Results of the 1st stage of the the comprehensive joint research on the modeling of slip process of earthquake source fault and plastic flow near the seismogenic region

Hisao Ito[1], Yoshihisa Iio[2], Koichiro Fujimoto[1], and Takeshi Sagiya[3]

Geological Survey of Japan/AIST[1]

Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University[2]

Geographycal Survey Institute[3]

1st stage: 1999-2001
2nd stage:2002-2003

Field Observations

GPS:

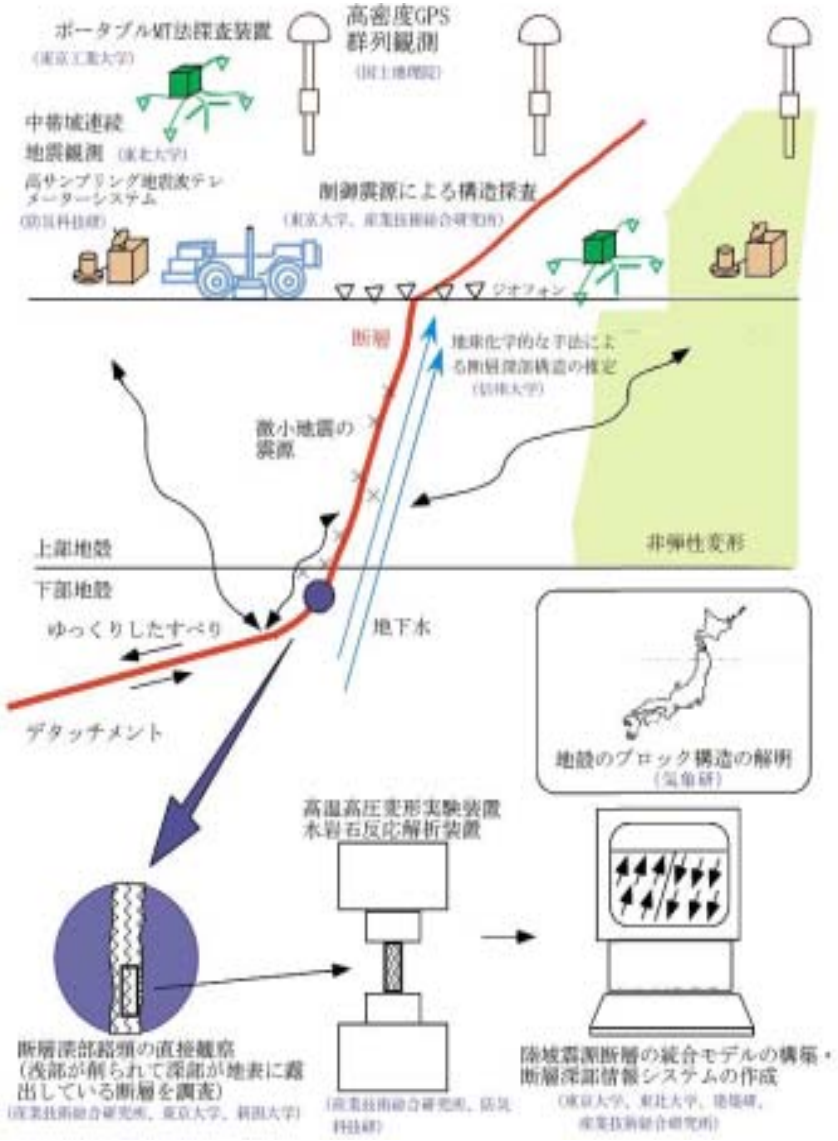
#Northern part of the Itoigawa-Shizuoka Tectonic Line (ISTL)
#Nagamachi-Rifu

Seismic:

1st stage: Nagamachi-Rifu
2nd stage: ISTL

MT:

1st stage: ISTL
2nd stage: Nagamachi-Rifu



Material Science

Geological Studies on Exhumed Shear Zones

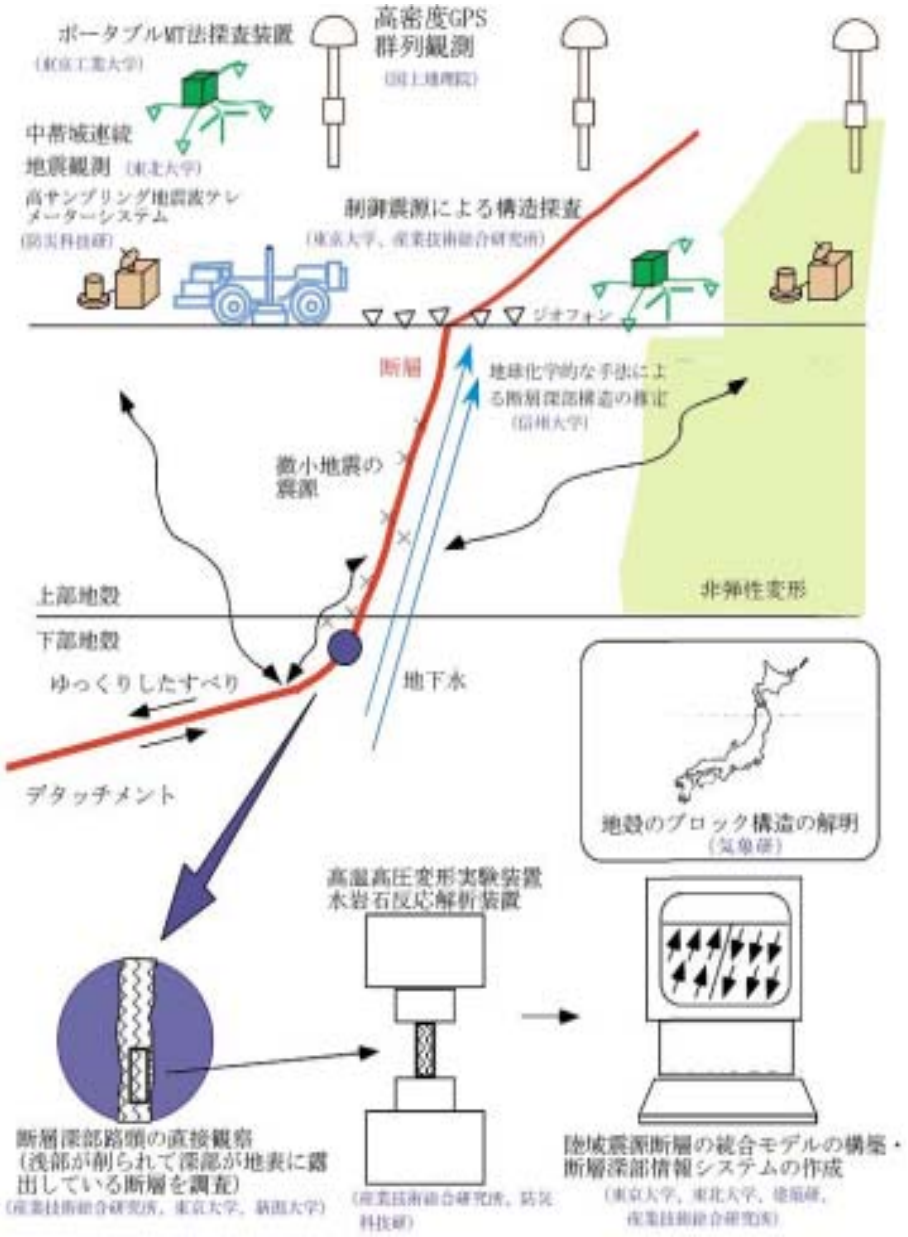
1st stage: Hatagawa

2nd stage: Hidaka (more deeper)

High T-P Deformation Experiments

1st stage: System Development

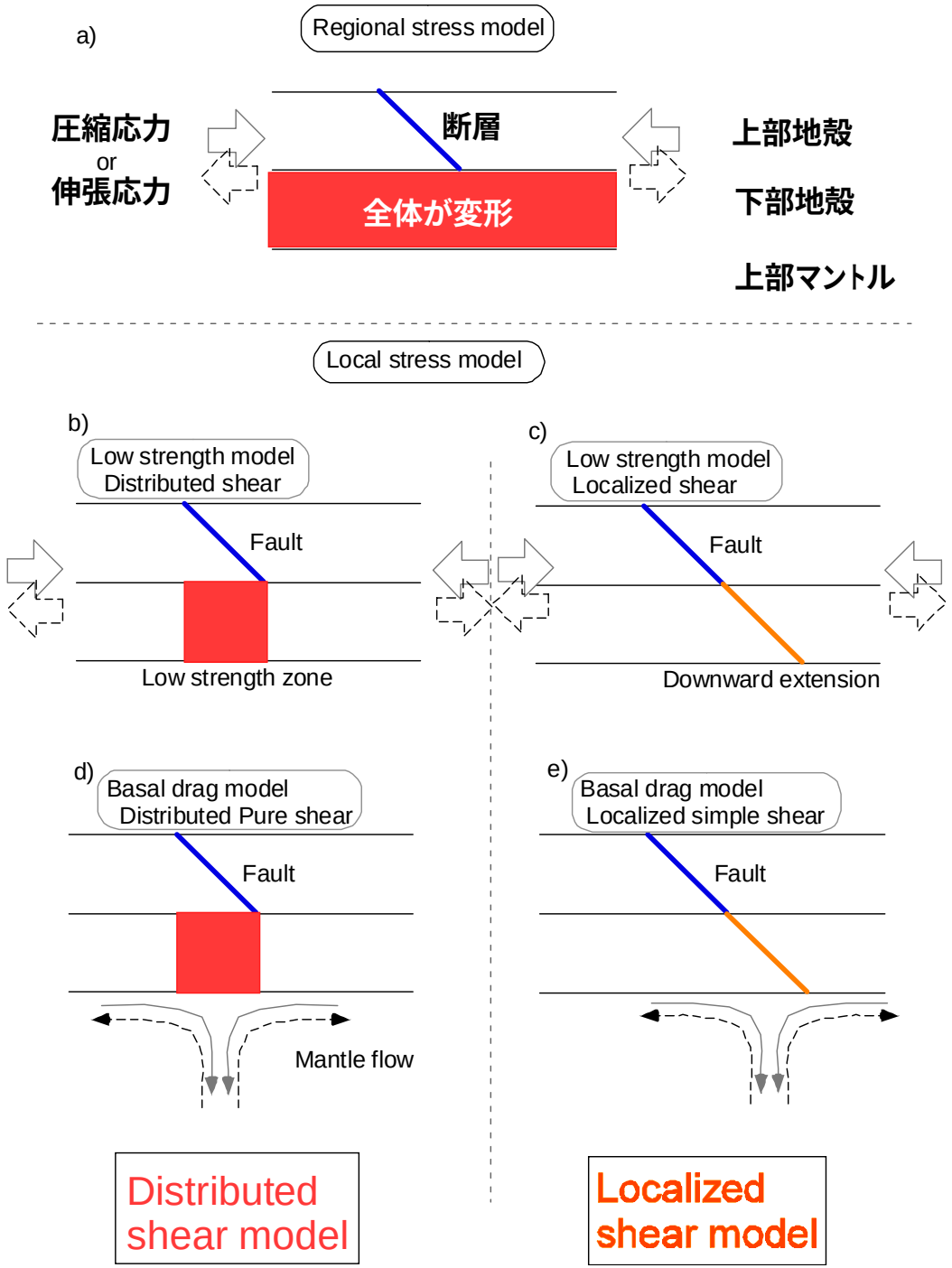
2nd stage:Extensive Experiments



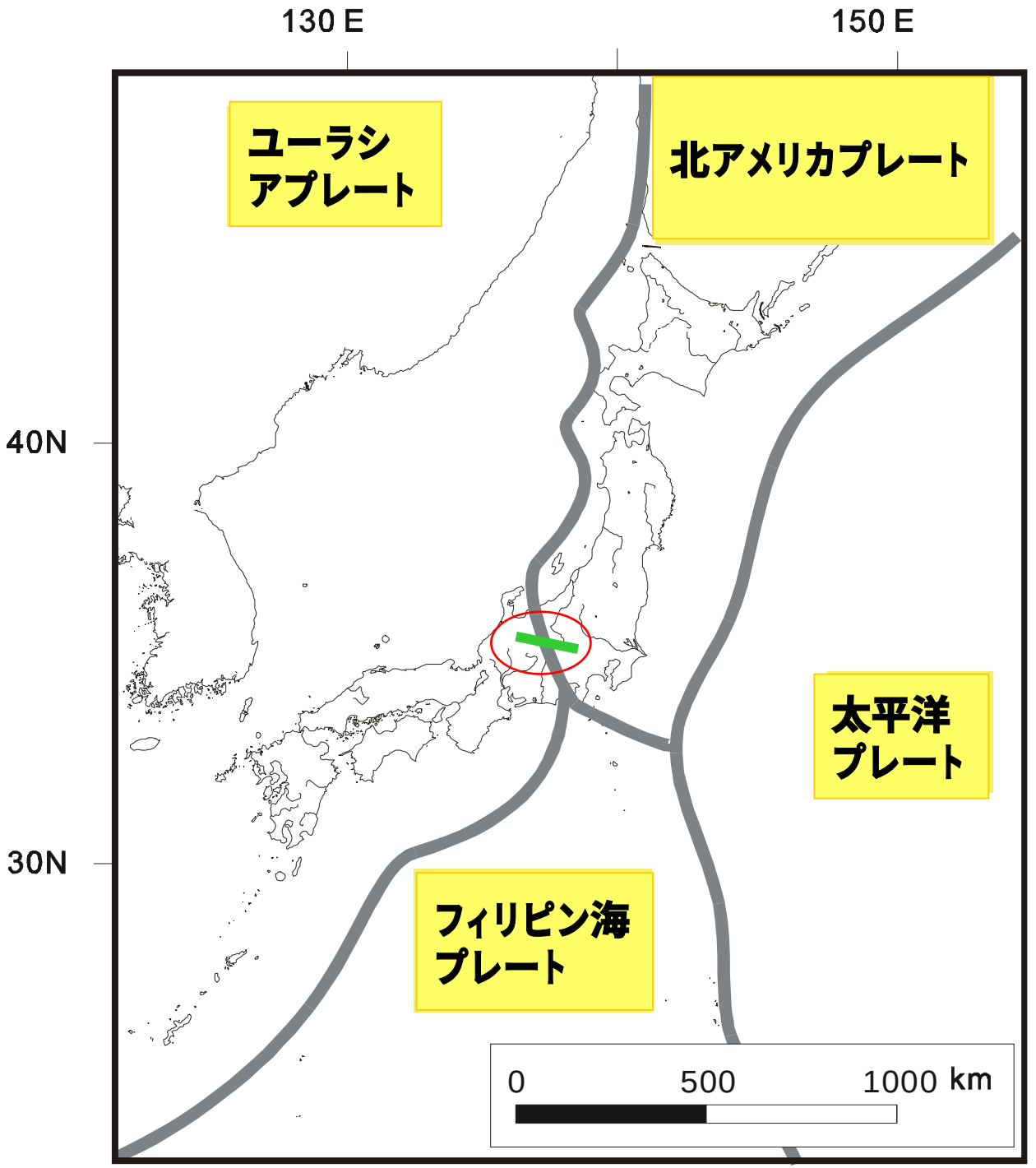
Key Questions

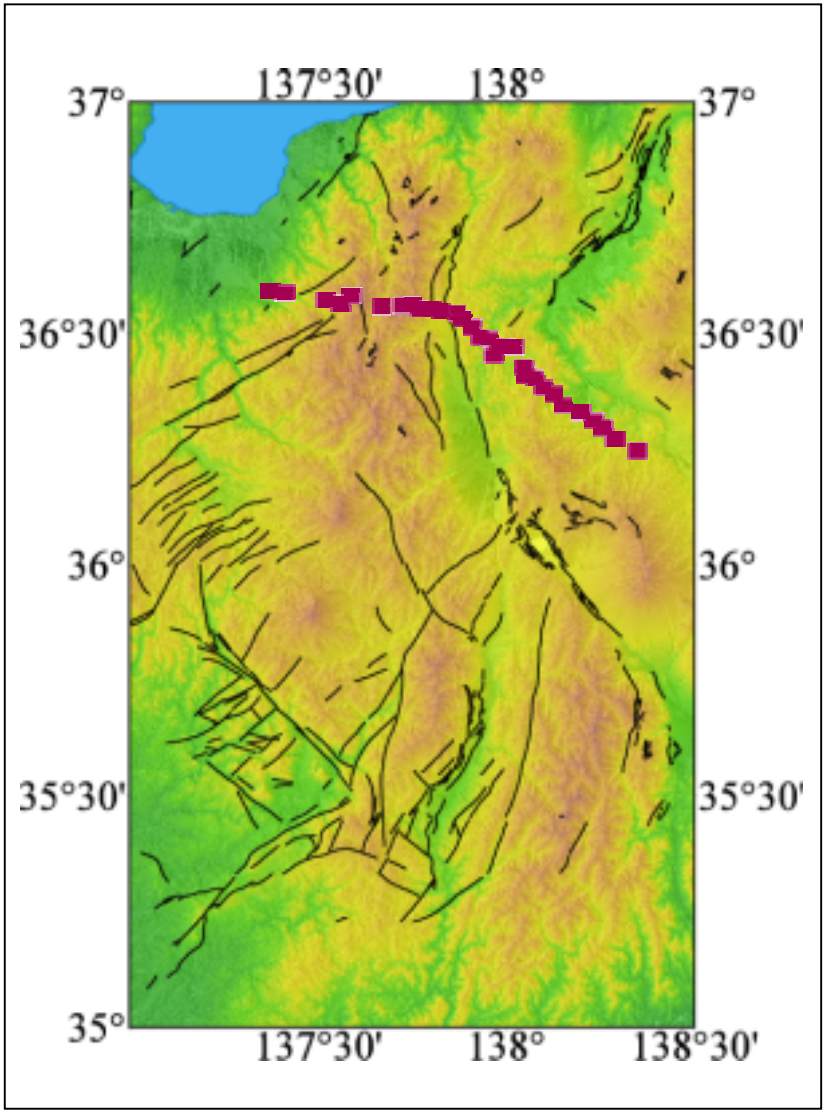
1. Localized shear in the lower crust?
2. What is the mechanism of shear localization in the lower crust?
3. What is the geometry of the downward extension of the fault in the lower crust?
4. How stress accumulation take place due to slip in the downward extension of the fault in the lower crust?
5. Does the slip in the downward extension of the fault in the lower crust accelerate before large earthquakes?

