Tsunami recurrence intervals from Holocene deposits on Ishigaki and Miyako islands along the Ryukyu subduction zone

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Highlights

- The Ryukyu subduction zone is characterized to be locked (coupled, seismic) based from the recent geophysical studies, which suggests that large tsunamis will potentially occur along the entire subduction zone.
- Tsunami sediments from past events were studied to establish the recurrence interval, size and location of tsunami sources,
- This is the first study of tsunami deposits in this region.

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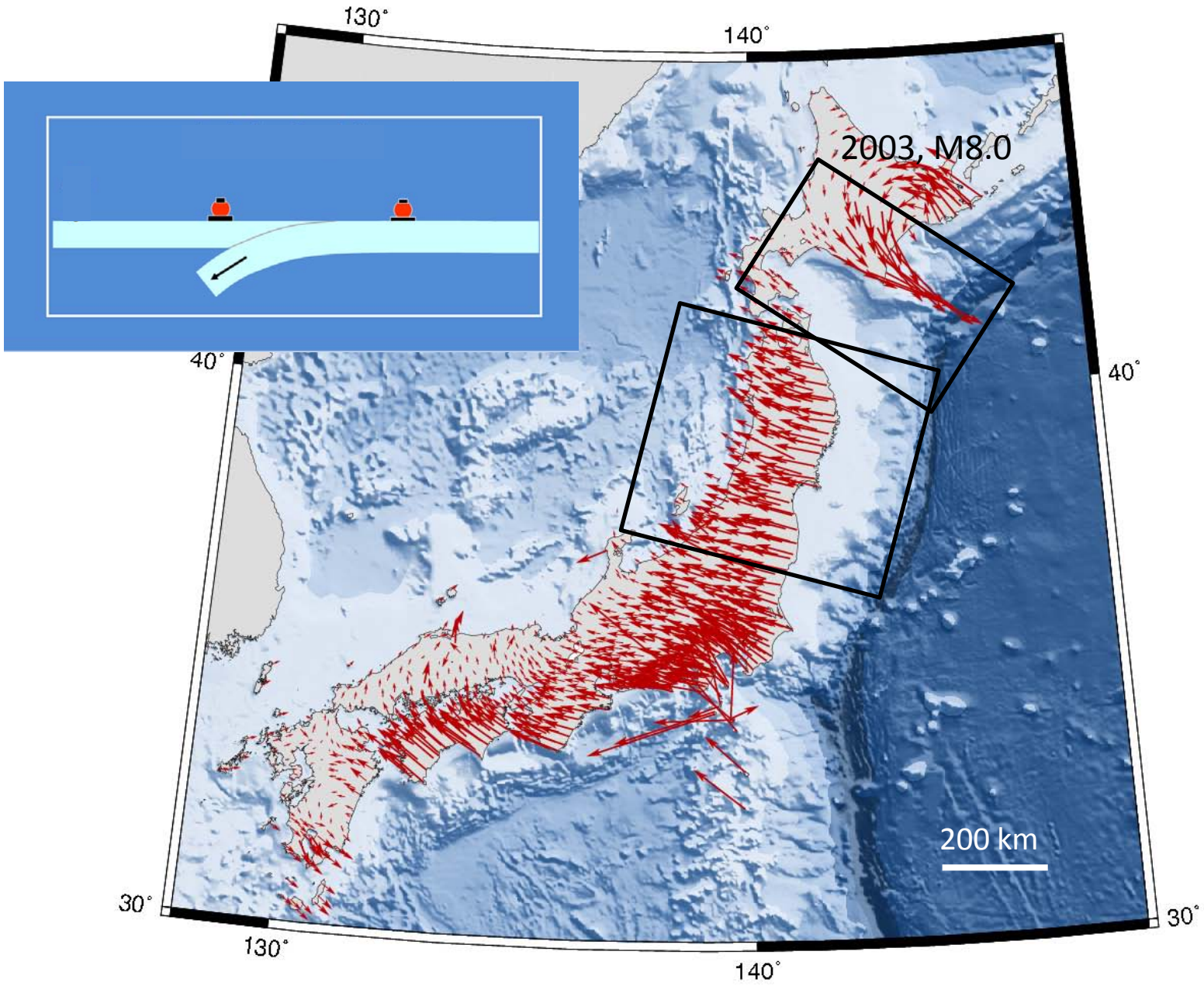
1. Locked or unlocked subduction
2. Ryukyu : Locked subduction zone
3. The 1771 Yaeyama tsunami
4. Excavation of tsunami sediments
5. Summary

