# New Development of Seismology by Deep Strain Observations

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Tono Institute of Earthquake Science (TRIES) is operating multi-component borehole instruments in deep boreholes. Seven borehole stations are accumulating observed data at the present time. The deepest borehole station is 1020m deep. Observation in deep boreholes can avoid the problems of both artificial and meteorological disturbances and enables the performance of high S/N ratio observations for detecting very small signals. There recently happened some large earthquakes. These earthquakes are as follows: 2003/9/26 Tokachi-oki eq. M8.0, 2004/9/5-6 Off Kii peninsula eq. M7.4 & 6.9, 2004/10/23 Mid Niigata eq. M6.8, 2004/12/26 Smatra eq. M9.0. Borehole strainmeters of 7 stations recorded well wave forms due to those earthquakes. It became clear that strainmeter data include important information which can not be recorded by seismometer.

Characteristics of strainmeter (strain seismometer) are to respond to DC component. It is also stable for tilt change of the instrument though a sensitivity of seismometer changes for that. Sampling rates of borehole strainmeters are 20Hz in the fastest case and 1 Hz in the slowest case. Primary analysis gives the following results:

1. Strain seismometer can record long period components that seismometer can not and that include important information about seismic source.
2. We can easily see source time function of earthquake source movement in strain seismograms.
3. We can easily see permanent displacement of earthquake source movement in strain seismograms.
4. Free oscillation of the earth can be precisely recorded even for toroidal mode.
5. Magnitude can be determined by only strain seismograms observed at one station without scale out of wave form amplitude.
6. Direction of epicenter can be determined by only strain seismogram observed at one station.
7. Strainmeter is stable for tilt change at an observation point though a sensitivity of seismometer changes depends on that.
8. By applying mechanical amplifying system used for borehole strainmeter, we can easily make an extensometer more than 1 km length and it makes possible strain observation with high S/N ratio.

These results indicate that strain observations include many important information about earthquake mechanism research.