Multi-component observation in deep boreholes, and its applications to earthquake prediction research and rock mechanics

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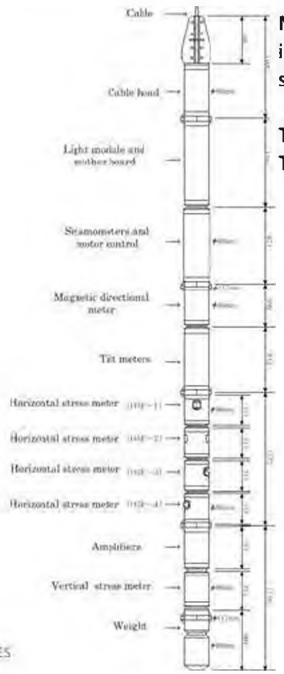
Summary

1. We have developed multi-component borehole instrument that can be operated in deep boreholes like 1 km depth. It is equipped with stress meters, strain meters, tilt meters, seismometers, magnetometers and thermometers and arbitrary combination of the sensors can be possible.

2. Stress meter is recently developed and it can observe both stress and strain.

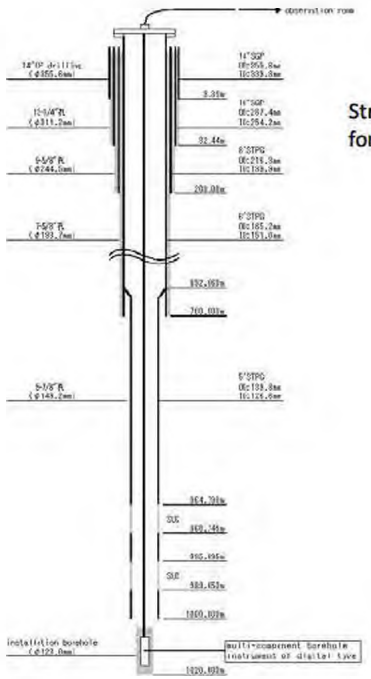
3. Reliability of stress meter was confirmed by use of invariant quantity of elastic theory and other tests.

4. Data obtained from stress meter will offer new information concerning seismology and rock mechanics in future.



Multi component borehole instrument (type equipped with stress meter

Total length: 7.843m
Total weight: 285kg



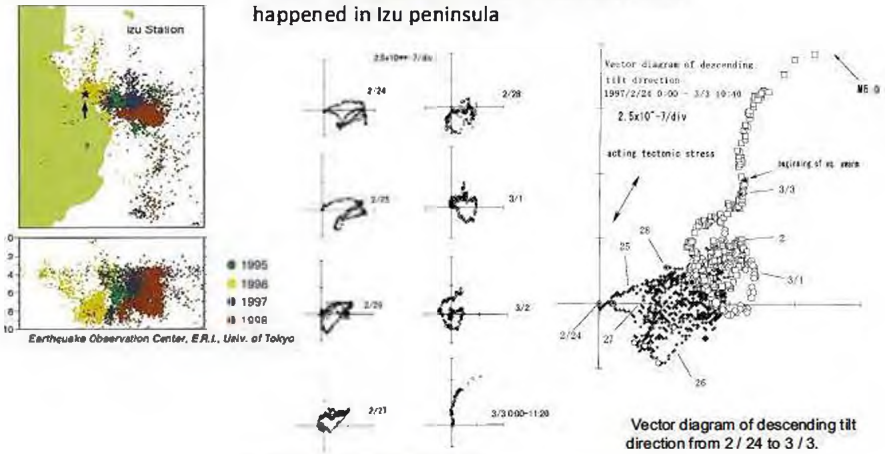
Structure of borehole for installation

Multi-component instrument and tower in case of installation

Installation of multi-component instrument

Cable drum and head quarters

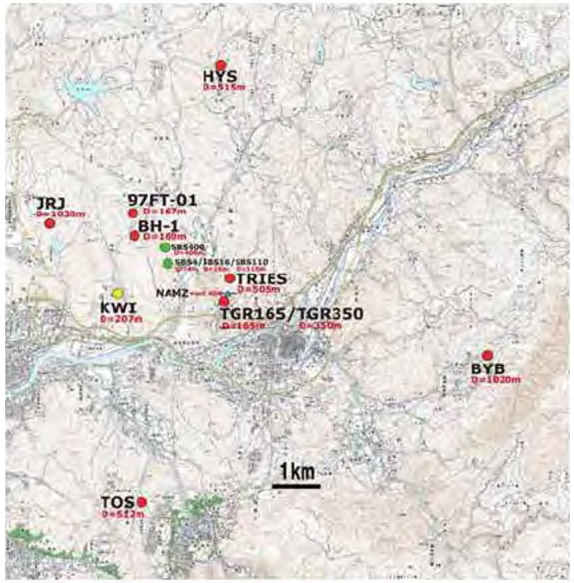
Tilt and strain variation for earthquake swarm happened in Izu peninsula



. Daily vector diagram of descending tilt direction from 2 / 24 to 3 / 3.