1. Locked or unlocked subduction

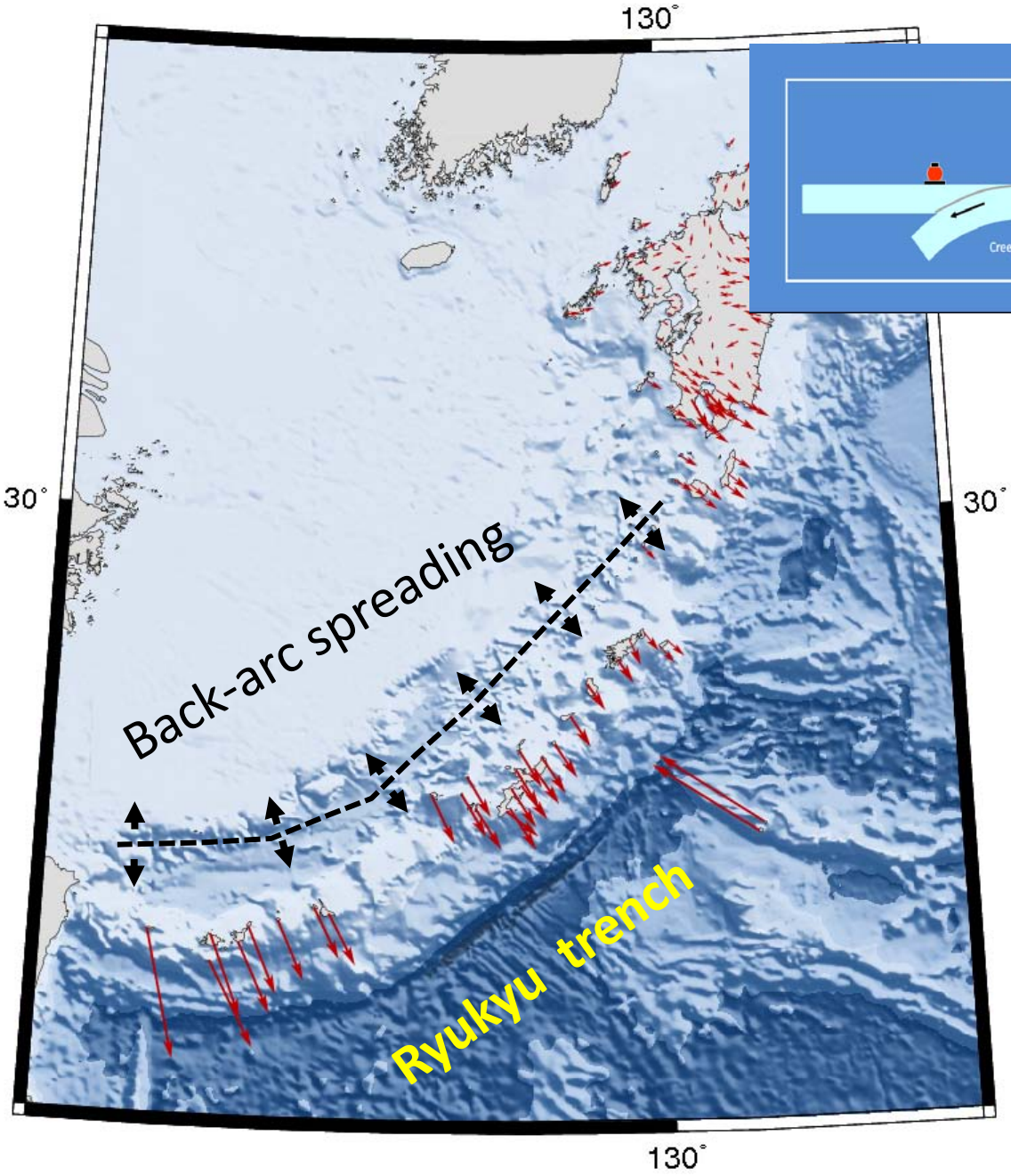
GPS , 1997-2006



Data from GEONET

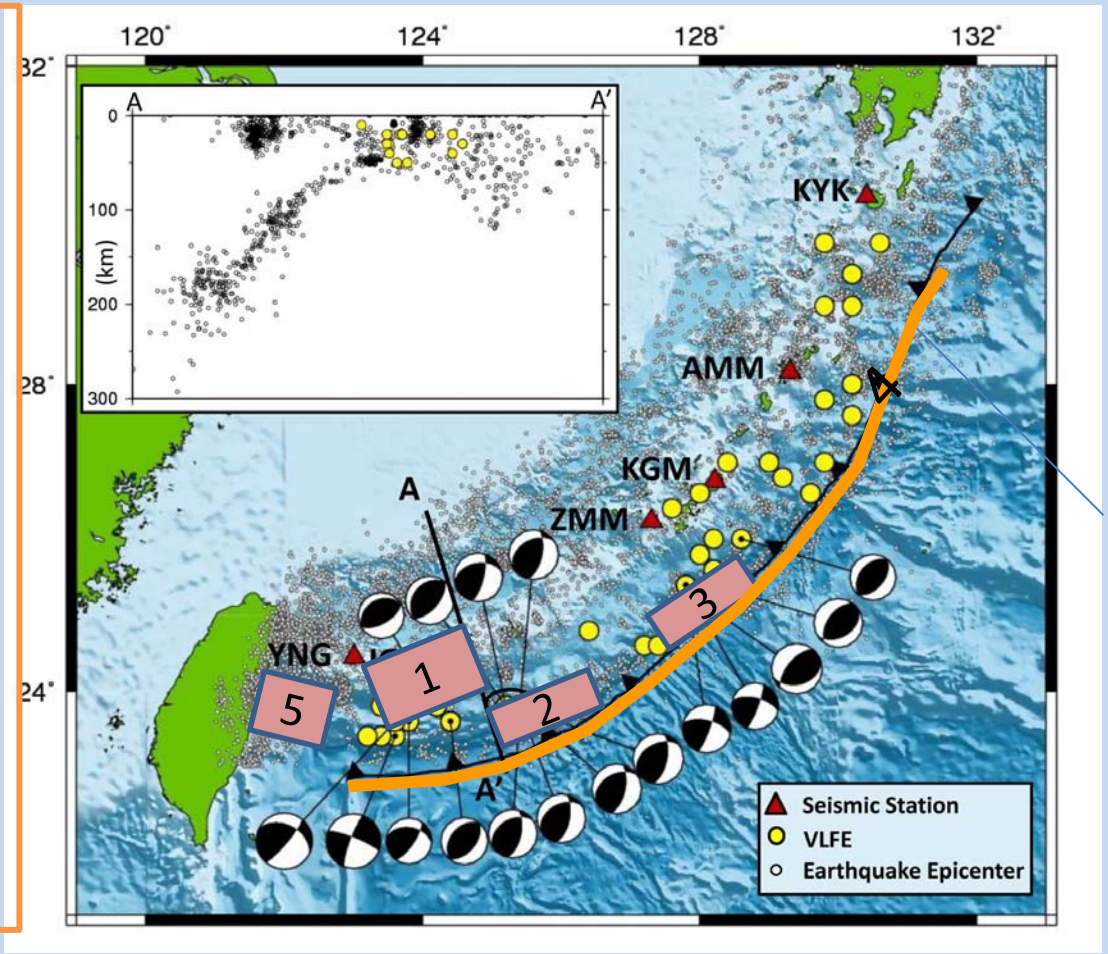
1. Locked or unlocked subduction

GPS
1997-2007



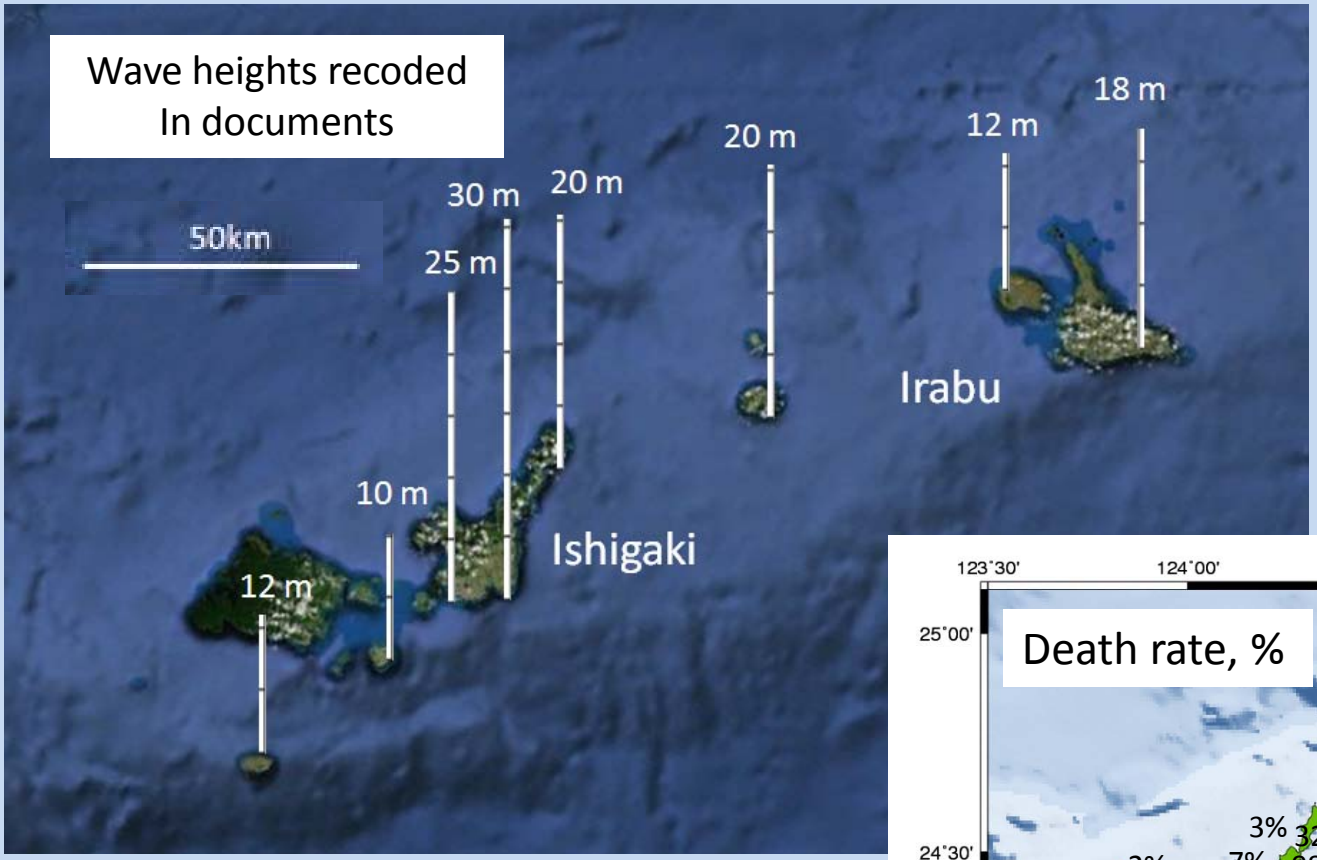
The Ryukyu subduction zone is locked because:

1. **Intermediate-depth slow-slips**
   (Heki et al. , 2008)
2. **The 1771 tsunami source**
   (Nakamura, 2009)
3. **Coupled interface from geodetic survey**
   (Nakamura et al., 2010)
4. **Very low frequency earthquakes**
   (Ando et al. ,2012)
5. **Locked zone from GPS**
   (Hsu et al. 2012)

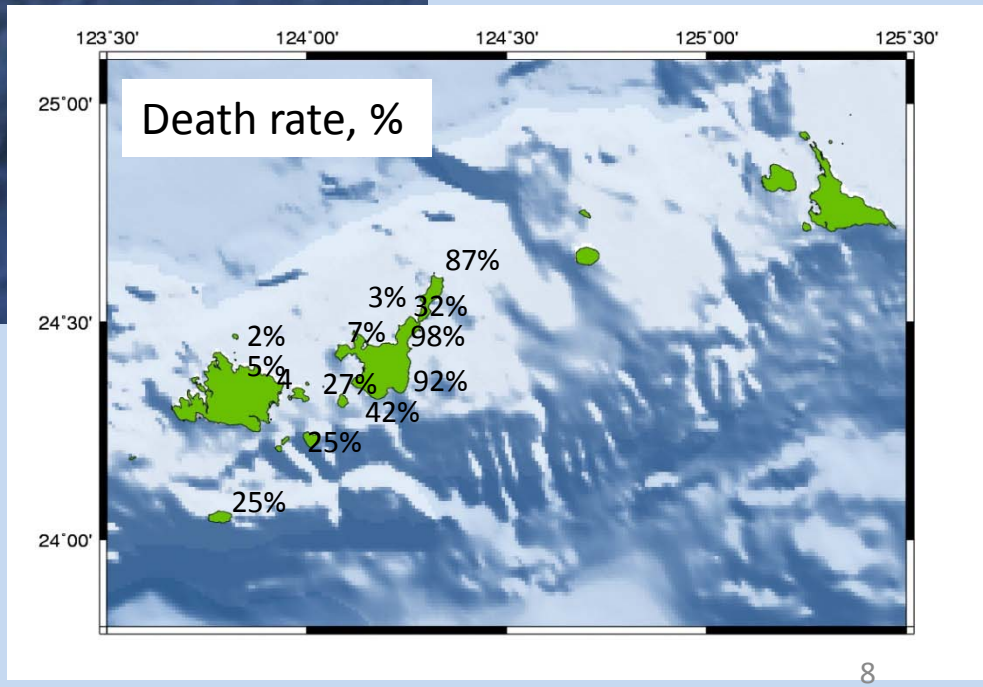


Focal mechanism: Very low frequency earthquakes

3. 1771 Yaeyama tsunami

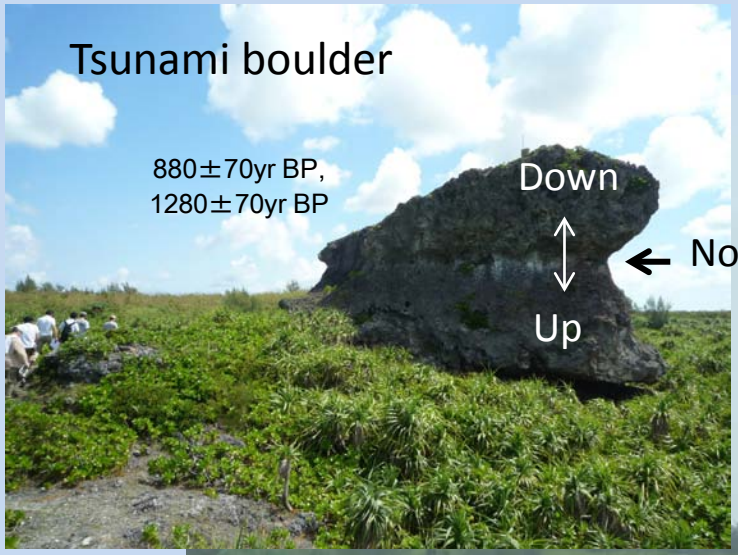


Death rate
Causalities/ Population
on ishigaki Island
= 8,910/17,394
= 51%



Population of each of
31 communities
ranging from 500 to 1000 people
(Nariyuki-Sho, 1771)
(大波之時各村之形行書 1771)

