Visit to the Monuments of the Nankai Earthquake

UJNR06 Excursion Guide (November 8, 2006)

Tsunami painted on a votive tablet at the *Senkoji* temple

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ITINERARY

AM:

Tokushima Tokyu Inn (departure 8:30) === **Oohama beach at Hiwasa** (break, bench mark and Yakuoji temple) === (10:00) **STOP 1** Tsunami shelter in Okuura Sange area, the town of Kaiyo -- on foot -- **STOP 2** *Tomoura Kaisho-Ki* -- on foot -- **STOP 3** *Keicho* and *Hoei* arge rock monument -- **STOP 1**===***YuuYuu NASA*** (restaurant, lunch break)

PM:

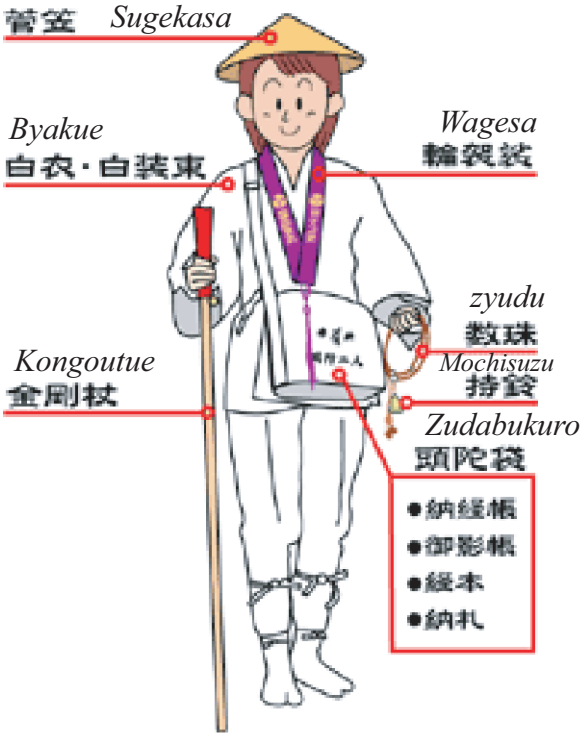
YuuYuu NASA (departure 13:00) === **STOP 4** *Maze* hill (view of Asakawa Bay, Levee for Tsunami, and GEONET (GPS-based) control station at Tokushima-Kainan) === JA Asakawa branch -- on foot – **STOP 5** Stone memorial at *Tenjin* shrine -- on foot – **STOP 6** *Kannon-Do-Jizo-Son* and stone steps -- on foot – **STOP 7** Stone memorial at *Misaki* shrine -- on foot – **STOP 8** Picture frame and votive tablet at *Senkoji* temple -- on foot – **STOP 9** Center at the Asakawa fishing village (In the exhibition room on the second floor, we will hear about actual experiences of the victims of the *Showa-Nankai* Tsunami disaster. We will see historical documents passed down to Mrs. *Tai*'s family that recorded the tsunami at Mugi. We will also hear about Mrs. *Tai*'s actual experiences. Departure by 16:00) === **Roadside station at Hiwasa**(break) === (arrival 17:00-18:00) **Tokushima Tokyu Inn**

BREAK POINT Hiwasa

It takes 2 hours to travel from Tokushima to the town of Kaiyo by bus. We will have a break at Hiwasa. The *Yakuou* temple, which is the 23rd hallowed ground in Shikoku, is at Hiwasa.

In Shikoku, people travel to 88 temples as ascetic training, which we call "*Ohenro*". The *Yakuou* temple is the 23rd temple. We may meet an "*Ohenro-san*", who wears a white gown, a wattle hat, and hits a stick in the temple or on our way.

The next temple is the 24th *Hotsumisaki* temple in Cape Muroto, which is 75 km from Hiwasa. There is a white sand beach at Hiwasa, where sea turtles lay their eggs. We will see a first order leveling bench mark, which was established by GSI near the break point.



STOP1 Tsunami shelter, Sange district, Town of Kaiyo

Before constructing this tsunami shelter, the Sange district had only a tsunami refuge on the hill. In the case of the tsunami with the Nankai earthquake, the area of the refuge and the road to the refuge were too narrow for many people to evacuate. In addition, it was too far for some residents and workers in the port to evacuate before the tsunami attacked.

This new tsunami shelter in the northern part of the Sange district provides a refuge to which all residents and workers in the Sange district may evacuate before the arrival of a tsunami. The new refuge also solves the problem of overcrowding on the road to the existing refuge on the hill.

On the basis of previous tsunamis, the height of the new shelter is sufficient to survive a 5 m tsunami and 1 m of coseismic land subsidence.

We will walk to the next stop because the road is too narrow for the bus.