Previous and Present Models



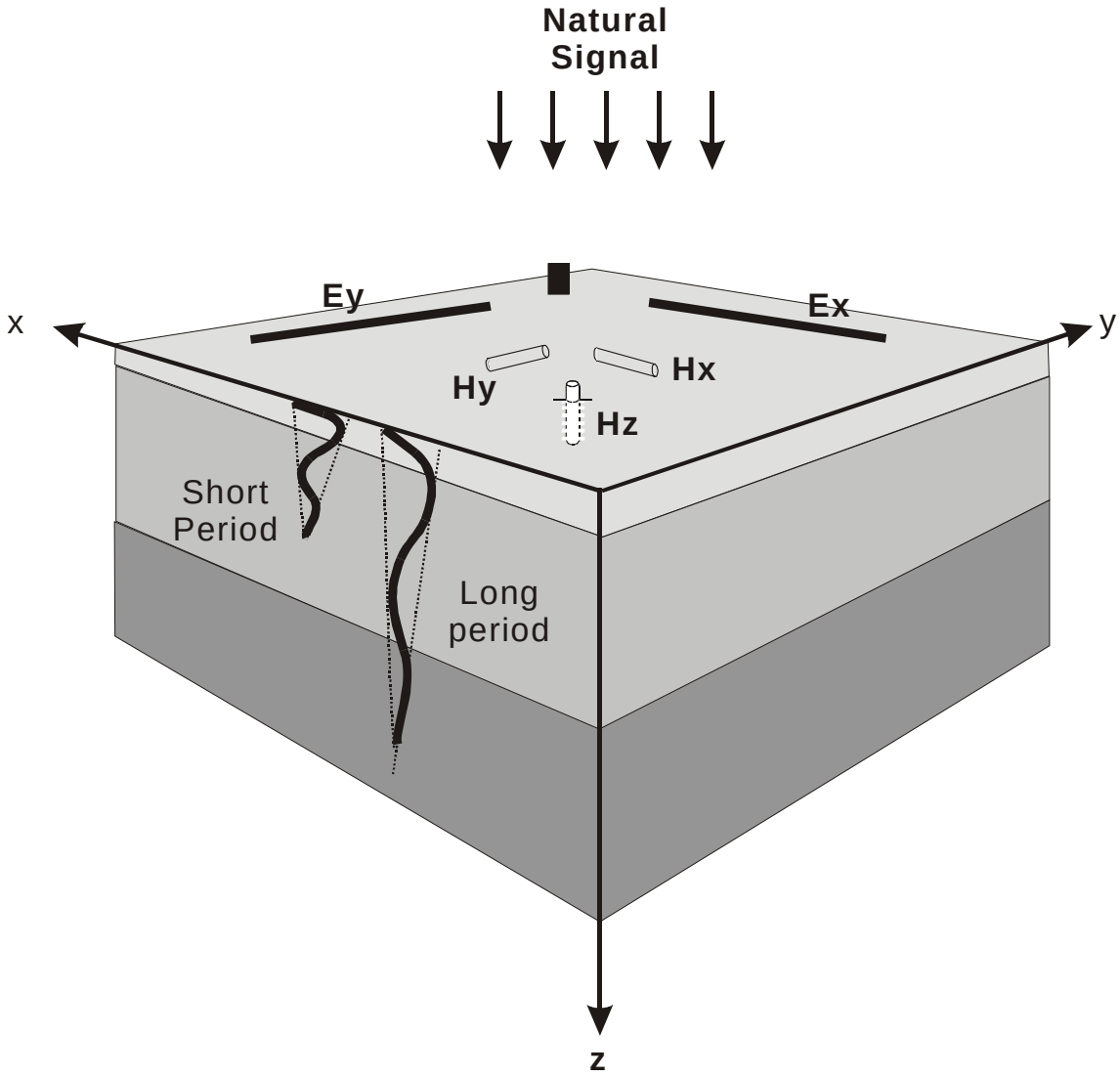
Itoigawa-Shizuoka



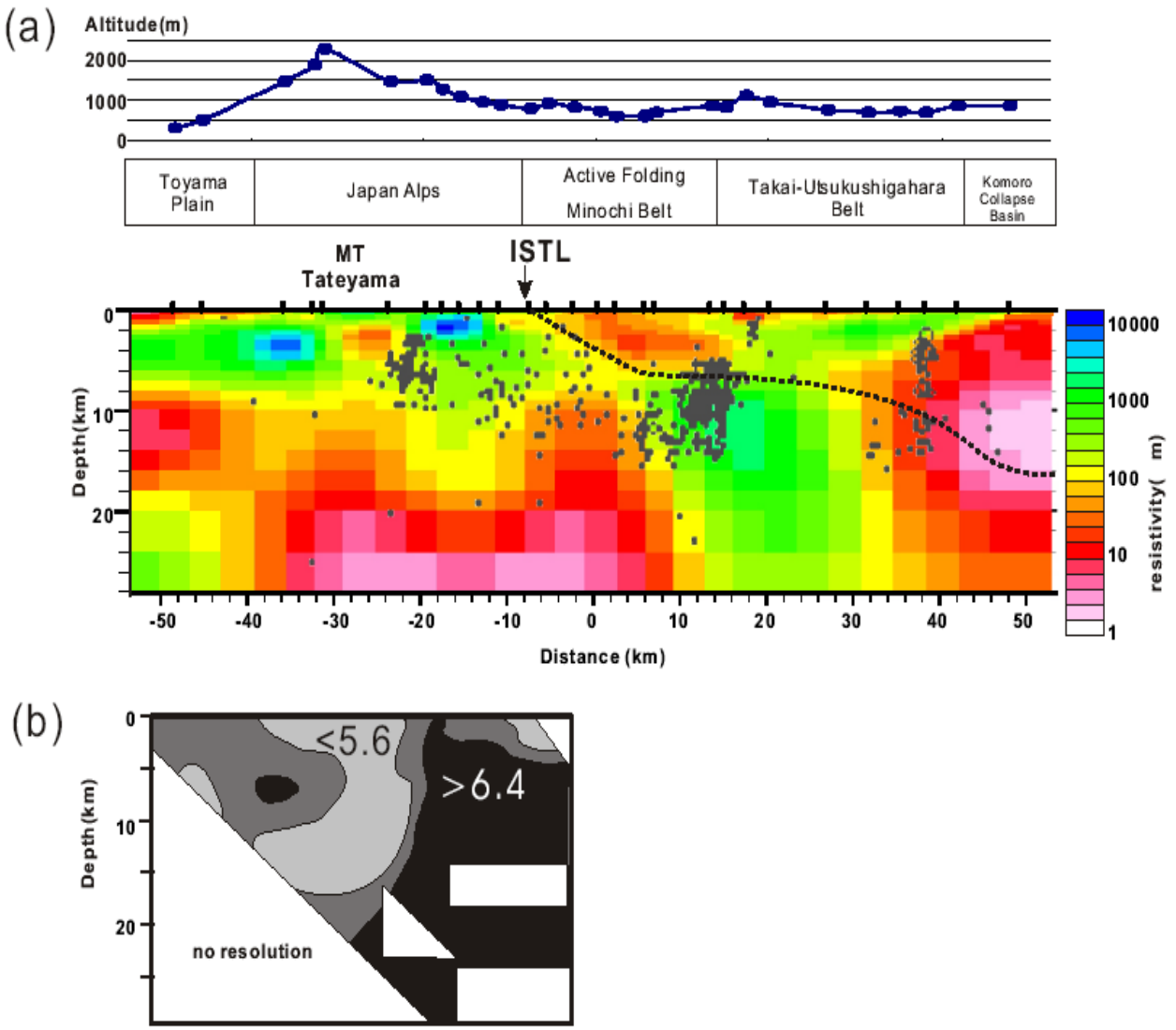

37°
137°30'
138°
37°
36°30'
36°30'
36°
36°
35°30'
35°30'
35°
137°30'
138°
138°30'

MagnetoTellulics (MT)

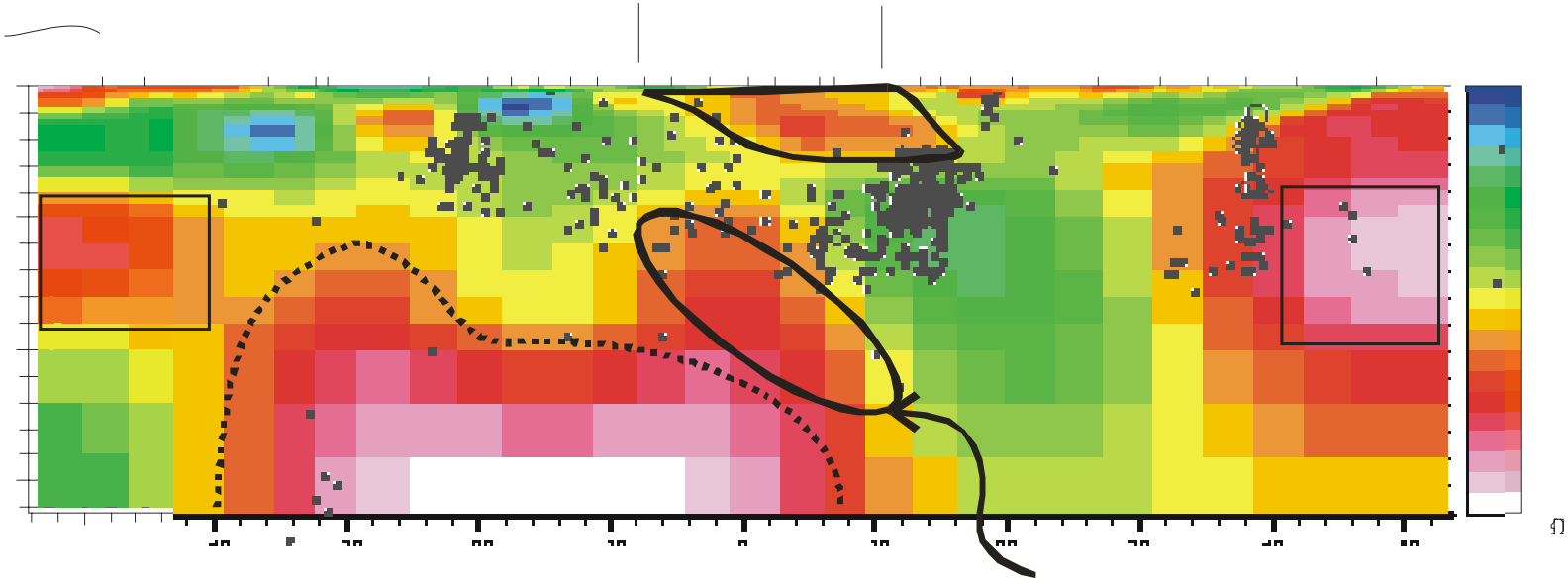
- Natural Signal

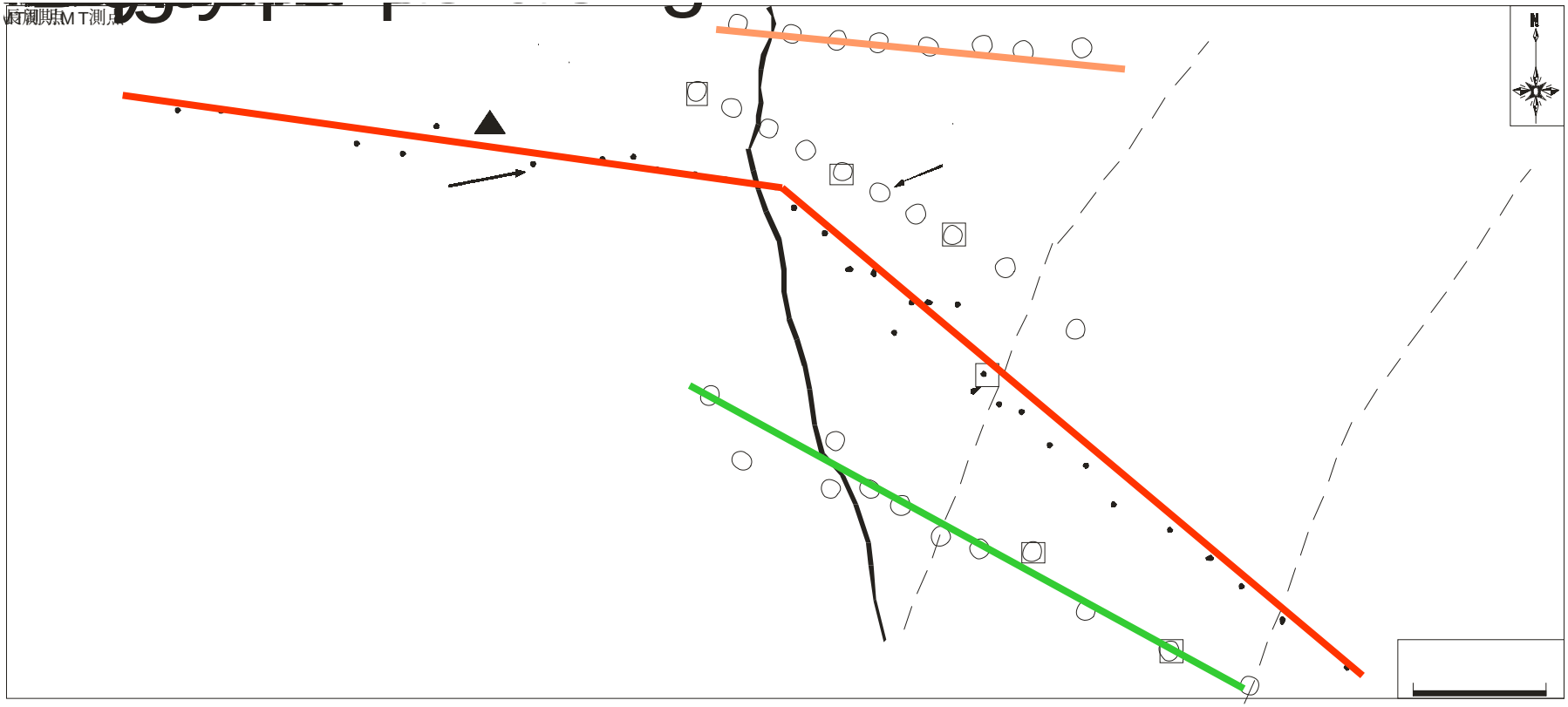


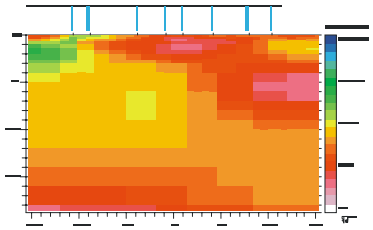
(a) A two-dimensional resistivity model and the seismicity along the profile. The resistivity model used TM mode only where electric field is across the assumed strike direction of N30ºE. Altitude of the sites and geological belts are also shown. (b) Seismic tomography result over the Japan Alps, simplified from Matsubara et al. (2000).