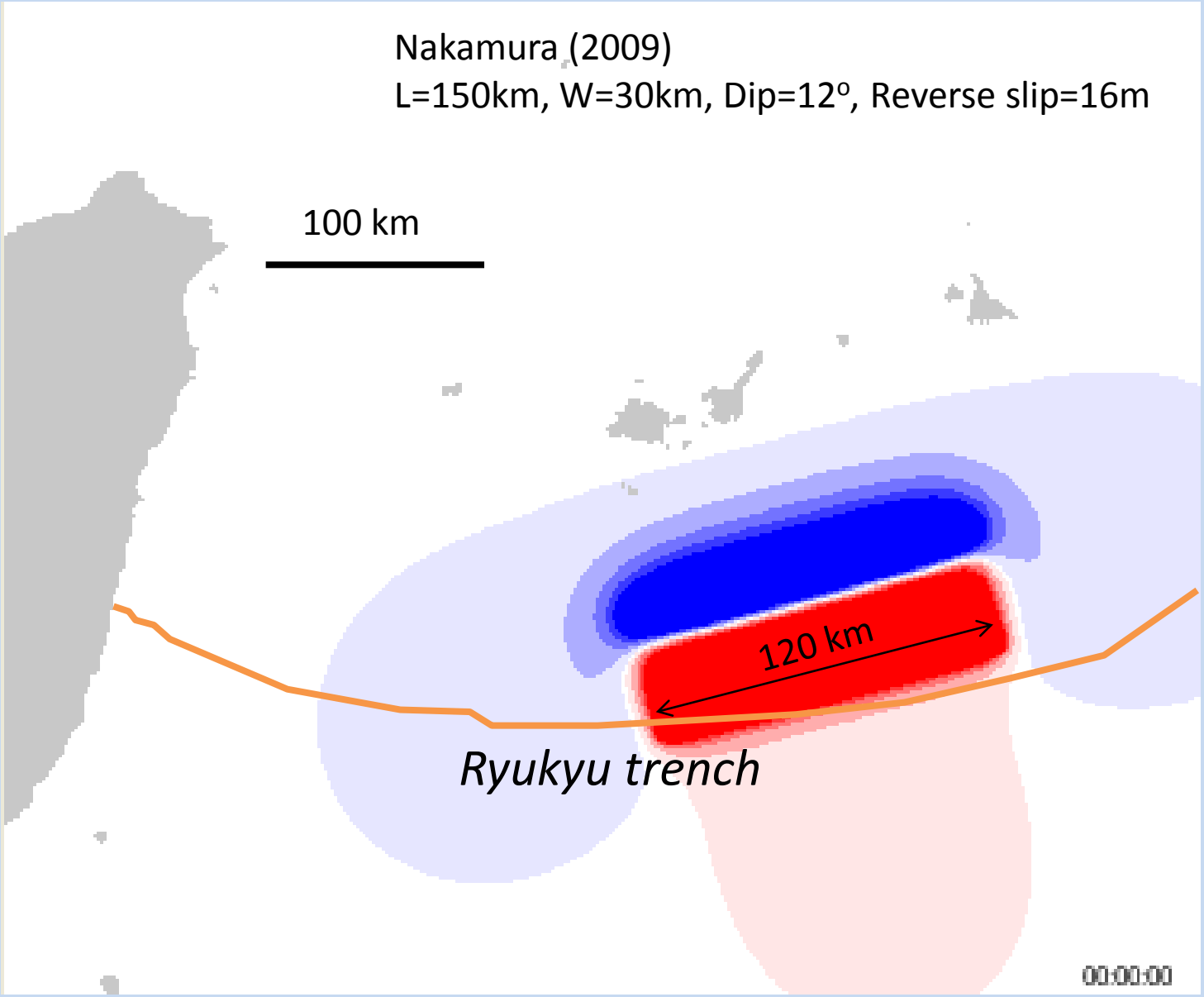
3. 1771 Yaeyama tsunami



A tsunami boulder on Shimochi Island

12 m

3. 1771 Yaeyama tsunami



4. Excavation of tsunami sediments

Ishigaki

10 km

Tozato North

Tozato South

30m in 1771

5m in 1771

Nagura

Arakawa

1771 tsunami

4. Excavation of tsunami sediments

Geoslicer excavation

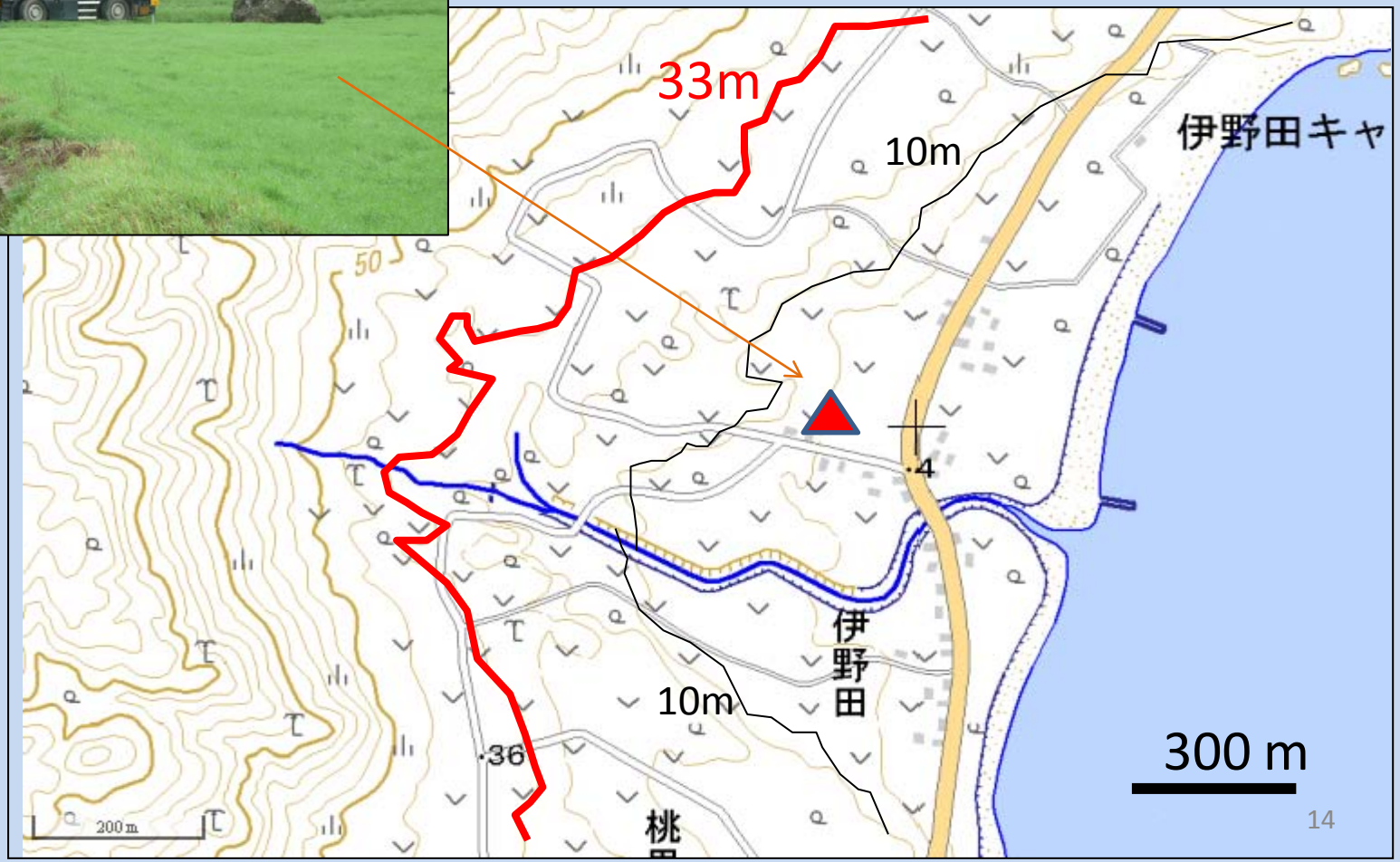
4. Excavation of tsunami sediments