Fig.1 Tsunami shelter, Sange district

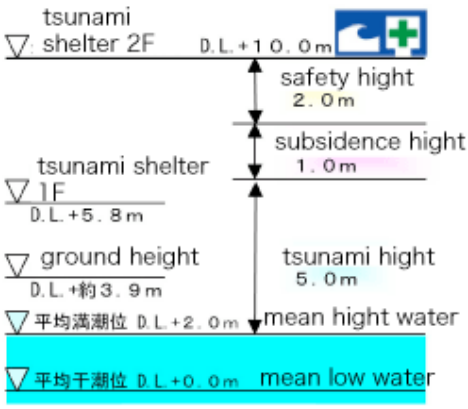


Fig.2 diagrammatic illustration of height

Fig.3 Map of Tomoura

Fig.4 *Tomoura Kaisho-ki*

STOP 2 *Tomoura Kaisho-Ki* 1854

A stone memorial named *Kaisho-Ki* along the former Kaifu River in the Tomoura district is related to the *Ansei-Nankai* earthquake. The epitaph, consisting of 894 characters on the memorial stone tells us that the *Ansei-Tokai* earthquake occurred on the day before the *Ansei-Nankai* earthquake, whose tsunami attacked the local area.

[Epitaph]

The earthquake occurred on the morning of November 4, Kaei 7(1854). It was warm and the weather was good even though it was winter. The wave attacked

the port and then calmed down. The next day was warmer, like an Indian summer. The ground started to shake around 4 p.m. The sea surface rose and the tsunami passed over Mukaihama, attacking the town. I was astonished and climbed up the nearby hill. The tsunami surged to the gate of the Tazenji temple and Wakinomiya along the Kaifu River. Shaking increased around 10 p.m., and the people on the hill intoned the Pure Land Buddha's name "Namu Amida Butsu". The tsunami reached a height of 3.6 m but caused no damage. An earthquake and tsunami occur every hundred years. You, therefore, should evacuate as soon as possible to save your life if you detect any unusual phenomena.

STOP 3 Large Rock, the *Keicho* and *Houei* Earthquakes Monument 1605, 1707

There is a large dark brown rock 5.5 m wide and 3 m high. It has a hole for mooring a fishing boat. The epitaph on the rock is related to the *Keicho*- and *Houei-Nankai* earthquakes.

Fig.5 Large Rock, the *Keicho* and *Houei* Earthquakes Monument

Documentation about the *Keicho-Nankai* earthquake is rare, and this rock has a unique epitaph related to the *Keicho-Nankai* earthquake in Shikoku, so it is very valuable. The epitaph related to the *Houei-Nankai* earthquake is half the size of that related to the *Keicho-Nankai* earthquake.

[Epitaph]

On the left: The tsunami caused by the three earthquakes was 30 m high at about 10 p.m. on December 16, 1605. Seven waves killed more than 100 people. I inscribe this to tell future generations about the tsunami.

On the right: The earthquake occurred on October 4 in 1707. A tsunami 3 m high came to the hill swiftly and ceased after approaching three times. It was fortunate that no deaths were caused by the tsunami in the inlet. Future generations should expect the arrival of a tsunami after an earthquake and escape from it.

We will return to the bus at STOP 1.

Lunch at *YuuYuu NASA*

We have lunch at the restaurant on the 1st floor of *YuuYuu NASA* which has a pleasant view of Nasa Bay.

Fig.6 Pleasant view of Nasa Bay at *YuuYuu NASA*

STOP 4 View of Asakawa Bay on "*Mazeonoka*" (*Maze* hill)

We will have a panoramic view of Asakawa Bay from "*Umino* Stage" at the campground. We can imagine that the V-shape of the bay amplifies tsunamis and we can see that breakwaters for tsunamis are almost completed in the mouth of the bay. If time allows, we will visit a permanent GEONET GPS station (GPS-based control station) in *Jaou Undou Kouen*.

