A Study of blasting vibration influence to ILC project using high sensitivity seismograph networks (Hi-net) in granite site

Ichiro Sekine [A)], Ryou Wakatake [A)], Masakazu Yoshioka [B)] ,
Tomoyuki Sanuki [B)], Satoru Yamashita [C)] ,
Katsuhiko Shiomi [D)], Tsuneya Tsubokawa [E)]

[A)] Toda Corporation, [B)] Tohoku University, [C)] Tokyo University,
[D)] NIED, [E)] Shin ei Keisoku

1. Background of this study

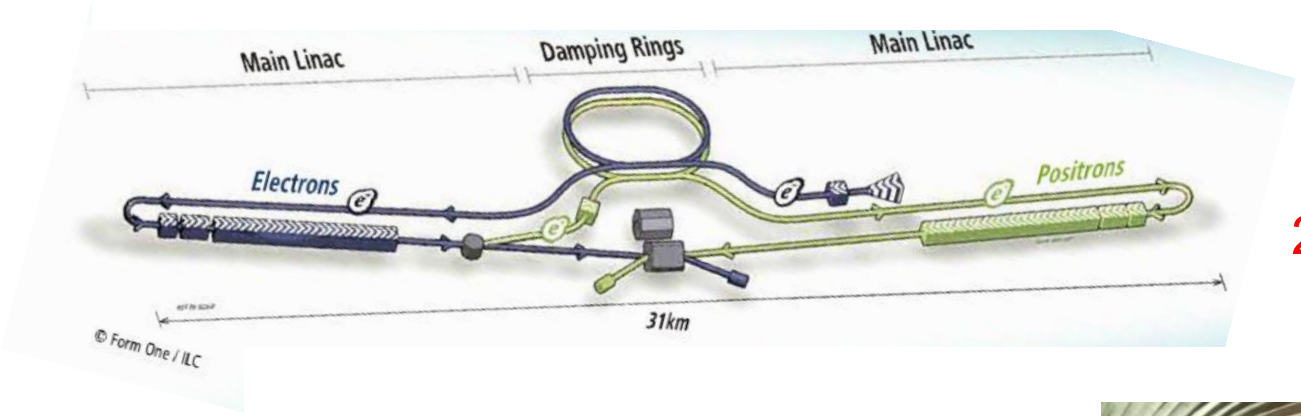
2. Blasting vibration with excavation in a granite area

3. Blasting vibration study at Kitakami candidate site

4. Conclusion

1 . Background of this study

・ILC is expected of invitation to Japan. In order to increase collision energies, it's considered that ILC extends the length of beamline during an experiment.



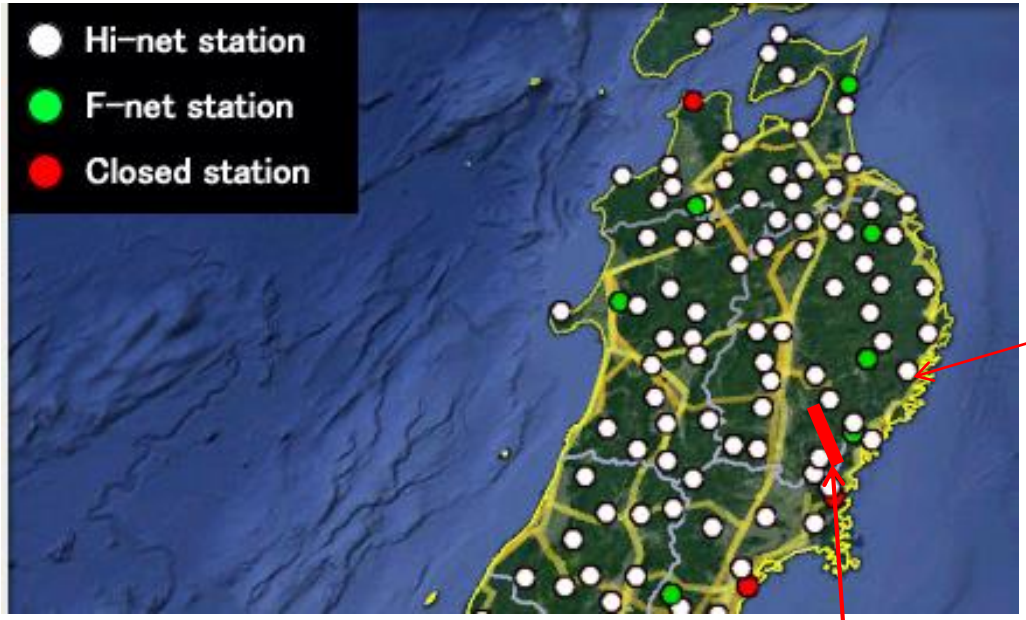
It extended

20km start → 31km

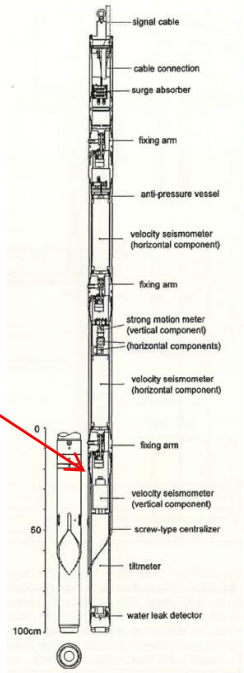
・ Blasting is used for extended excavation in tunnel facilities.

We have to consider the influence of blasting for ILC project.

・ There are a lot of seismograph (Hi-net etc.) installed by NIED (National Research Institute for Earth Science and Disaster Resilience) etc. in Japan.



Velocity seismometer (Vertical)



ILC Kitakami candidate site

Hi-net is installed 100m underground from surface

・ In this presentation we studied the blasting vibration observed by seismograph of Hi-net etc. and researched the data about the spread of the blasting vibration to the distant place.

2. Blasting vibration with tunnel excavation in a granite area

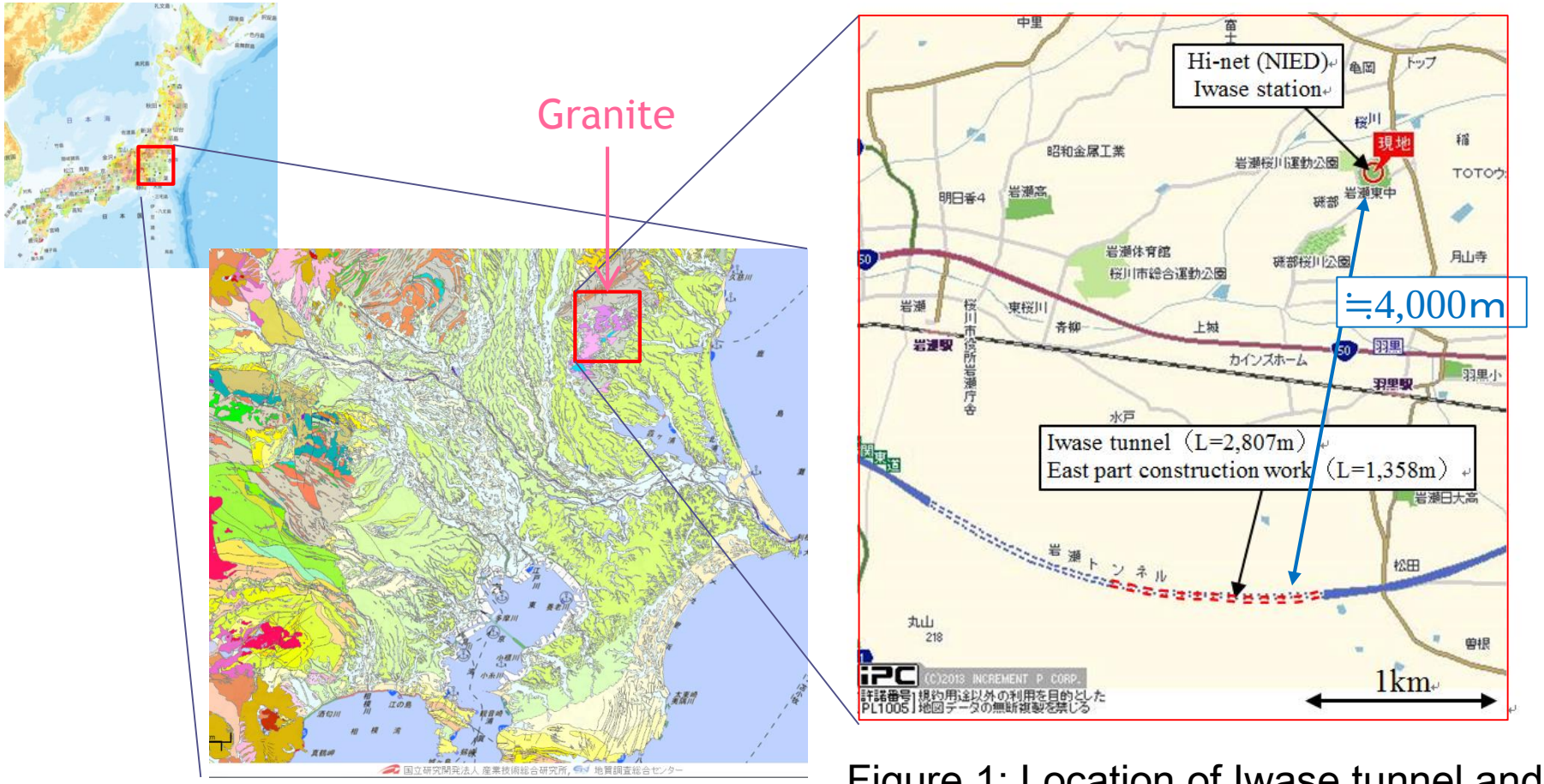


Figure 1: Location of Iwase tunnel and Iwase station.

