Borehole Array observation system operated by Tono Research Institute of Earthquake Science and Some Interesting Result

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Our principles for deep borehole observation

1. Instrument installation to the deep borehole

Deep borehole (**deeper than about 500m**) enables ***<u>the high S/N ratio observations</u>*** for detecting very small signals without both artificial noise and meteorological disturbances.

2. Multi-component observation

The cost of digging deep borehole is too expensive.

Therefore, in order to bring cost down per a sensor, we have developed **multi-component borehole instrument** for deep borehole.

3. Certain installation and data acquisition

a. Realtime monitoring of all sensors during the installation. We can immediately make sure of the installation succeed

b. Thorough lightning protection installation

4. In-situ stress measurement

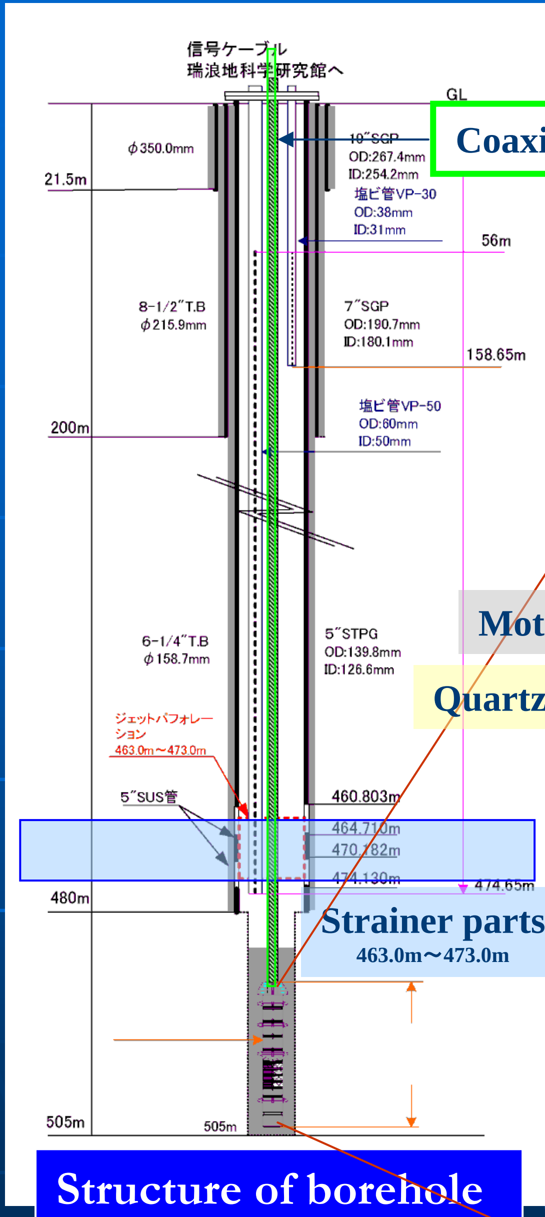
Before installation of the multi-component borehole instrument,

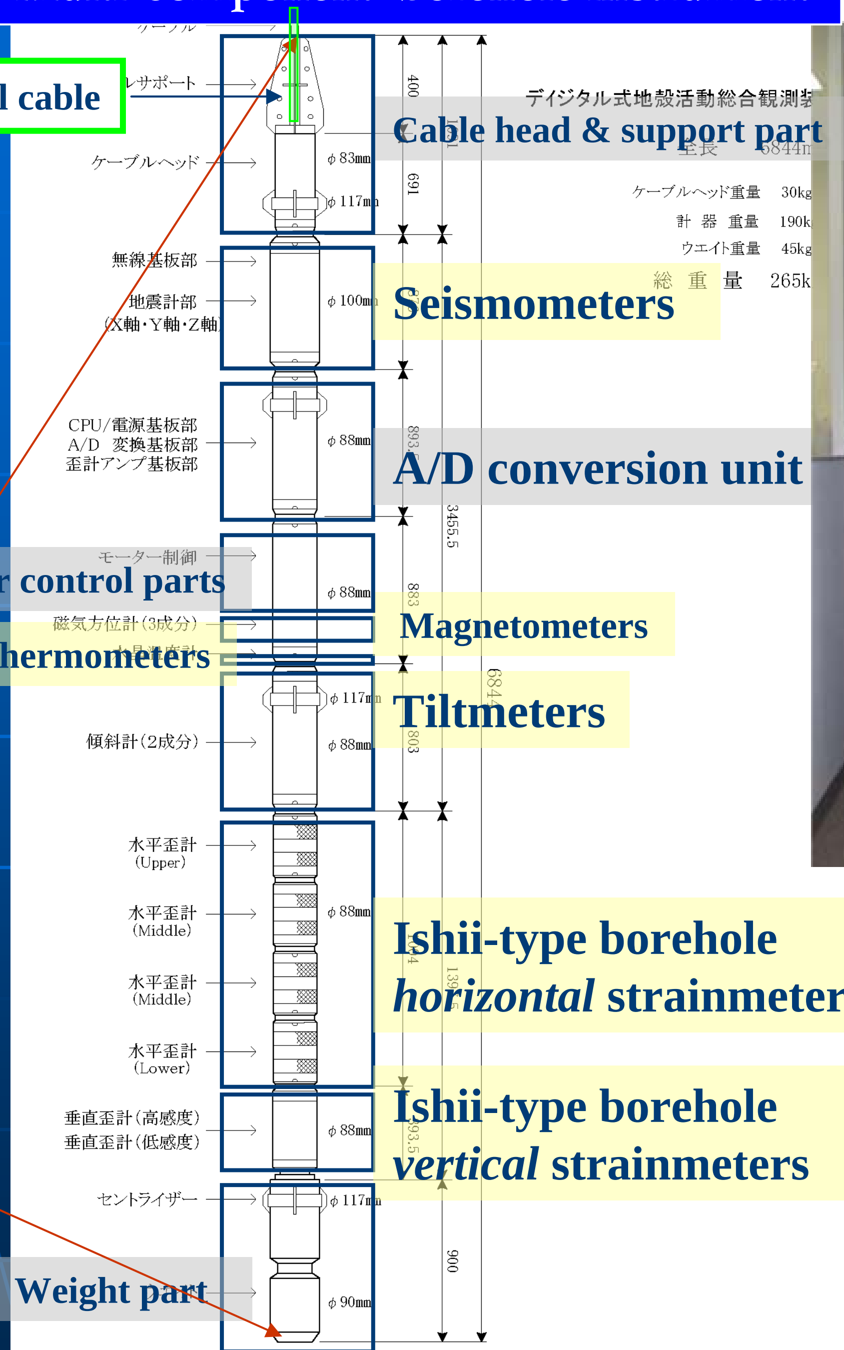
we install a wireless intelligent type strainmeter at the bottom of the borehole, and perform in-situ stress measurement by using the overcoring method.