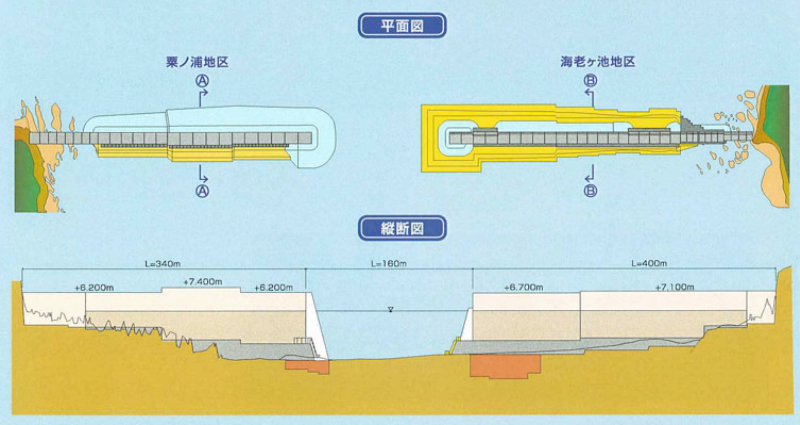


Fig.7 Breakwaters for tsunamis

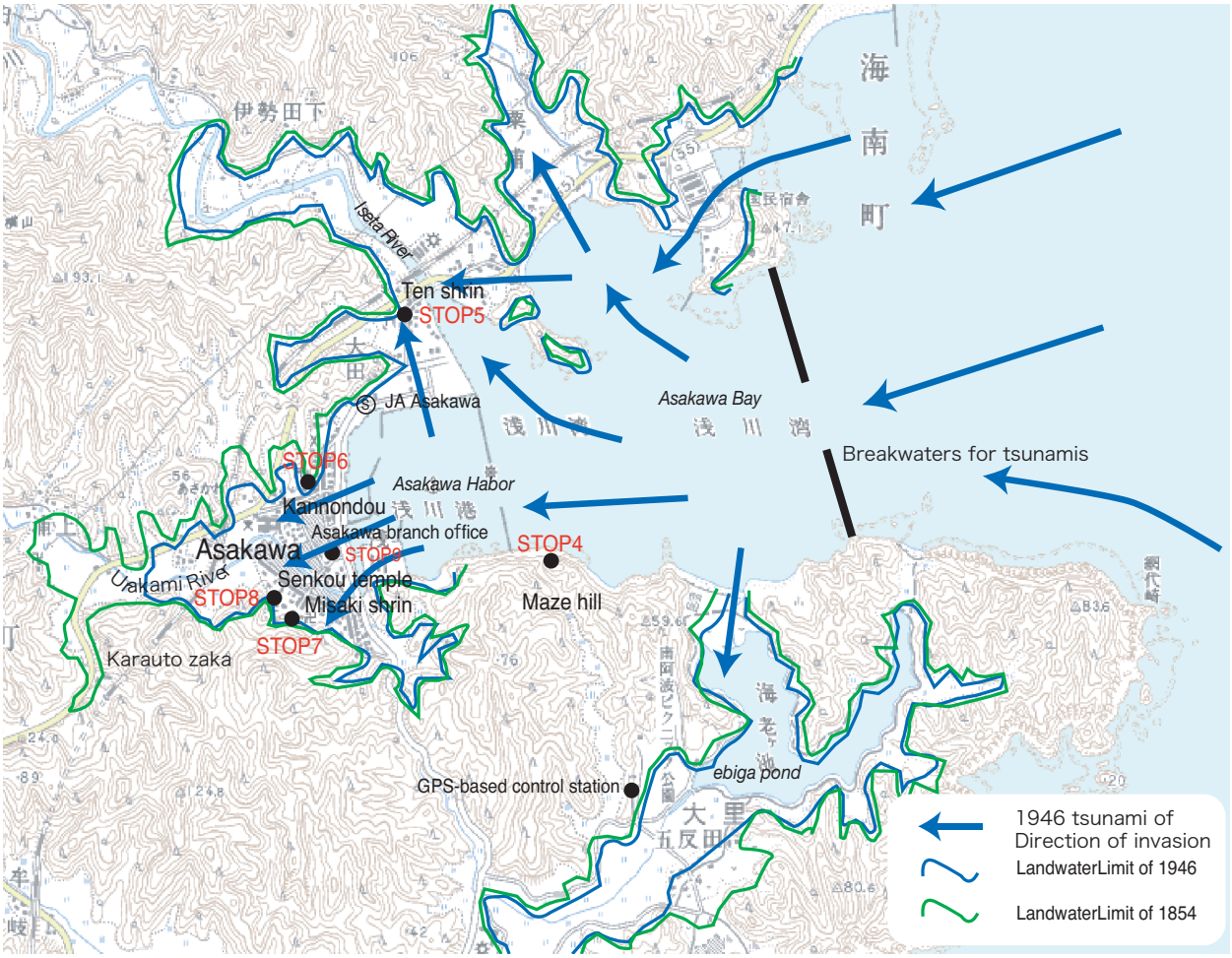


Fig.8 Map of Asakawa

Green and blue lines show Landward limit of 1854 tsunami and 1946 tsunami, respectively. Arrows indicate 1946 tsunami of Direction of invasion.

STOP 5 Asakawa-*Tenjin* shrine: The monument of the *Ansei* tsunami 1854, 1946

We will stop at JA Asakawa branch and walk to the Asakawa-*Tenjin* shrine. At the foot of the mountain is a monument of the tsunami from the 1854 *Ansei-Nankai* earthquake in the *Tenjin* shrine. Though the monument is at the end of the shrine, it has been eroded and is difficult to read. A monument has been established on the premises closer to the entrance. The broken torii is located at the end of the shrine. This torii existed when the building of the shrine took place at the time of the 1605 *Keicho* earthquake. A monument of the 1946 *Showa-Nankai* earthquake is also near the entrance of the shrine.

Fig.9 The monument of the *Ansei* tsunami

[Epitaph]

On the day after the 1854 Ansei-Tokai earthquake, the weather was fine without clouds and wind. It was as warm as March. Some people were worried about this strange weather and brought their belongings to the top of the mountain. A great earthquake occurred at around 4 p.m. After the shaking of the ground, a tsunami with a wave 9 m high surged over the houses and washed them away without casualties or injuries.