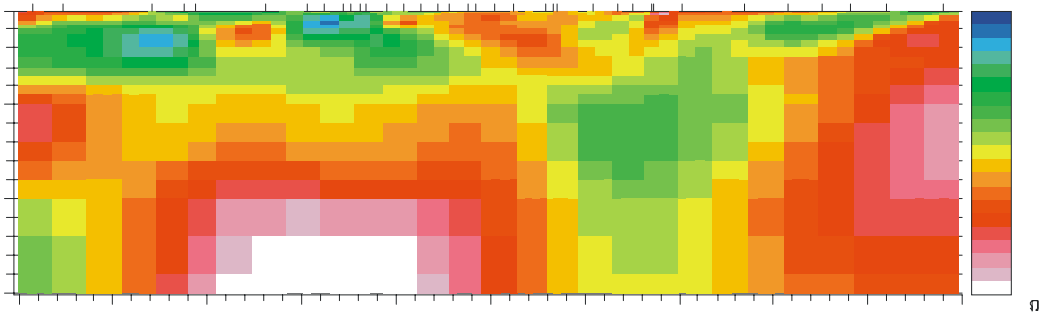


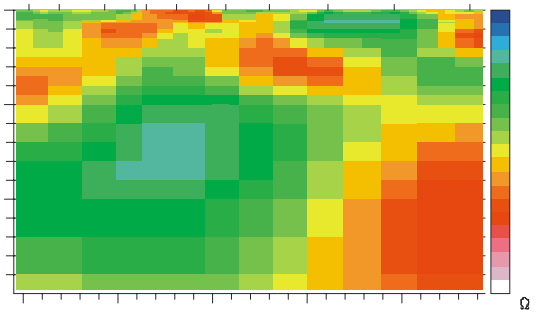
域直下の低比抵抗異常。
速度異常低速度異常に対応しないので、
低比抵抗異常は薄いシート状。
水が断層帯に局在化している可能性あり。