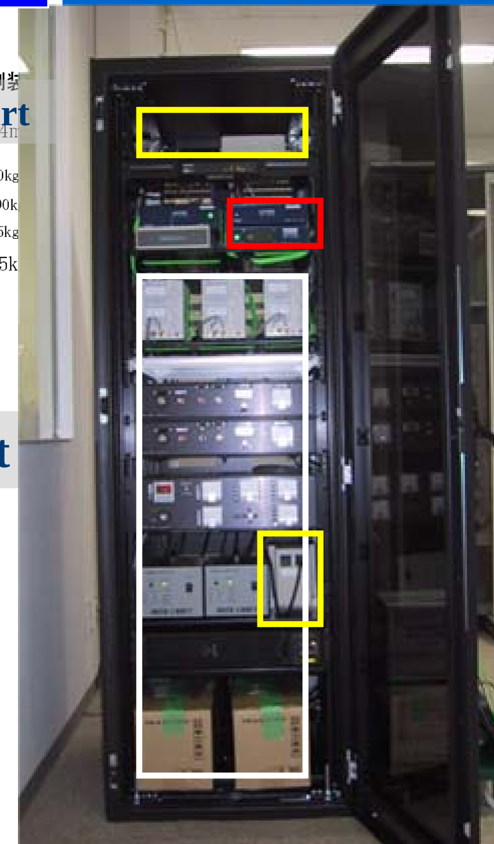
We can grasp the preliminarily stress field around borehole station.

Multi-component borehole instruments have been developed by cooperating work with Nagoya University and Earthquake Research Institute, the University of Tokyo.

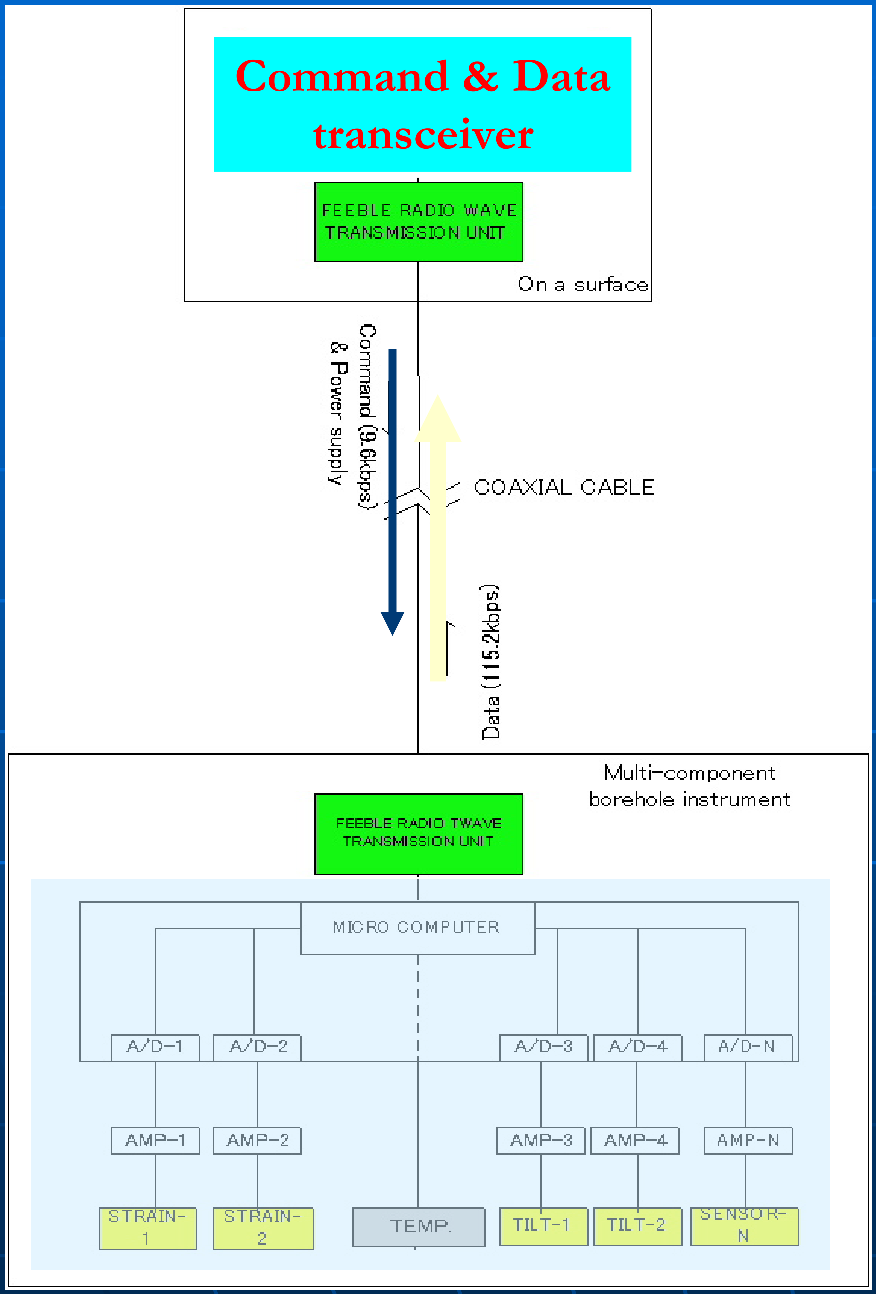
Multi-component borehole instrument







Ground facilities (Power supply, UPS, Command & Data transceiver , Lightning protection, etc.)