Gluing the soil sample to a net sheet

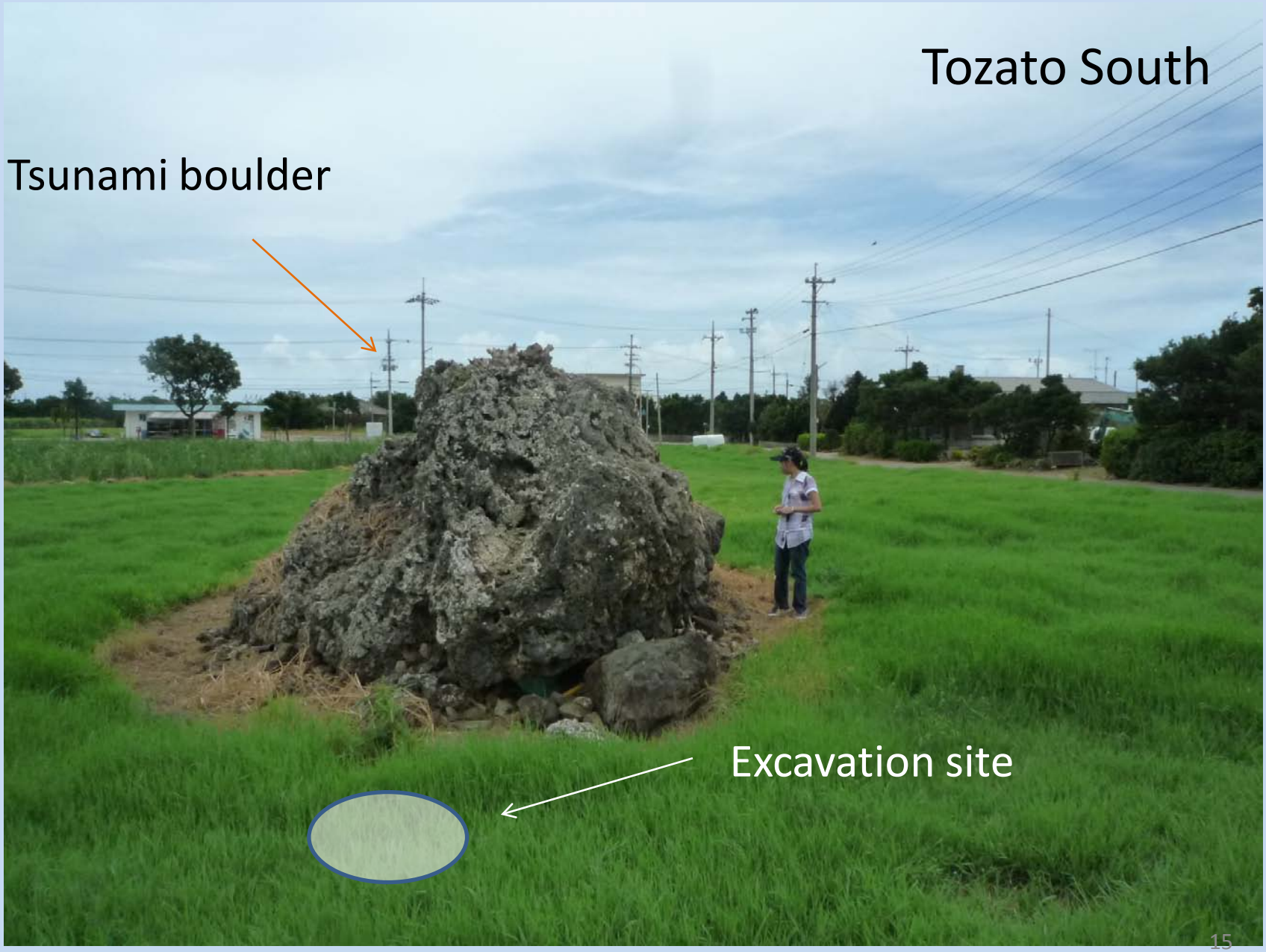
4. Excavation of tsunami sediments

Tozato S. excavation site

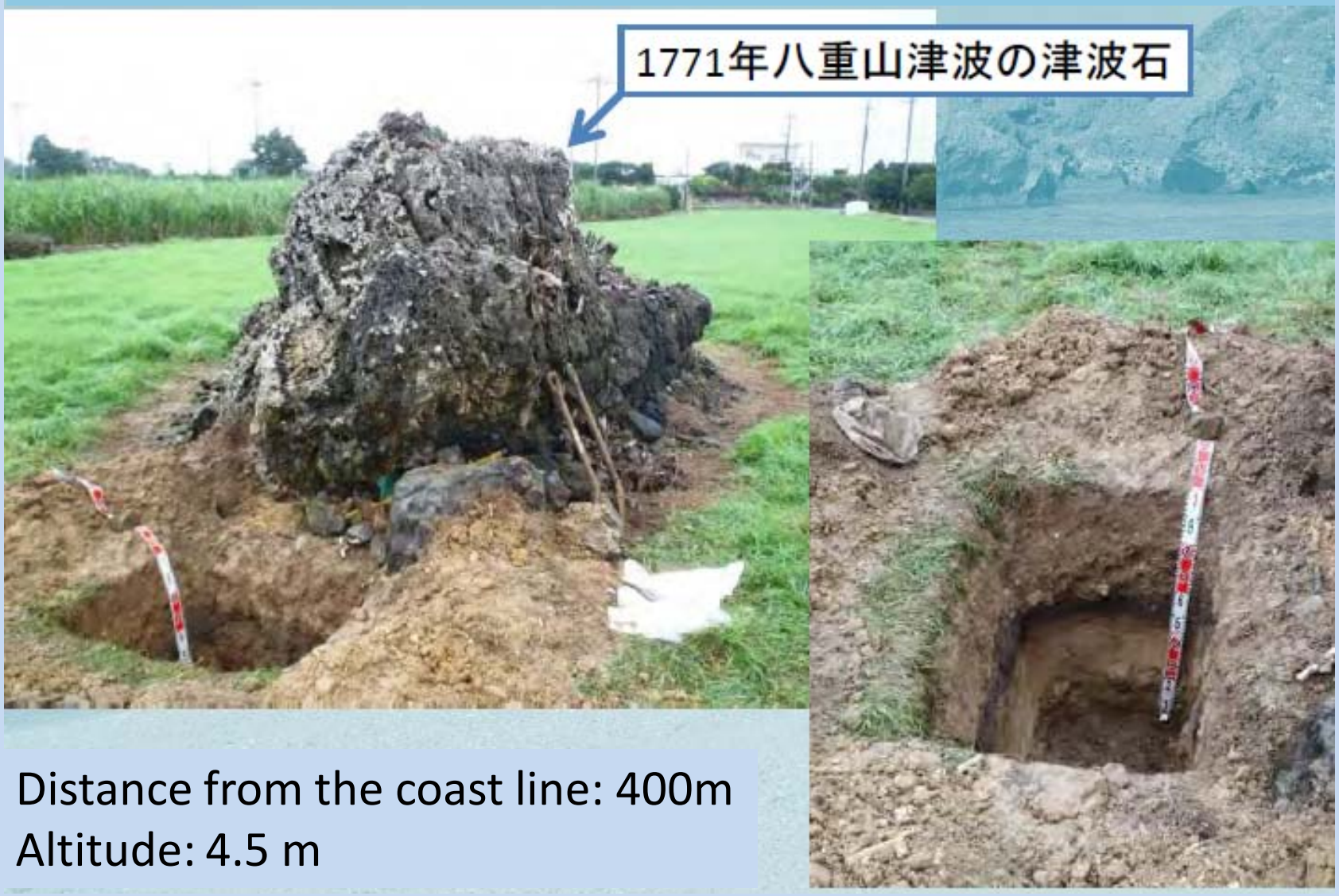
Tsunami height in 1771: 33m



4. Excavation of tsunami sediments

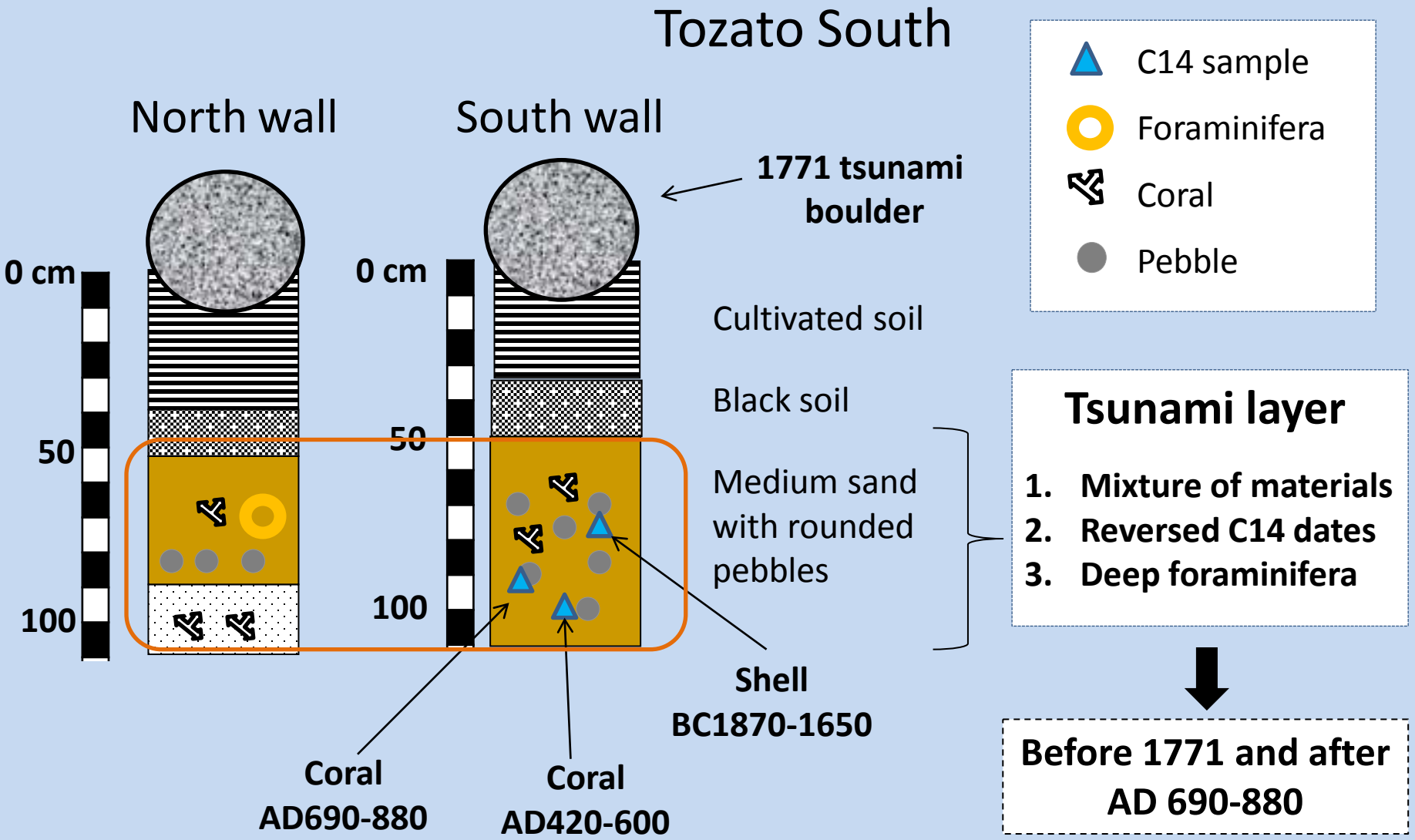


Tozato site



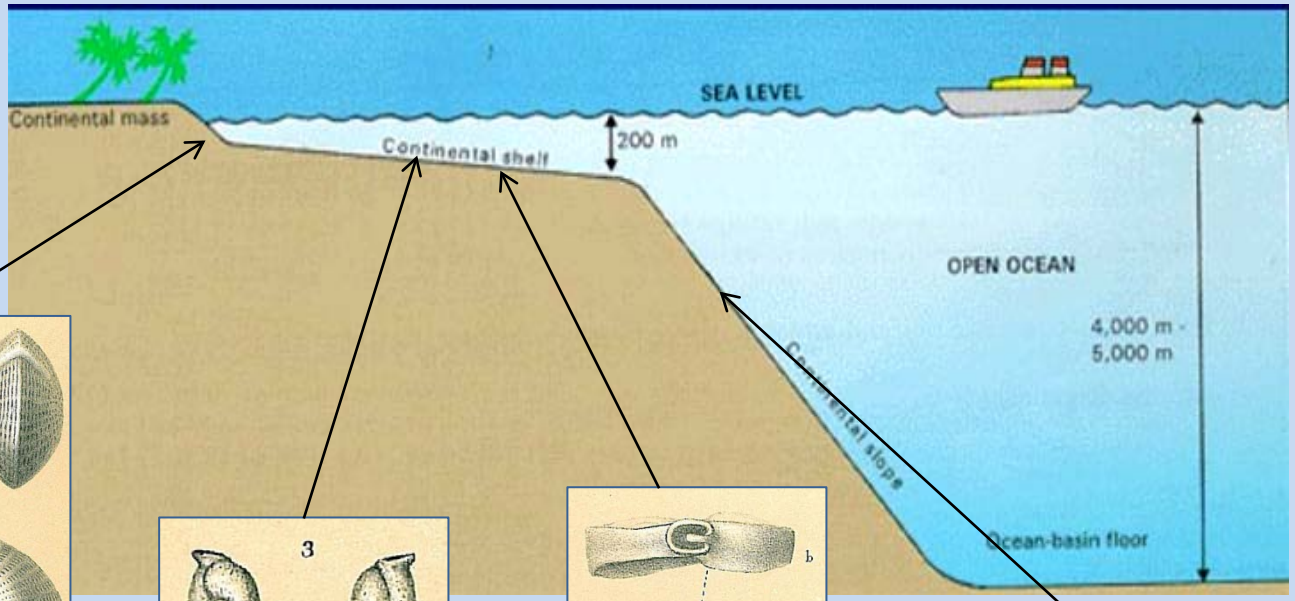
Distance from the coast line: 400m
Altitude: 4.5 m

