X is related with and caused by EQs, occurs short time before for various types of EQs, ...
==> Can examine only after extensive observation and analysis.
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- (1) **Basic Req.:** Observable/measurable clearly with high S/N ratio.
==> Need to develop measurement method/instrument (at one site)
- (2) **Confirmation Req.:** Observable at multiple sites similarly, for many EQs, confirming occurrence of EQs just as predicted.
==> Data accumulation at multiple sites to confirm correlation with EQs
- (3) **Practical Req.:** Automatic/stable/continuous measurement, and methods for predicting EQs (where, when, magnitude)
==> Reliable technical system and thorough analysis of experimental data
- (4) **Advanced Req.:** System integration and proving causality with EQs.
==> Need advanced research in seismology, esp. the EQ process.
- (5) **Social Req.:** Reliable operation of short-term EQ prediction/alert system.
==> Need recognition/approval by academia, society, government, etc.

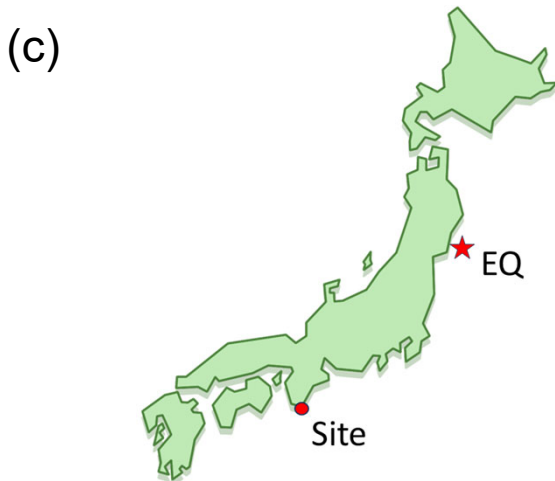
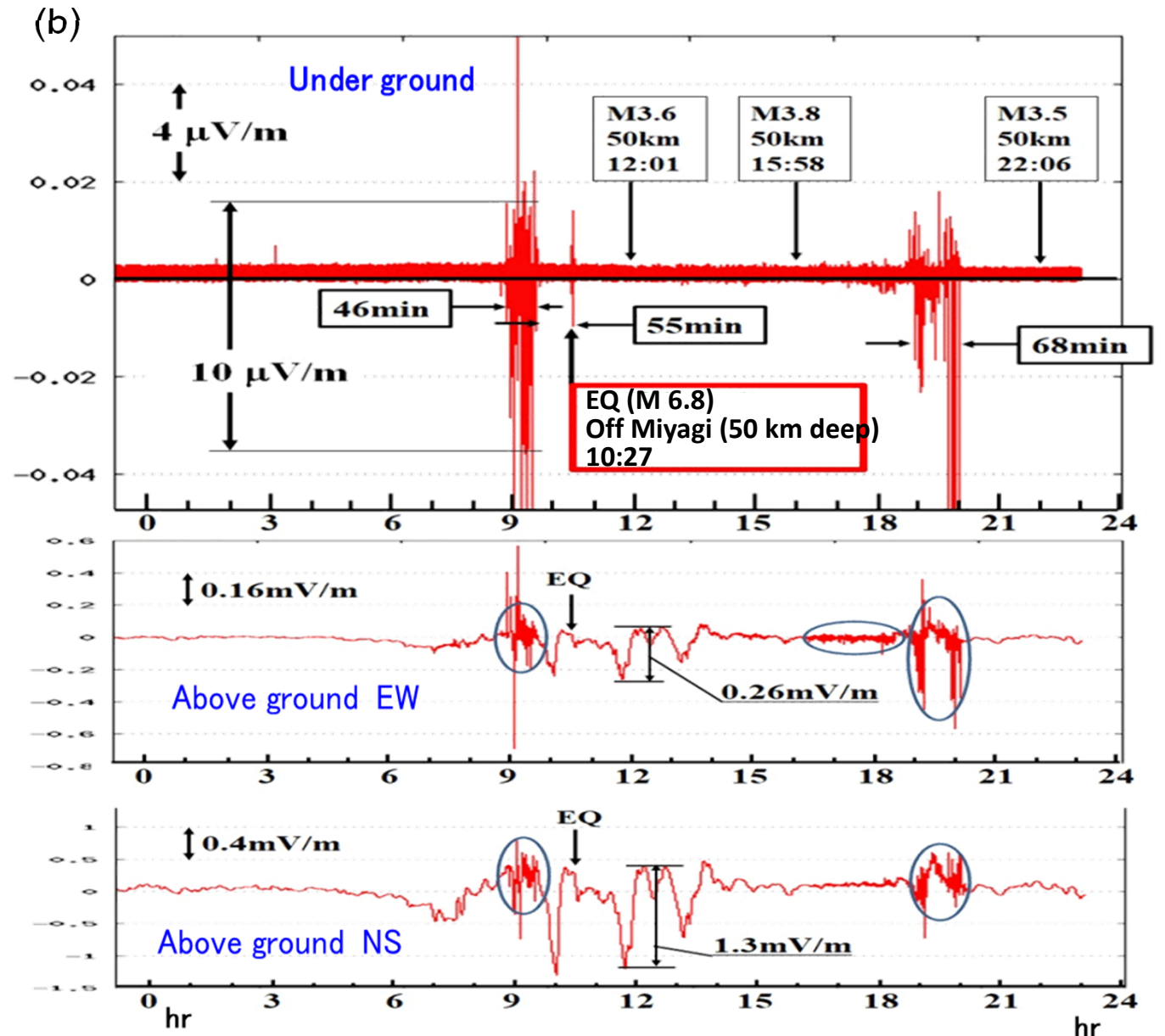
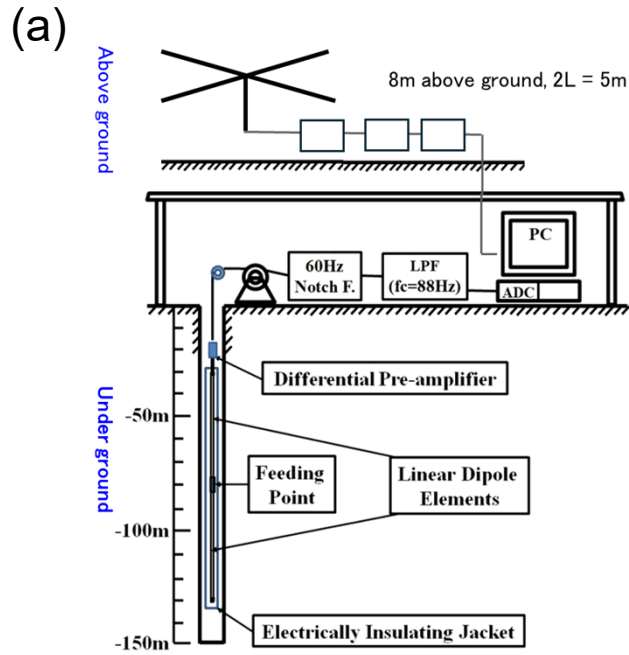
Kamiyama Method: Observing Crustal Strains using GNSS Data