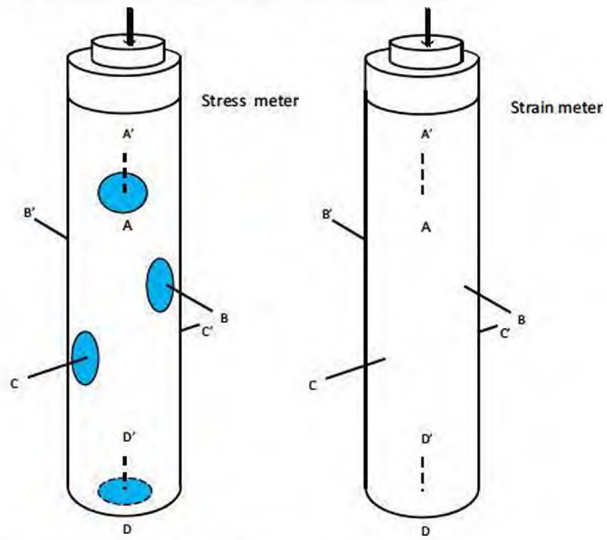
Vector diagram of descending tilt direction from 2 / 24 to 3 / 3.

Distribution of borehole station operated by Tono Research Institute of Earthquake Science (TRIES): Red numerals indicates depth of borehole



Development of stress meter

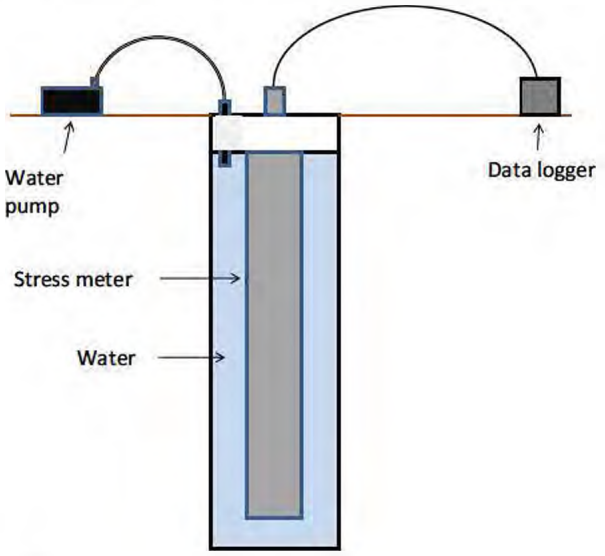
Outside view of stress meter and strain meter



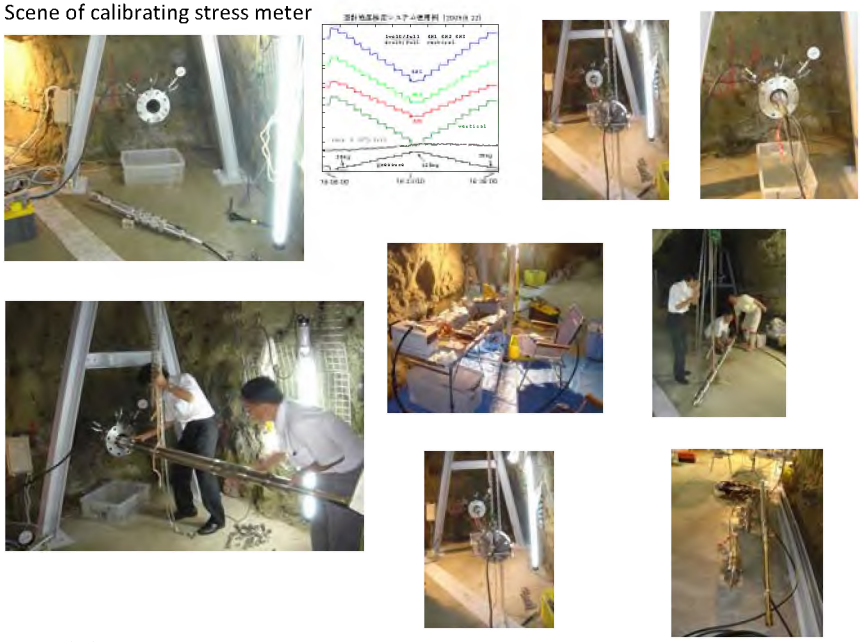
Stress meter can record both stress and strain.
Stress meter can not effected by deformation of container