Data acquisition transmission system

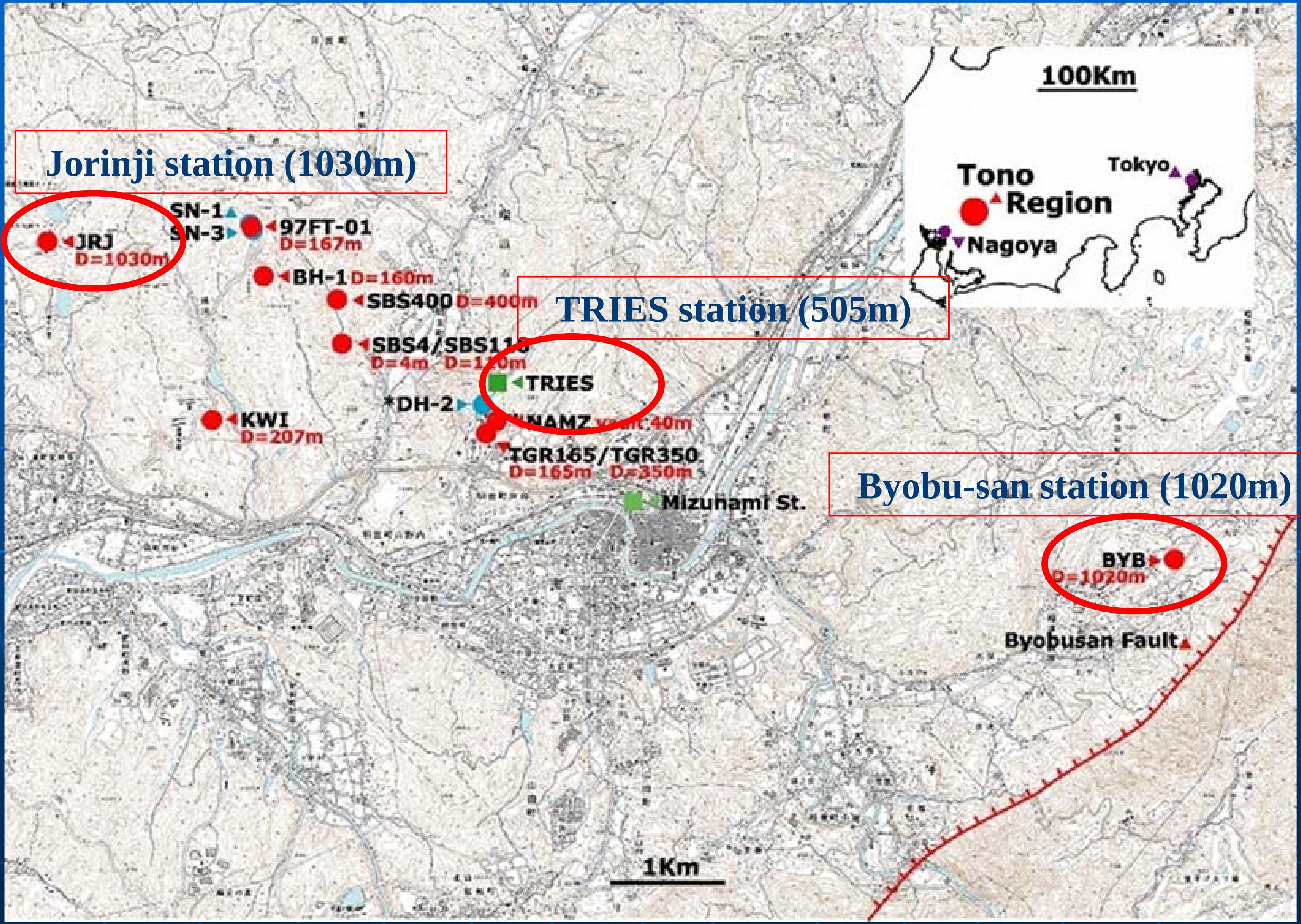
We use the 16 bit SAR (successive approximate register) A/D converter. The original sampling interval for each sensor is 9.6 kHz.

The dynamic ranges for seismometers and others are improved 21 bits and 24 bits from 16 bits by averaging the 17 and 129 sampling data, respectively. Frequency responses of the observation system are not spoiled by this procedure, because averaging numbers are determined in consideration of final sampling rates.

Final sampling rates are 400 Hz for seismometers, 40 Hz for strainmeters and tiltmeters, and 20 Hz for magnetometers and thermometer,respectively.

Data obtained from each record are transmitted to a surface by using only one coaxial cable.

Borehole Array Observation System operated by TRIES



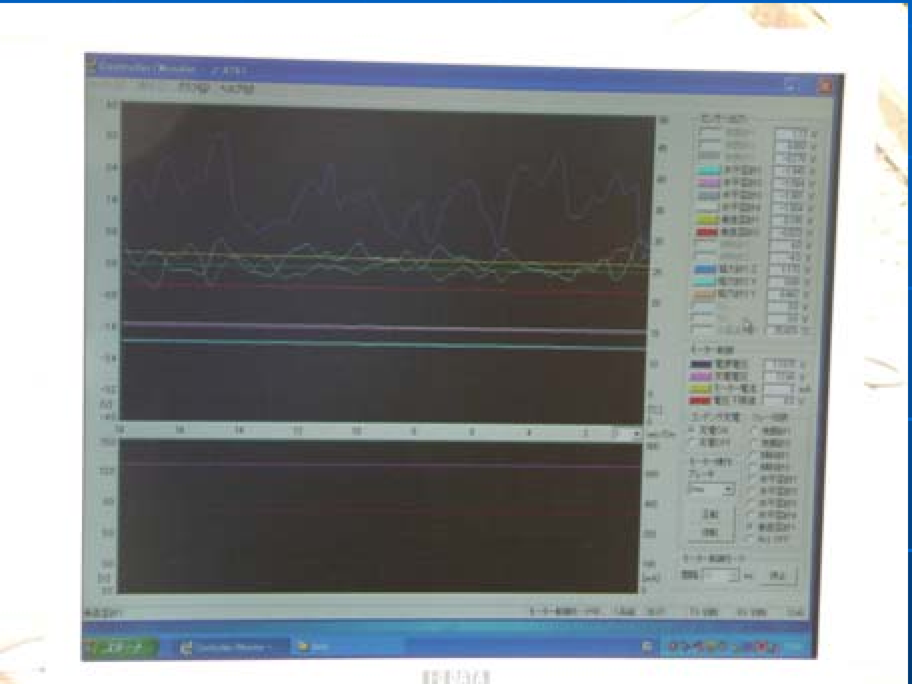
Installation of multi-component instrument

Multi-component instrument and tower

Cable drum, coaxial cable, and headquarters

Realtime monitoring of all sensors during the installation.