Hokkaido Iburi East EQ (Sept. 6, 2018, M 6.5)



Tsutsui Method: Observing Underground DC Electric Field

2021 Off Miyagi EQ (May 1, 2021, M 6.8)



For Further Development of the Tsutsui Method

Stage (1) Excellent results already:

Difficulties: Retired professor is **working alone**; hard to maintain the remote site.

Stage (2) Initiate a collaborative research project with multiple groups and sites:

Raise funding for ourselves; Improve the way of site building;

Confirm the correlation with (some types of) EQs;

Try to predict the impending EQs (where, when, how large).

Stage (3) Research project supported by MEXT (KAKENHI):

Build a network of about **40 observation sites** all over Japan;

Analyze all the damaging EQs and try to apply the imminent prediction methods;

Establish a method for **imminent prediction of (some types of) EQs ($M > 5.5$)**.

Stage (4) National research project for establishing the technical system:

Integrate various other methods for **predicting different types of EQs**;

Establish and demonstrate a **technical system** of Short-term/Imminent EQ Prediction.

Stage (5) Official operation of the warning system of EQ Prediction:

Tsutsui method will be the core method for the imminent EQ prediction.

--- Hopefully in 20 years.

- 9 - --> **International deployment of the whole system.**

Concluding Remarks: Summary and Future

EQ prediction research has been **in the dark** until recently (Stage (0)).

Recently, **groundbreaking researches** have been developde (Stage (1)):

Kamiyama method: Analysis of GNSS satellite data --> Short term EQ prediction.

Tsutsui method: Observing underground DC electric field --> Imminent EQ prediction

We should work in **a collaborative research project of several groups** (Stage (2)):

Work with Tsutsui method at multiple sites in parallel to confirm the correlation with EQs.

Obtain the understanding in academia (especially SSJ) (Stage (3)):

Work with a **country-wide network** of observation sites, establish an EQ prediction method.

Integrate several methods to build a technical system of EQ prediction (Stage (4)).

Get the understanding by academia, society, and government

Official operation of the warning system of short-term/imminent EQ prediction. (Stage (5)).

Let's work together with the vision !

Hopefully in 20 years, for reducing the damages caused by coming EQs in Japan and the world