Inside picture of stress meter for horizontal and inclined components

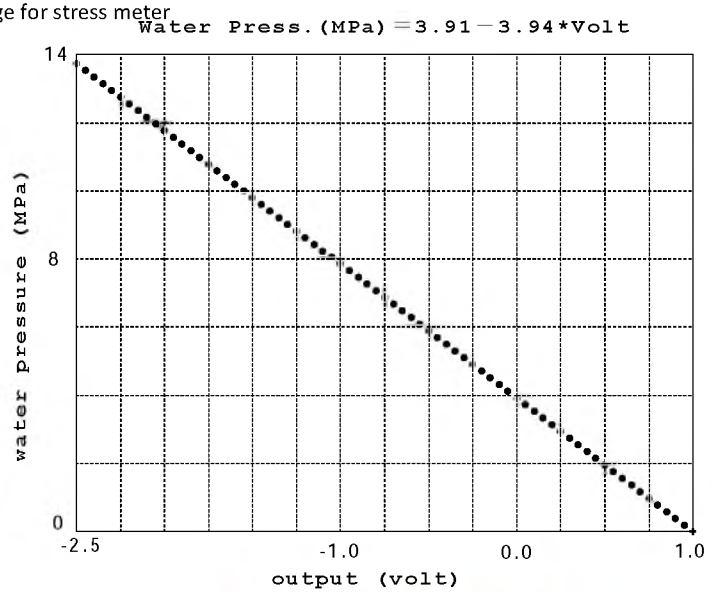
Schematic depiction of calibration of stress meter



Scene of calibrating stress meter

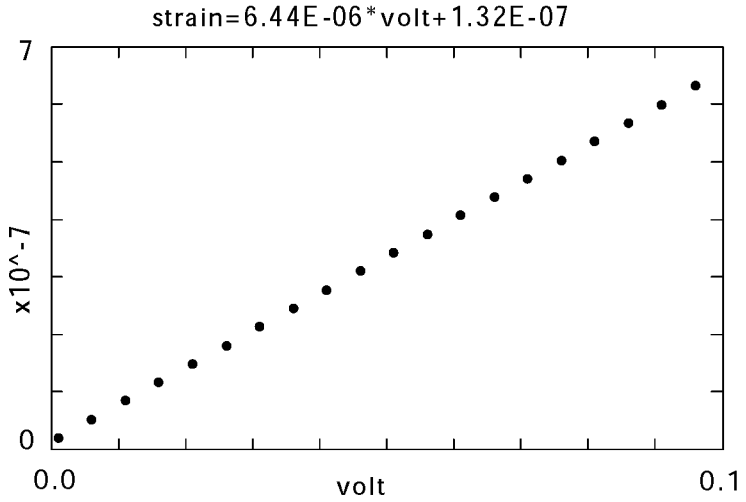


An example of calibration showing relationship between water pressure and output voltage for stress meter



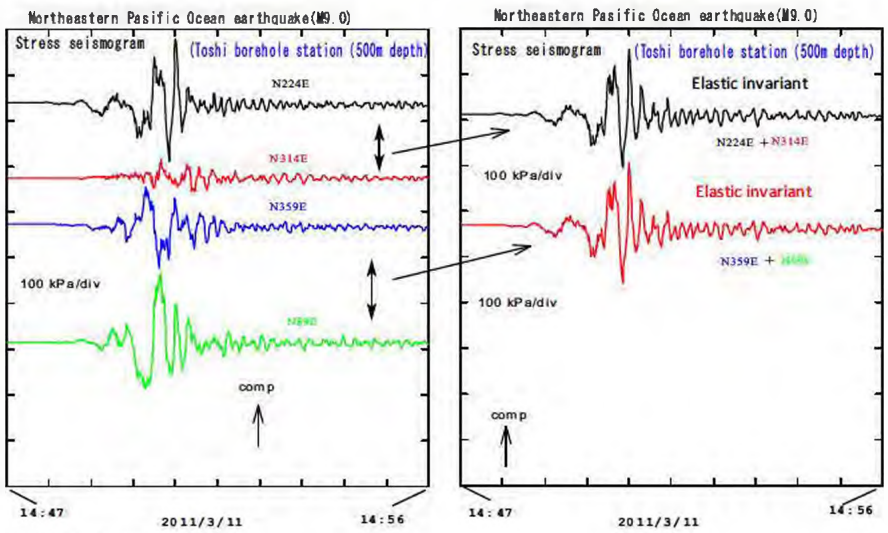
応力計の水圧と出力電圧の関係の例

An example of calibration showing relationship between strain and output voltage for stress meter