[The monument of the 1946 Showa-Nankai earthquake in the Tenjin shrine]

A great earthquake occurred at 4:19 a.m. on December 21st in 1946 at 135˚ east longitude and 33˚north latitude, 50 km south of Cape Shiono-misaki. The tsunami struck the area about 10 minutes after several minutes of great shaking of the ground. The first wave with a maximum height of 9 shaku (1 shaku is about 30.3cm) arrived at 4:40 a.m., the second wave came at 5 a.m. with a height of 12 shaku, and the third wave arrived at 5:20 a.m. with a height of 11 shaku. There were 85 fatalities, 80 injured, 185 flooded houses, 161 houses completely destroyed, and 169 houses partly destroyed. In particular, the Ohta area in Shin-yashiki, the town of Higashi was completely destroyed: Enormous damage was done to ships, fishing tools, household effects, and agricultural products. At that time, no one thought about restoration. Though there were scarcely any goods shortly after the war, aid came to us from many areas. We establish this monument to remember with heartfelt gratitude the aid we received. The date of the monument is December, Showa 21 (December 1946).

STOP 6 *Asakawa Kannondo* temple 1707, 1854, 1946

After entering a lane and climbing up stone steps, one comes to a temple on a small hill overlooking Asakawa bay. Fossilized traces of sea creatures are visible at the top of the stairs. This temple was built to provide repose for the spirits of the dead from the tsunami of the 1707 Hoei earthquake, and a tribute to those dead is inscribed on a pedestal under a *Jizo* statue. Upon descend-

ing the stone steps, one comes to monuments of the 1854 *Ansei-Nankai* earthquake and the 1946 *Showa-Nankai* earthquake, which show the highest points reached by the tsunami waves. Looking at them, one can image the scale of the tsunami at the time of these earthquakes.

Fig.10 The highest points of the runup tsunamis near the *Kannondo* temple

[Epitaph of the 1707 Hoei earthquake in the Kannon Jizo temple]

A great earthquake occurred at around 2 p.m. on October 4 in Hoei 4 (1707). After the earthquake, a tsunami with a wave height of 9 m arrived, reached the foot of Kuraut hill, and soon withdrew. Except for the Senkoji temple, all the houses were carried into the sea and about 140 people drowned. For the repose of the souls of the dead, this monument was built.

STOP 7 *Misaki* shrine 1854

Although a fan-shaped picture frame describes the 1854 *Ansei-Nankai* earthquake at the next stop, the Senkoji temple, a monument inscribed with the same writing and the names of those killed by the tsunami exists in this *Misaki* shrine. Since the epitaph is illegible, a new monument was established in the shrine, showing the people's desire to convey the lesson of the tsunami to their descendants.


Fig.11 Stone monument of *Misaki* shrine

[Epitaph]

See the next fan-shaped picture frame in the Senkoji temple.
A picture frame of the tsunami votive tablet

Stop 8 Votive tablet and fan-shaped frame in the *Senkoji* temple 987, 1861

In the main hall of the temple, there is a votive tablet and a fan-shaped frame. In the votive tablet, people praying to their God *Yakushi Nyorai* in a boat shaken by the tsunami are drawn. On the right-hand side of this picture, the date is written as *Heinen* 1, which corresponds to AC 987. This clate is 100 years after the 887 *Ninna* earthquake and 100 years before the 1099 *Kowa* earthquake. The fan-shaped frame depicts the tsunami from the 1854 *Ansei-Nankai* earthquake.

[Epitaph]

The tsunami from a great earthquake

At around 8 a.m. on November 4, Ansei (1854), the ground shook for a while and the tide overflowed into the roads at about 10 a.m. People were fright-

Fig.12 Votive tablet and fan-shaped frame in the *Senkoji* temple

ened and brought their belongings up the mountain in a hurry and spent one night there with vigilance. The next day, it was clear without clouds and wind and the temperature was as high as that in March. Some people, who were worried and suspicious about the strange weather, brought their belongings to the top of the mountain. Some people thought that the disaster of the previous day was over. At around 4 p.m. a great earthquake occurred, and after that, a tsunami wave with a height of about 9 m rushed toward the bay like an arrow. A large tsunami wave reached the foot of the Urakami Karaut hill and ascended to the Isedato and Yamano-seki. That night, large tsunami waves attacked repeatedly.

Though the Tenmangu, the Ohtoshi, the Misaki shrines and three temples in Asakawa-Ura were not destroyed by the tsunami, all the other houses were washed away. Though all the houses were carried away in Toya at the west side of the Asakawa village, there were no fatalities nor injured there, since people were on the alert.

At the time of the Eisei and the Keicho earthquakes, there were also tsunamis. The event of the tsunami on October 4 in Hoei 4 (1707) is recorded in a Jizo stone statue in the Ine temple.