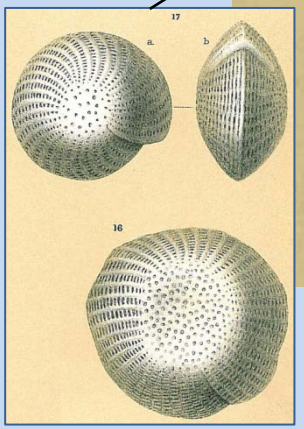
4. Excavation of tsunami sediments



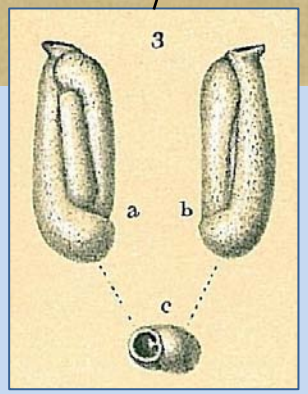
Foraminifera analysis

Continental shelf Continental slope

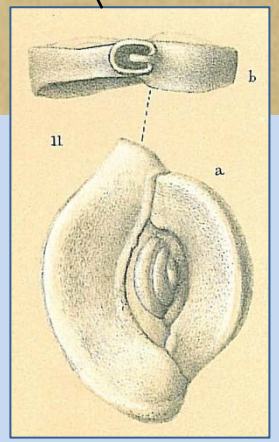




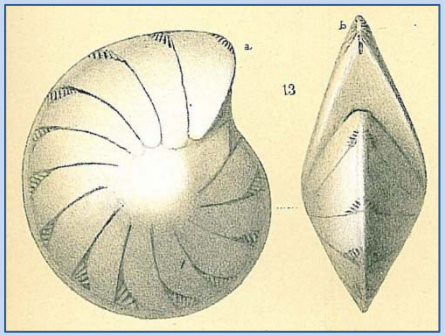
3-4m, Cellanthus craticulatus



70m,Quinqueloculina tropicalis



80-110m, Spiroloculina henbesti

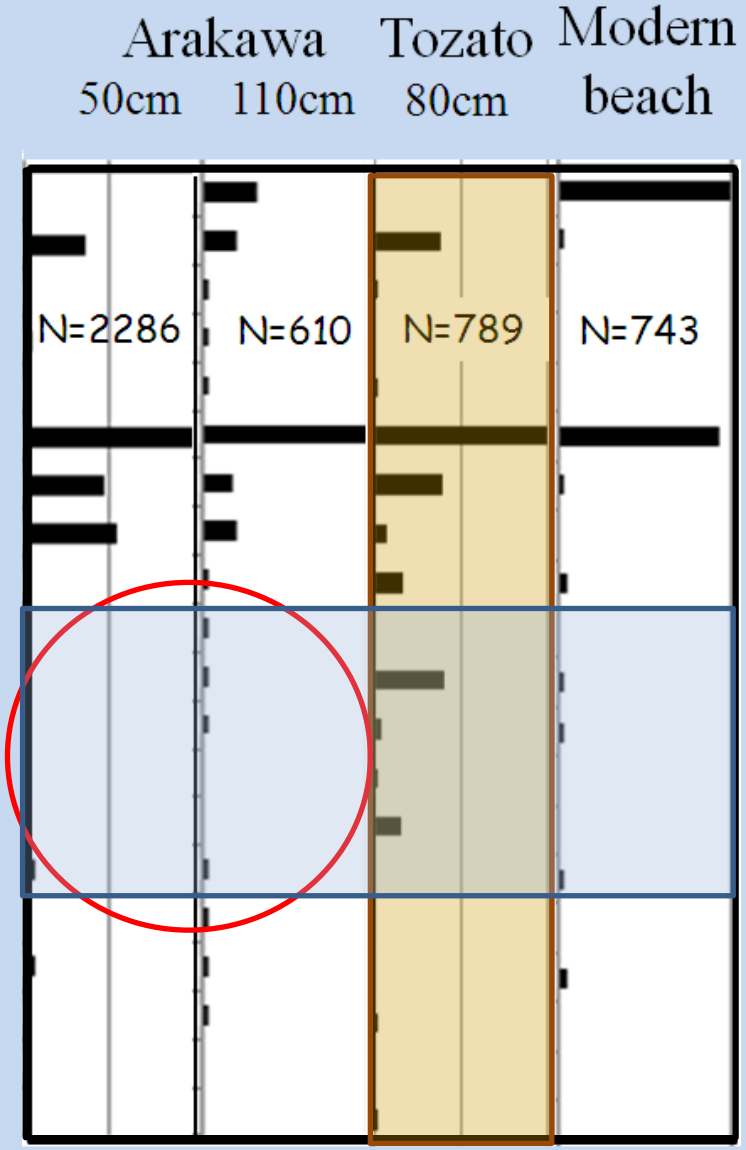


250m, Lenticulina thalmanni

4. Excavation of tsunami sediments

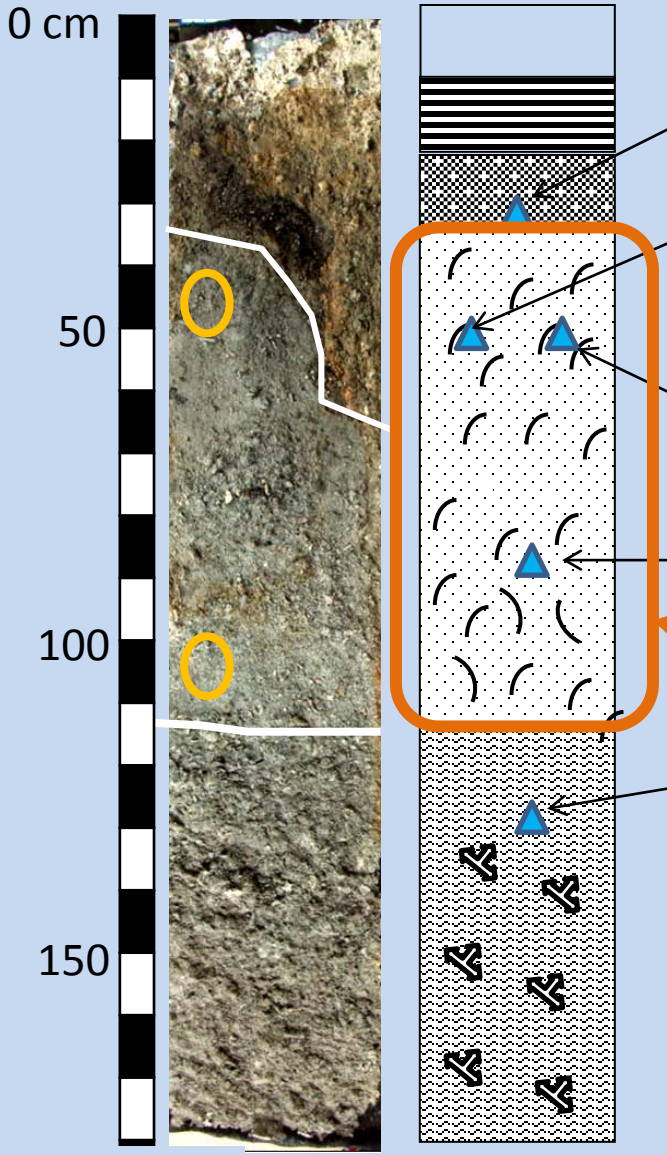
Relative abundance of benthonic foraminifera species

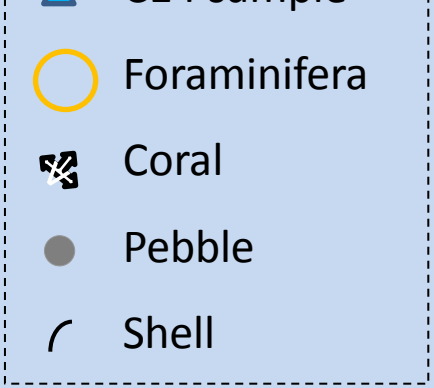
Species Name	Preferred depth
Baculogypsina sphaerulata (Parker and Jones)	**Shallow 0 - 15 m**
Cellanthus craticulatus (Fichtel and Moll)	
Sphaerogypsina globula (Reuss)	
Monalysidium okinawaensis (Ujiie and Hatta)	
Quinqueloculina parkeri (Brady)	
Calcarina calcar d'Orbigny	
Ammonia beccarii (Linnaeus) forma beccarii	
Ammonia beccarii (Linnaeus)	
Calcarina defrancii d'Orbigney	**Intermediate depth 15 - 50 m**
Miliolinella oceanica (Cushman)	
Amphistegina radiata (Fichtel and Moll)	
Triloculina tricarinata d' Orbigny	
Spiroloculina hadai Thalmann	
Spirosigmoilina pasquai Saidova	
Peneroplis carinatus d'Orbigny	
Quinqueloculina seminulum (Linnaeus)	**Deep 50 - 150 m**
Peneroplis pertusus (Forskål)	
Astrononion stelligerum (d'Orbigny)	
Quinqueloculina tubilocula Zheng	
Quinqueloculina laevigata d'Orbigny	



4. Excavation of tsunami sediments

Arakawa site 1





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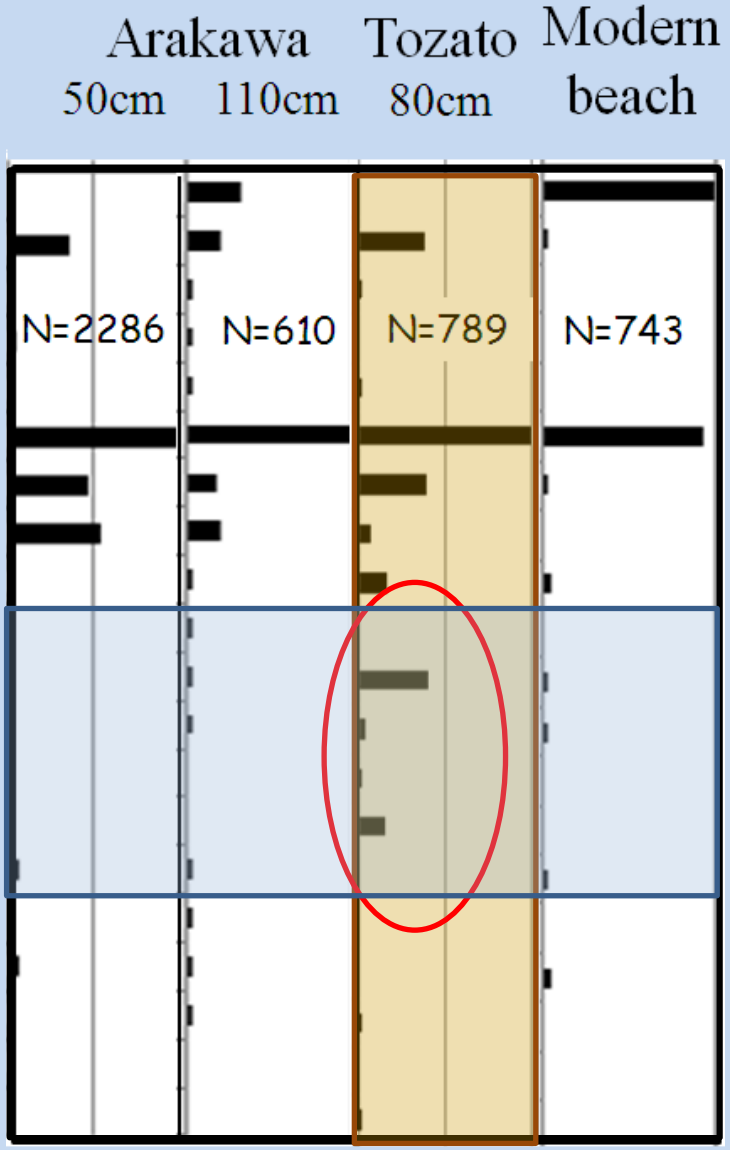
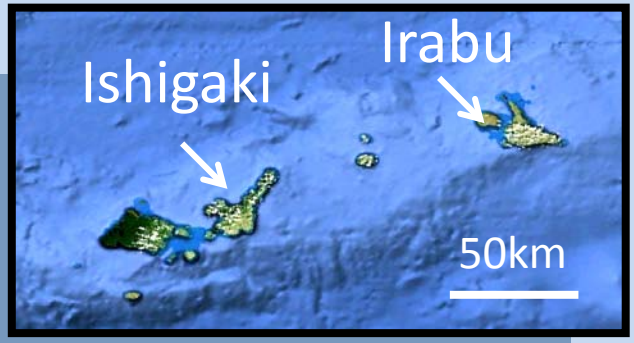




Irabu 2

Ikema 1

>12 m in 1771

Irabu 1

Irabu 1

Miyako Is.