Location of Iwase tunnel and Hi-net station for blasting study

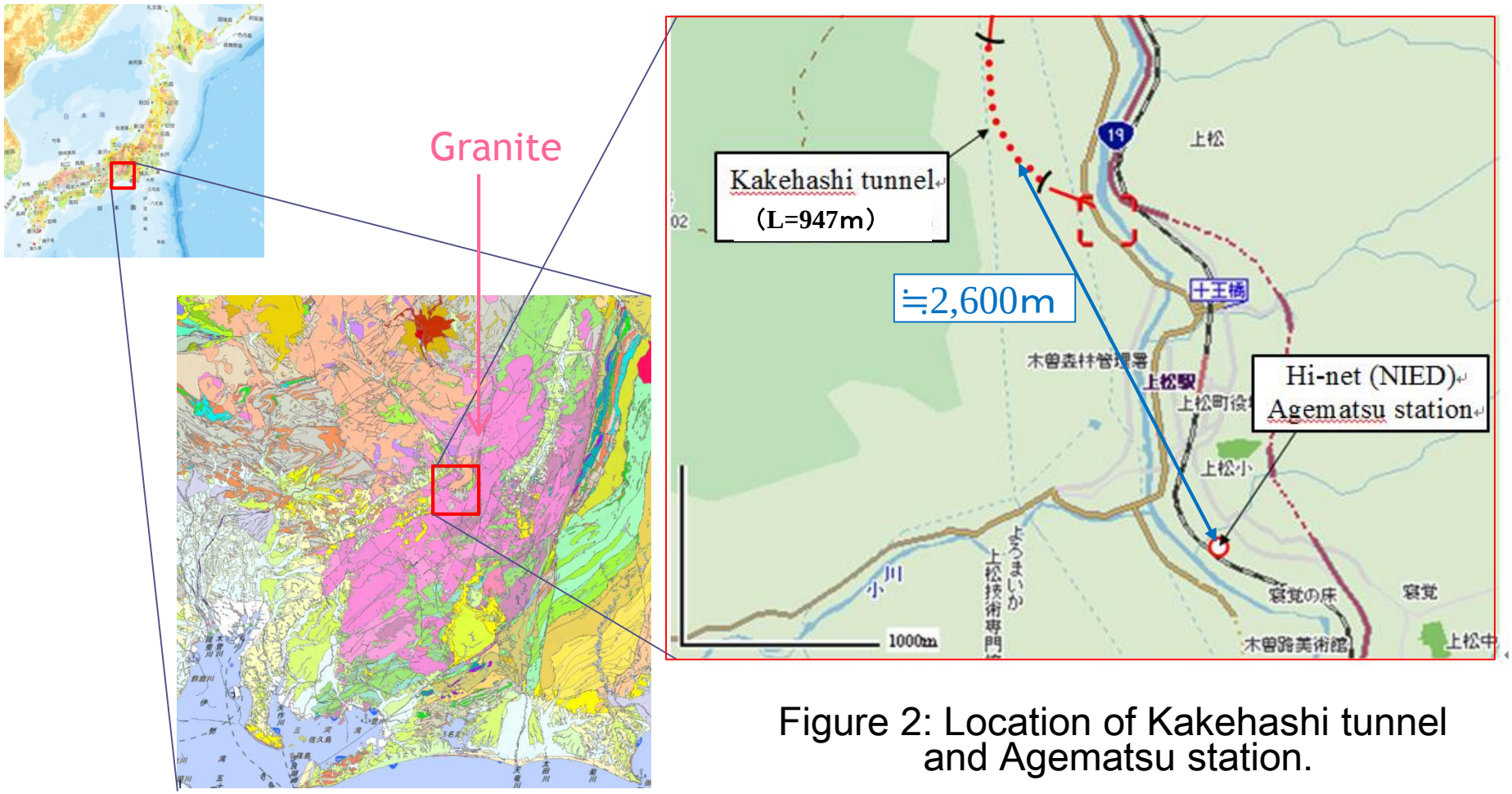
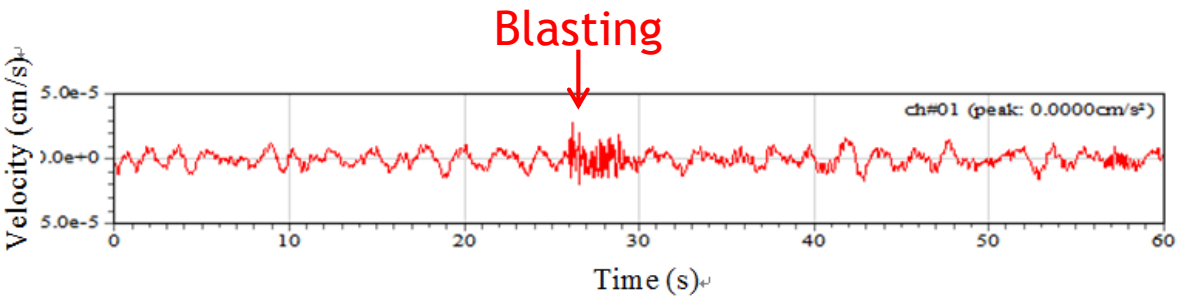
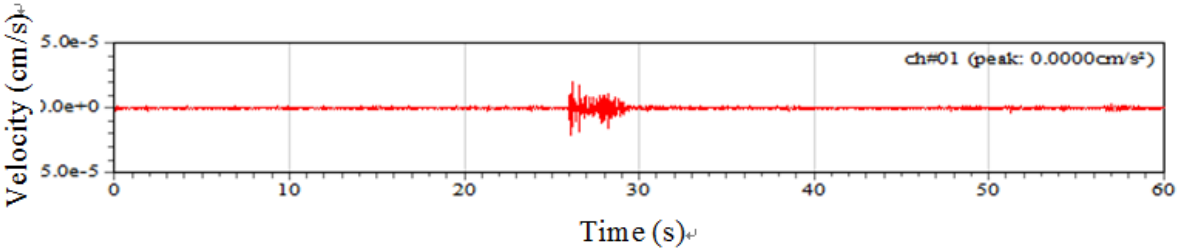


Figure 2: Location of Kakehashi tunnel and Agematsu station.

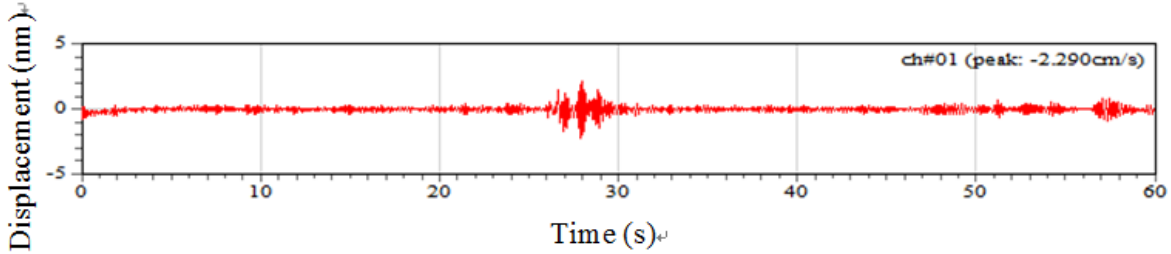
Location of Kakehashi tunnel and Hi-net station for blasting study



a) Velocity wave form



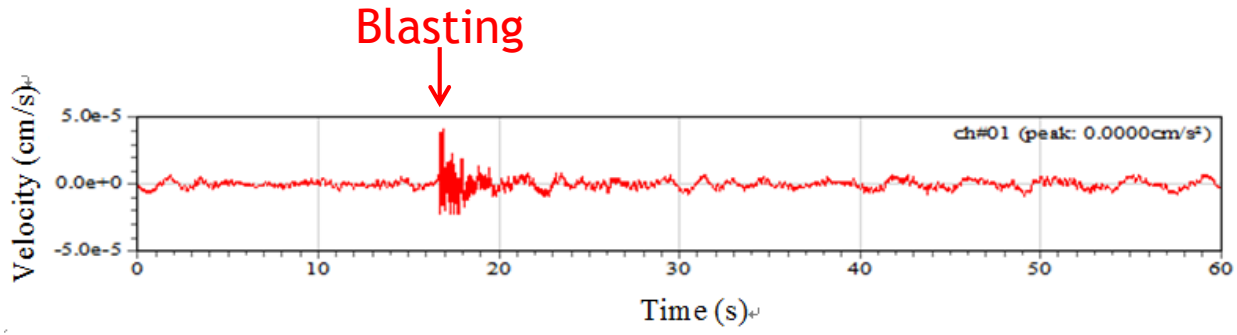
b) Velocity wave form filtered under 5Hz