Until the tsunami in 1707, disasters recurred about every 100 years. The following earthquake occurred after 148 years. Even today, we must be vigilant when a great earthquake occurs and the temperature is not that expected for the season. This epitaph is provided for descendants to encourage preparation.

STOP 9 Center at the Asakawa fishing village

In this place, there is a monument to commemorate the 50th anniversary of the tsunami from the 1946 *Showa-Nankai* earthquake, a monument telling 10 lessons about tsunami, and a monument indicating the highest point of the tsunami wave from the 1946 *Showa-Nankai* earthquake. In a meeting room on the second floor of the fishing village center there are descriptions of the 1946 *Showa-Nankai* earthquake tsunami and precious photographs taken at the time of the disaster. In this excursion, we will listen to the experiences of victims and of *Haruyo Tai*, who published "*Shin-Cho-Ki*" as a written record of the *Nankai* earthquake in modern Japanese.

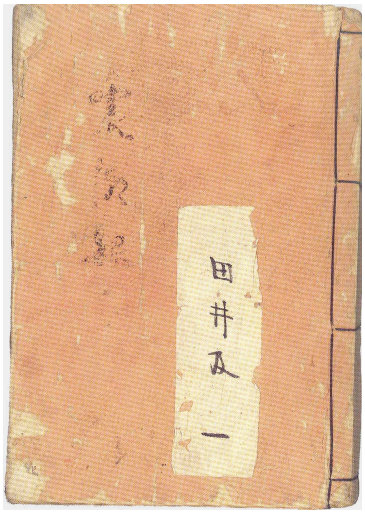


Fig.13 *Shin-Cho-Ki*

[Shin-Cho-Ki]

This book is a detailed record of the disasters caused by the earthquakes and tsunamis which attacked the town of Shishikui, Kaifu county, between the Eisei and Ansei eras ancestor. Haruyo Tai wrote this book in November 1854. The town of Shishikui was attacked by a large tsunami in 1512, the 1604 earthquake and tsunami, the 1707 earthquake and tsunami, and the 1854 earthquake. Because of this series of disasters, Shishikui experienced enormous damage. In April 1998, this book was designated a national cultural asset.

Fig.14 Mrs. Haruyo Tai.

Column-1

Asakawa Tsunami

A great earthquake with a magnitude of 8.1 occurred at 4:19 a.m. on December 21, 1946 off the Kii peninsula; we call this the "*Showa Nankai* earthquake". A large tsunami attacked villages along the coast. The damage in Asakawa was enormous. There were 85 fatalities, 164 completely destroyed houses, and 44 houses washed away. We can recognize that the Asakawa region experienced destruction by the *Hoei* and *Ansei* tsunamis from the many monuments to tsunamis .

Fig.15 Landforms and the ground

Here we replicate the situation of an onrushing tsunami from knowledge of the affected area and physical traces.

The tsunami which attacked Asakawa had periods 20 minutes long. The height of the first wave was 2.7-3.6m; the second, 3.6-5.2m; and the third, 3.3-4.4m. The tsunami came into Asakawa Bay from the direction shown in Figure 8. Figure 15 shows the geography and topography in the Asakawa region. There is a high beach ridge along the coast, the Urakami River flows to the back, and an estuary lines to the south. Figure 8 shows the area flooded in the 1946 *Showa-Nankai* earthquake and the 1854 *Ansei-Nankai* earthquake. We recognize that the flooded area extends to the low-lying area of the beach in both events. Most of the area in the village of Asakawa was flooded except for temples and shrines at the base of the mountains. Comparing both events, the *Ansei* tsunami seems to have flooded a wider area.

Figure 16 shows the maximum flooded height distribution of the *Nankai* earthquake. The height flooding increased where the mountains approach the coast, and it decreased inland. An iso-

Fig.16 Maximum flooded height distribution relative to sea surface

Fig.17 Height of flooding from the ground

water line stretches upstream of the mouth of the river, and then the iso-water line becomes dense. A tsunami flowed into the Urakami River and raised the water level, and the surface of the water inclined suddenly, and then a bridge was washed away.

Figure 17 shows the height of flooding from the ground. In the Urakami River mouth, we recognize that the depth of flooding reached 2.5 to 3.0m.