The headquarters



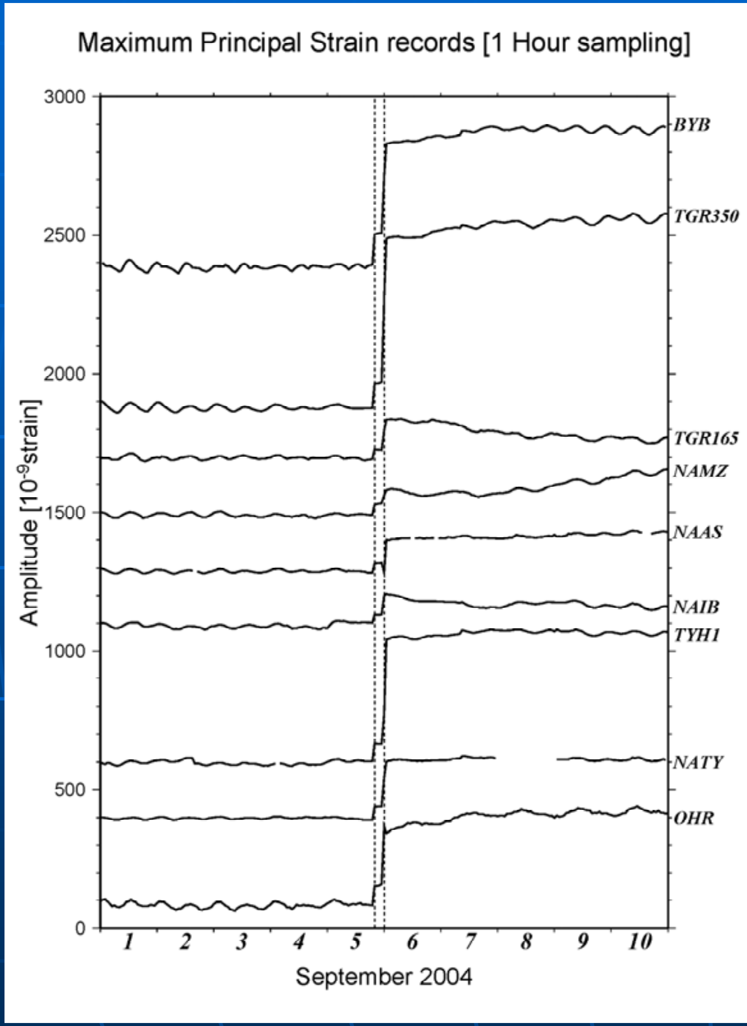
Monitoring System

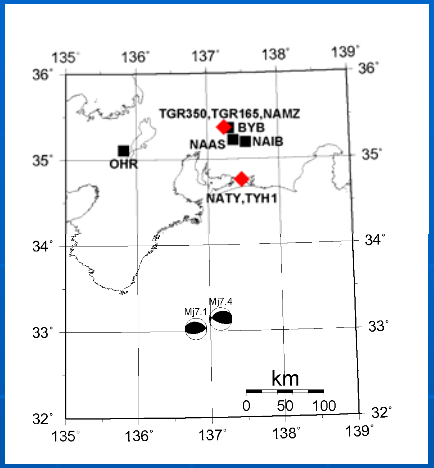
We can immediately make sure of the installation succeed.

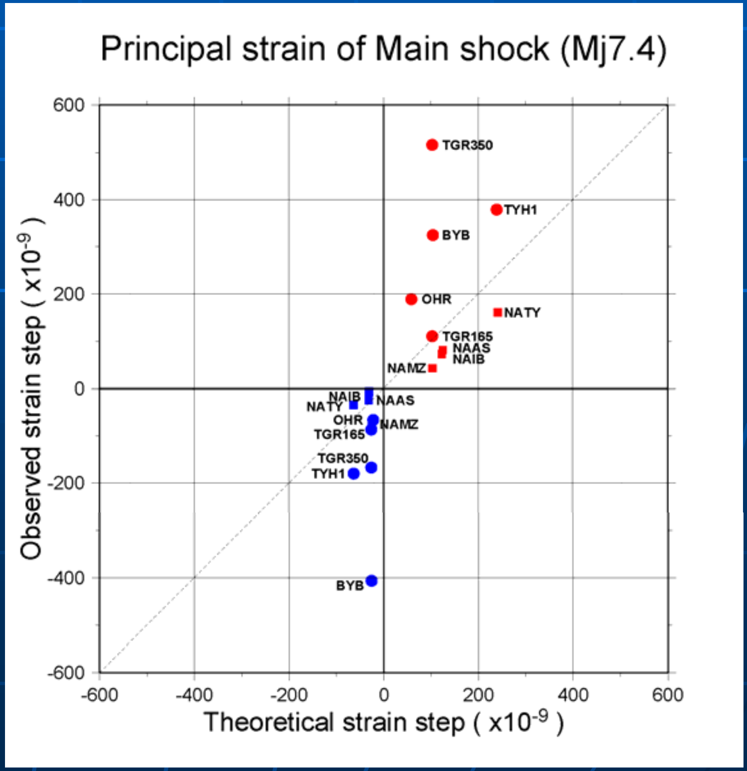
Some interesting results obtained from the Borehole Array Observation System