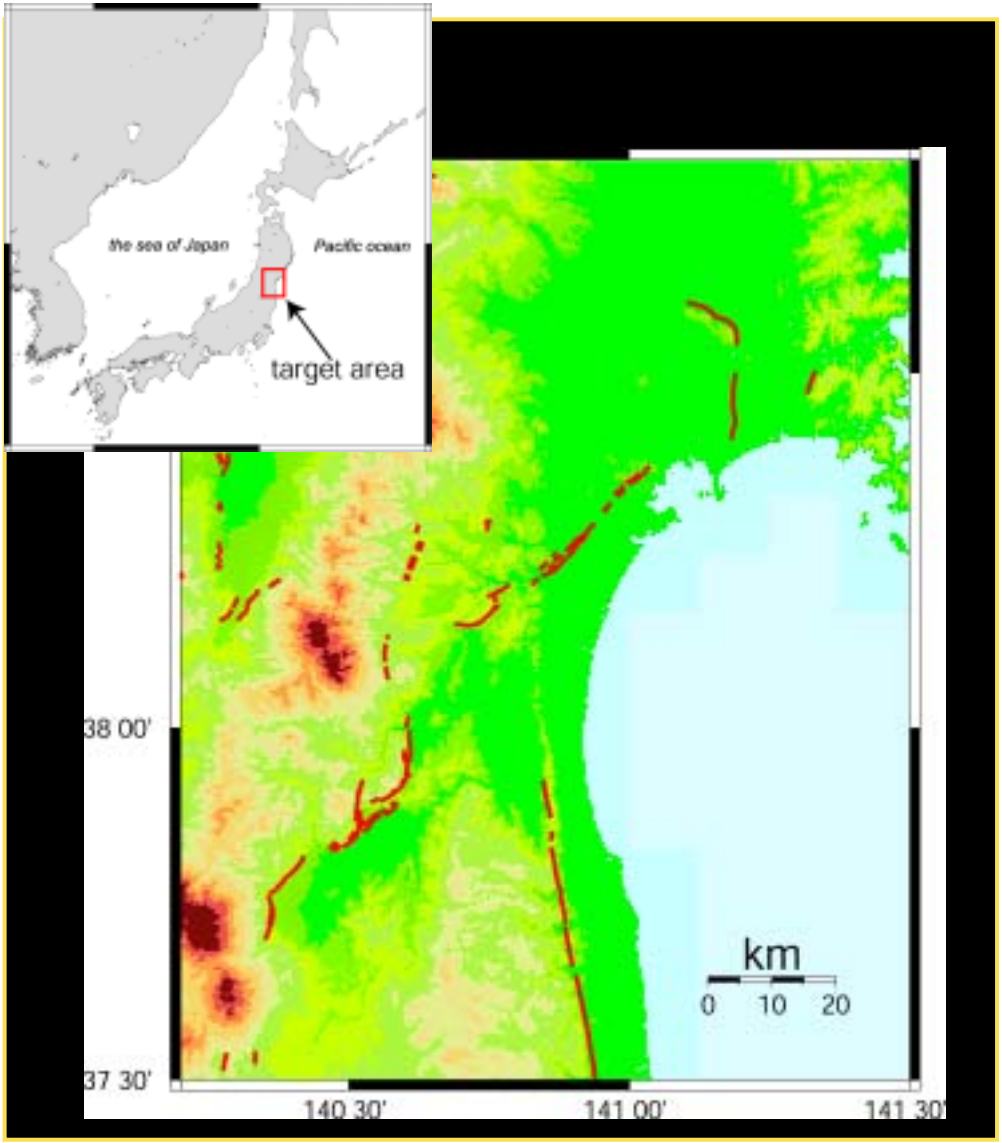

N







Nagamachi-Rifu Fault



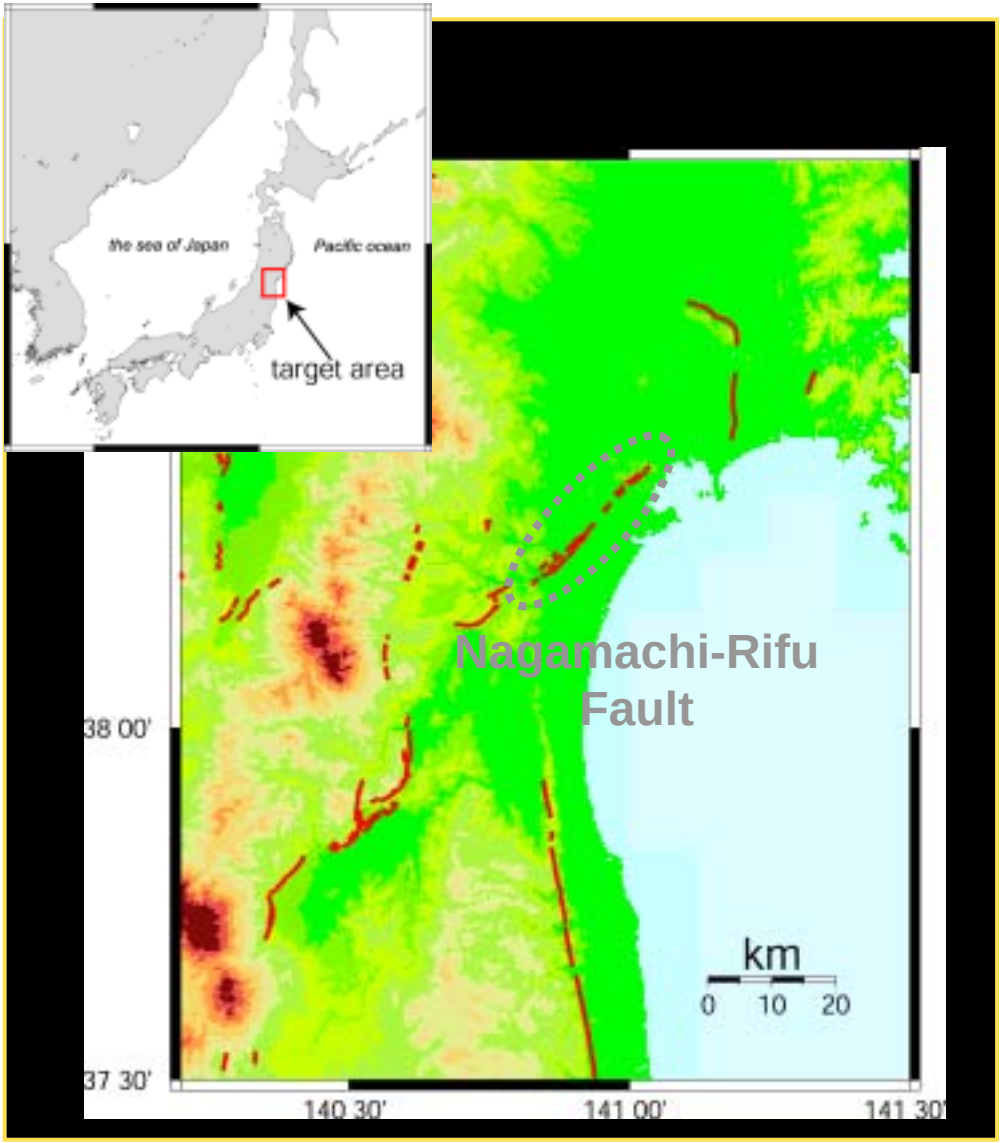
Reverse Fault

Length：20km

Slip Rtae: 0.7m/1000年

Expected Magnitude: 7.0

Nagamachi-Rifu Fault



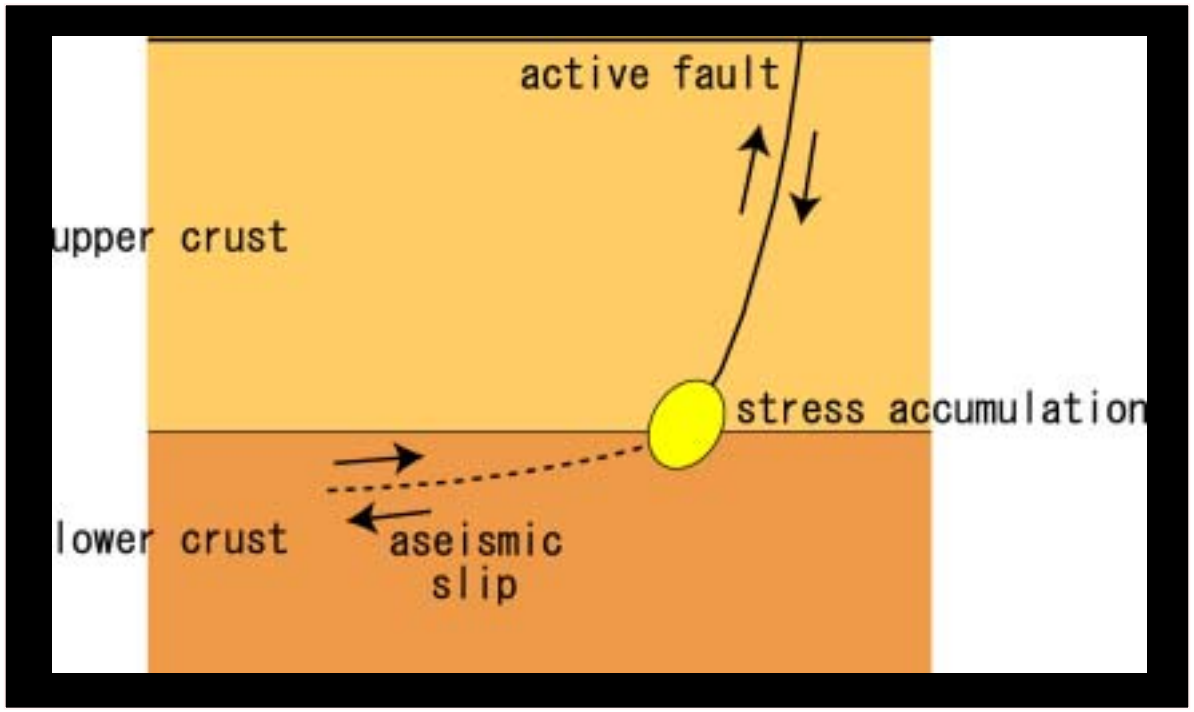
Reverse Fault

Length：20km

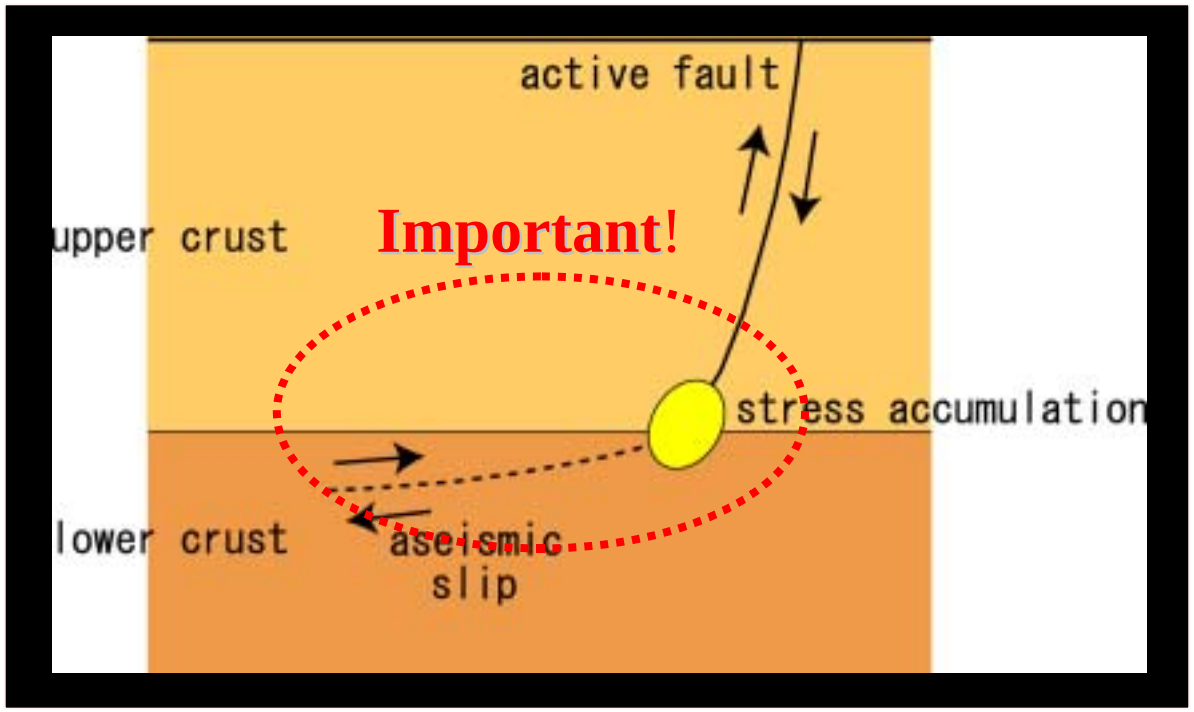
Slip Rtae: 0.7m/1000年

Expected Magnitude: 7.0

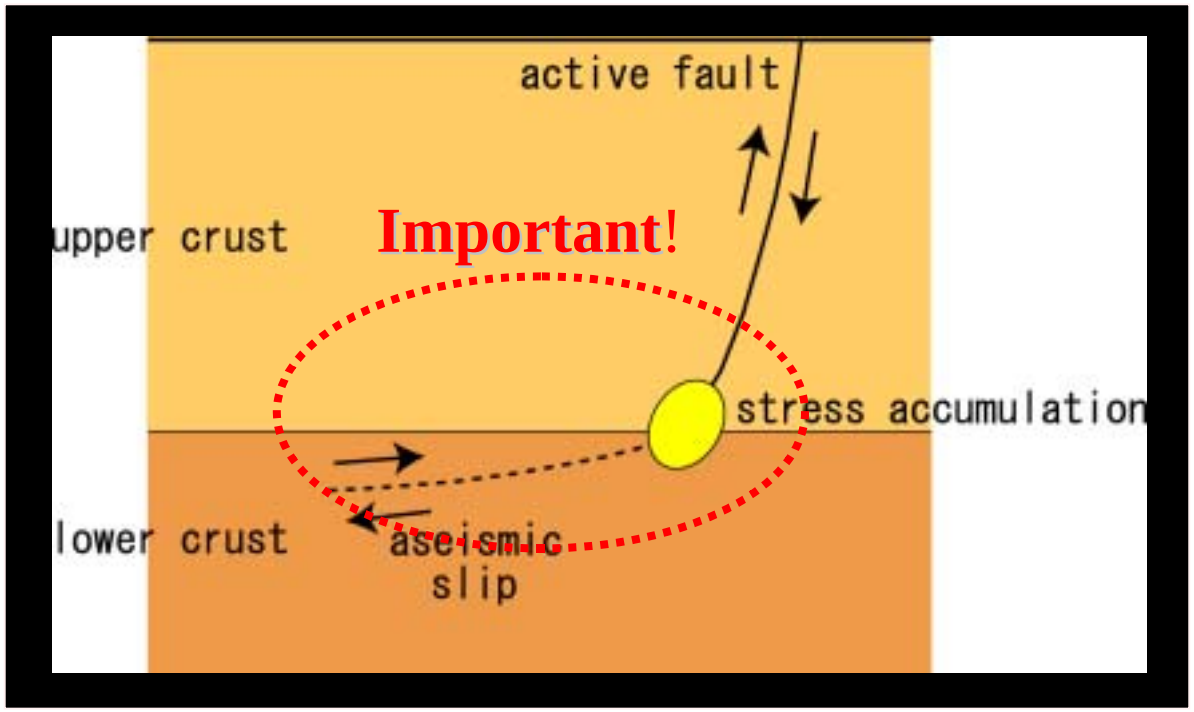
Object of this study



Object of this study

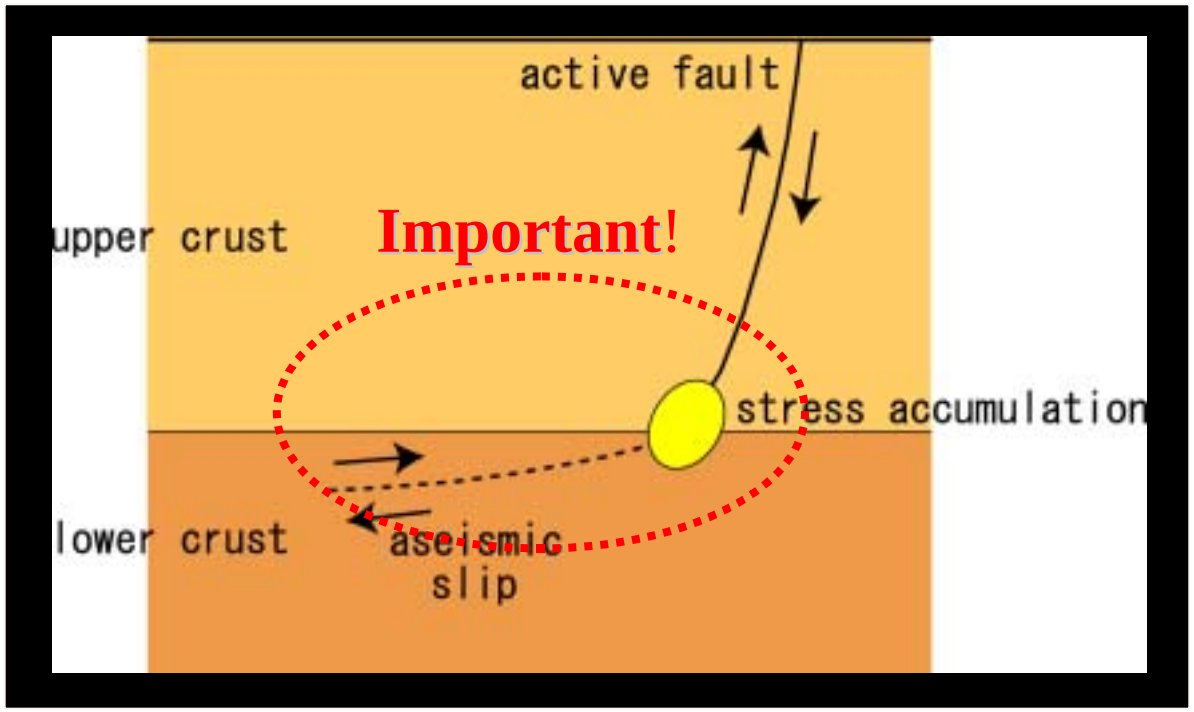


Object of this study



Object: Investigate whether deep extension exist or not

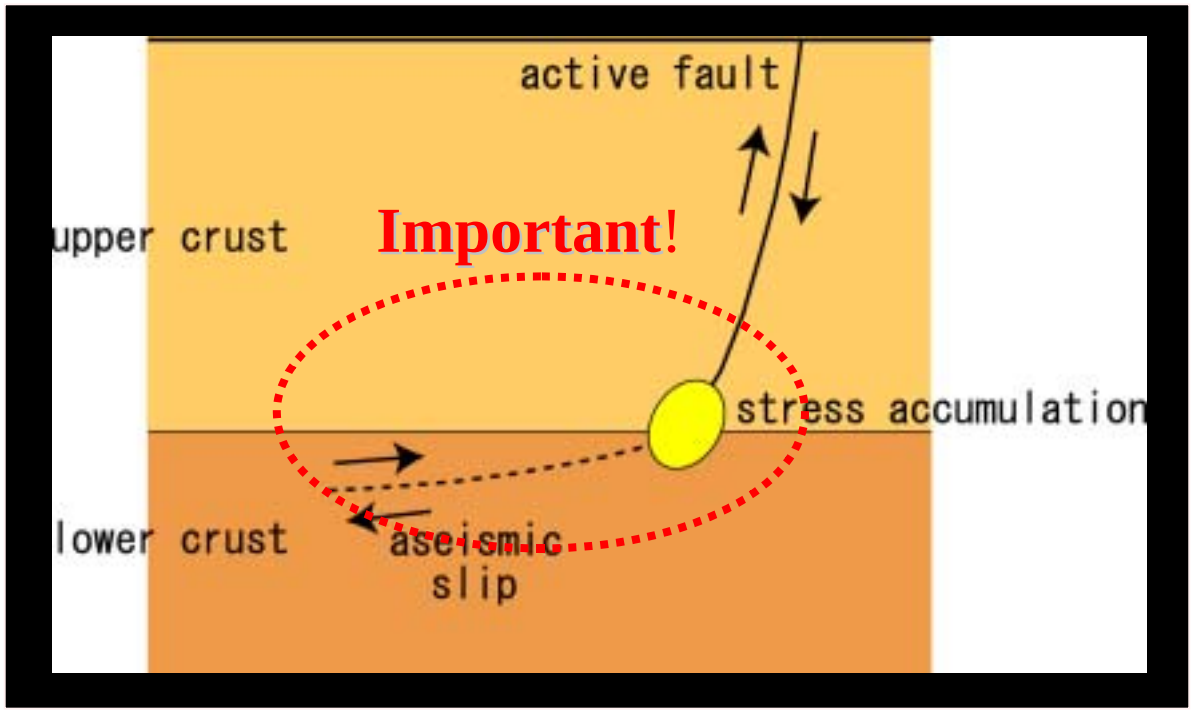
Object of this study



Object: Investigate whether deep extension exist or not

Target active fault: Nagamachi-Rifu fault

Object of this study



Object: Investigate whether deep extension exist or not

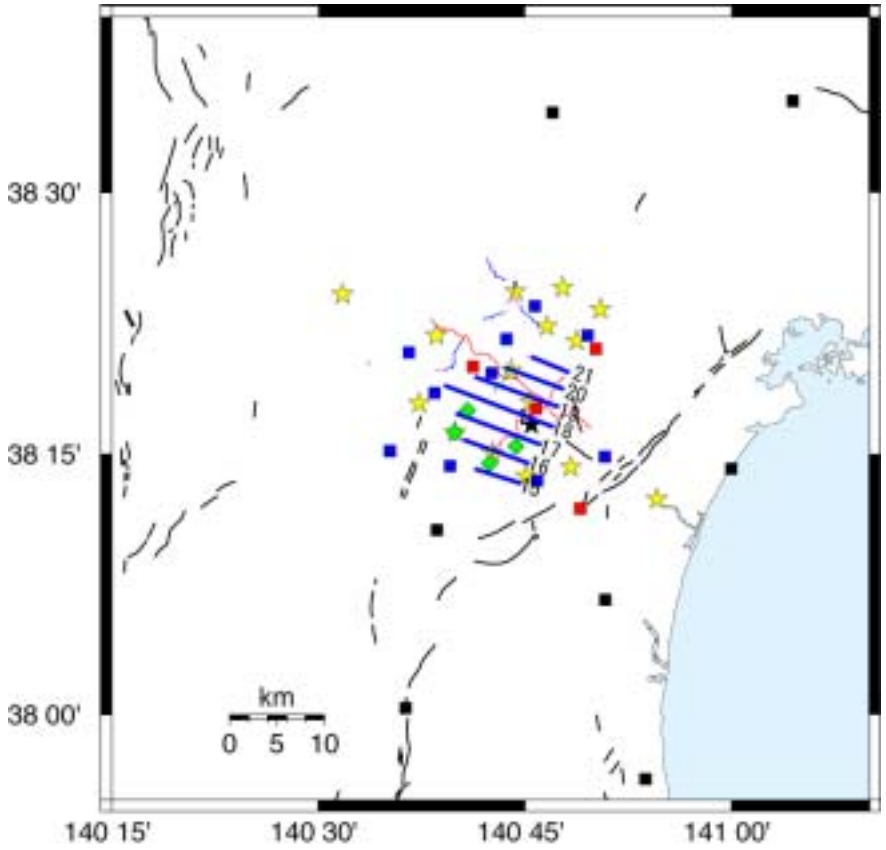
Target active fault: Nagamachi-Rifu fault

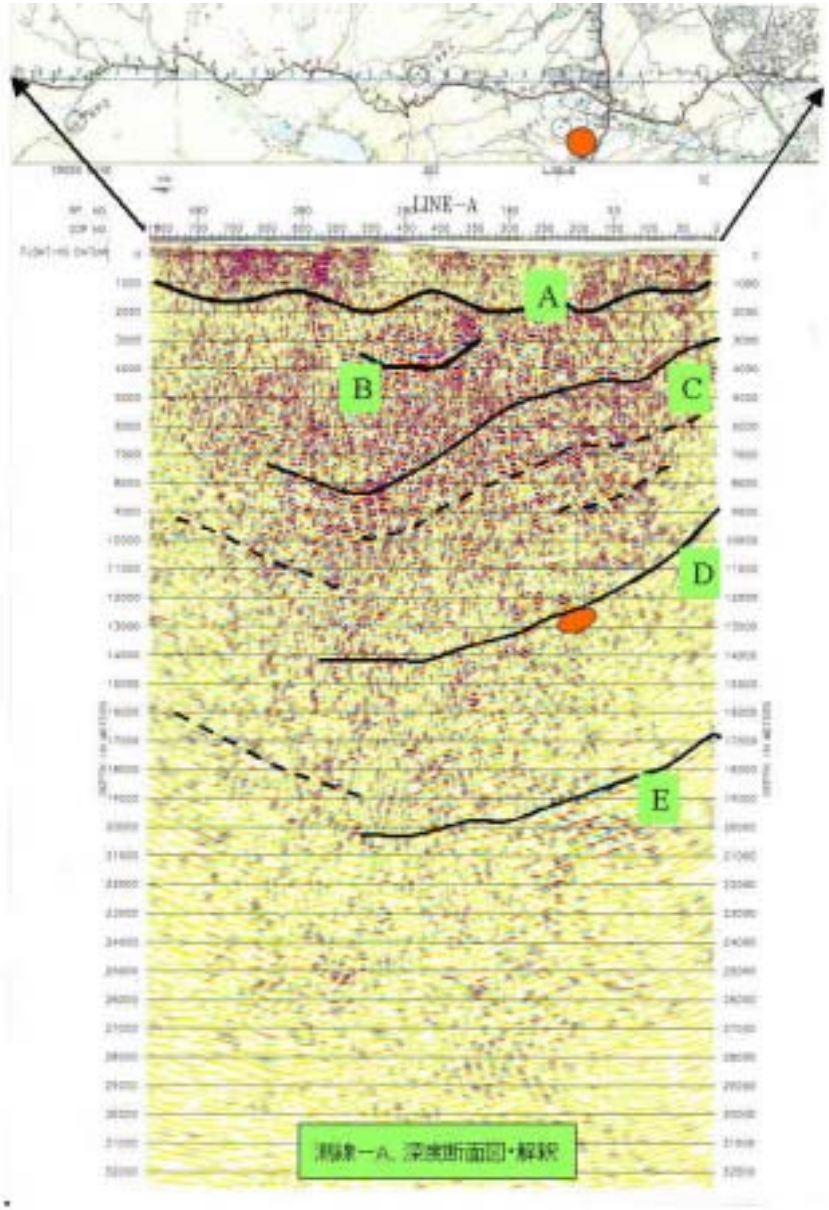
Approach:

Reflection survey with vibrator and explosions

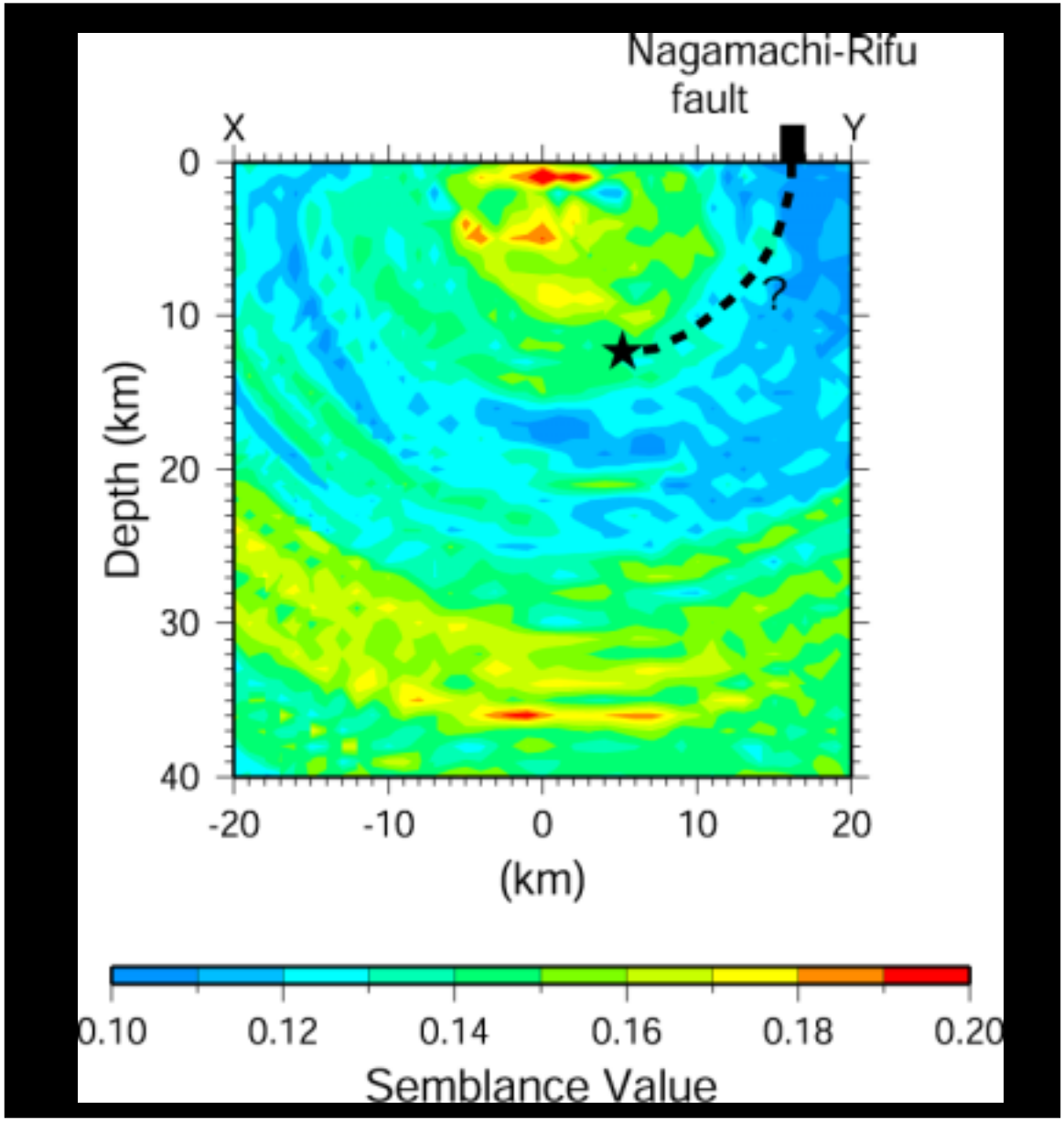
Seismic array analysis

Reflectors from eartquakes

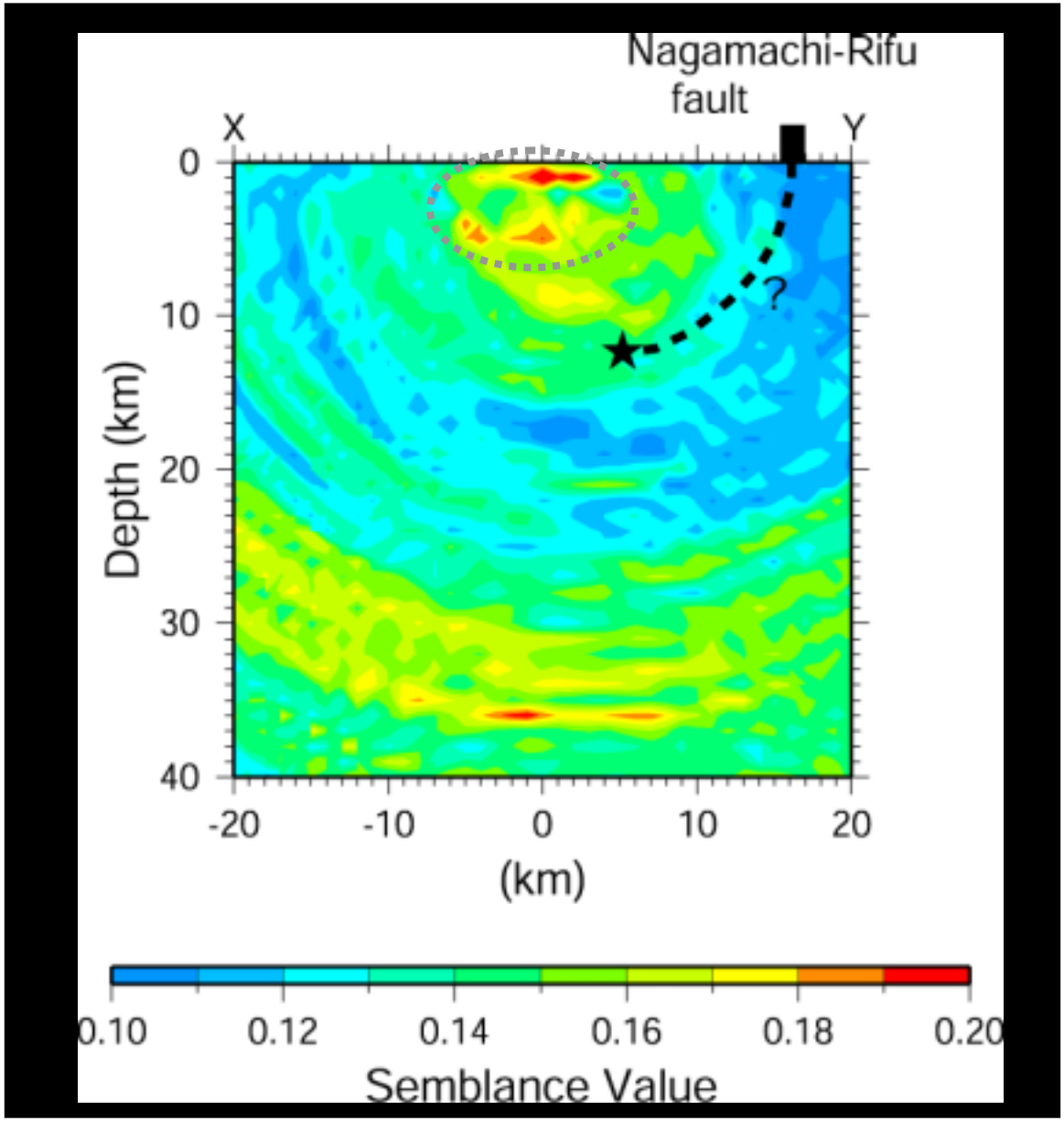

38 30'
38 15'
38 00'
140 15'
140 30'
140 45'
141 00'
km
0 5 10
21
20
19
18
17
16
15
Explosives
Reflection Survey Line
LS8000
DAT+LS7000
GSJ Small Aperture Array
Higf Sanpling Rate Stations
Broadband Stations
Hi-net Stations
S Reflectors


