

Remarkable Crustal Tilt variation caused by excavation of underground gallery

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1. Introduction

Tono Geoscience Center, Japan Atomic Energy Agency (JAEA) has been carrying out a wide range of geoscientific research in order to build a firm scientific and technological basis for geological disposal. One of the major components of the ongoing geoscientific research program is the Mizunami Underground Research Laboratory (MIU) Project in the Tono area, central Japan (Fig.1 and 2; MIU, 2002; http://www.jaea.go.jp/04/tono/miu_e/index.html). Excavation of MIU causes the large amount of discharge of groundwater. For 11 years until 2015, discharge of groundwater is over 800m³/day (Fig.3; Kimata et al, 2016; NGWA Groundwater Summit 2016).

Tono Research Institute of Earthquake Science (TRIES) has been investigating the relationship between the variation of groundwater level and variations of crustal tilt, stress, and strain, in the MIU area. We have observing the remarkable crustal tilt variation caused by excavation of MIU.



Fig.1 Location of MIU and borehole array observation system operated by TRIES. (modified from GSI Maps <http://maps.gsi.go.jp>)



Fig.2 Cross section of MIU(500m depth), and location s of STG100 & STG200 borehole site (φ 98mm, 20m depth). Modified from JAEA report; http://www.jaea.go.jp/04/tono/miu_e/weeklyweekliumiu.html.

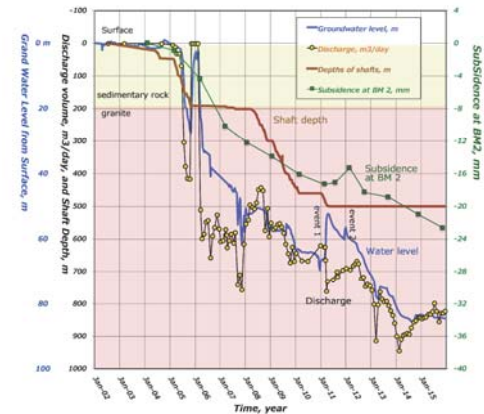


Fig.3 Time series of water level change, drain volume ground deformation and shaft depth (Kimata et al, 2016).

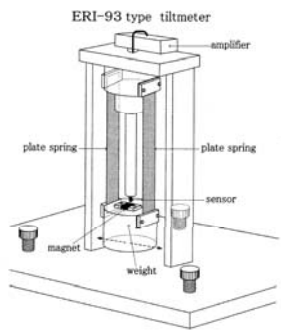


Fig.4 Tiltmeter consists of two parallel leaf springs 50cm long, 10mm wide, and 50 micrometers thick support a weight and movement of the weight is recorded for measuring tilt by using a displacement-to-voltage transfer sensor (Ishii et al, 2002) . Not employ any damping oil for this tiltmeter.



Fig.5 Installation of borehole tiltmeter at STG100

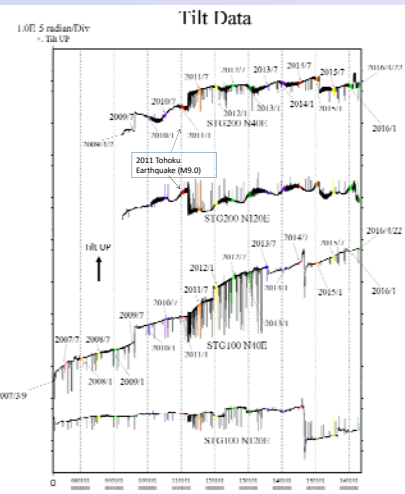


Fig.6 Hourly tilt record for each observation site. N40E and N120E are direction of tilt sensors (clockwise from the north). Colored plots denotes the record for a month.

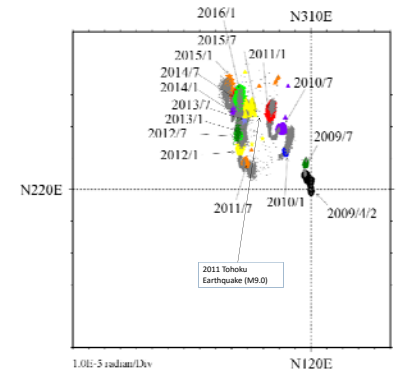


Fig.7 STG200: Vector diagram of descending tilt direction from 2 April 2009 to 22 April 2016. Horizontal axis is equal to strike of sub-stage (N40E - N220E) .

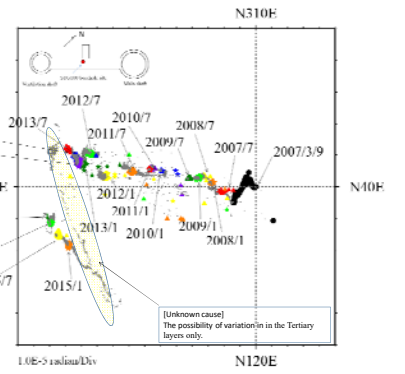


Fig.8 STG100: Vector diagram of descending tilt direction from 9 March 2007 to 22 April 2016.

3. Tilt variation in STG100 & STG200

Fig.6 shows the observed tilt variation in STG100 and STG200. Vector diagram of descending tilt direction (Fig.7 and Fig. 8) at each borehole site were calculated from the tilt variation (Fig.6).

To date, the following results were obtained:
 (1) Amount of descending tilt variation at the STG100 site is approximately 1.7×10^{-5} radian/yr, and variation for the STG200 site is approximately 1.0×10^{-5} radian/yr.

(2) Direction of observed descending tilt variation at STG100 is almost south-southeast, and direction for STG200 is almost east.

2. Observation

We have developed a Borehole tiltmeter (Ishii et al., 2002, Balkema; Fig 4) and installed it at the bottom of two boreholes site (STG100 and STG200; Fig. 2, and Fig. 5) in the MIU in the Tono region, central Japan. The Tono region is a relatively stable block of Cretaceous Toki granite uncomformable overlain by Tertiary layers (Mizunami sedimentary formations) with a thickness of approximately 100-200m (e.g. Kimata et al 2016, at this summit ; Honda et al, 2016, at this Summit ; King et al, 1999, JGR). TRIES constructed the STG100 in March 2007, and STG200 in April 2009. STG100 is located in the Tertiary layers, and the STG200 in the Toki granite.

4. Discussion and Conclusion

From observation results (Fig.7 and 8), and discharge of groundwater with volume of 600~800m³ was generally pumping a day in MIU (Kimata et al, 2016 ; at this Summit), we consider that observed descending tilt variations may be caused by the some “source” located in neighboring south-southeastern/eastern area of MIU.

A detailed investigation of the “source” is the subject for next/future study.