- Strain observations –
- Groundwater Level observations-

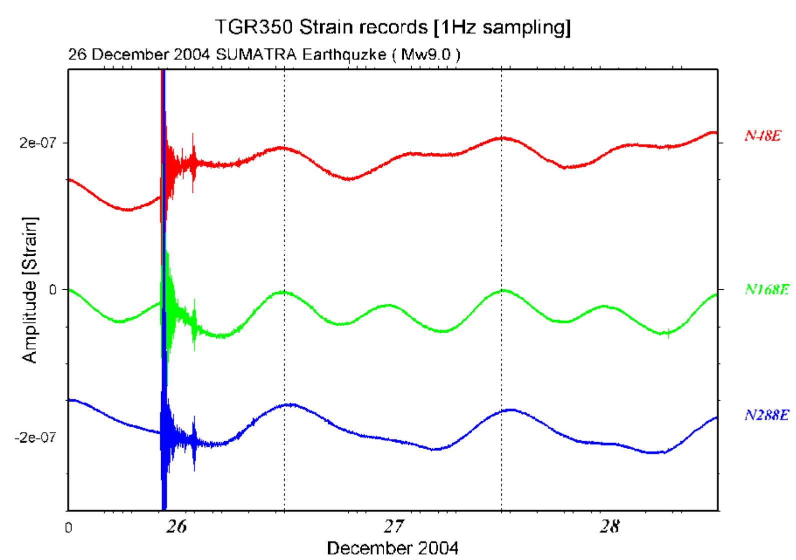
Strain steps associated with the 2004 off the Kii peninsula earthquakes (Mj 7.1 and Mj 7.4; Asai et al, 2005)