LINE-A
A
B
C
D
E
測線ーA、深度断面図・解釈

P-wave scatterer distribution

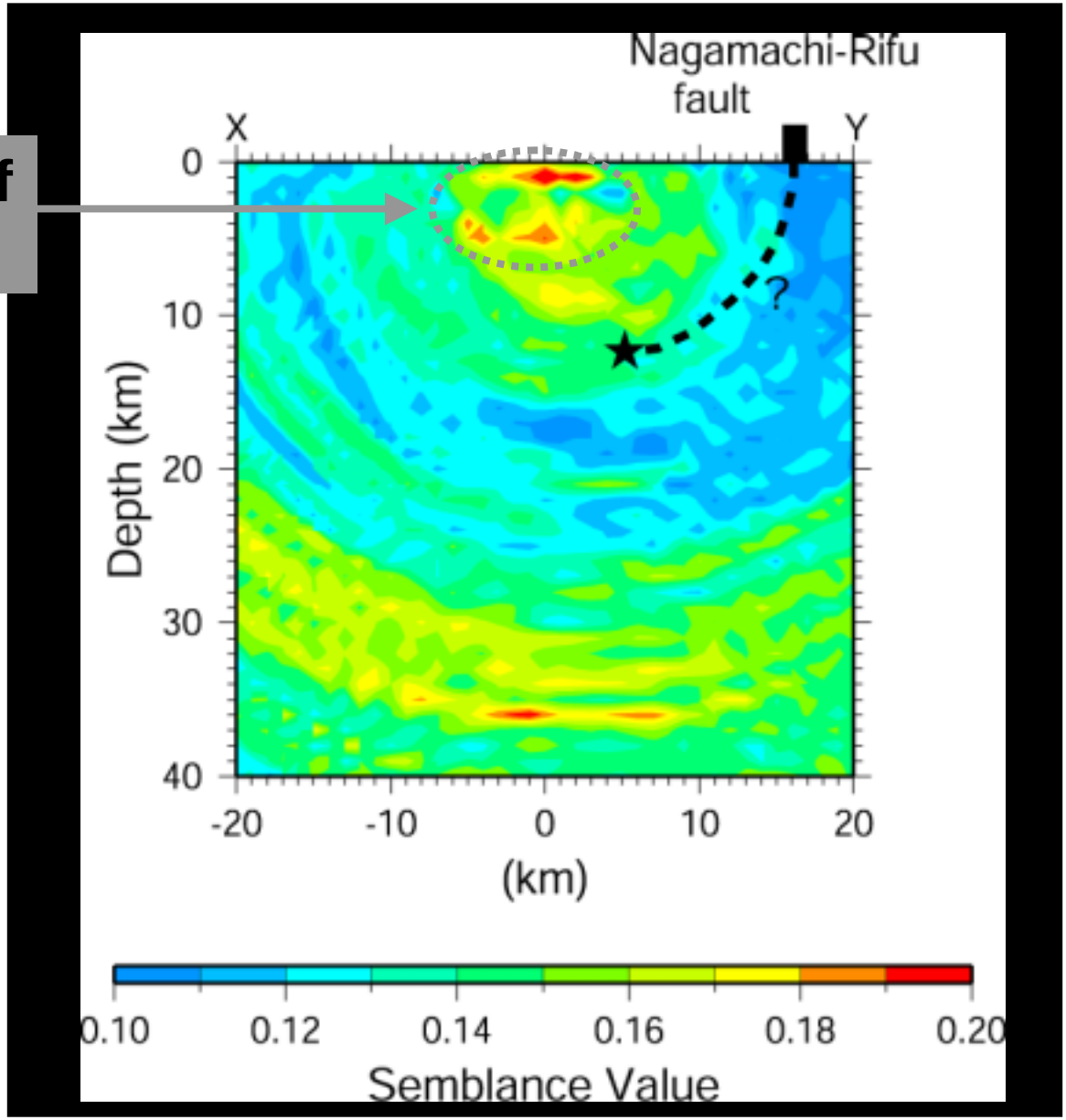


P-wave scatterer distribution



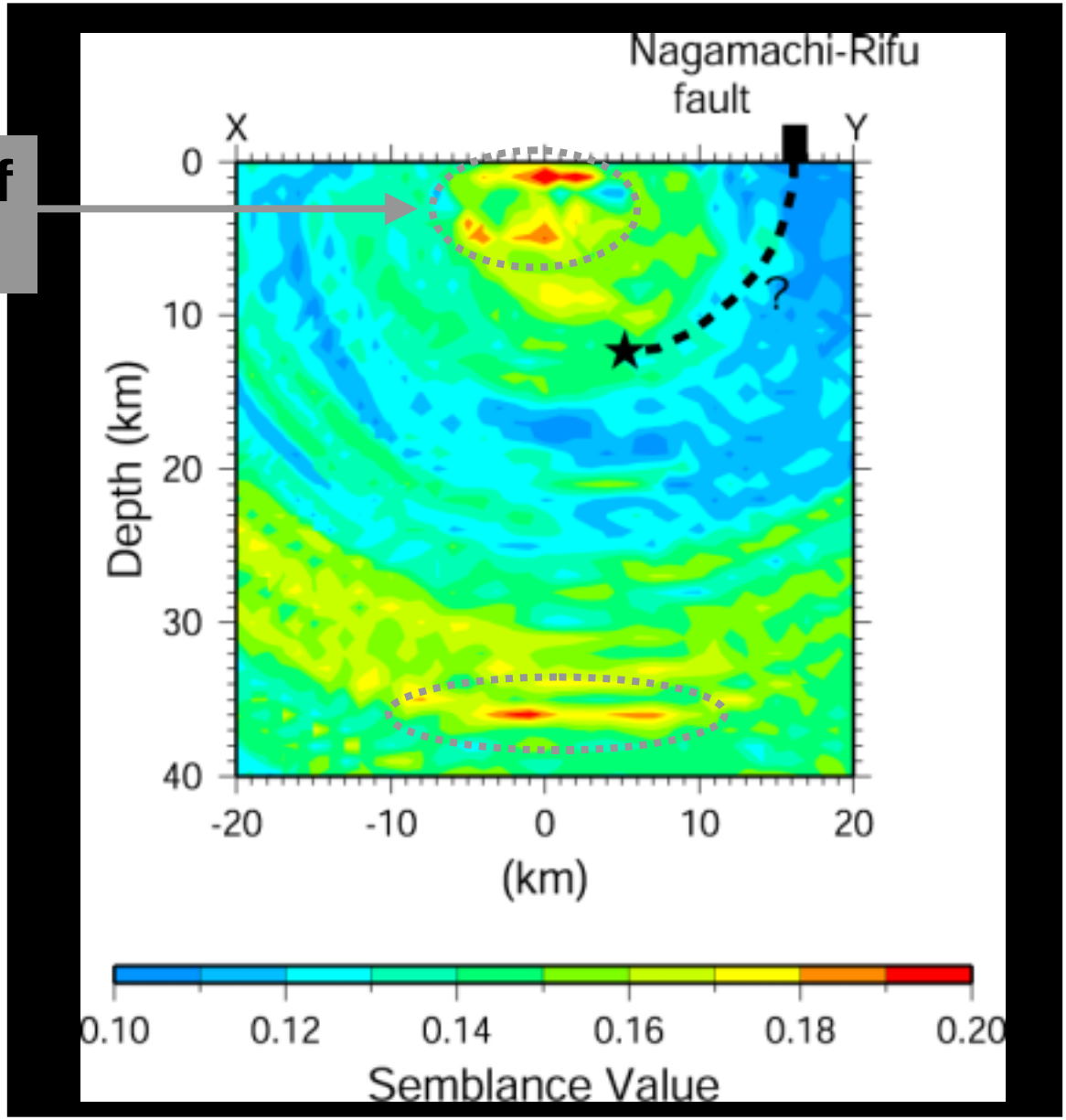
P-wave scatterer distribution

Structure of caldera



P-wave scatterer distribution

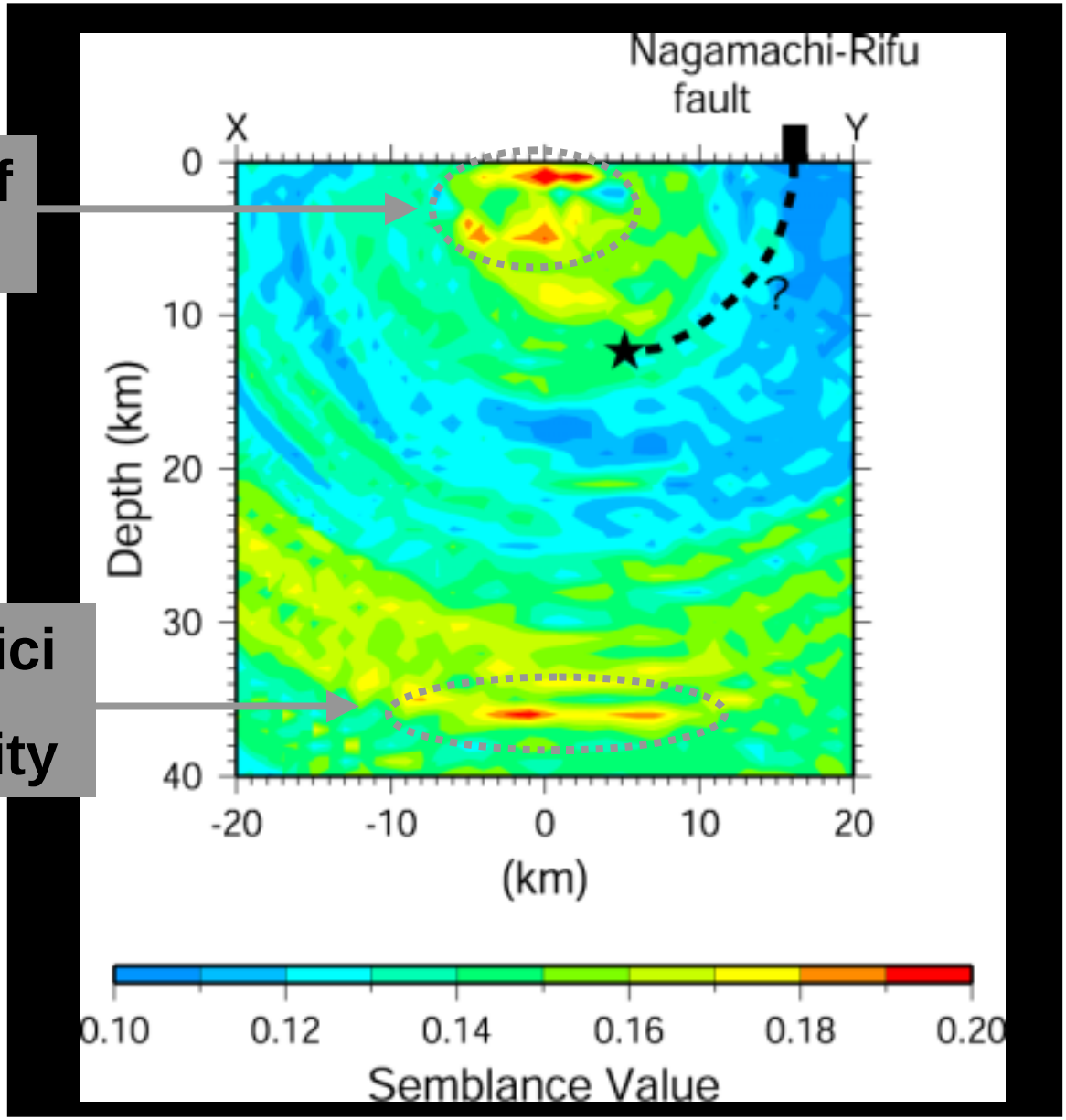
Structure of caldera



P-wave scatterer distribution

Structure of caldera

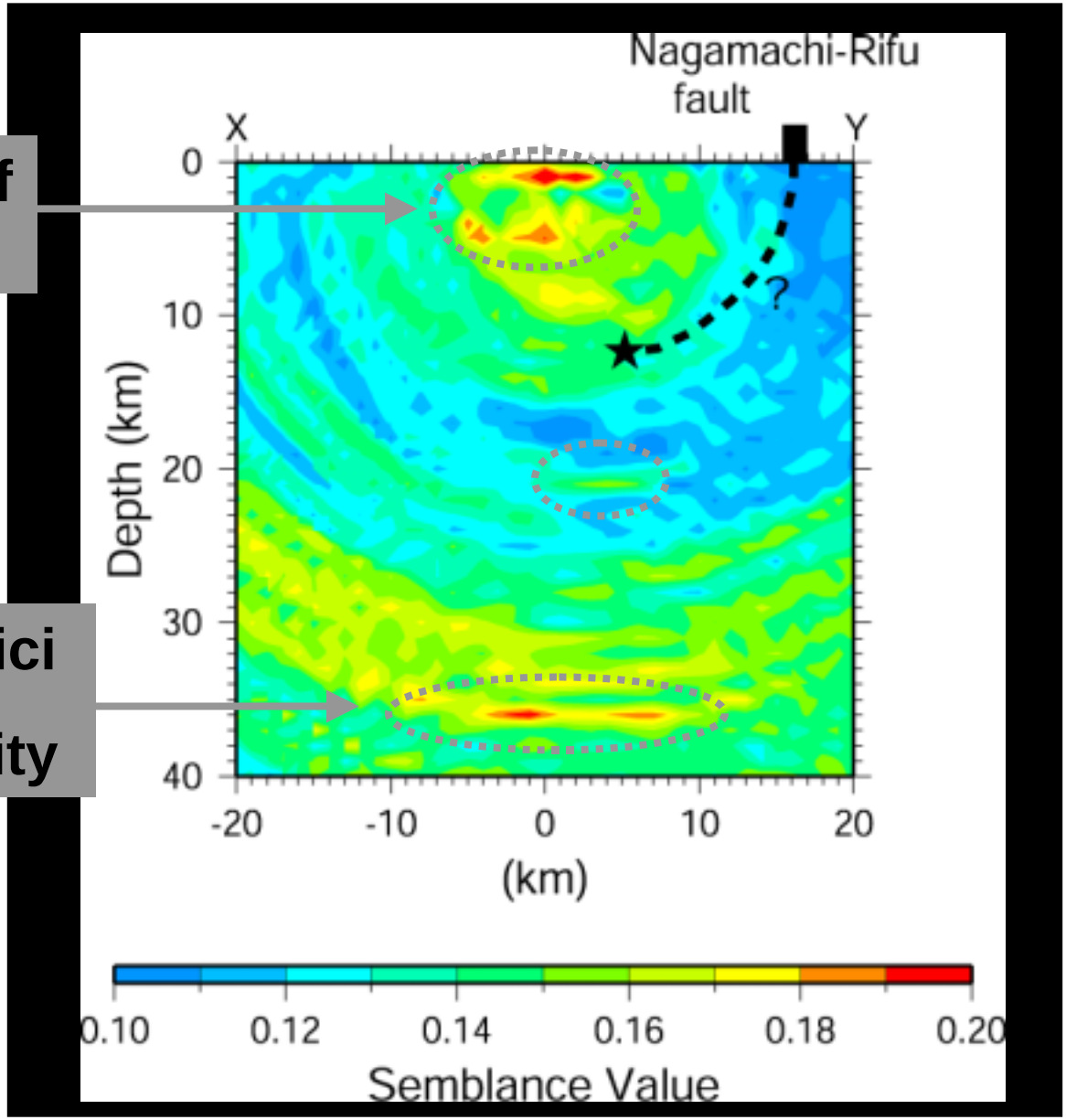
Mohorovicici discontinuity



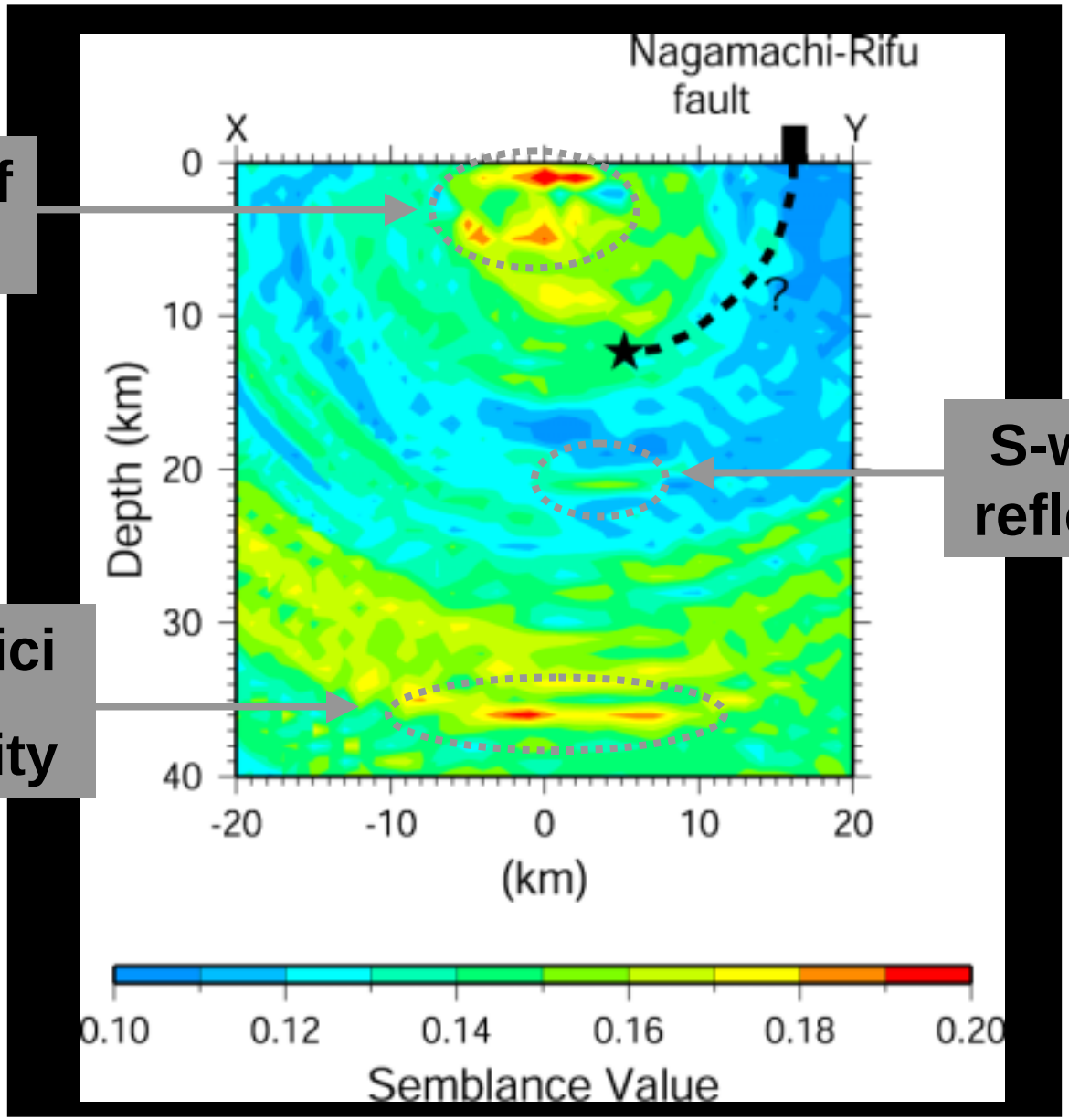
P-wave scatterer distribution

Structure of caldera

Mohorovicici discontinuity



P-wave scatterer distribution

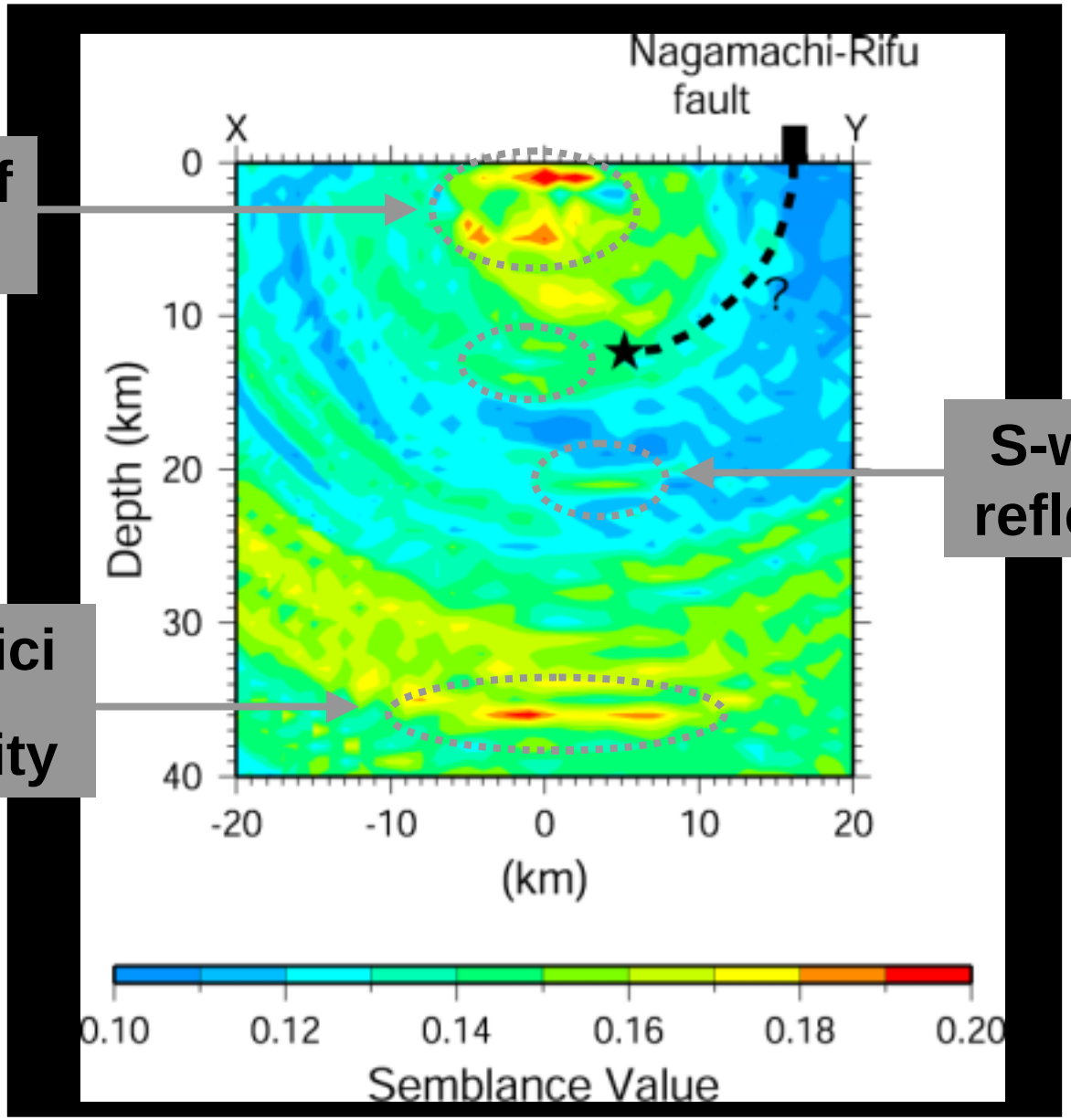


Structure of caldera

S-wave reflector

Mohorovicici discontinuity

P-wave scatterer distribution

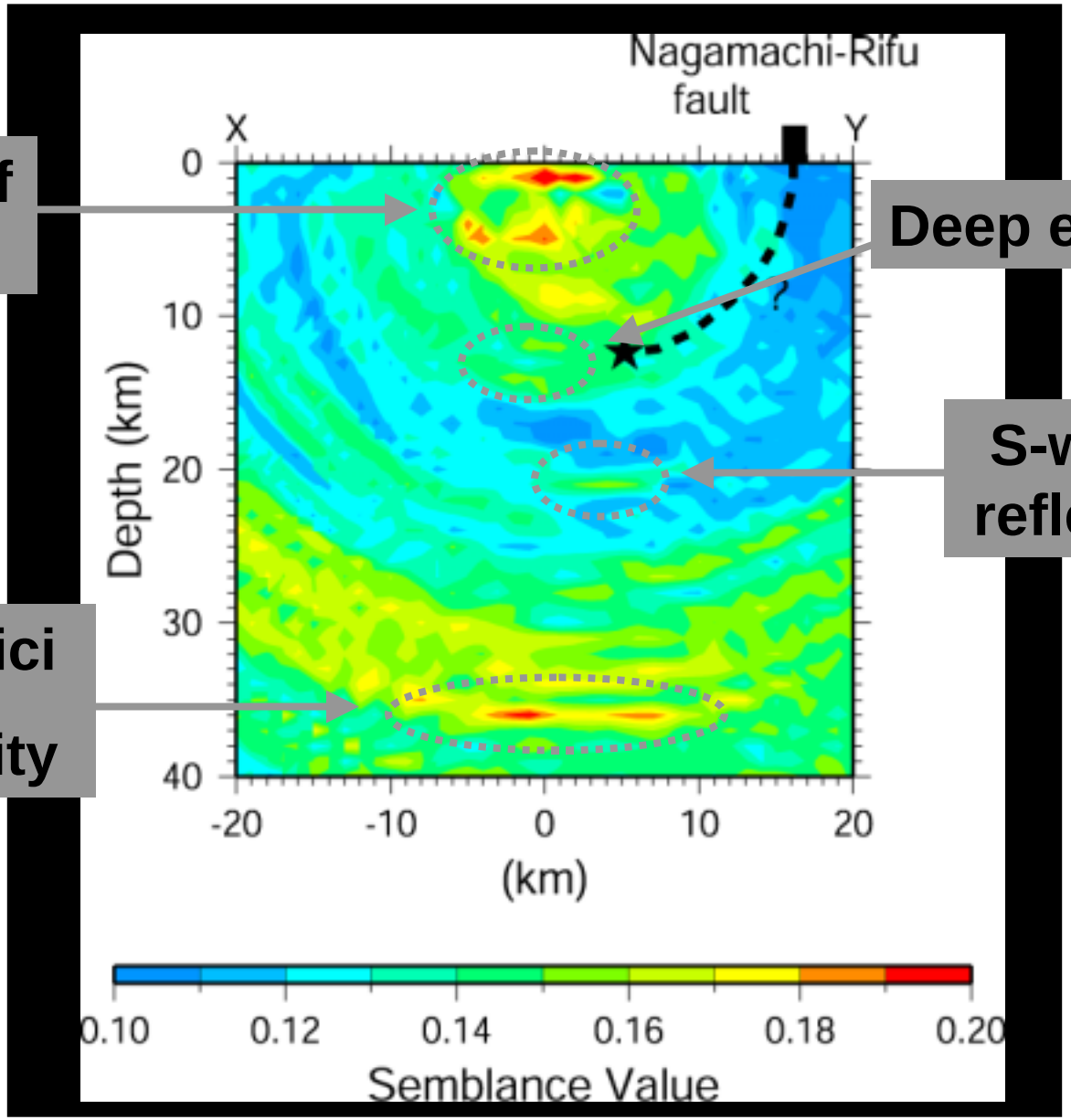


Structure of caldera

S-wave reflector

Mohorovicici discontinuity

P-wave scatterer distribution

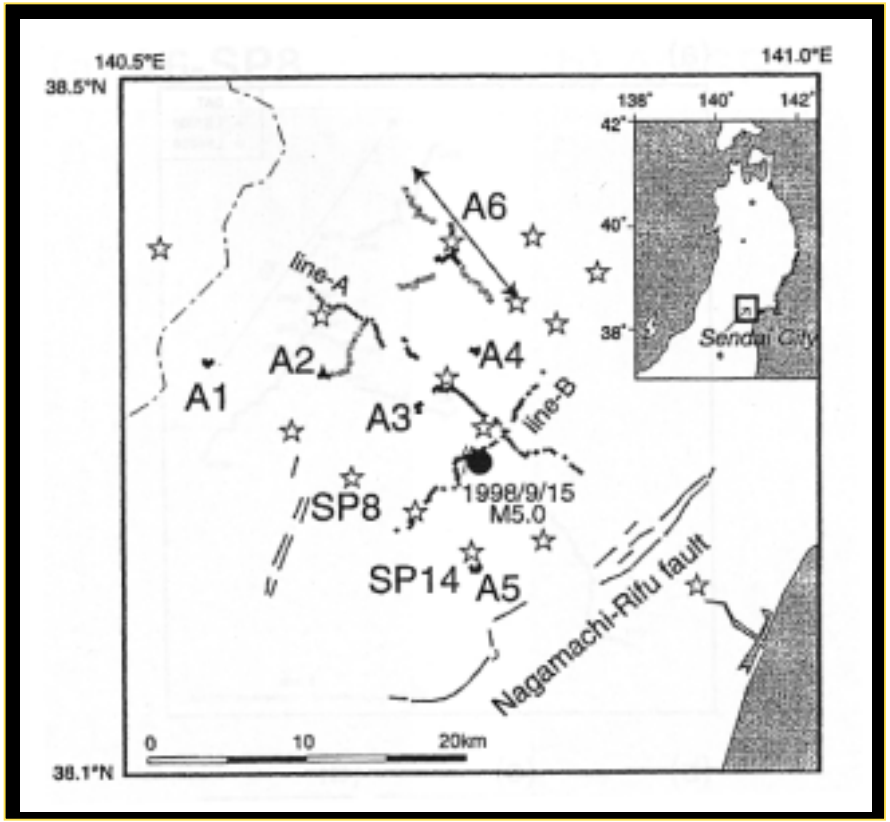


Structure of caldera

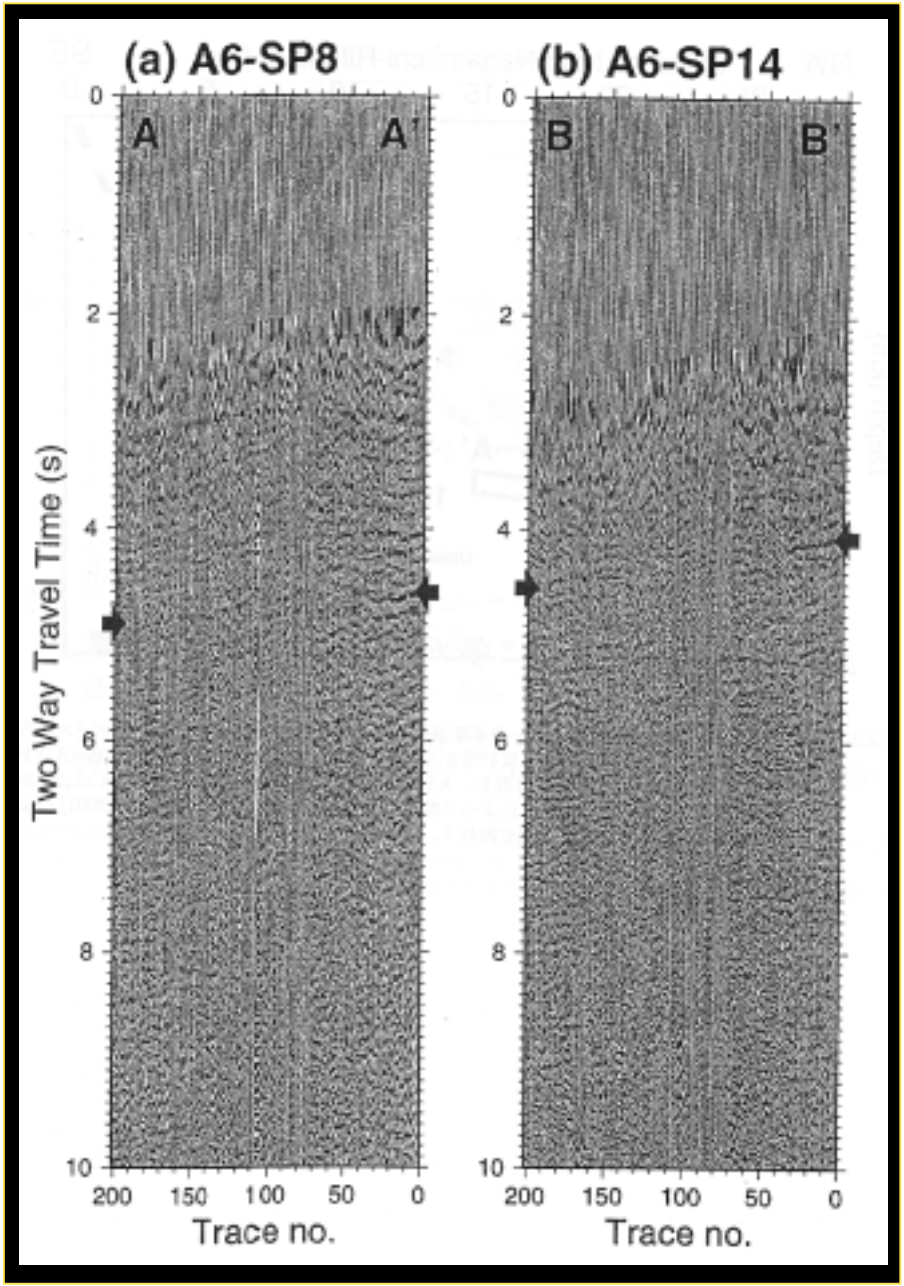
Deep extension