Fig.18 Velocity distribution of tsunami flow

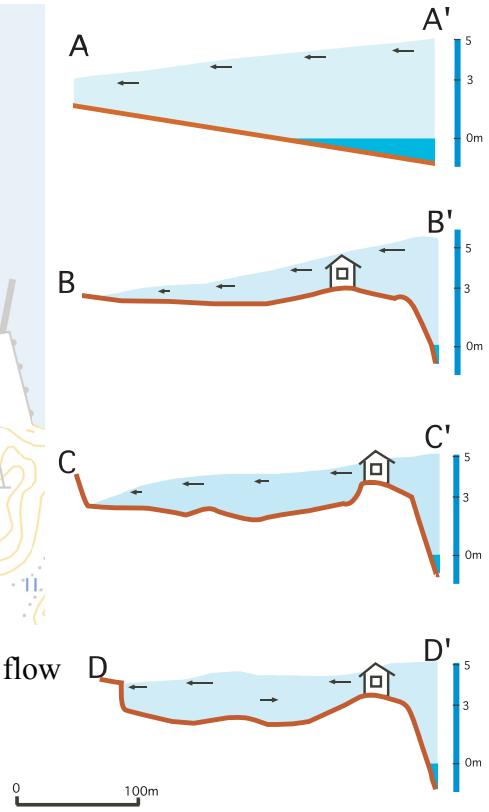


Fig.19 Profiles of topography and tsunami flow

Figure 18 shows the direction and speed of the flow of the tsunami that flooded the center of a village. The tsunami progressed inland from the shore. Then, it flowed into the Urakami River and flooded the land around the river. Then it joined the inshore flow and drifted toward the upper reaches of the Urakami River. Finally, the flow slackened in the vicinity of an elementary school, and many items washed away by the tsunami accumulated there.

Figure 19 shows the profiles of the flux. The water level generally fell as it moved inland. In the case of the profile B-B', when there was not a mountain at the back, the drop in the surface of the water incline is remarkable. However, there is a mountain at the back in the profile D-D', and the surface of the water incline decreased. If the period of a tsunami is longer than this tsunami, the water level may rise near the mountains more than at the shore regions in profiles D-D' and C-C'. A dilatational wave is sufficient for there to be a danger of a house being dragged underwater.

Figure 20 shows the distribution of houses in a disaster in the Asakawa region. The reason why the rate of destruction is small at the mouth of the Urakami River is that a sandy shoal at the mouth of the Urakami River controlled the force of the tsunami. At a break in a levee, a large ship was unmoored and destroyed a house in the district. However the water speed was not high, the rate of destruction of houses upstream was small.

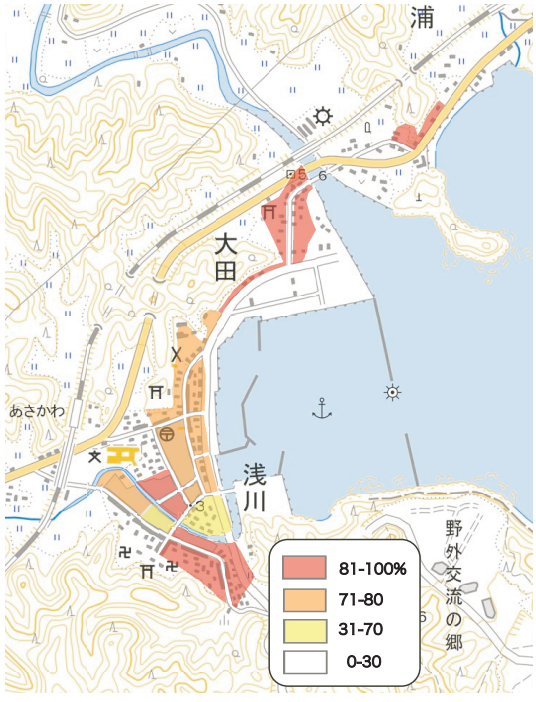
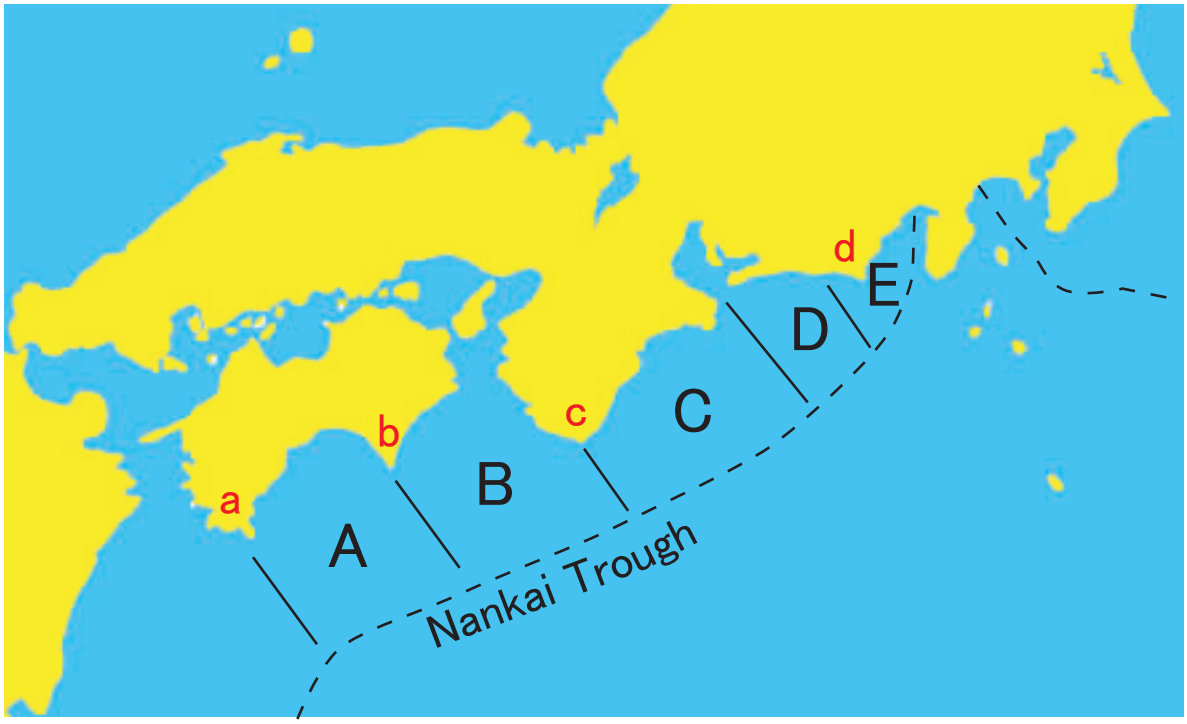