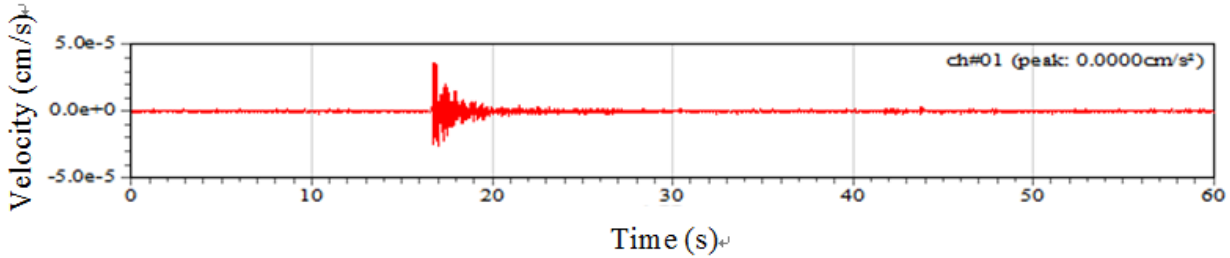
c) Displacement wave form filtered under 5Hz

It is obtained by integration of velocity wave form.

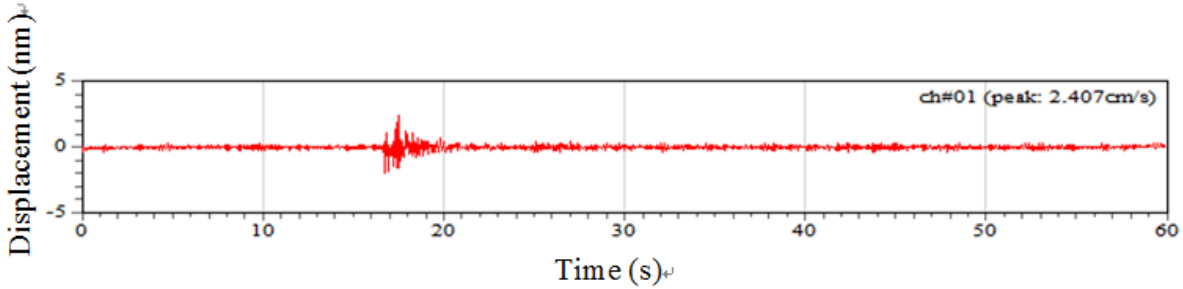
Figure 4:
Typical waveform observed at Iwase station caused by blasting at Iwase tunnel.
(Time: 2006.3.28 02:19, Charging weight for blasting :39.9kg/step, Distance: 4,045m)



a) Velocity wave form

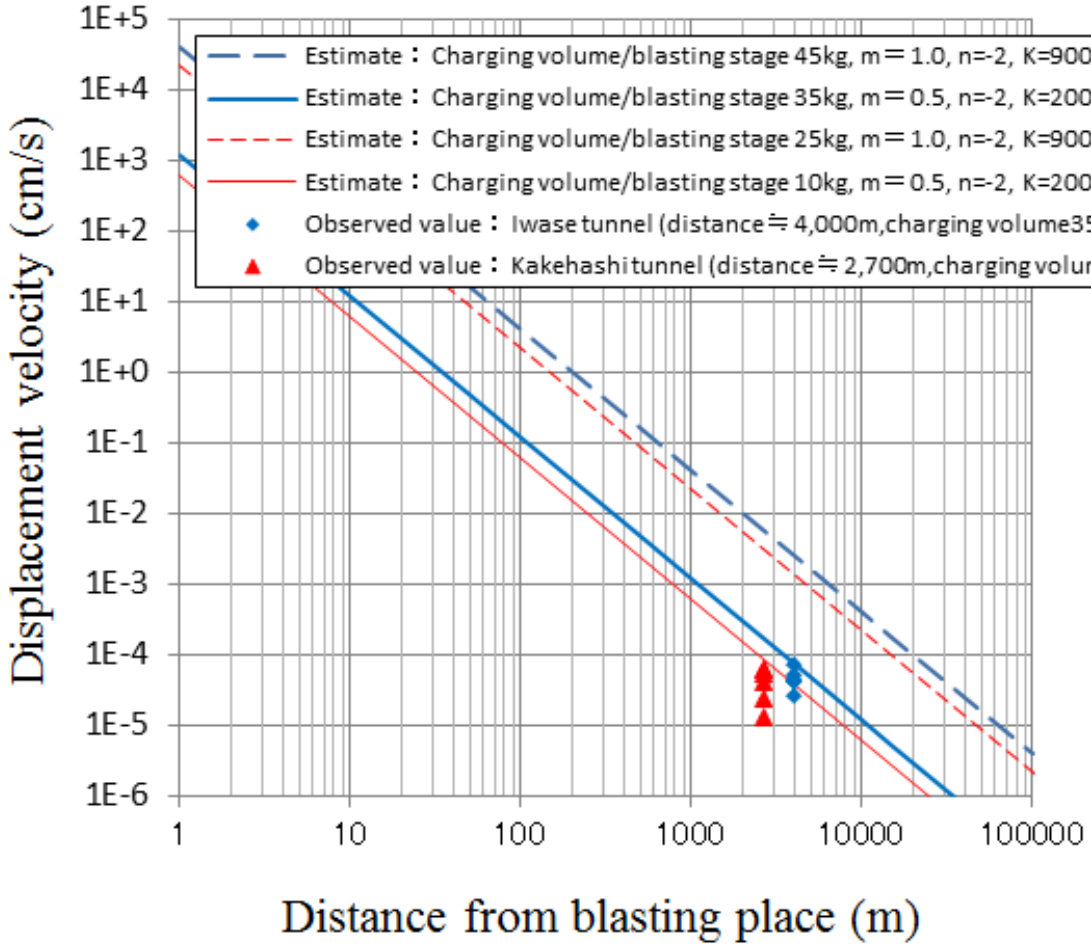


b) Velocity wave form filtered under 5Hz



c) Displacement wave form filtered under 5Hz

Figure 5:
Typical waveform observed at Agematsu station caused by blasting at Kakehashi tunnel.
(Time: 2012.6.13 09:34, Charging weight for blasting :24kg/step, Distance: 2,660m)



$$V = K \times W^m \times D^n$$

V : Displacement Velocity(cm/s)
K : Factor related to blasting condition and rock property（200～900）
W : Charging Volume of blasting stage(kg)
D : Distance from blasting place(m)
m : Experimental facter（0.5~1.0）
n : Experimental facter（-2）

Figure 6: Relation between displacement velocity and distance from blasting place