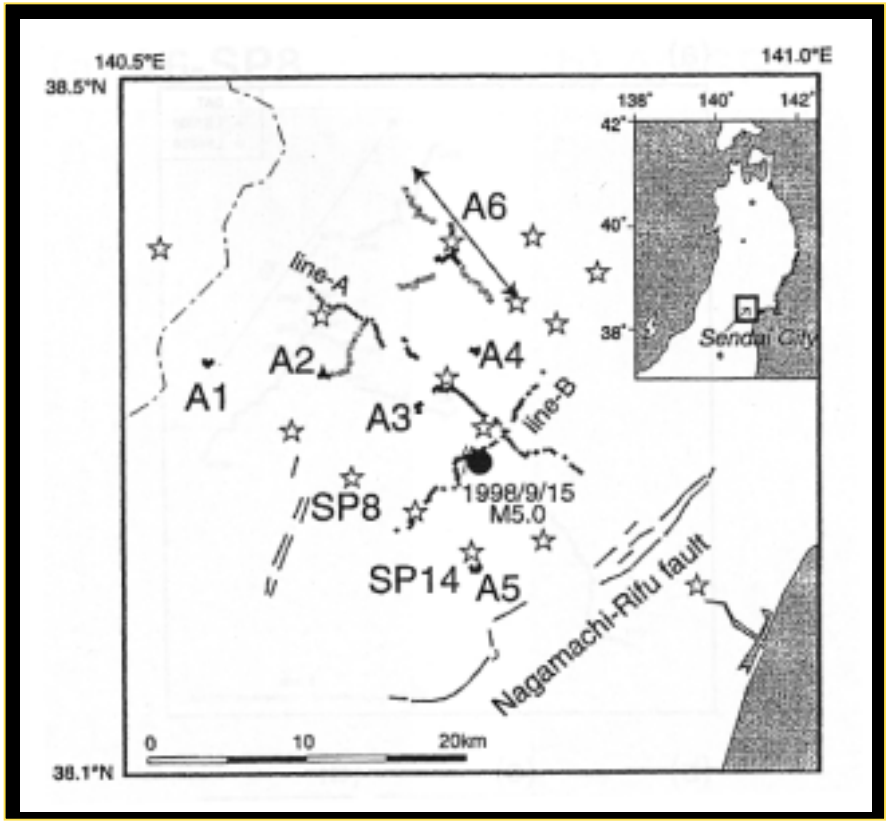
S-wave reflector

Mohorovicici discontinuity

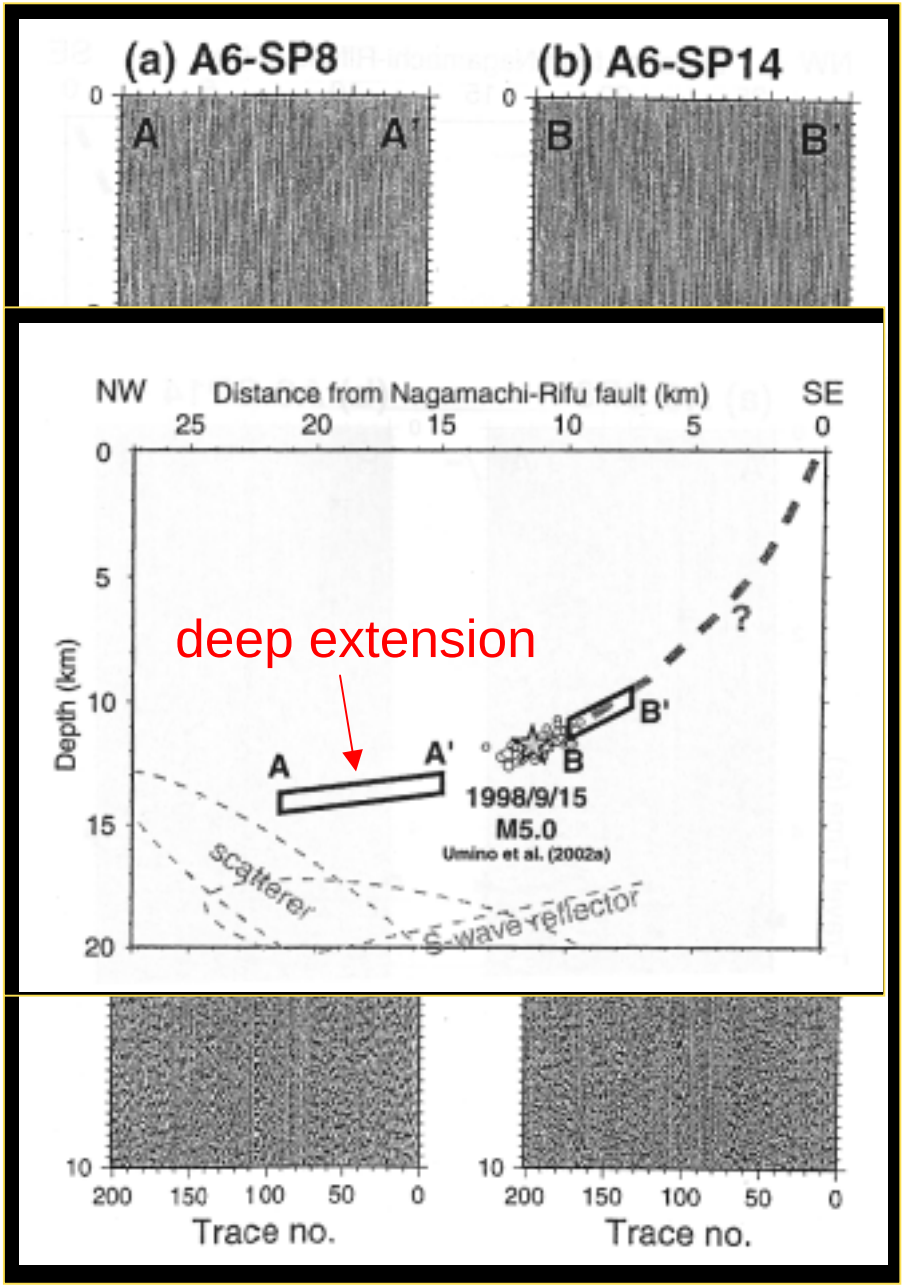


Tohoku University (2002)

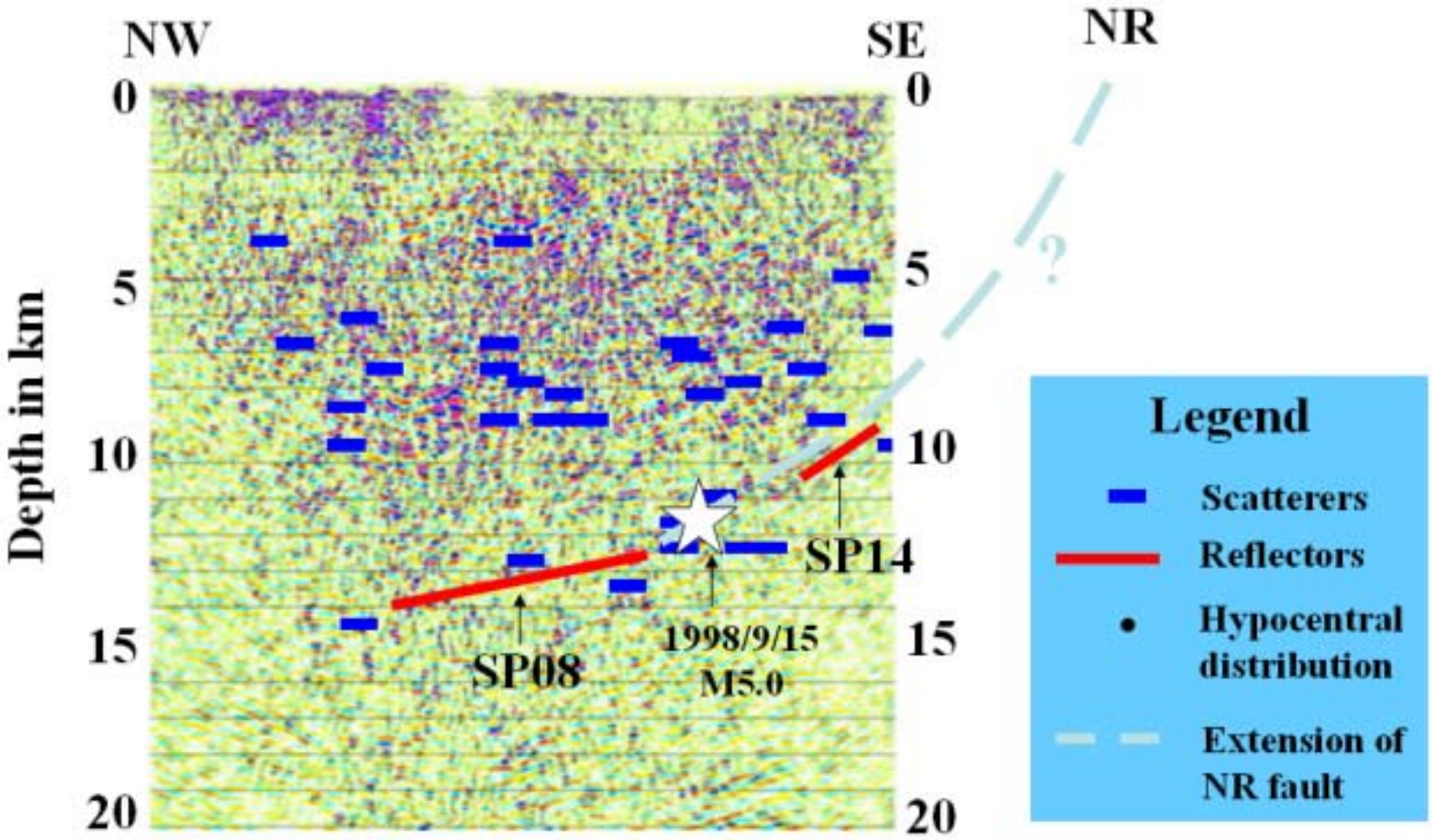




Tohoku University (2002)



Deep Extension of the Nagamachi-Rifu Fault



Geological Studies on Exhumed Shear Zone

Geological studies on exhumed shear zones:

The **Hatagawa** fault zone, NE Japan

The **southern part of the Itoigawa-Shizuoka tectonic line**, Central Japan

Geology of the Hatagwa fault zone:

Fault rocks derived mostly from Cretaceous granitoids

The granitoids intruded in the relatively shallow level (**5 to 10 km depth**)

The main **cataclasite zone**, which is considered to be the core of the Hatagawa Fault Zone, extends continuously in an N-S direction and has a **width of about 100m**.

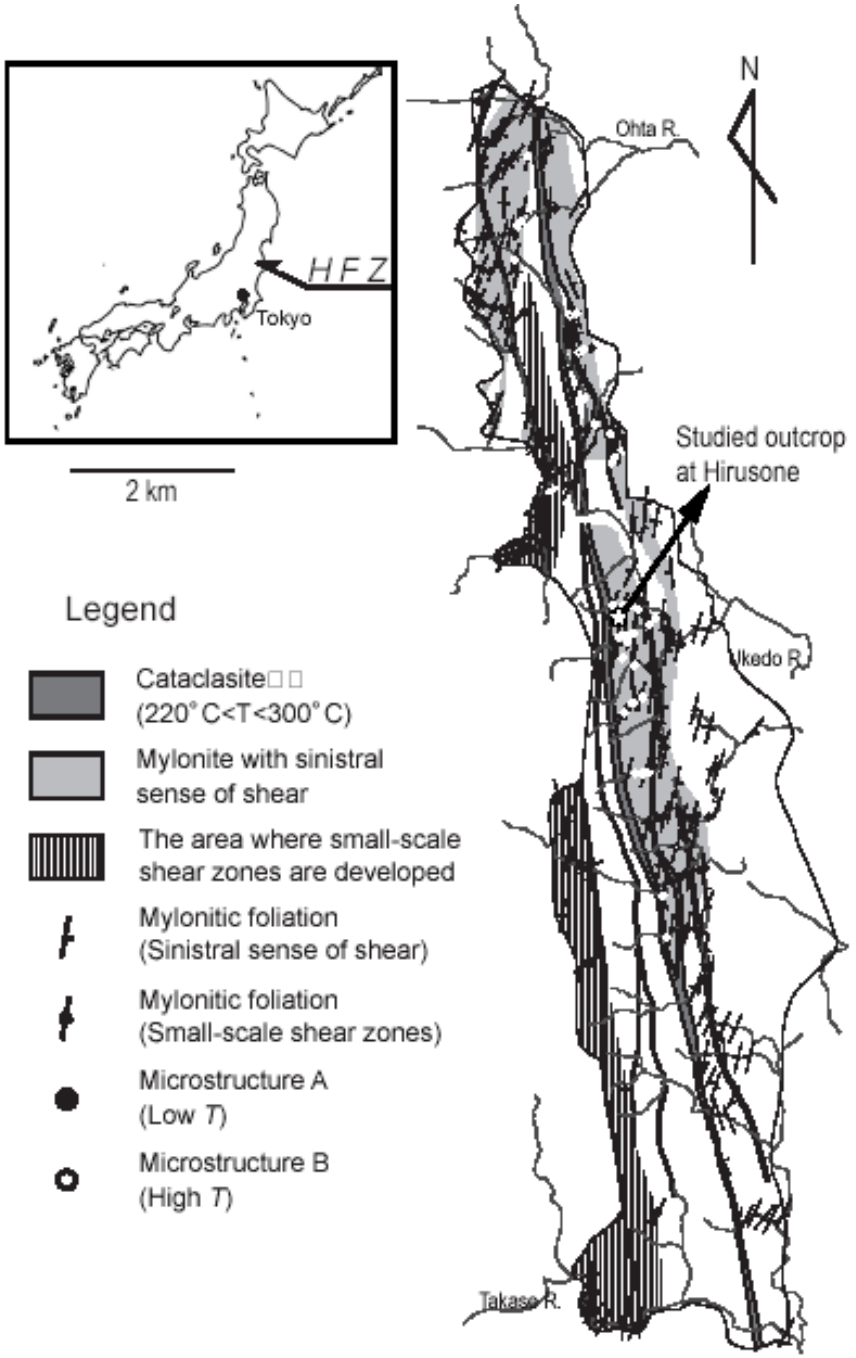
Mylonite zones with a sinistral sense of shear partially surround the cataclasite zone and have a maximum width of 1 km (Shigematsu and Yamagishi, 2002).