18m in 1771

Tomori 2

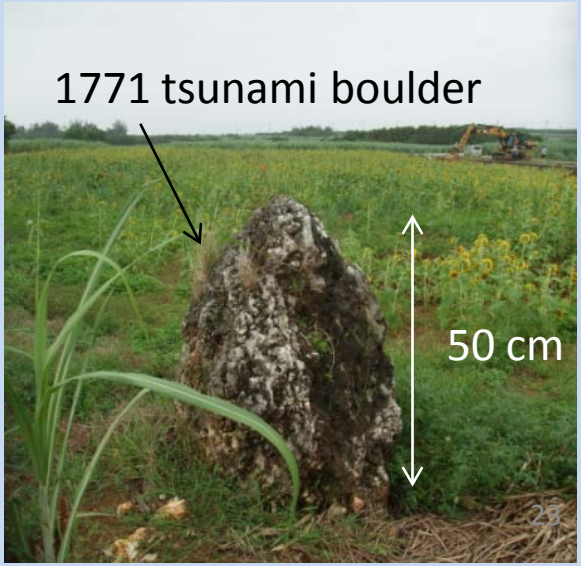
Tomori 1

5 km

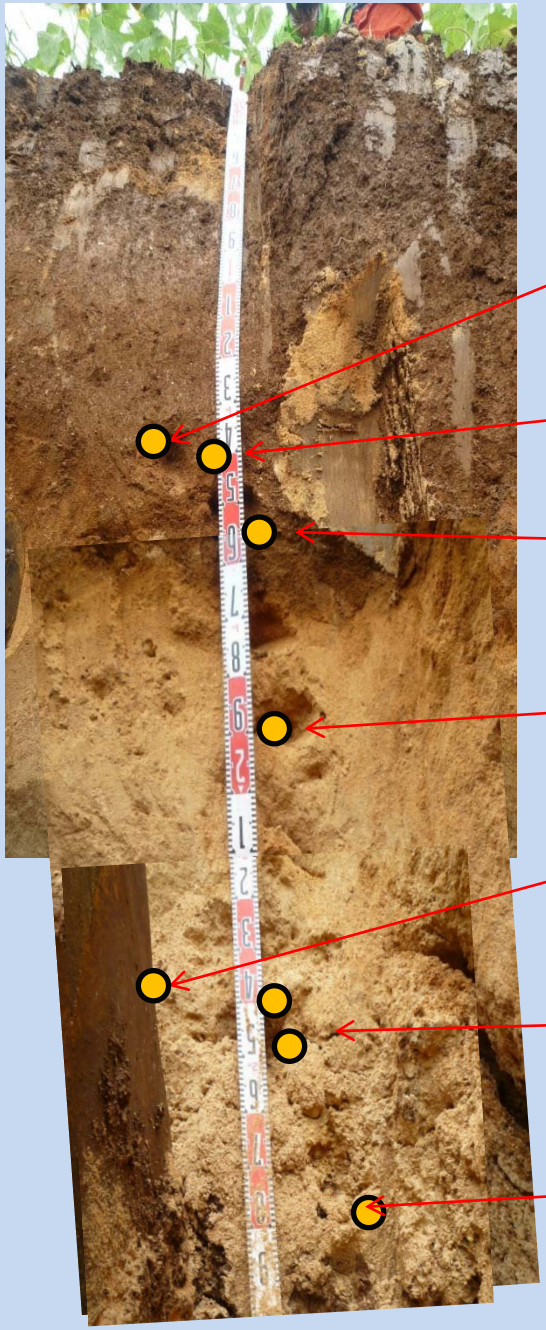
4. Excavation of tsunami sediments

Irabu island

A tsunami layer, occurred possibly between 11th C. and 1771



Irabu site



AD 1030 - 1170

AD 910 - 1030

AD 1060 - 1200

AD 550 - 660

BC 2270 – 2110

AD 160 - 300

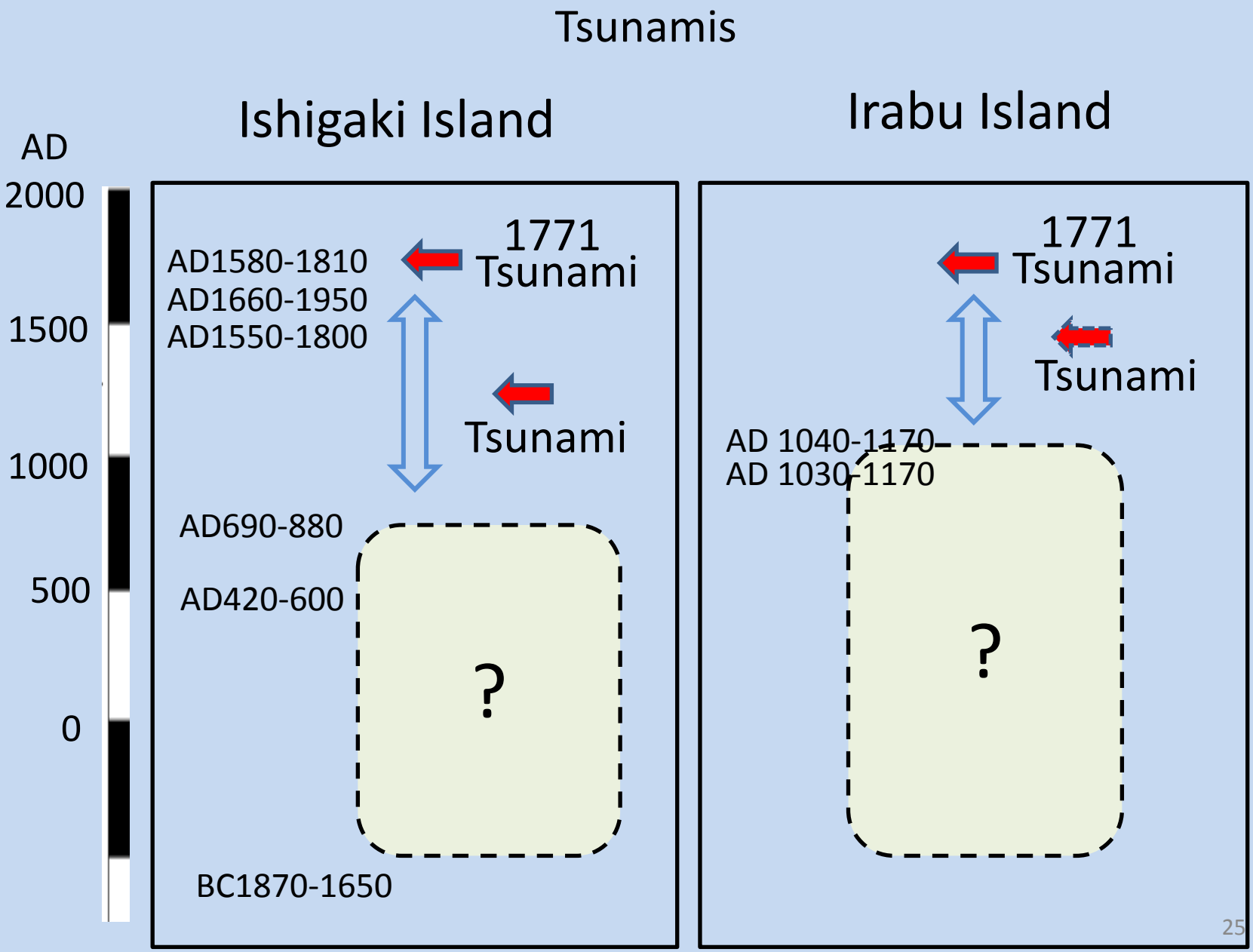
AD 120 - 40

Cultivated soil

Tsunami layer?

