Geothermal Reservoir Monitoring with a Combination of Absolute and Relative Gravimetry

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Abstract

Generally, microgravity monitoring involves the measurement of small changes in gravity over time, across a network of stations, with respect to a fixed base. Regional gravity variations can cause errors in the determination of the gravity "datum" against which any measured changes are referred.

A combination of absolute and relative gravimetry, which is named "Hybrid Gravity Measurement", provides a solution to this problem. It is useful to connect the array of observation stations with absolute gravity stations, to reduce any uncertainties caused by regional gravity variations.

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Hybrid Gravity Measurement

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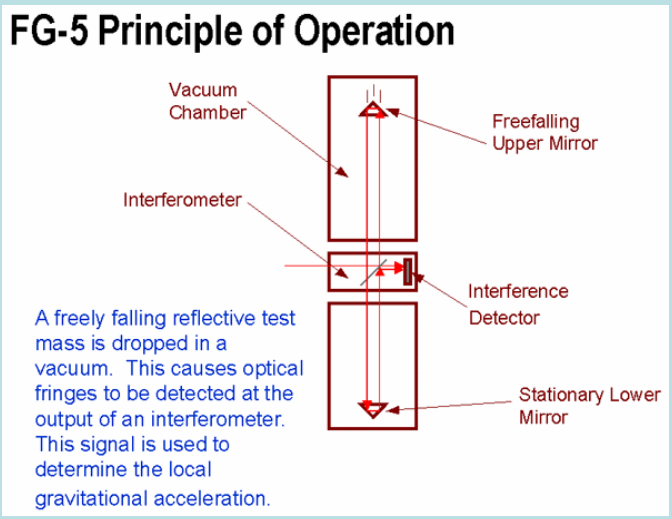
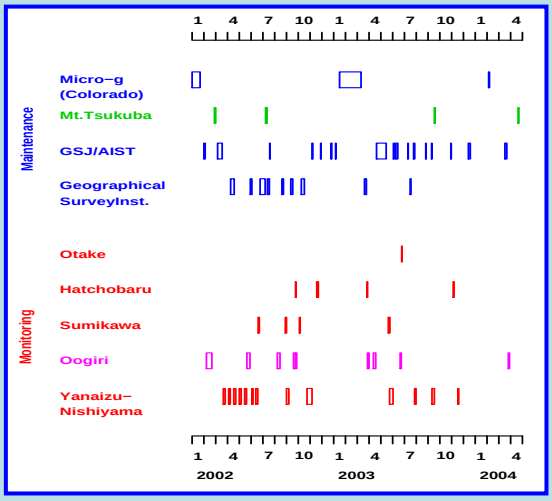
Absolute Gravimeter FG-5



History of the measurements with the FG5/217 absolute gravimeter



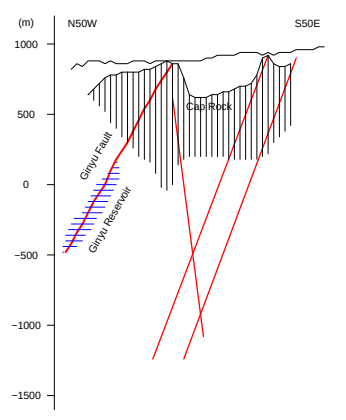
The FG5 requires only a few days to provide useful results at each survey location. Therefore one FG5 gravimeter can be used at many fields. We have already used it at the five geothermal fields in Japan.

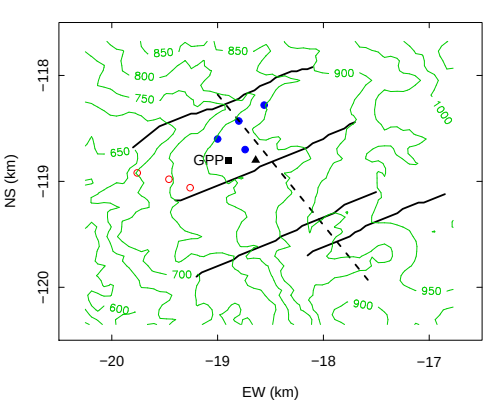
Gravity monitoring at Ogiri field

The 30 MW Ogiri geothermal power plant started its operation in early 1996 on the western slope of Kirishima volcano in Kyushu island, Japan.