Fig.20 Distribution of houses in a disaster

Column-2

Repetition of the *Nankai* earthquake

The most recent *Nankai* earthquake occurred on December 21, 1946, the *Showa-Nankai* earthquake. The damage extended from the Chubu district to the Kyushu district. There were 1,330 fatalities, 3,842 injured, 11,591 completely destroyed houses, and 2,598 partly destroyed houses. In Tokushima prefecture, there were 202 fatalities, 602 completely destroyed houses, 413 flooded



a:Cape Asizuri, b:Cape Muroto, c:Shionomisaki, d:Omaezaki

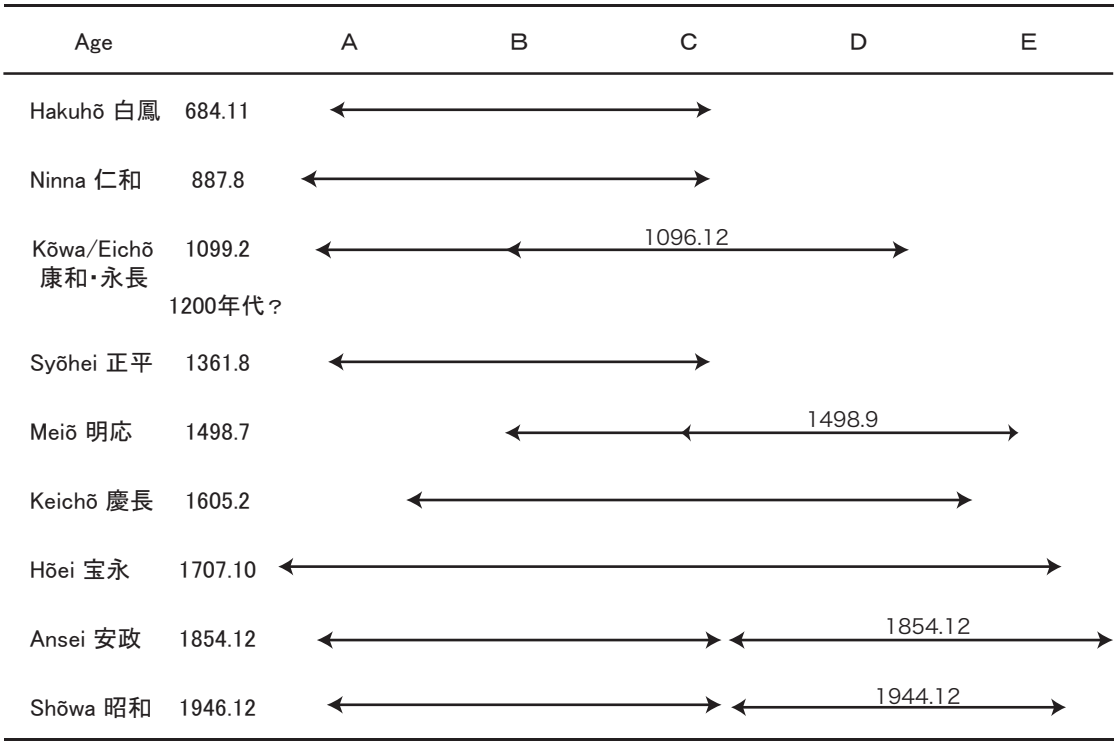


Fig.21 Segmentation of the *Nankai* and *Tokai* earthquake along the *Nankai* trough

houses, and 914 partly destroyed houses.

The earliest known *Nankai* earthquake, which is documented in "*Nihon Shoki*", was the *Hakuho-Nankai* earthquake that occurred in 684, and nine earthquakes are documented in historical times, as shown in Figure 21. There are few regions in the world where so many huge earthquakes have occurred repeatedly in the same place. The recurrence time has been about 90 to 150 years since the 1605 *Keicho* earthquake. This is a very long interval, and, as the saying goes, "A natural disaster comes again when we have forgotten it"

Alhough before 1605 the recurrence time was 200 to 260 years, it is hard to assume that the recurrence time has changed. It is very likely that historical documents have been scattered and lost on do not reflect on understanding of the events. For example, there was an earthquake in 987 (*Eien* 1), which is indicated on a picture frame of a tsunami votive tablet in *Senkoji*, which we will visit this excursion. This earthquake occurred between the 887 *Ninna* and 1096 *Eicho* earthquakes, and the recurrence time was about 100 years.