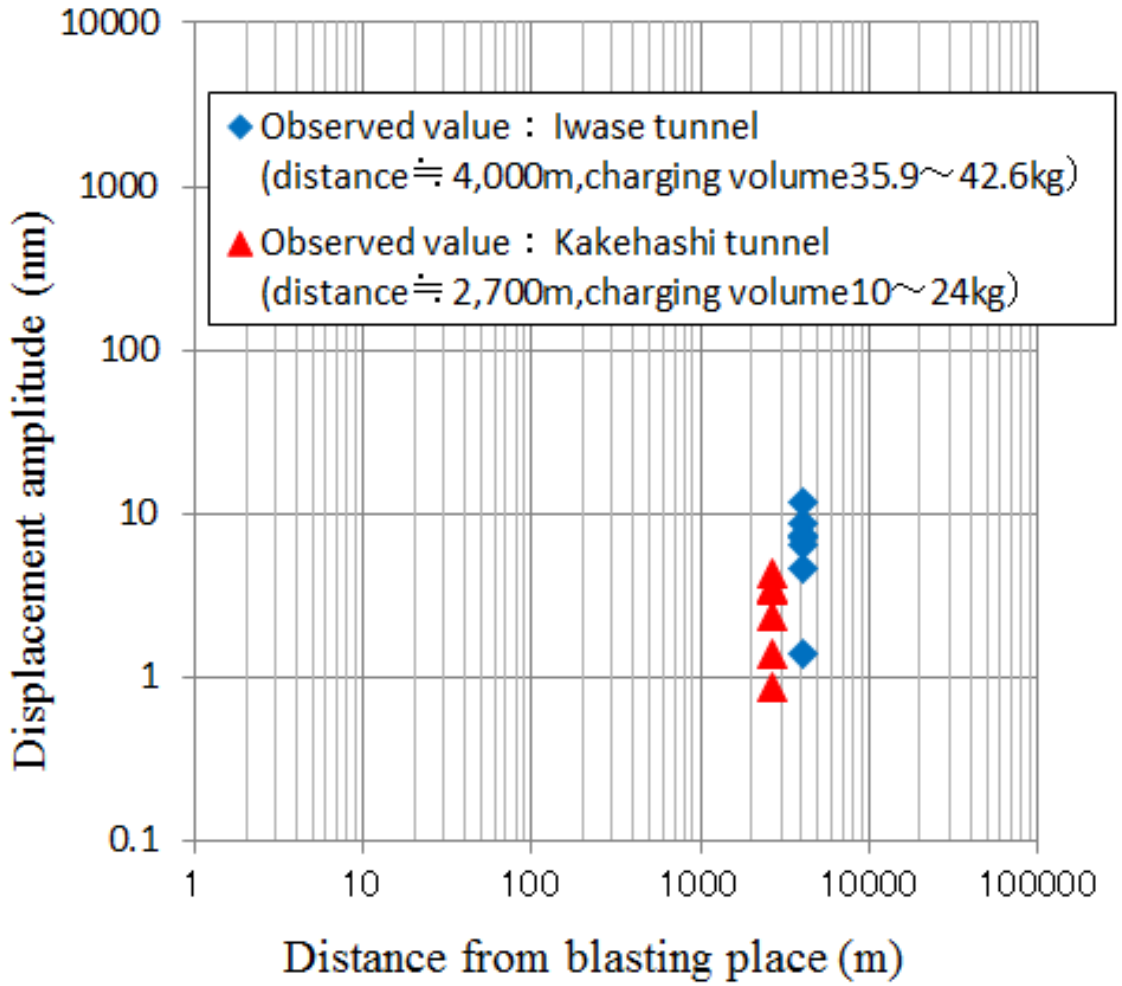


Figure 7: Relation between displacement amplitude and distance from blasting place.

3. Blasting vibration study at Kitakami candidate site

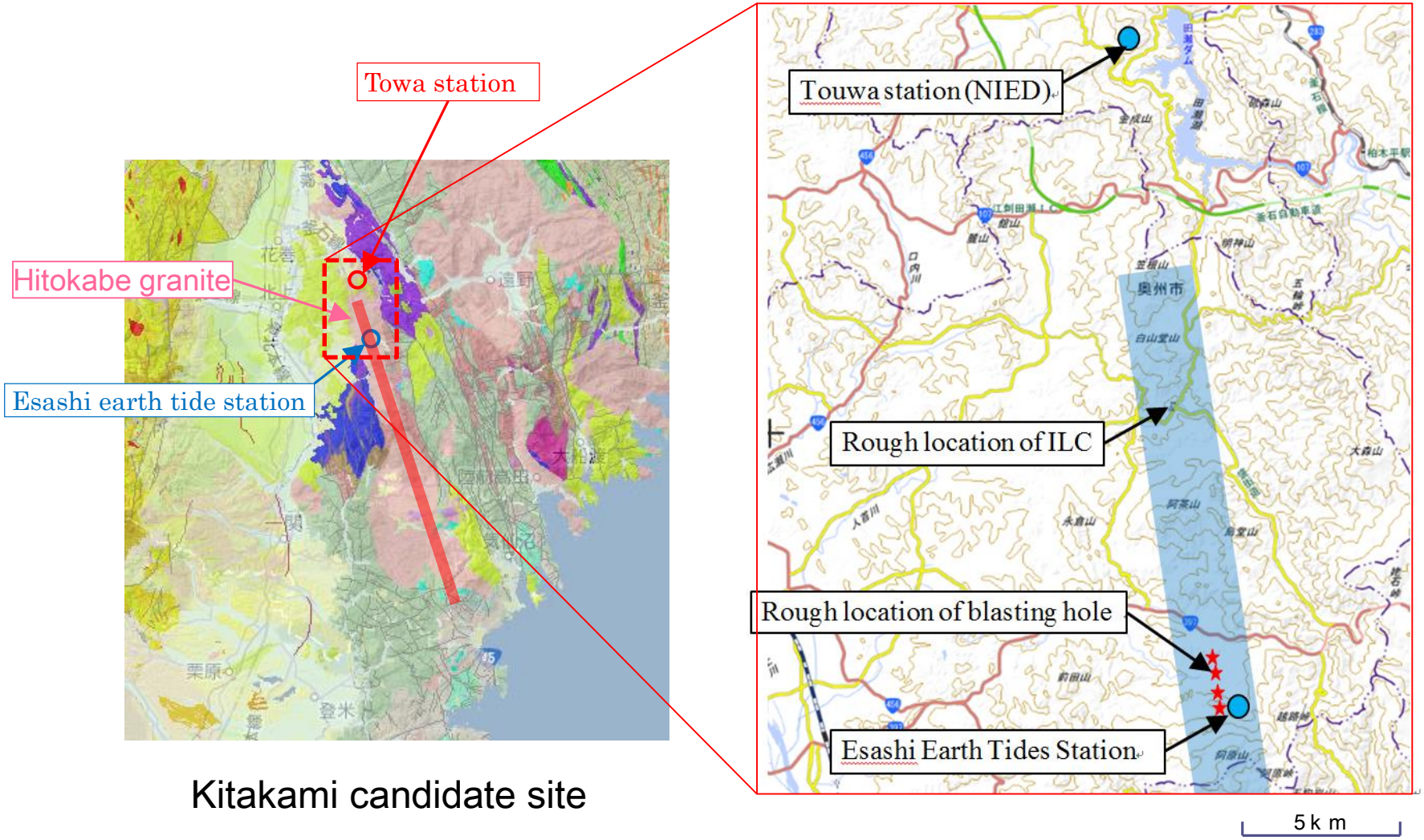
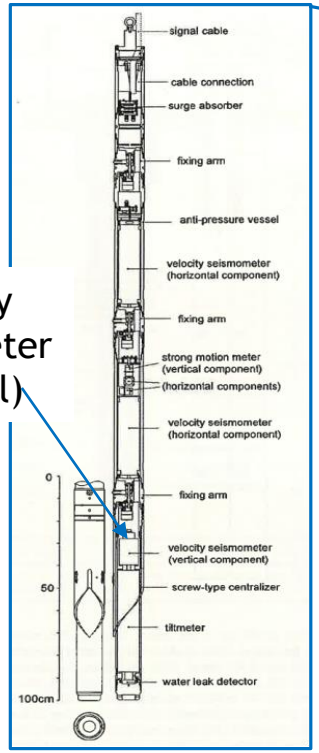
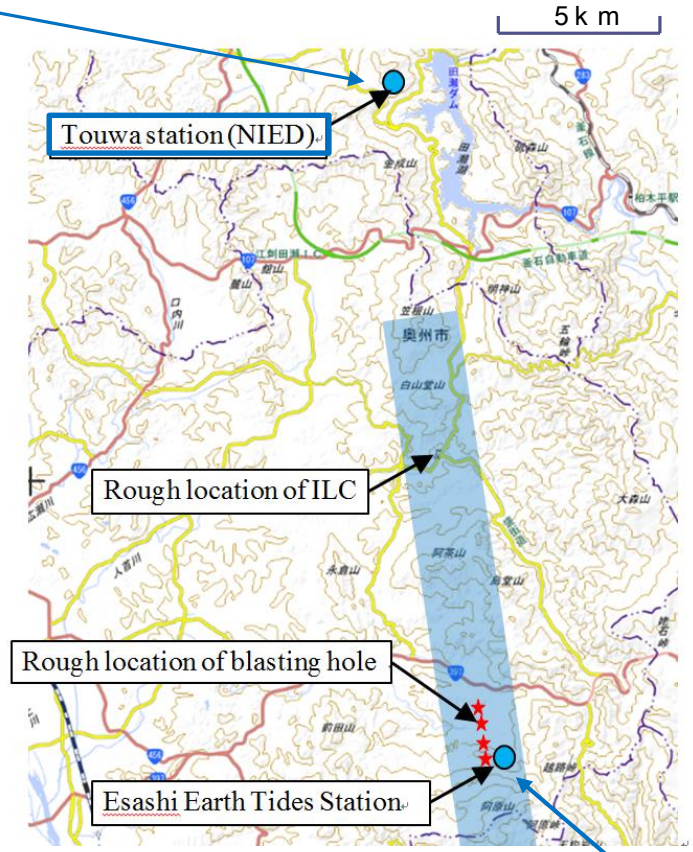


Figure 8: Location of blasting hole, Esashi earth tides station and Towa station.