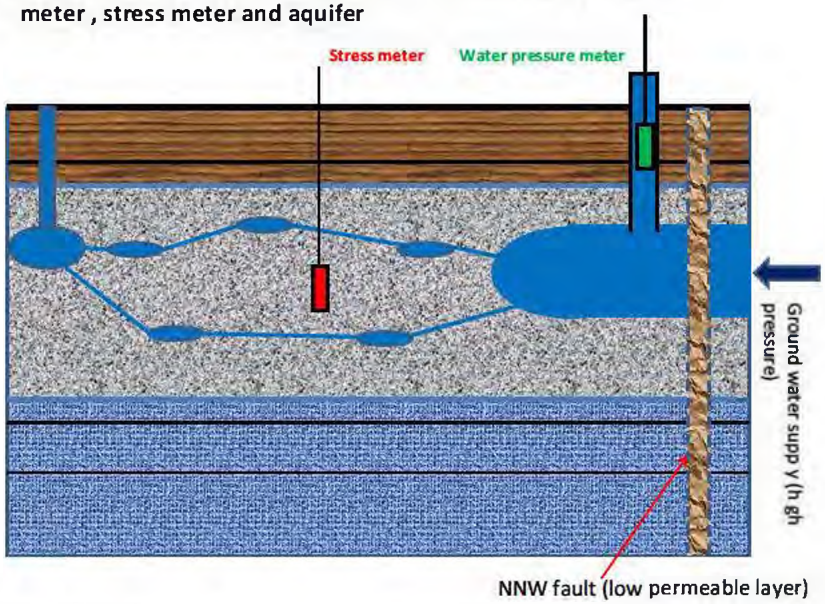


3 examples showing reliability of Stress meter

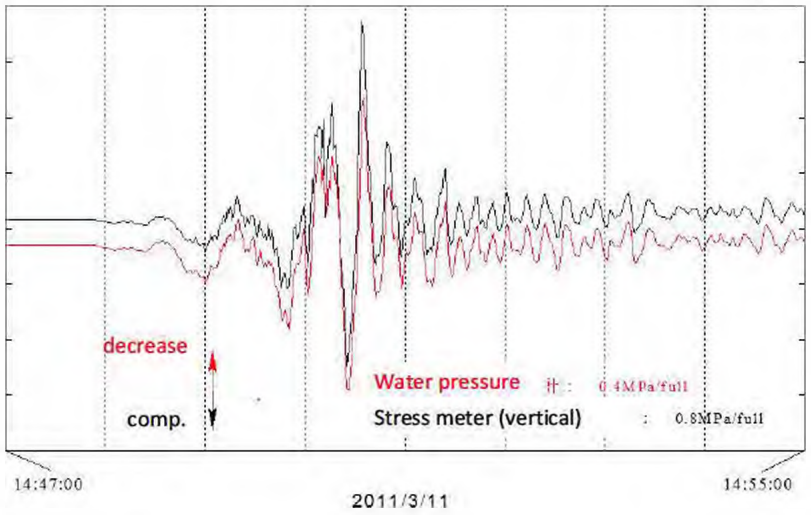
Elastic invariant obtained from different components coincides



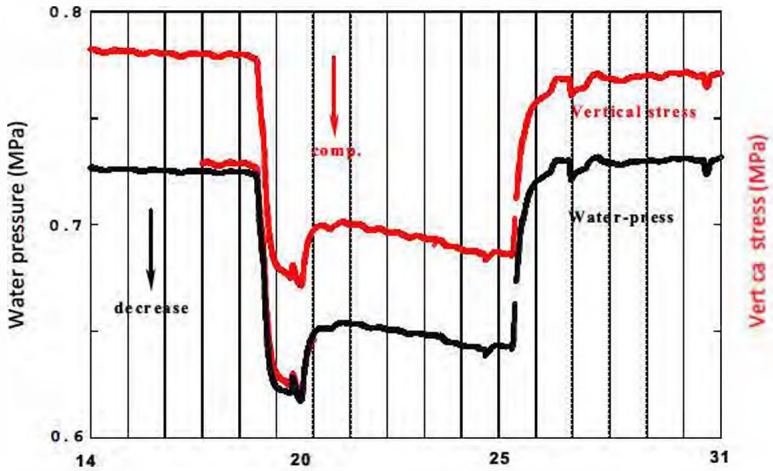
Schematic depiction showing arrangement of water pressure meter , stress meter and aquifer