Coarse-grain sand layer

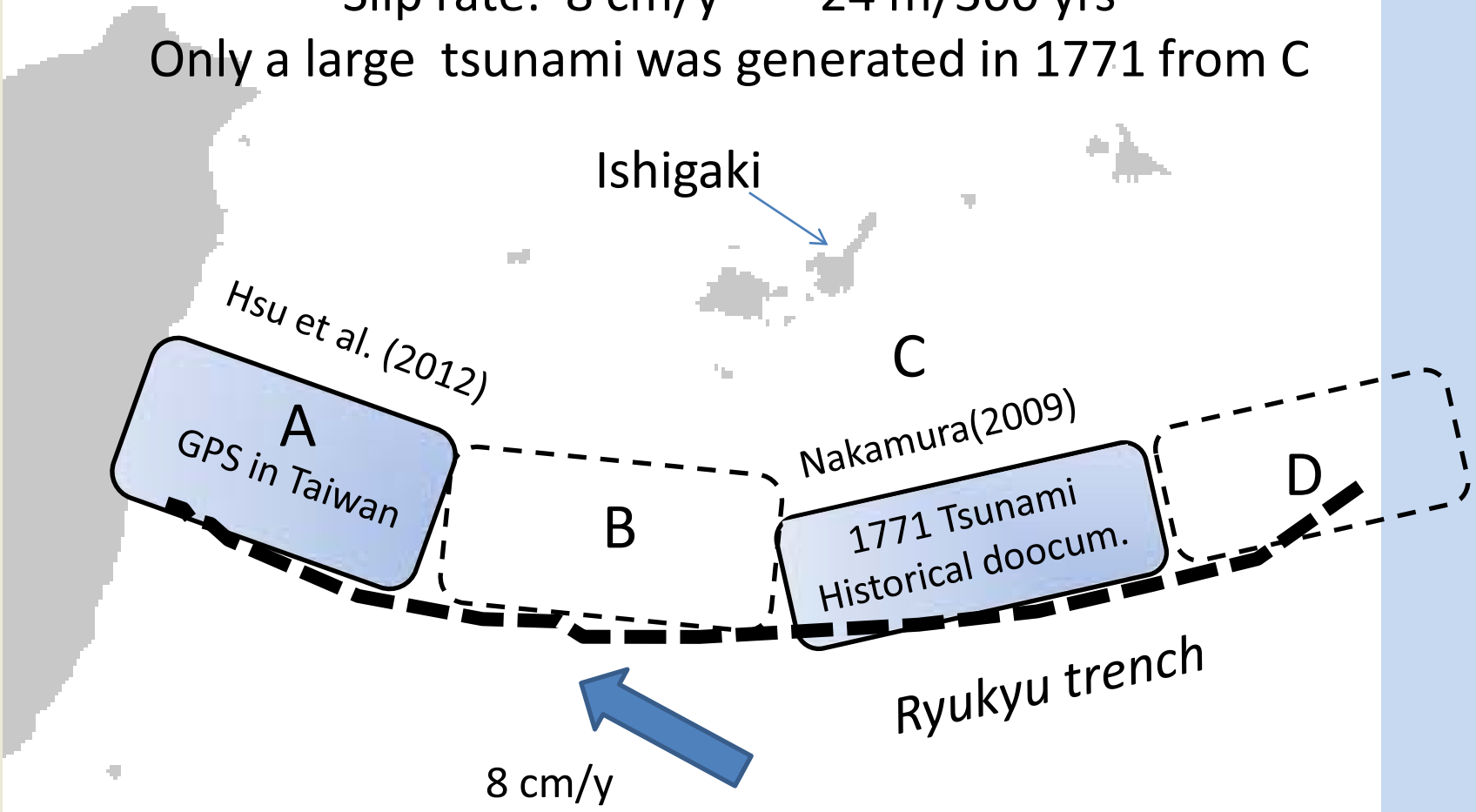
4. Excavation of tsunami sediments



Large slip deficit

Slip rate: 8 cm/y → 24 m/300 yrs

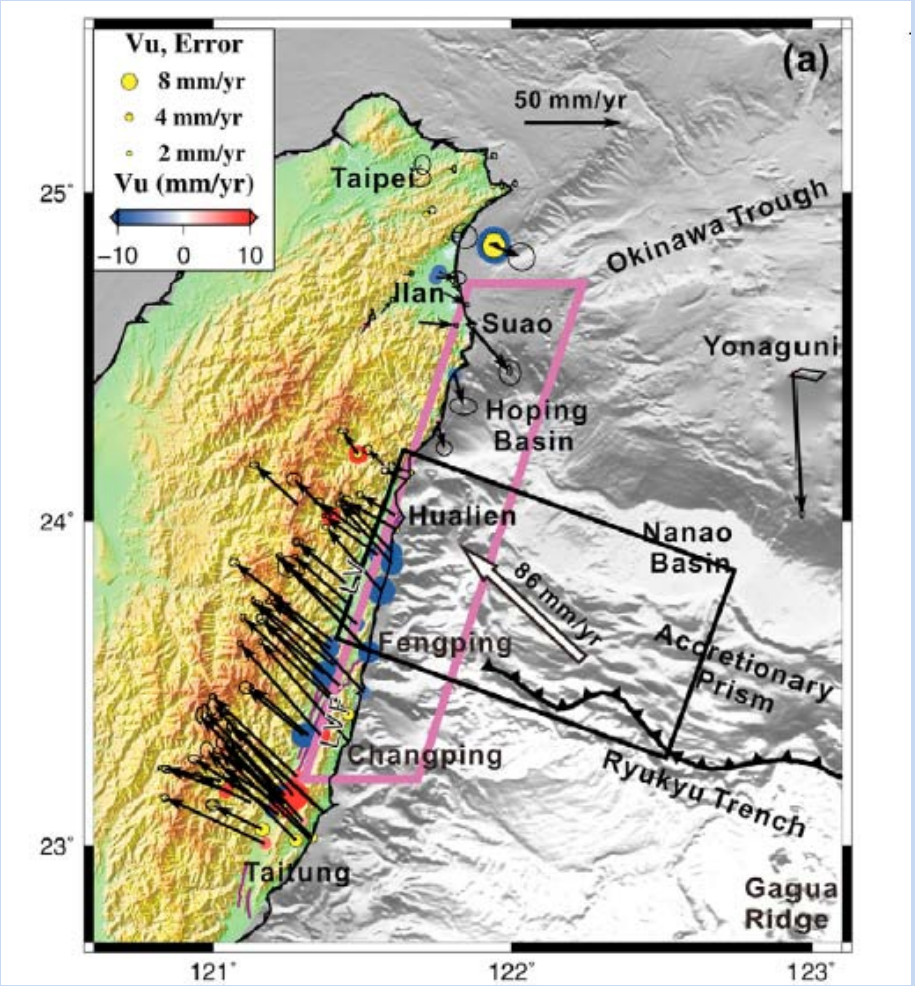
Only a large tsunami was generated in 1771 from C

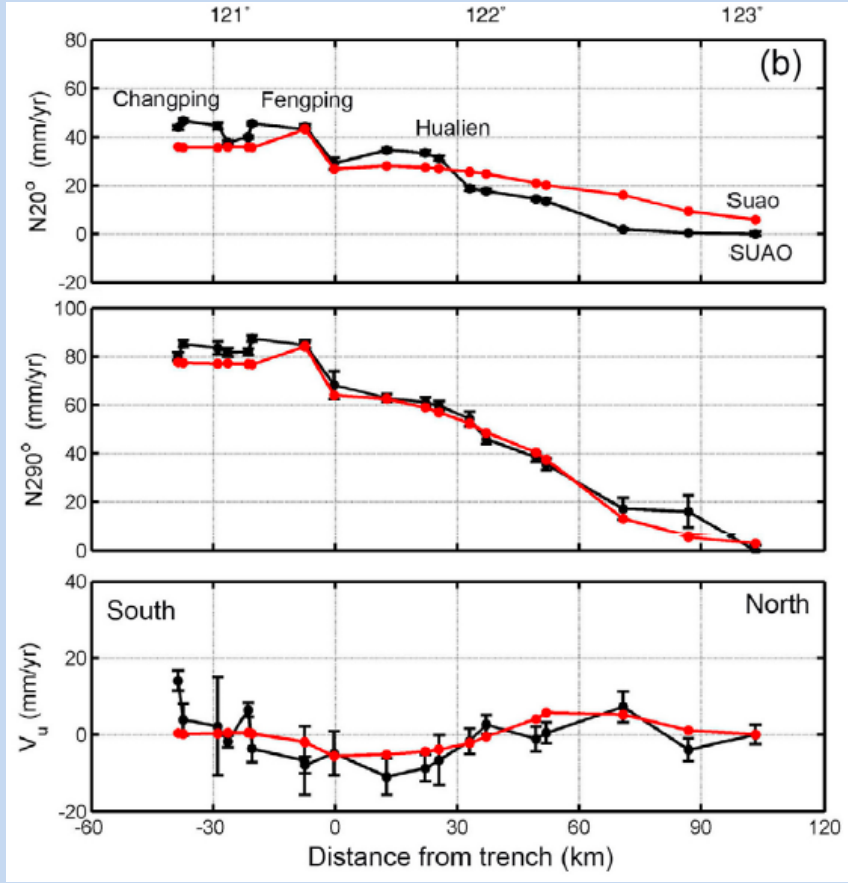


5. Summary

Western Ryukyu (WR) subduction zone

- Tsunami sediments were found from excavation surveys on the islands.
- Sediments from the 1771 tsunami and a previous event between 8-9th C. and 1771 were identified.
- The WR subduction zone has the potential to generate large tsunamis in the future.
- Further evidence is necessary to identify past tsunamis.

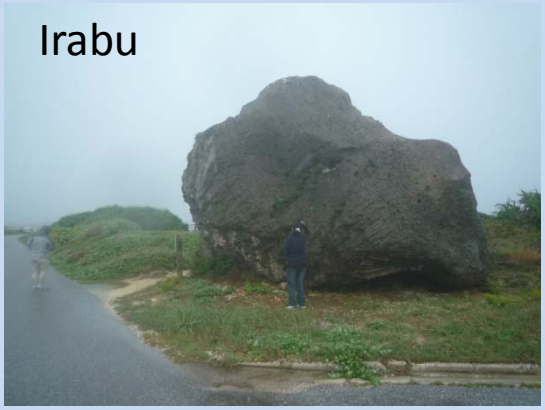


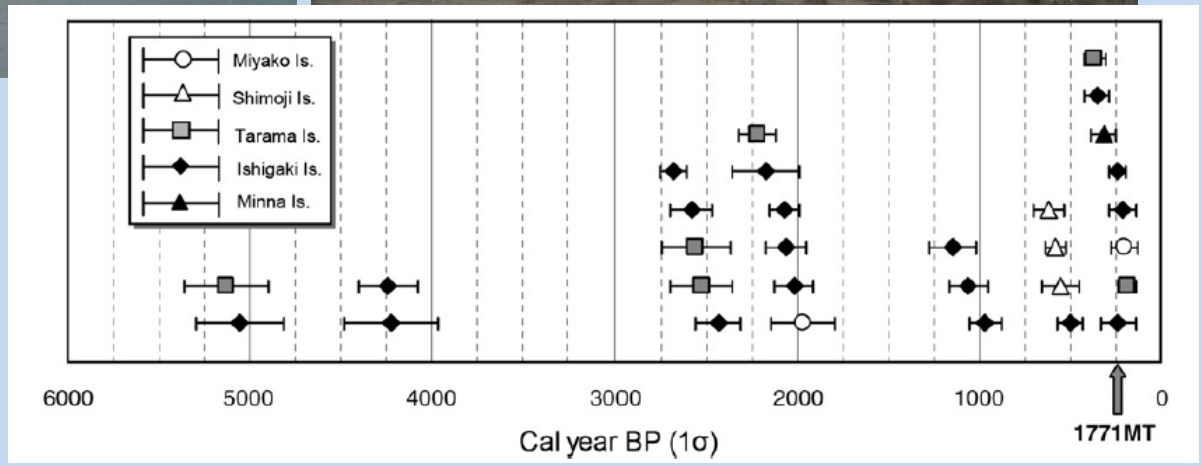


Hsu et al. (2012)