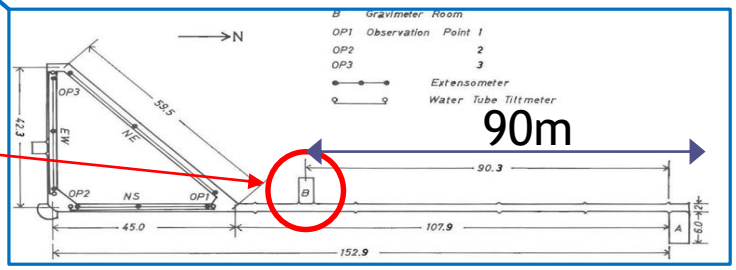
Velocity seismometer (Vertical)

Hi-net
（installed in the hole underground 100m）



Underground facility
(Esashi Earth Tides Station)

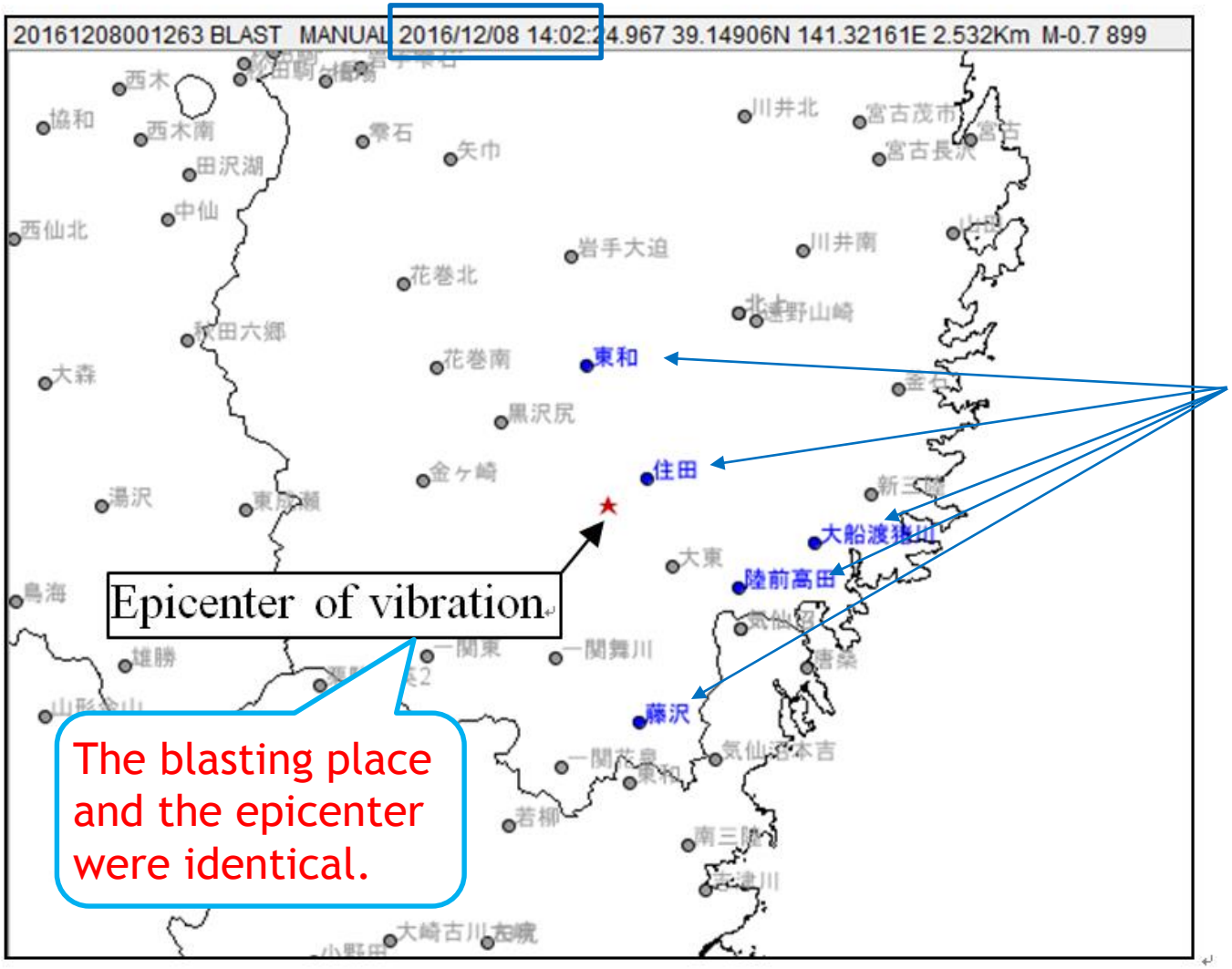
Velocity seismometer



Detail of observation station of this study

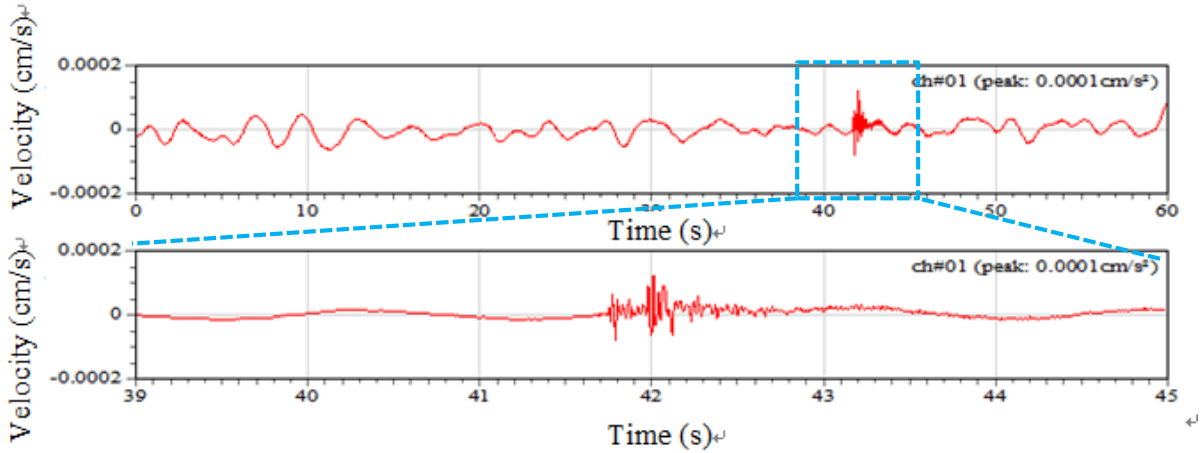
Table 1: Blasting for this study

Blasting time (2016/)	Blasting hole No.	Distance to Esashi earth tides station (m)	Distance to Towa station (m)	Depth of blasting (m)	Charging volume (kg)
12/5/13:20	Bor.3	1,147	19,103	14.5	1.0
12/6/13:10	Bor.1	2,950	17,300	22.0	2.0
12/6/13:30	Bor.3	1,147	19,103	14.5	1.0
12/6/13:54	Bor.4	275	20,250	14.0	0.2
12/6/14:25	Bor.2	2,022	18,228	20.0	1.0
12/8/12:57	Bor.2	2,022	18,228	20.0	3.0
12/8/13:27	Bor.3	1,147	19,103	20.0	1.5
12/8/14:02	Bor.4	275	20,250	14.0	3.0

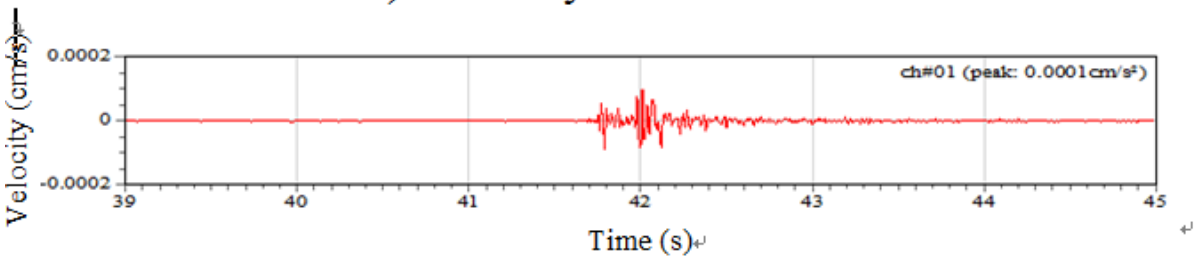


Hi-net station where vibration was observed.