Small-scale shear zones, with widths ranging from **a few mm to a few meters**, are distributed in the surrounding granitoids (Shigematsu, 1999; Shigematsu and Tanaka, 2000; Takagi et al., 2000).

Deformation structure is well preserved in these small shear zones and **pseudotachylyte** bands sometimes occur (Kubo and Takagi, 1997).

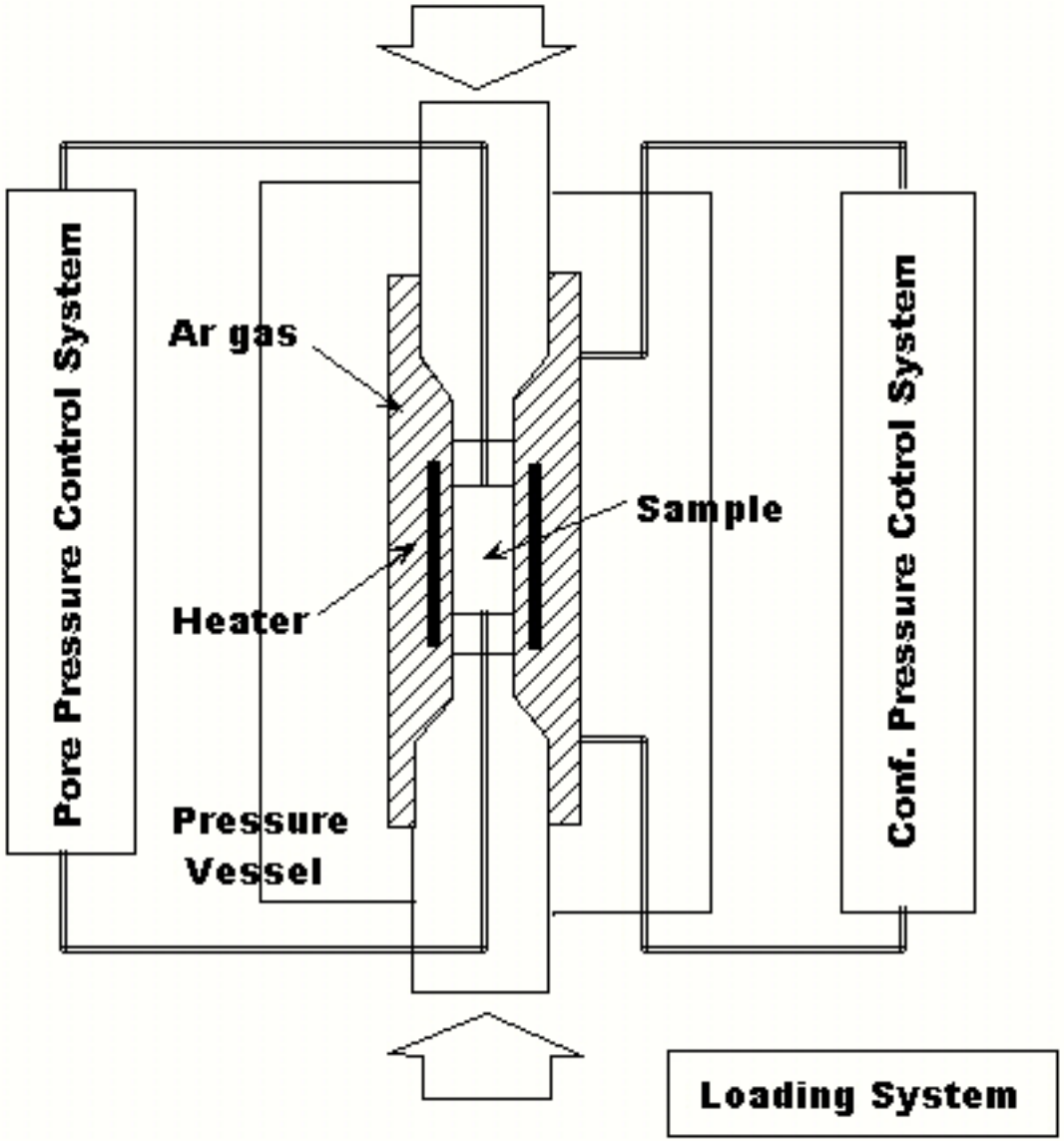
Plastic deformation and brittle deformation are often closely associated in the shear zones (Takagi et al., 2000; Shigematsu et al., submitted).

The deformation conditions are estimated to be 260 to 310˚C for the mylonite with microstructure A and 310 to 450˚C for the mylonite with microstructure B based on the two feldspar thermometry (Shigematsu and Yamagishi, 2002).


HFZ
Tokyo
2 km
N
Ohta R.
Studied outcrop
at Hirusone
Ikedo R.
Takase R.
Legend
Cataclasite
(220°C<T<300°C)
Mylonite with sinistral
sense of shear
The area where small-scale
shear zones are developed
Mylonitic foliation
(Sinistral sense of shear)
Mylonitic foliation
(Small-scale shear zones)
Microstructure A
(Low T)
Microstructure B
(High T)

Gas - HPT

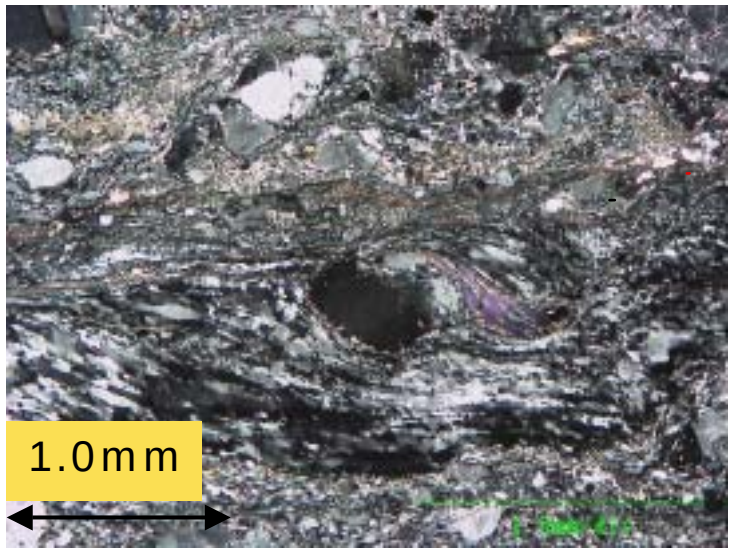
Gas HPT Apparatus

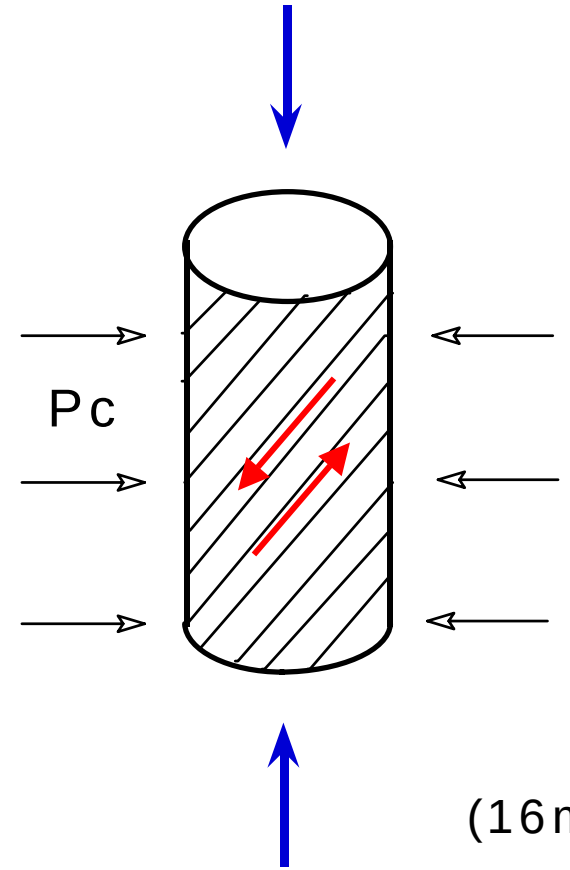


Temp: 800C
Pc : 200MPa
Pp: 200MPa
Load: 270 ton

Sample:
20mmΦx 50mm

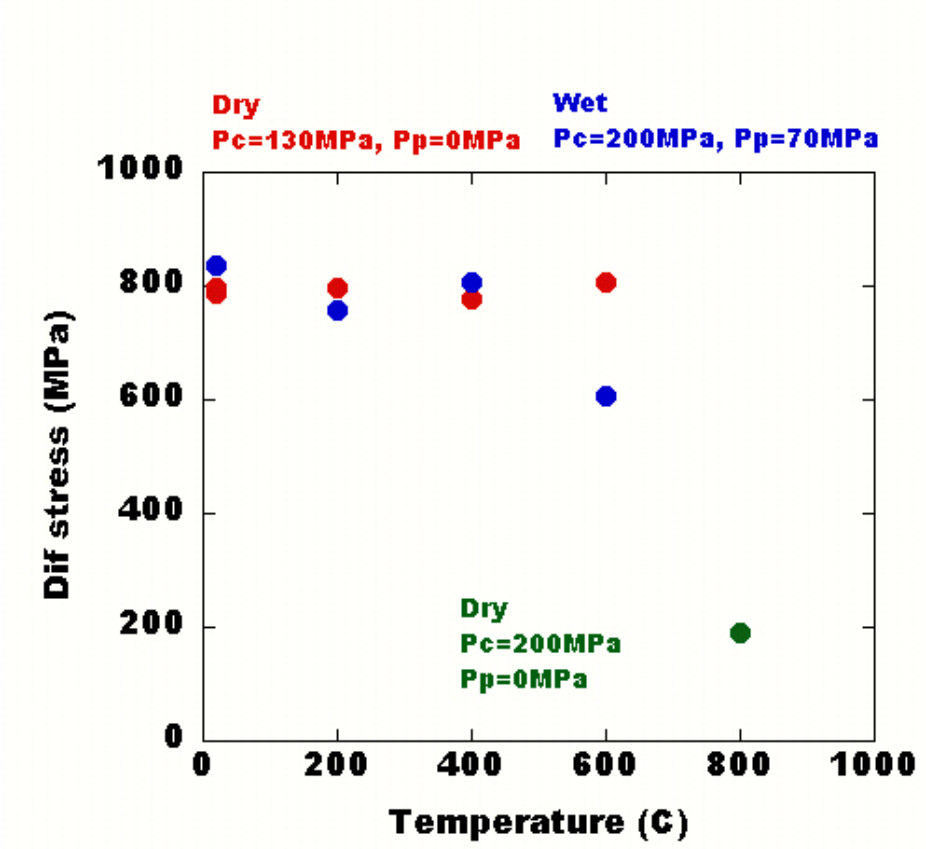
Deformation experiments of mylonite

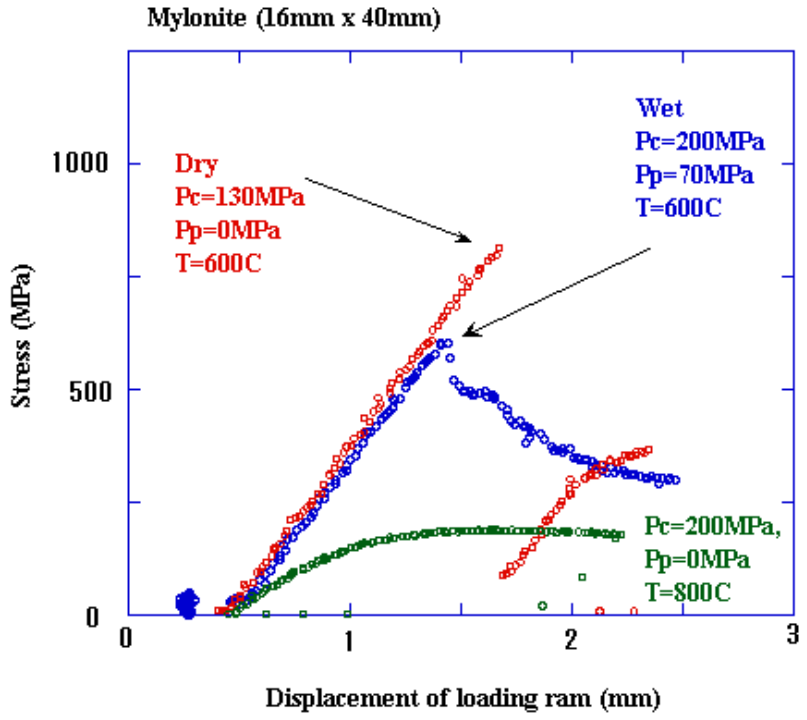




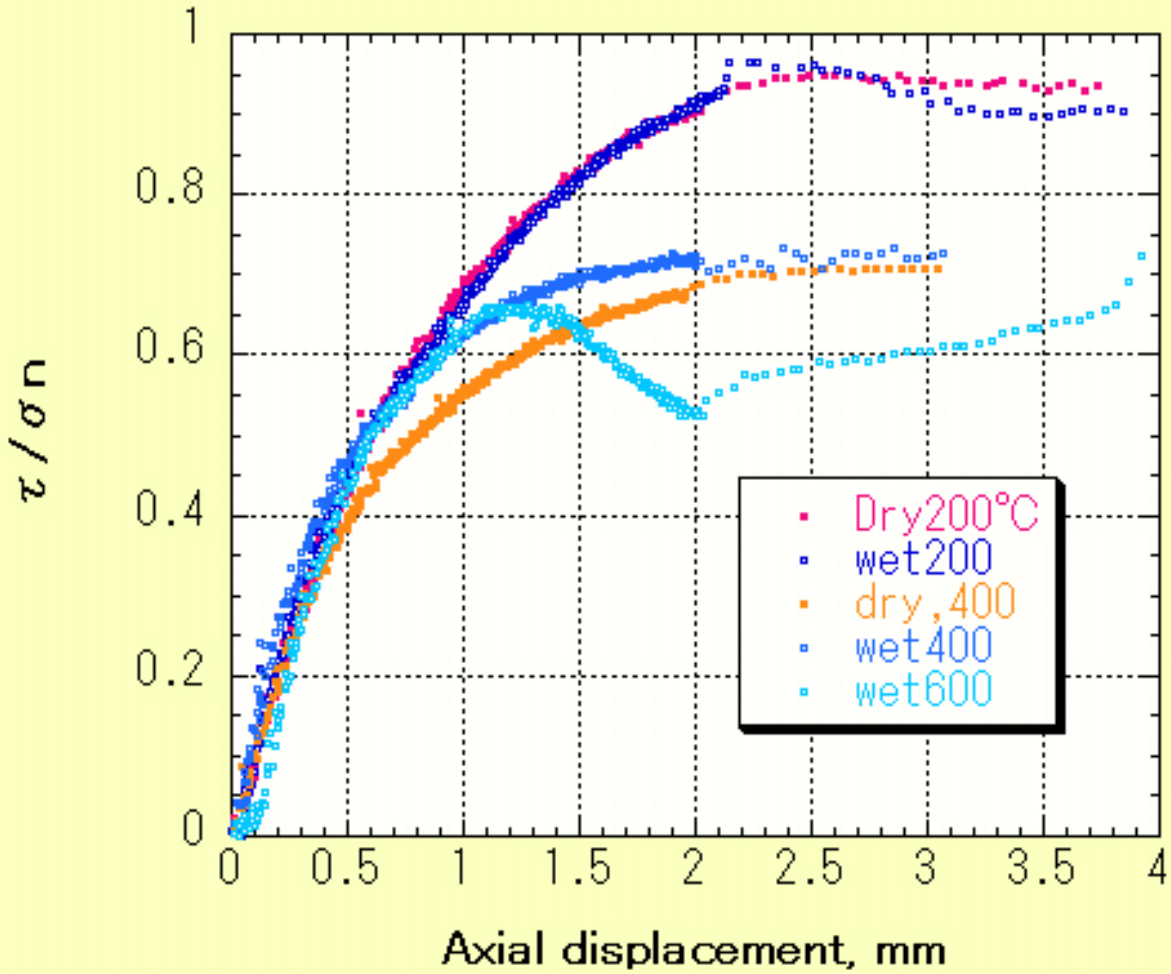
(16mmϕ, 40mm)

Deformation Experiments of Fault Materials under High Temp.(800 deg. C)・High Pressure(200MPa)・with pore fluid





Relationship between wet and dry conditions



Summary of the 1st stage

1. Field Observations

   Downward extension

   Localization of shear in the fault zone

2. Mechanism: Water (MT, Field, Experiment)

   small grain size…

3. Geological Studies on Exhumed Shear Zones

Plastic deformation and brittle deformation are often closely associated in the shear zones

Shear localization

4. Evidence of slip by GPS observation

2nd Stage

1. Specity the shear localization mechanism
2. Deep extension: more deeper part
3. Acceleration mechanism
4. Integration