We have carried out the so called hybrid gravity measurements at the Ogiri geothermal field since 2002.

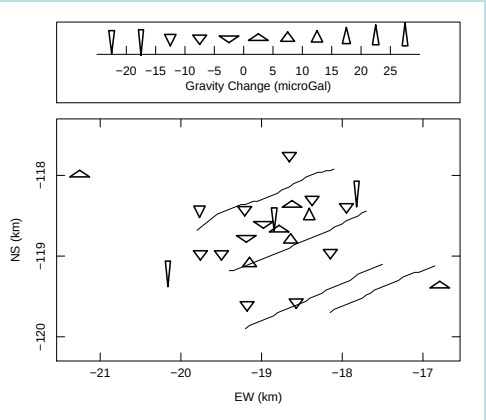
Ogiri geothermal field





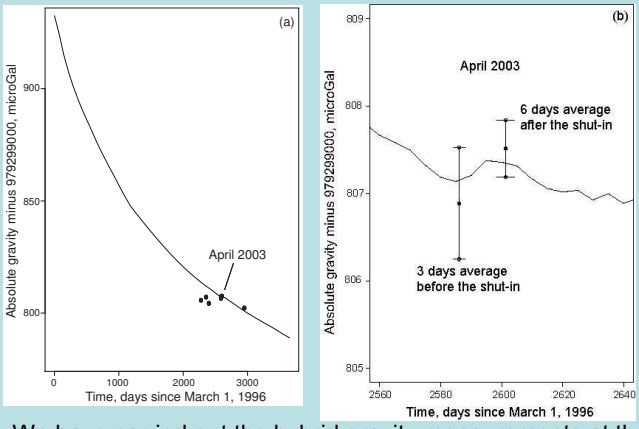
The major faults control the geothermal system in the Ogiri area. Fractured-type geothermal reservoir was found below about 900 m depth along the Ginyu fault. Ten production and nine reinjection wells were drilled to 1000-1500 m depth and to 800-1300 m depth respectively. All waste water is reinjected into a wellfield located about 800 m west of the production area.

Long-termgravity change



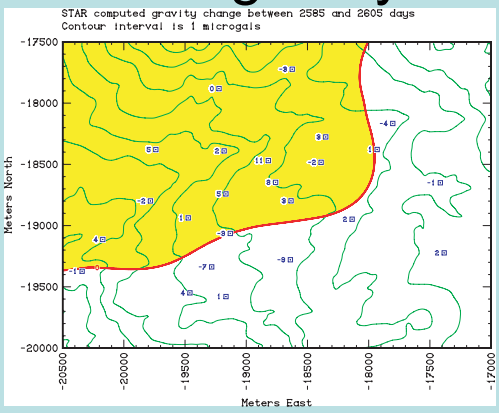
The observed long-term gravity changes should constrain the representation of the reservoir boundary conditions (particularly the deep recharge boundaries) under conditions of fluid withdrawal. This figure shows gravity changes observed in the field over the period between 2003 and 2007.

Short term gravity change



We have carried out the hybrid gravity measurements at the Ogiri geothermal field in March – April 2003, during which field wide shut-in of production/reinjection wells took place, and detected small changes less than five microGal.

Short term gravity change



The distribution of measurement stations showing gravity increase and decrease during the shut-in are consistent with the locations of main production and reinjection zones respectively and reproduced by numerical simulation based on a reservoir model which is constructed from various reservoir engineering data.

Conclusion Remarks

An absolute gravimeter supplies the gravity “datum” anytime and anywhere. This advantage is effective for long-term surveys or wide range survey.

The FG5 requires only a few days to provide useful results at each survey location. Indeed gravity changes were detected accurately enough for practical use at the Ogiri absolute gravity point, where seismic noise is much greater than the other absolute gravity points.

It suggests another advantage of the FG5 absolute gravimeter for practical use, that is, providing not only the reference “datum” for the relative gravity measurements but also gravity changes at the target site directly.