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GEOTHERMAL RESERVOIR MONITORING WITH AN FG5 ABSOLUTE GRAVIMETER

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ABSTRACT

A Micro-g FG5 (S/N 217) absolute gravimeter was introduced and tested in 2002 at the Yanaizu-Nishiyam geothermal fields in Japan. The test confirmed that the FG5 absolute gravimeter is suitable for practical use in monitoring geothermal fields.

INTRODUCTION

Microgravity monitoring is recognized as a valuable tool for mapping the redistribution of subsurface mass that is associated with geothermal exploitation. 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 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.

An absolute gravimeter, the Micro-g FG5 (S/N 217), was introduced and tested in 2002 at four geothermal fields in Japan. In this paper we show the results of the Yanaizu-Nishiyama field.

PAST GRAVITY MEASUREMENTS

Commercial operation of a 65 MWe power station began in May, 1995 at the Yanaizu-Nishiyama field. The gravity monitoring survey of the field began in September 1994. In 1997 the gravity network was expanded by the New Energy and Industrial Technology Development Organization (NEDO) to 138 stations, covering a 30 km^2 area. Seasonal gravity measurements were carried out at these stations. In 1998 short-term gravity changes were detected; these were related to a suspension in production (NEDO, 1999). Large scale negative (20 μ Gal / 3Yr) gravity changes were observed around production zone, and reproduced by reservoir modeling (NEDO, 2001).

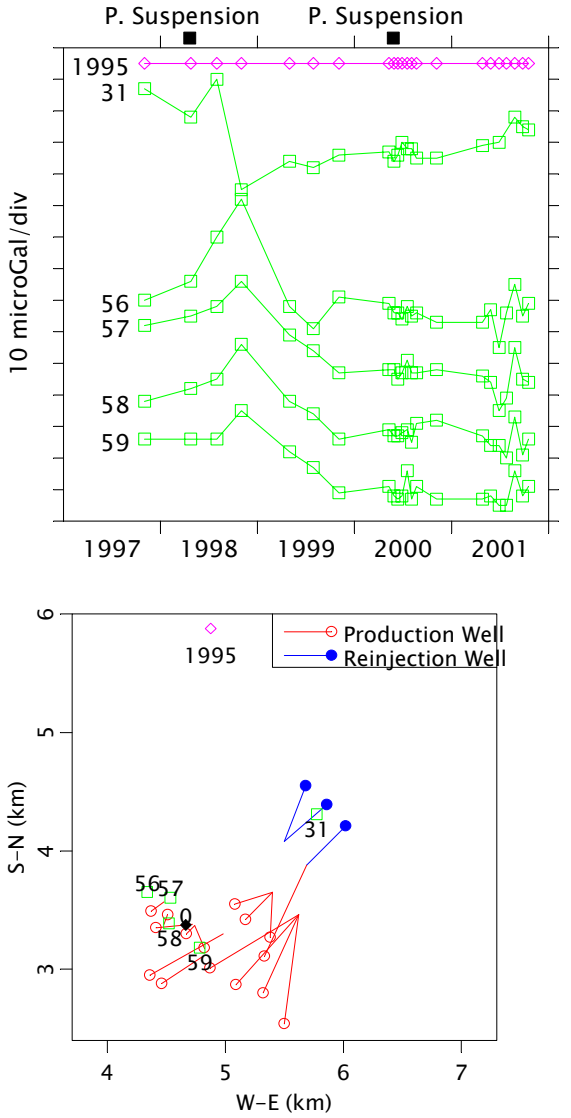

Figure. 1. Gravity changes versus time in 1997-2001, measured by NEDO (upper) and location of the stations (lower).

GRAVITY MEASUREMENTS IN 2002

Absolute gravity measurements

Nine surveys have been made since March 2002. Every time the absolute measurements were made for about five days at the center of the production zone (#0 in Figure 1). Every day 24 or 48 sets of 100 drops per set were collected every 30 minutes (at 10 seconds drop interval). Figure 2 shows plots of measured gravity values (set values) during the 4th survey between 0932 May 1 to 2151 May 5, 2002 (UT). The "set value" is the weighted mean of 100-drop values, excluding abnormal values beyond 3-sigma of every "set". At each survey an absolute gravity value was inferred from averaging all the set values.

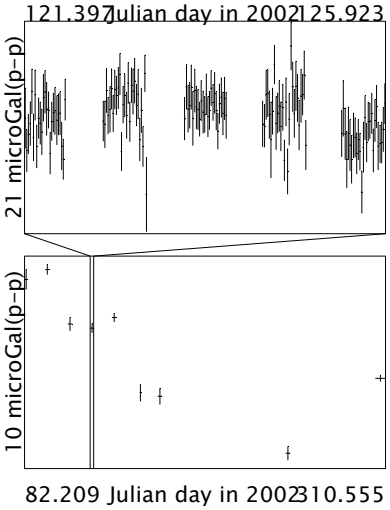

Figure. 2. Plot of absolute gravity measurements: Set values of the 4th survey (upper) and gravity changes during the nine surveys (lower).

Relative gravity measurements

A Scintrex CG-3M gravimeter (S/N 385) was used for the 2002 surveys, and the measurement procedure was similar to that described by Ohta et al. (2001). The CG-3M gravimeter was operated in cycling mode at night by the FG5 absolute gravimeter. Each day's measurements were tied to the local base (#1995 in Figure 1). The gravity differences of the stations to the local base were determined (Figure 3). The gravity difference of the absolute station to the local base was also determined. Data reduction techniques similar to those described by Ohta et al. (2001) have yielded preliminary gravity values with an estimated uncertainty better than +-10 microGal.

By combining the absolute measurements (Figure 2) and the relative measurements (Figure 3 left), the temporal gravity differences to the absolute reference (Figure 3 right) can be determined.

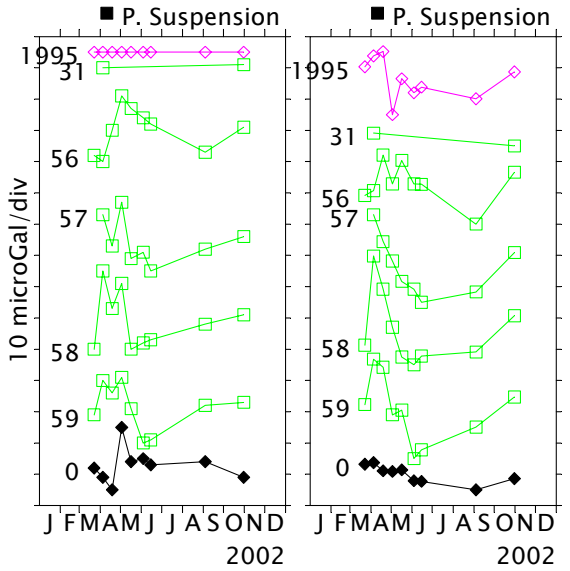

Figure.3. Temporal gravity differences in 2002; to empirical datum (left), to absolute datum (right).

CONCLUSION

The successful performance of the FG5 absolute gravimeter has been proved at the Yanaizu-Nishiyama geothermal field. Statistical tests of the data samples indicate that the estimated uncertainty is about 2 microGal. At the production zone, no significant absolute gravity changes were found when production was suspended in 2002. Short-term changes similar to those occurring in 1997-2001 were found in the relative gravity data. The future surveys should be conducted more sufficiently in a hybrid mode than this year's absolute and relative surveys to confirm the short-term changes.

REFERENCES

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