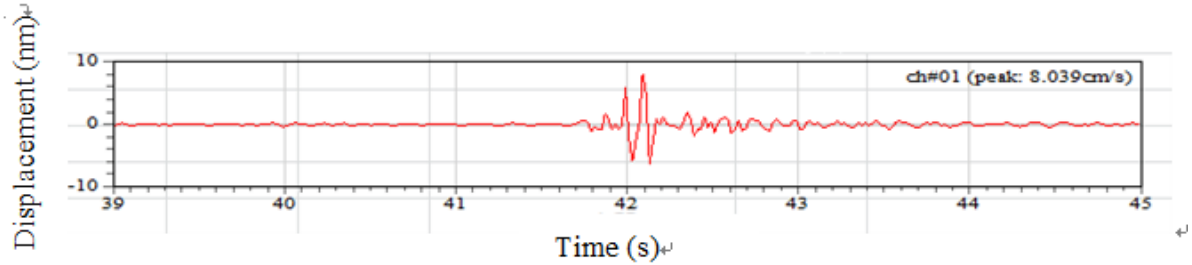
Figure 11: The estimate location of epicenter of vibration.



a) Velocity wave form.



b) Velocity wave form filtered under 5Hz.



c) Displacement wave form filtered under 5Hz.

Figure 9:
Typical waveform (UD) observed at Esashi Earth Tides Station caused by blasting at Bor.1.
(Time: 2016.12.5 13:20, Charging weight for blasting :1.0kg, Distance: 1.15km)

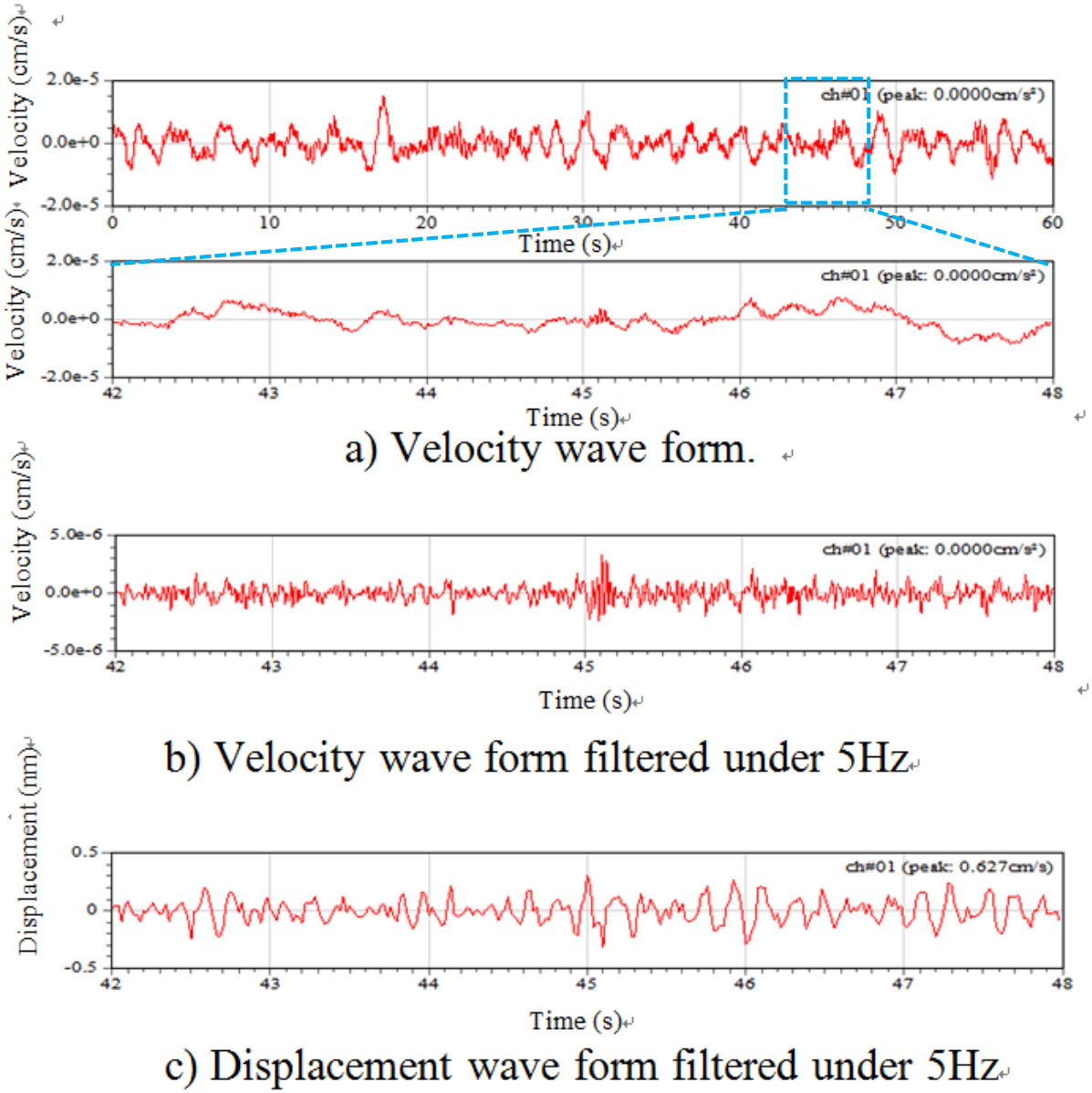
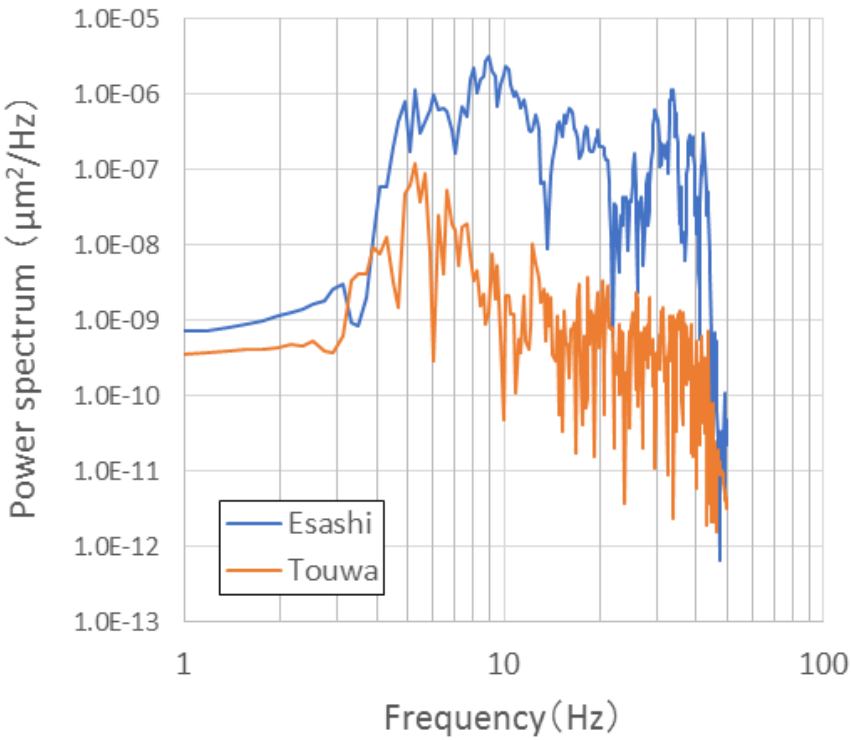