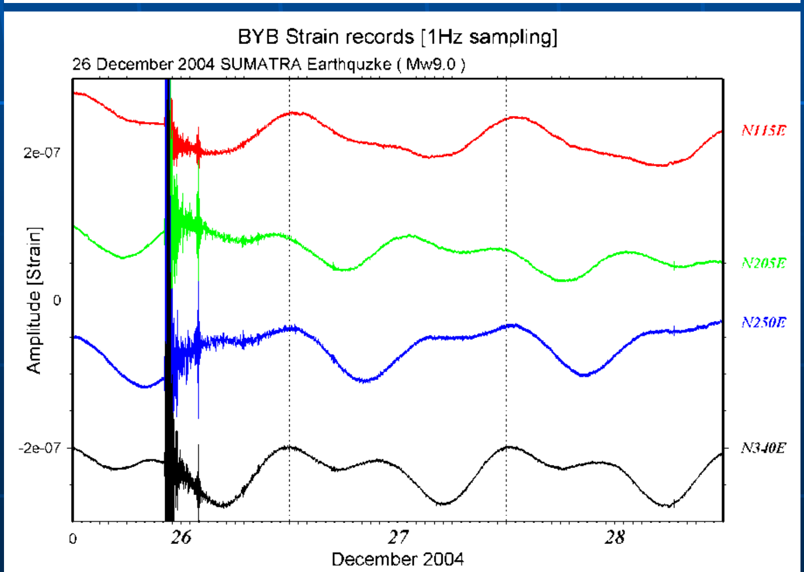






Strainmeter records of the 2004 Sumatra earthquake

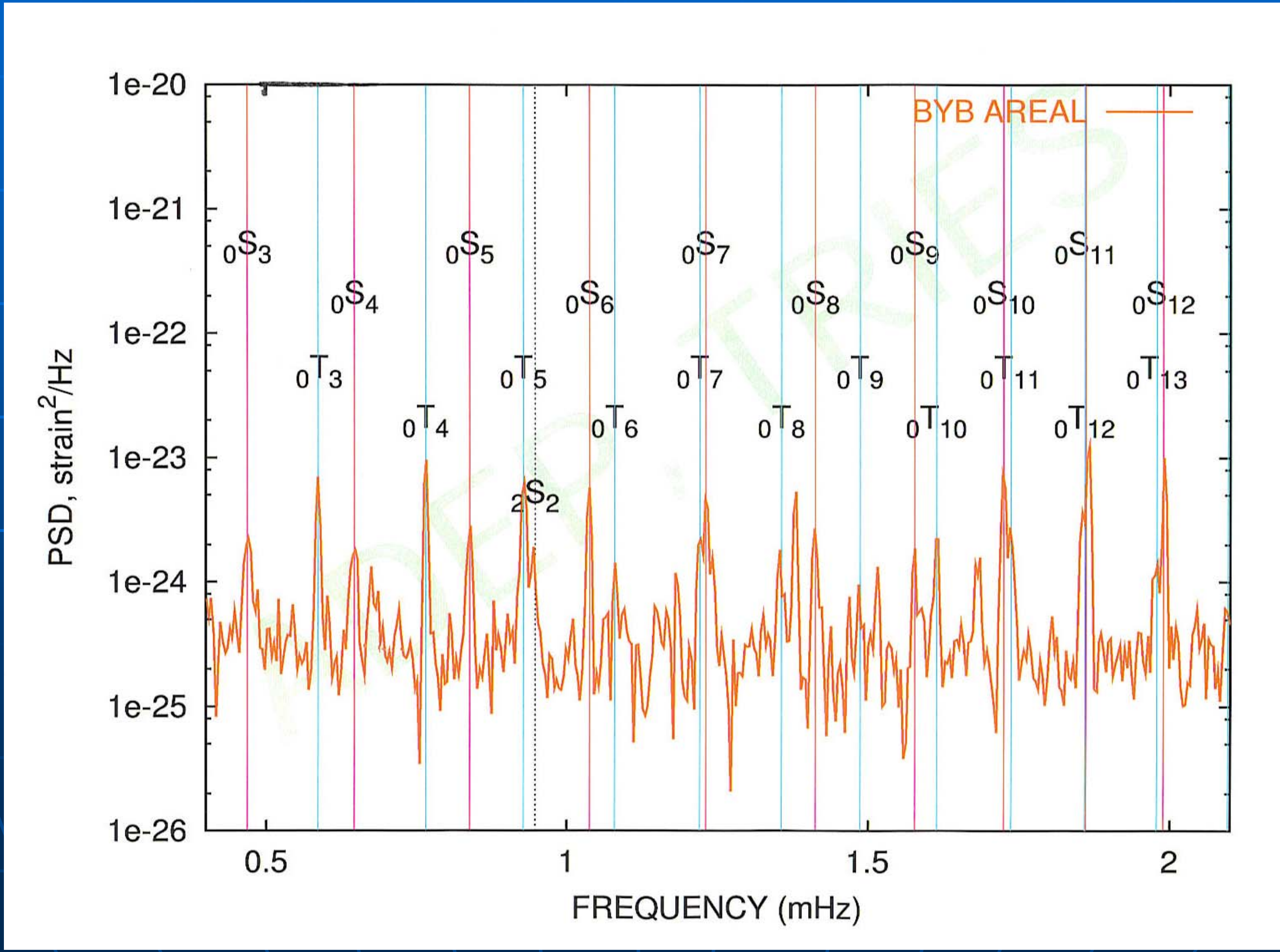




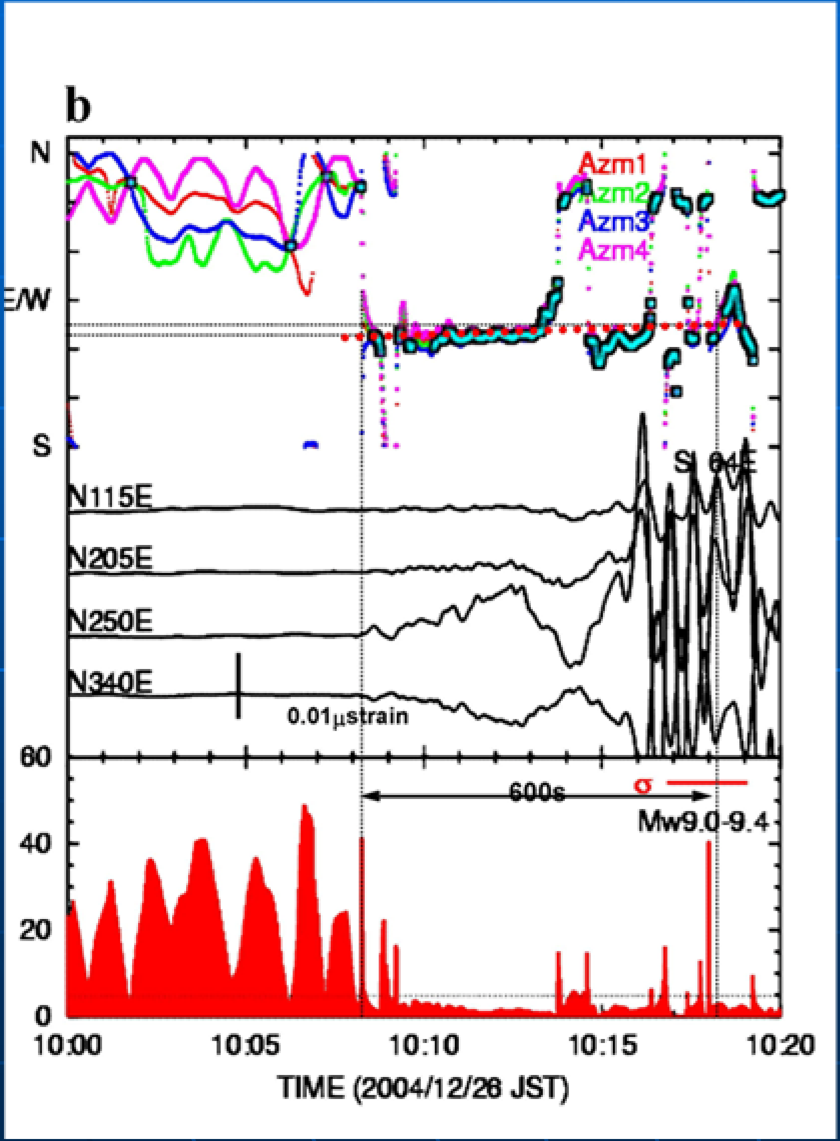
Strainmeter records (1-Hz resampling) of the 2004 Sumatra earthquake . TGR350 (Upper) and BYB (Lower) are located at Tono region Clear tidal signals and strain-steps associated with dynamic strain variation were observed.

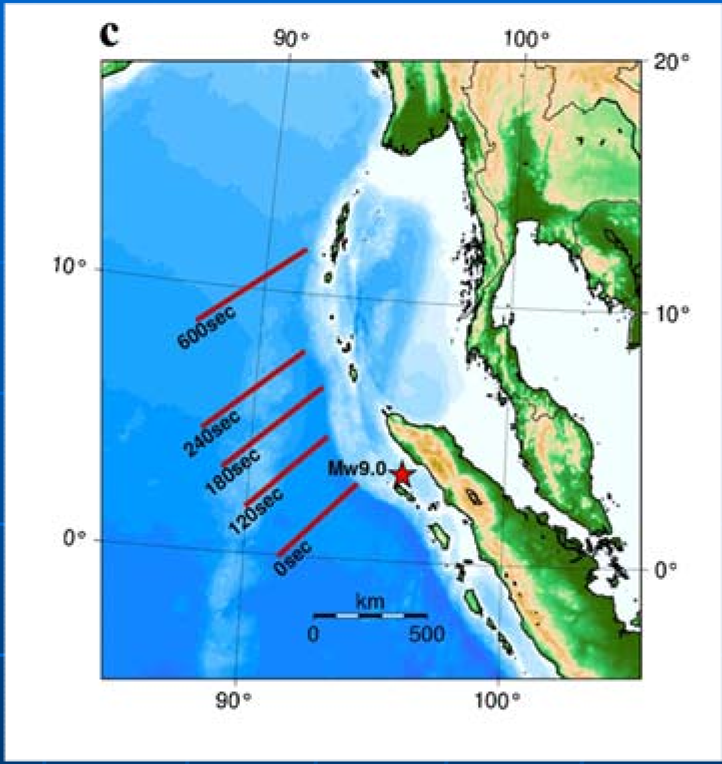
Although observed strain-steps are approximately 100 times larger than the theoretical changes at this region, we consider that these are real signals, because steps were observed simultaneously at another place by using different strainmeter.