We can recognize that it is rare that *Nankai* earthquakes occur separately; they occur with the same frequency as the *Tokai* earthquakes shown in Figure 21. In the case of the *Showa-Nankai* earthquake, the *Tonankai* earthquake occurred two years before the *Nankai* earthquake. In case of the *Ansei-Nankai* earthquake, the *Ansei-Tokai* earthquake occurred 32 hours before the *Ansei-Nankai* earthquake. In case of the *Hoei*-earthquake, the *Tokai* and

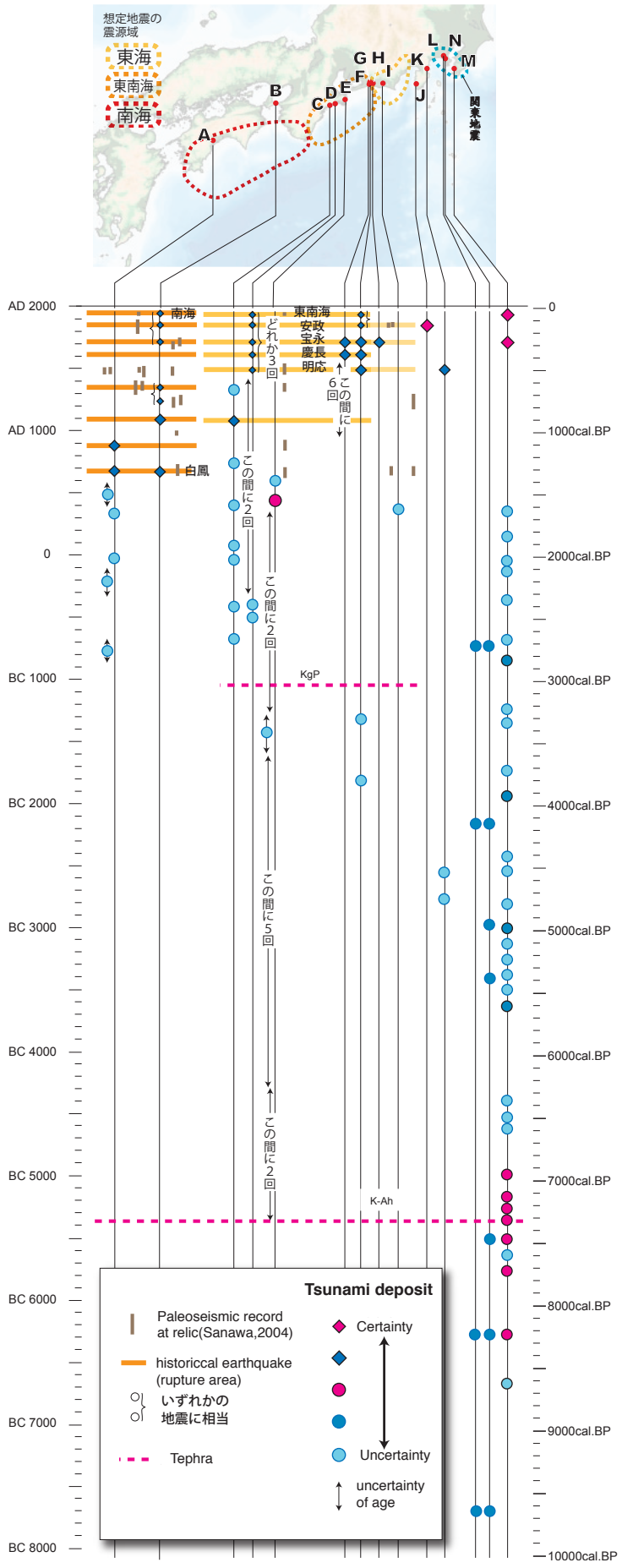


Fig.22 Tsunami deposit distribution after Komatsubara(2005)

Nankai earthquakes occurred at the same time and seems to be the largest earthquake among the historical events.

To evaluate historical earthquakes, we can examine historical documents that were left in temples and among the nobility, and monuments of earthquake and tsunami. On this excursion, we will visit many monuments to earthquakes and tsunamis, and we will see "*Shin-Cho-Ki*"

However, few historical documents reveal the early history. In the times without a letter, we examine history using physical remains such as sediment from tsunamis that remained on the ground. Since *Nankai* earthquakes occur on the bottom of the ocean along the Nankai trough, we can examine traces in the ground(Fig.22). We have identified 5 events based on the tsunami sediment at *Suzaki-Shi Tasukugaike*, Kouchi prefecture.

Refercence

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