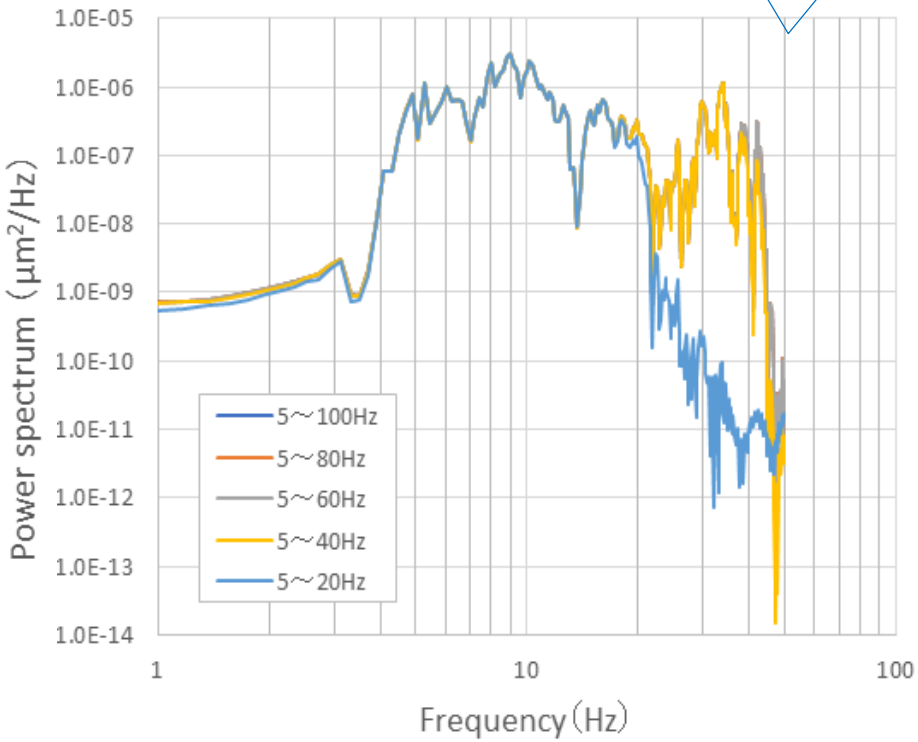
Figure 10:
Typical waveform(UD) observed at Towa station caused by blasting at Bor.1.
(Time: 2016.12.5 13:20, Charging weight for blasting :1.0kg, Distance: 19.1km)

We can discuss under 40Hz



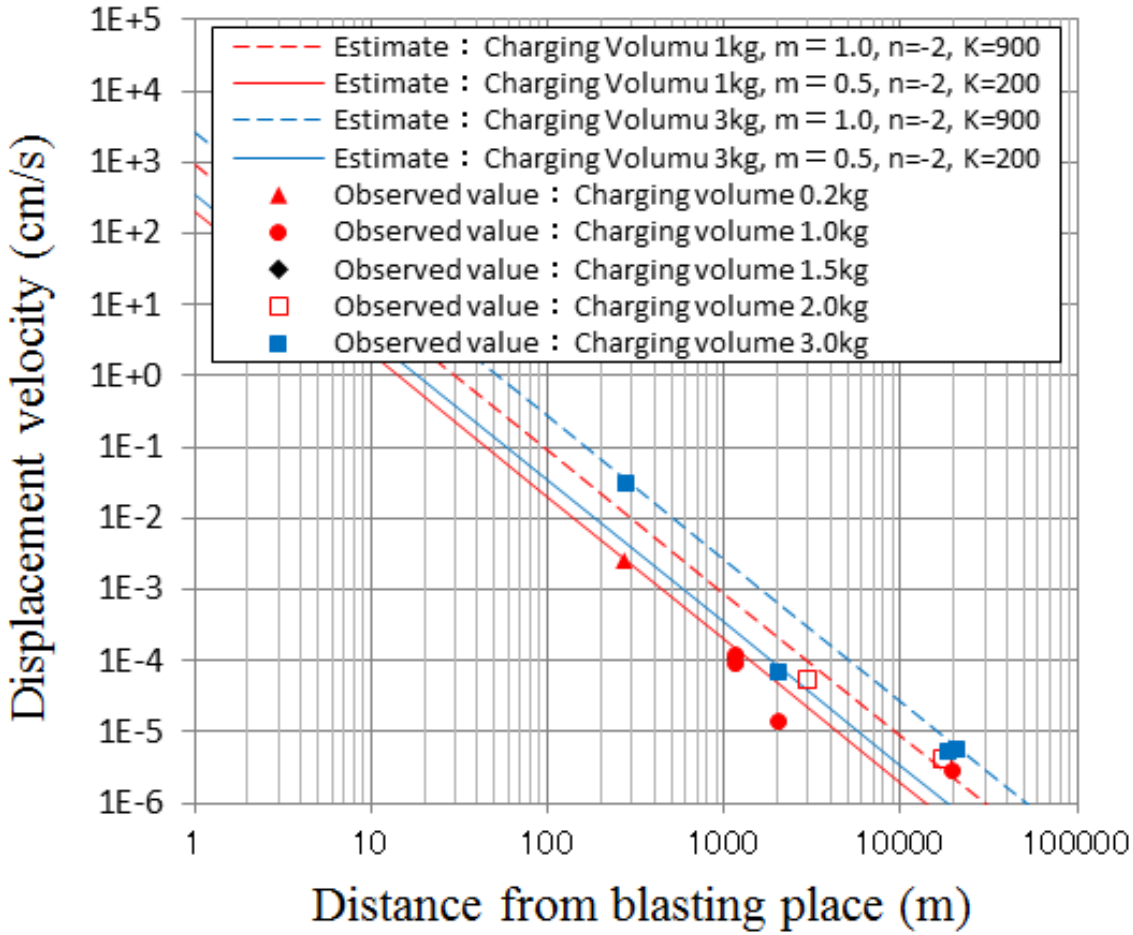
2016/12/5 13:20　5 seconds from blasting
Direction : UD　Filter : 5Hz

Figure 10-1: Comparison of Power spectrum between Esashi and Towa



2016/12/5 13:20　5 seconds from blasting
Direction : UD

Figure 10-2: Comparison of Power spectrum by a filter at Esashi



$$V = K \times W^m \times D^n$$

V : Displacement Velocity(cm/s)
K : Factor related to blasting condition and rock property（200～900）
W : Charging Volume of blasting stage(kg)
D : Distance from blasting place(m)
m : Experimental facter（0.5~1.0）
n : Experimental facter（-2）

Figure 12: Relation between displacement velocity and the distance from blasting place.

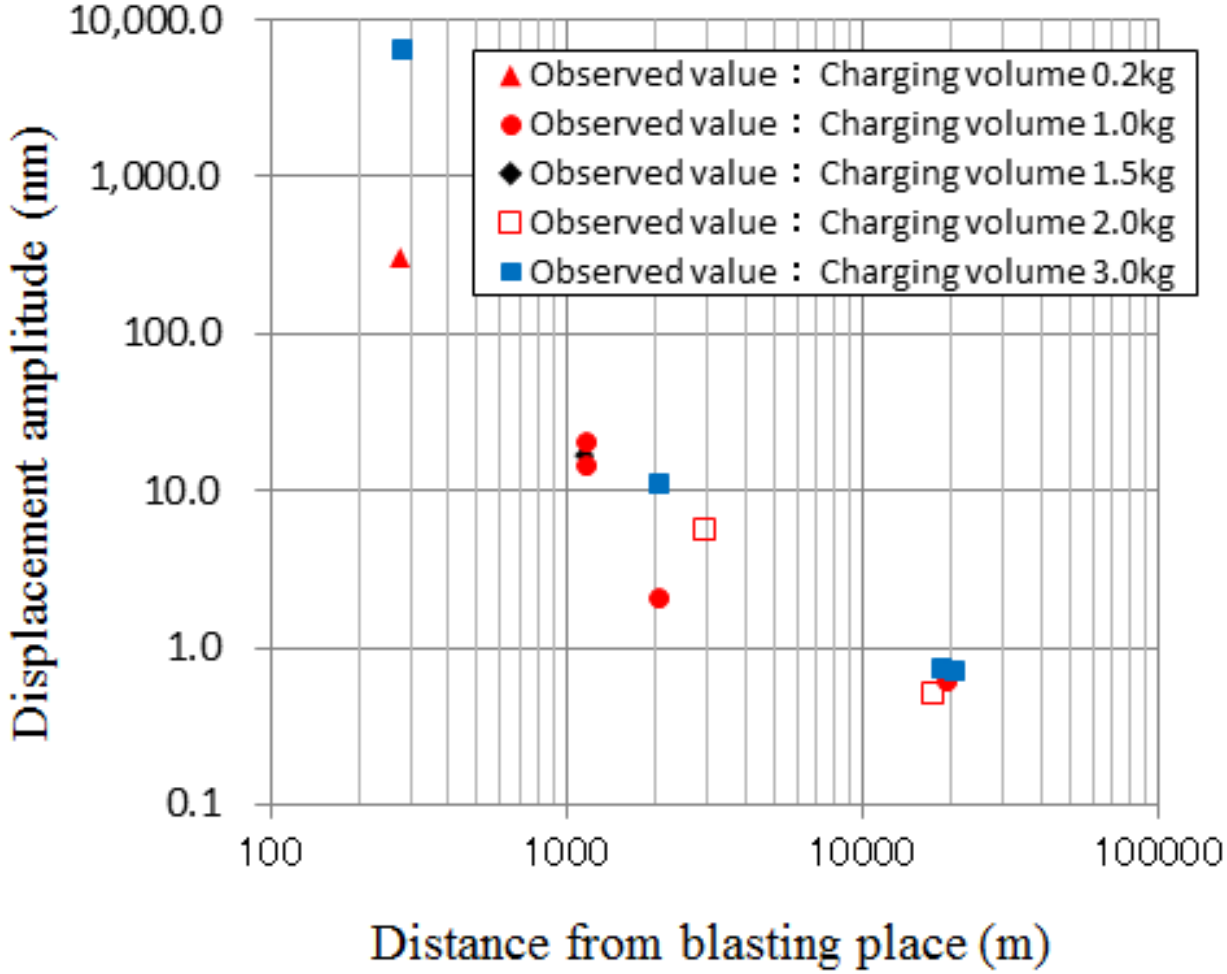


Figure 13: Relation between displacement amplitude and the distance from blasting place.