Earth free oscillation observed by BYB borehole strainmeter (2004 Sumatra Earthquake Mw9.0)



Streaming Strain Analysis adopted to BYB borehole strainmeter (2004 Sumatra Earthquake Mw9.0)



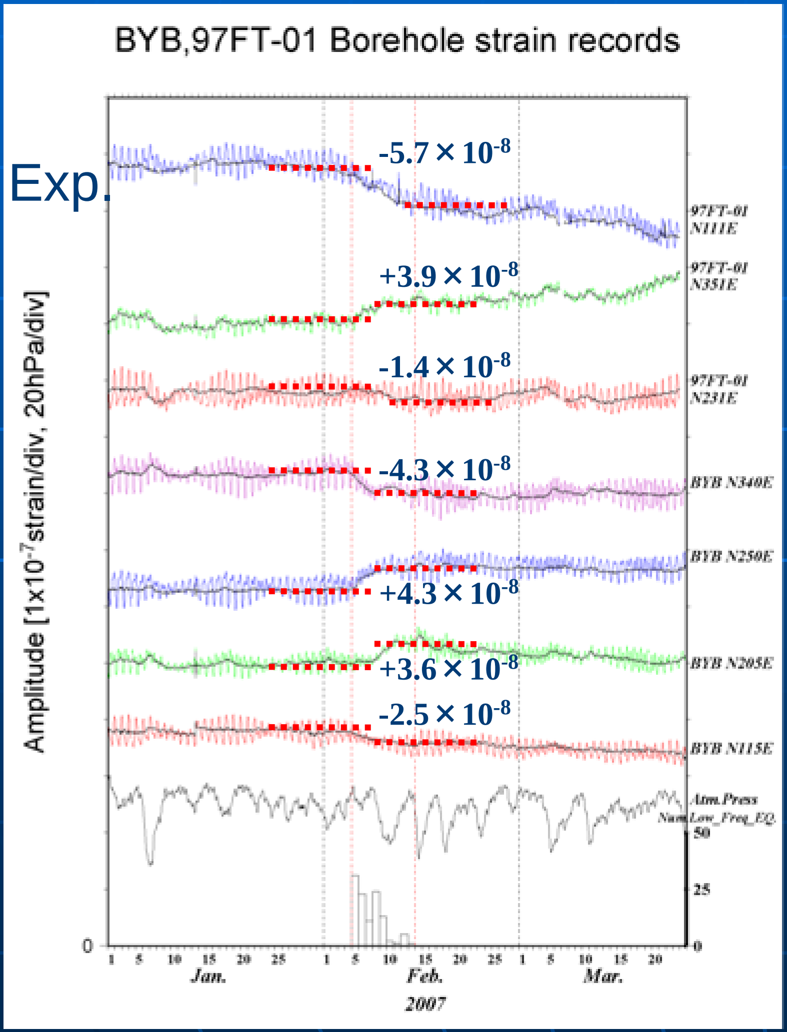


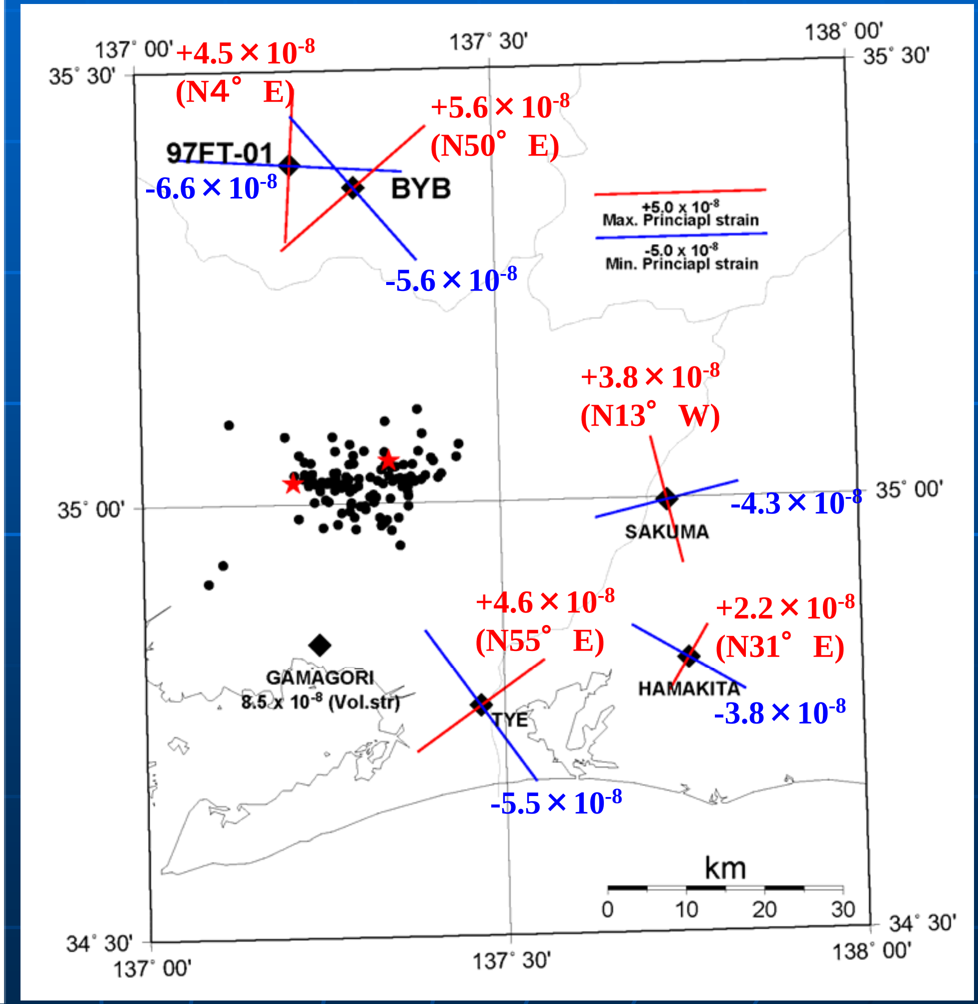
b: Variation of principal strain azimuth, strain record and standard deviation observed by the borehole station BYB.

c: Positions of rupture front and lapsed times derived from strain analysis (After Okubo *et. al.*, 2006)