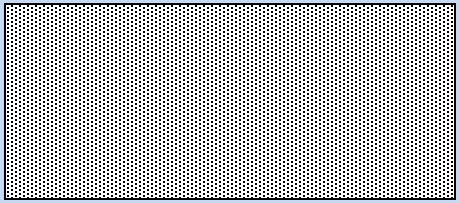
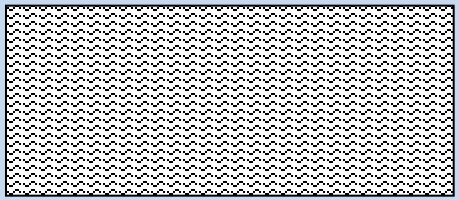
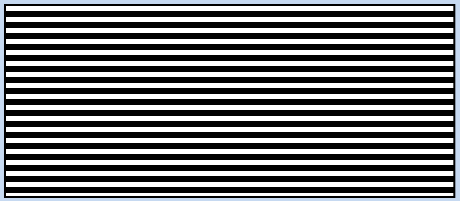
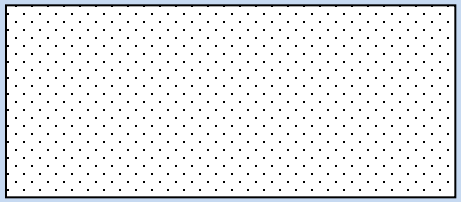
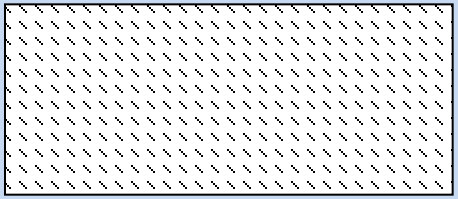
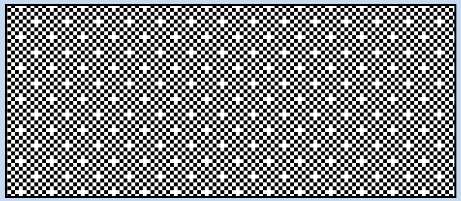
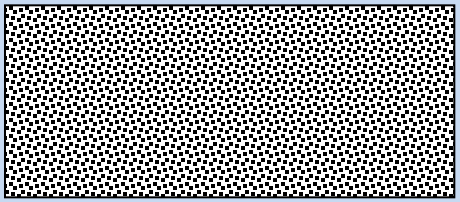
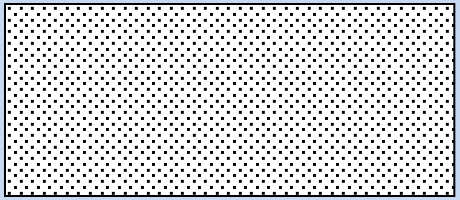
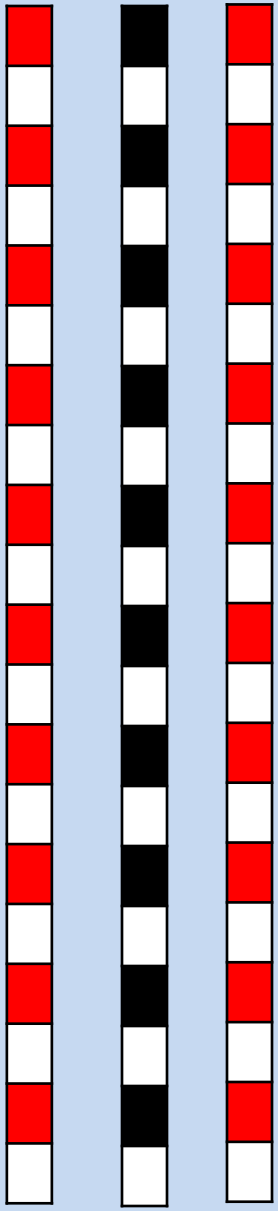
Previous paleotsunami studies on Ryukyus

All based on tsunami boulders

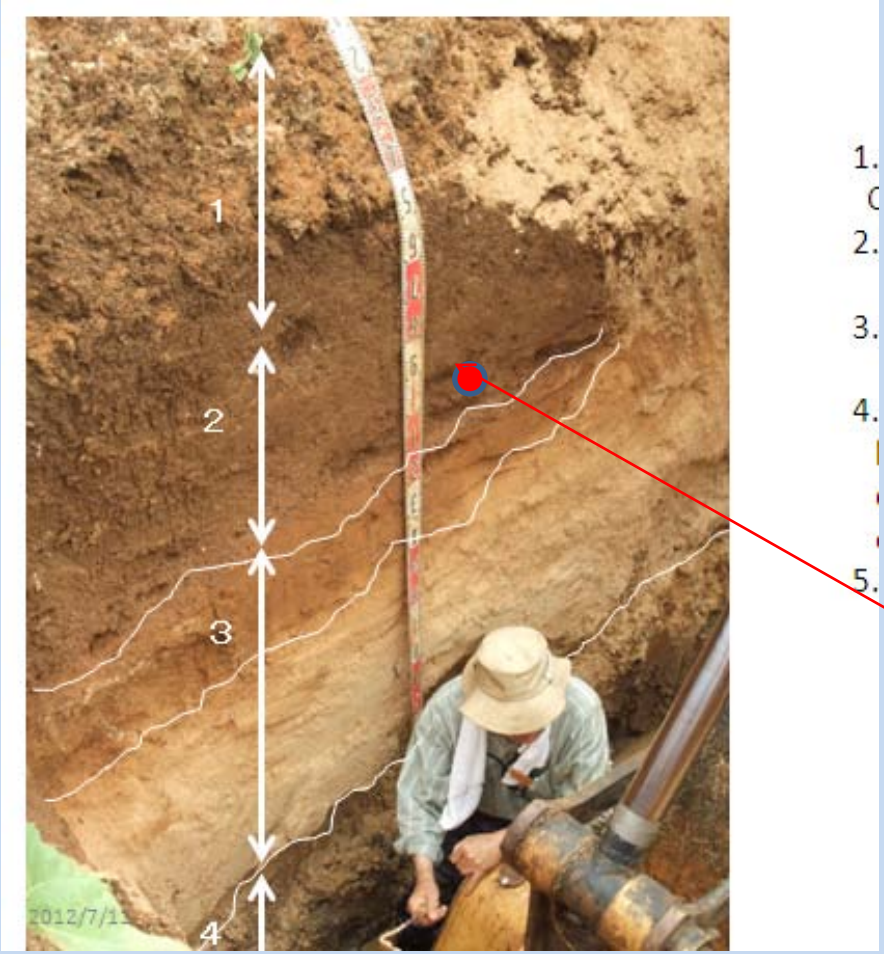




Summarized by Goto et al. (2010)

C14 Irabu-3, 105cm



1.
2.
3.
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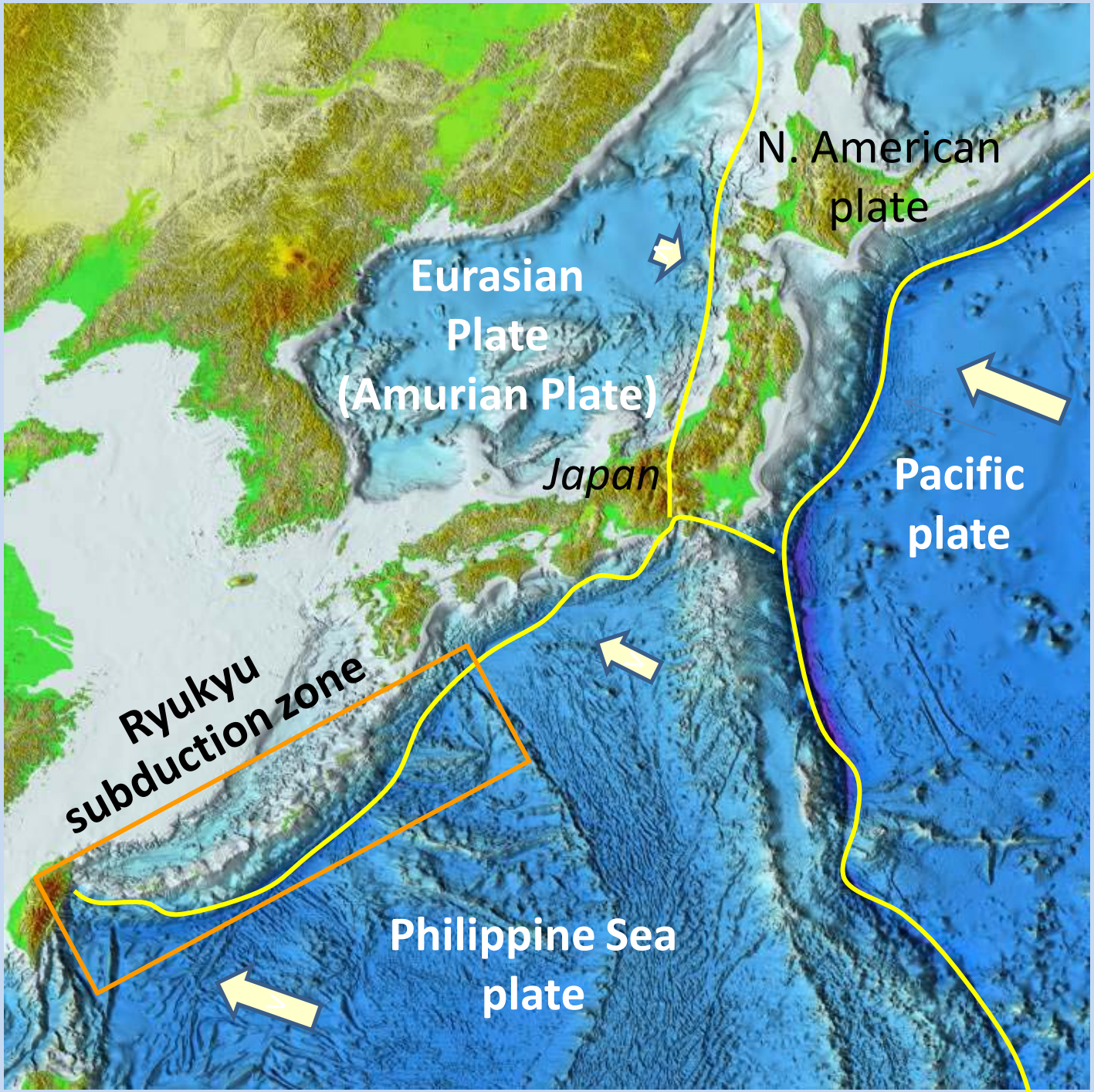
5.

BP1310+-30


N. American
plate
Eurasian
Plate
(Amurian Plate)
Japan
Pacific
plate
Ryukyu
subduction zone
Philippine Sea
plate

Taiwan