Table 3: Summary of Measurement result in Kitakami candidate site

Blasting data		Esashi Earth Tides Station			Touwa station (Hi-net)			Esashi～Touwa
Blasting time (2017.12)	Direction	Recieving time (s)	Velocity amplitude (cm/s)	Displacement amplitude (nm)	Recieving time (s)	Velocity amplitude (cm/s)	Displacement amplitude (nm)	Vp (km/s)
5/13: 20	UD	41.67	1.89E-04	14.5	45.03	5.75E-06	0.63	5.34
	NS	41.60	2.04E-04	10.1	45.01	7.46E-06	0.37	5.27
	EW	41.65	1.63E-04	8.6	45.06	5.25E-06	0.33	5.27
6/13: 10	UD	6.85	1.06E-04	5.80	9.52	8.39E-06	0.51	5.37
	NS	6.80	1.60E-04	8.03	9.53	9.87E-06	0.94	5.26
	EW	6.88	1.16E-04	6.62	9.52	7.67E-06	0.72	5.44
6/13: 30	UD	37.42	2.51E-04	20.5	Earthquaqe viblation was detected.			
	NS	37.42	2.65E-04	14.4				
	EW	37.41	2.27E-04	10.7				
6/13: 54	UD	5.86	4.94E-03	304.0	Blasting viblation wasn't detected clearly.			
	NS	5.81	2.20E-03	133.0				
	EW	5.78	4.05E-03	207.0				
6/14: 25	UD	41.04	2.90E-05	2.14	Blasting viblation wasn't detected clearly.			
	NS	41.05	3.87E-05	1.82				
	EW	41.04	2.49E-05	1.40				
8/12: 57	UD	21.99	1.43E-04	11.20	25.06	1.11E-05	0.76	5.28
	NS	22.10	1.84E-04	8.90	25.04	1.37E-05	0.95	5.51
	EW	22.08	1.22E-04	6.67	25.05	7.98E-06	0.61	5.46
8/13: 27	UD	36.68	2.26E-04	16.9	Earthquaqe viblation was detected.			
	NS	36.60	2.22E-04	12.3				
	EW	36.61	2.01E-04	10.5				
8/14: 02	UD	25.12	6.65E-02	6530	28.82	1.21E-05	0.72	5.32
	NS	25.14	2.94E-02	2570	28.81	1.04E-05	0.75	5.37
	EW	25.11	4.64E-02	2680	28.84	8.45E-06	0.65	5.28

※Velocity wave and displacement wave were filtered with 5Hz.

Average Vp of Hitokabe granite was 5.35km/s

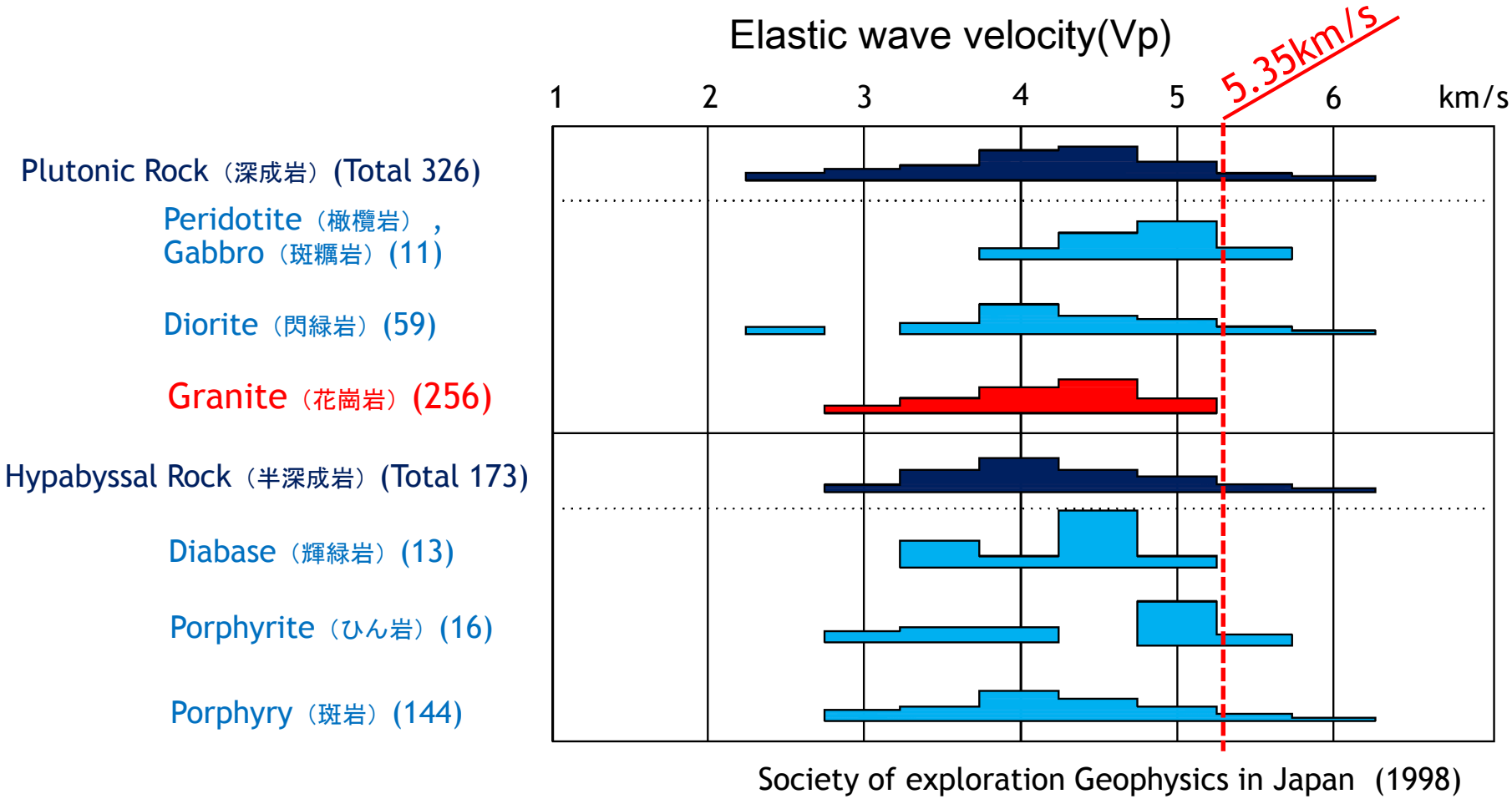


Figure 14 : Distribution of elastic wave velocity (Vp) of granite etc. in Japan.

4. Conclusion (1/2)

1) After blasting data at the time of tunnel excavation in a granite area was investigated, the displacement amplitude of vibration with blasting could get a result with about 1 ~10nm by distance 2-4km.

2) The vibration at a distant place by blasting was checked in the Hitokabe granite. The displacement velocity was adjusted to the blasting vibration estimated formula which is usually used mostly.

3) The displacement amplitude of vibration was about 10 nm by the distance of the 1~2km from the blasting location. When I consider that the frequency of blasting by tunnel excavation is about 0~4 times/day, The blasting vibration isn't quite so influential compared with micro earthquake.

4) Average Elastic wave velocity (Vp) of Hitokabe granite was 5.35km/s in 20 km of area from Esashi earth tides station to Towa station. We could confirm that very good granite is distributed in this area.

4. Conclusion (2/2)

- The vibration of Machine for tunnel excavation is more important problem. Because those machines are working long.

- The vibration by blasting has more high-frequency content than that measured by seismometer for earthquake observation.

As a result, we considered the reference data was obtained for the vibration with blasting. If this study will give useful information for the construction of facilities by staging, we will be very happy.

Thank you very much for your kind attention.