Comparison of data between stress meter(vertical comp.) and water pressure meter for Northern Pacific Ocean Earthquake (2011/3/11 M9.0)

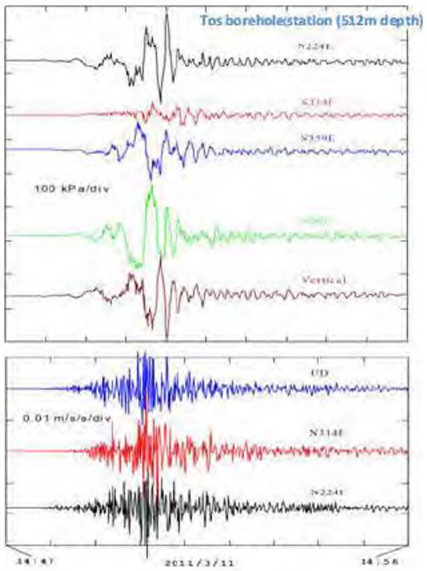


Comparison of data between stress meter(vertical comp.) and water pressure meter for spring water (2012/7/14 – 7/31)



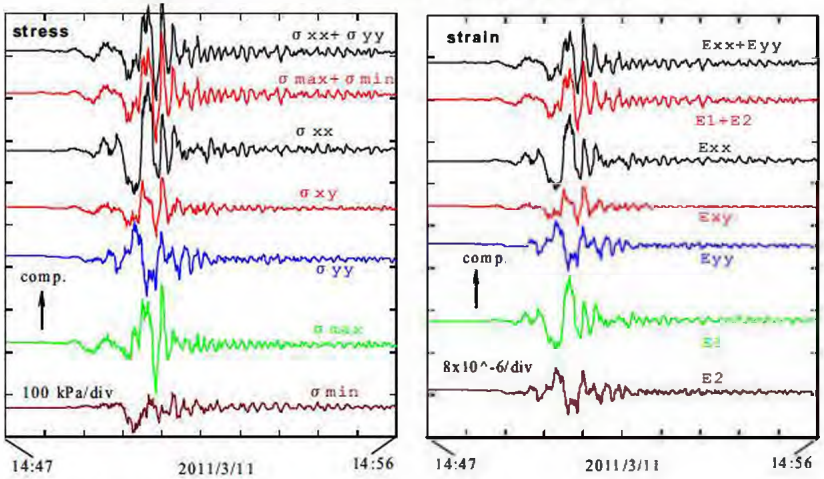
Observed examples

Stress seismogram and seismogram for Northern Pacific Ocean Earthquake (2011/3/11 M9.0)

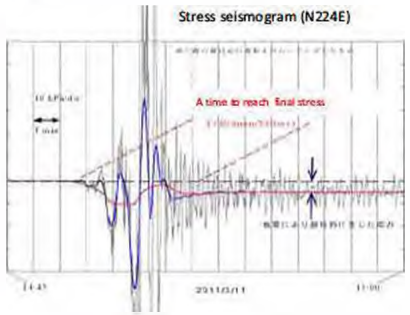


Stress meter can observe both stress and strain

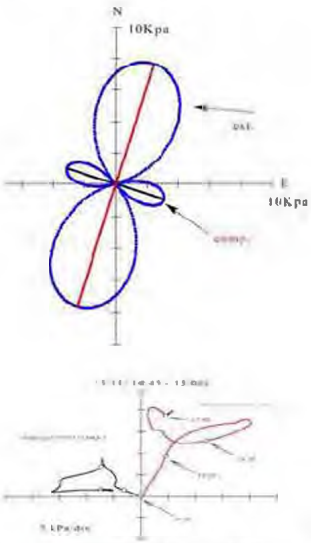
Stress and strain obtained from stress meter of TOS borehole station for Northern Pacific Ocean Earthquake (2011/3/11 M9.0)



Stress change produced at TOS station by Northern Pacific Ocean Earthquake (2011/3/11 M9.0)



Final stress



Time variation of principal stress

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