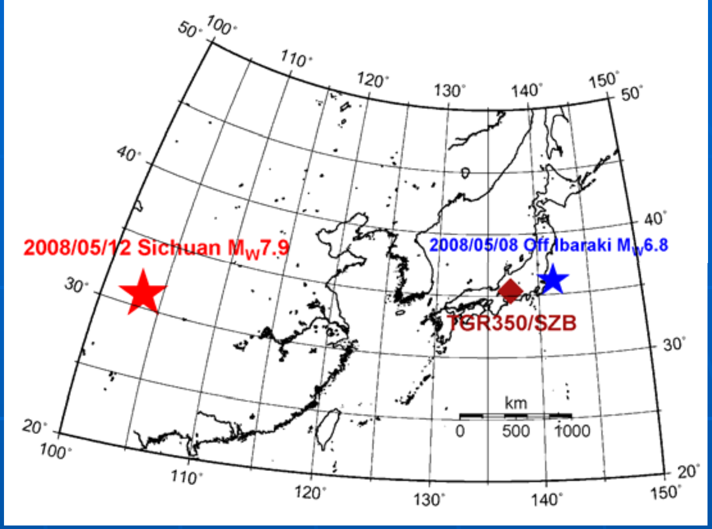
Remarkable strain changes associated with the activity of non-volcanic deep low-frequency tremor (LFT) in the Tokai district on February 2007 (Asai et al, 2007)

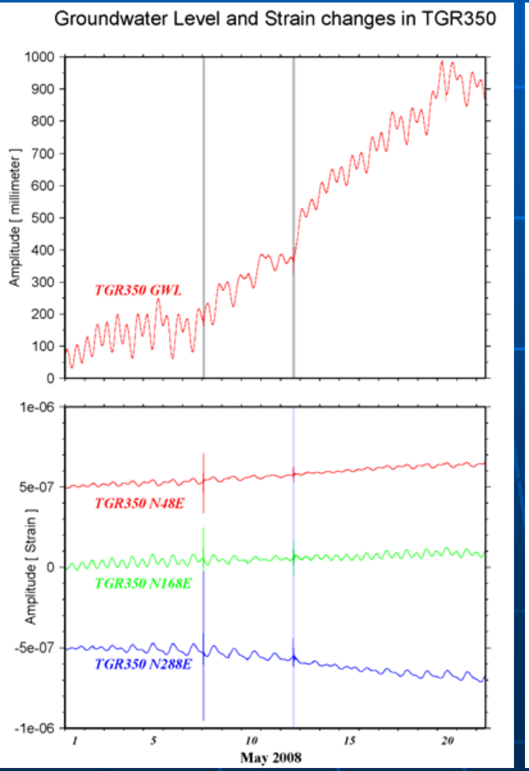
Exp.

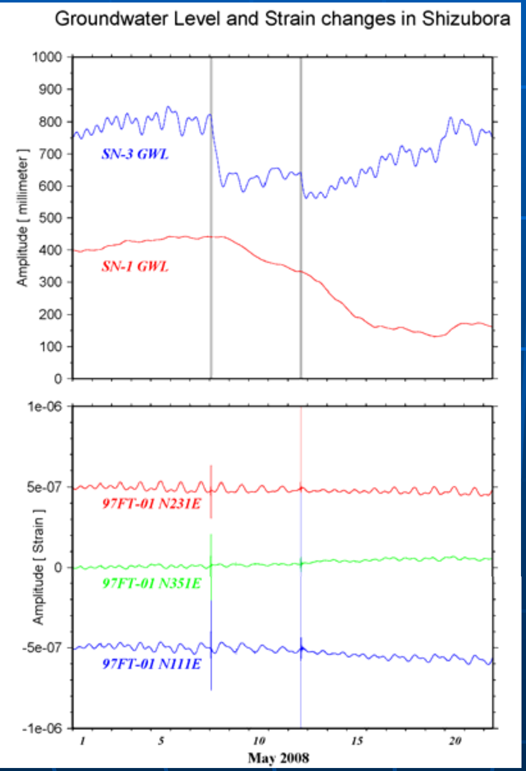


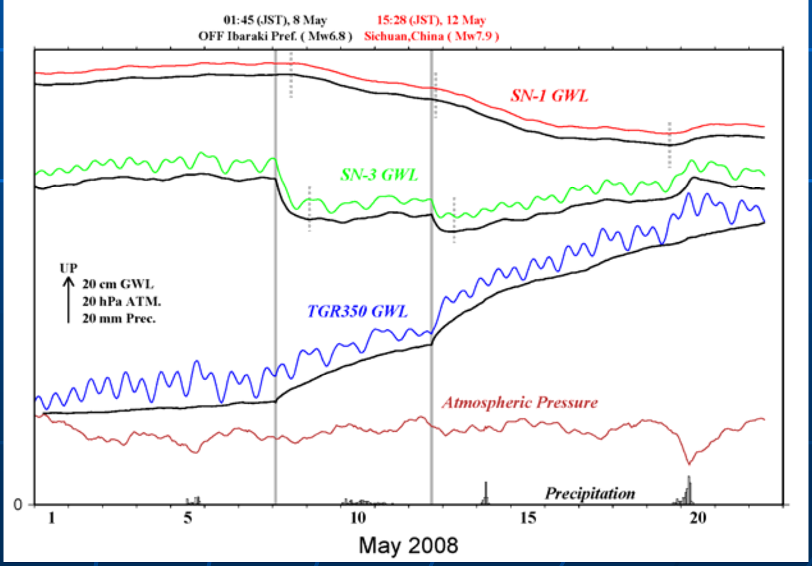


Coseismic groundwater level changes and dynamic strain variations associated with the Sichuan, China Earthquake (Mw7.9) observed at TGR350 SN-1, and SN-3 (Asai et al, 2008)









Summary

1. We have developed small diameter multi-component bore hole instrument for deeper boreholes than about 1km with small diameters than 98mm.

2. Multi-component observation can obtain much information in a borehole and save cost.

3. Deep borehole (deeper than about 500m) enables the high S/N ratio observation without both artificial noize and meteorological disturbance.

4. We can observe very long period and very small signal.

5. We can observe DC change that seismometers cannot observe

Such as permanent strain changes caused by slow slips or earthquakes

Such as free oscillations (spheroidal and troidal mode), tidal variation.