Subsidence Following Groundwater Drawdown by Excavating of Deep Shafts in Granite in Mizunami, Japan in 2004-2014

JAEE Deep Shaft Excavating Project in Mizunami, central Japan

Tono Geoscience Center (TGC), Japan Atomic Energy Agency (JAEE) 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 programs is the Mizunami Underground Research Laboratory (MIU) Project in the Tono area, central Japan.

Two 1000m* deep shafts and several drill holes were excavated for geoscientific research and applicability of engineering techniques will be estimated (MIU, 2002). A 1000m depth was a plan in 2002, and stopped at 500m depth in 2011.

Levelling Network and Detected Subsidence nearby Shafts in 2004-2012

Tono Research Institute of Earthquake Science (TRIES) establishes the monitoring system to detect the ground level and ground deformation around the 500m depth shafts since 2002.

Water level was observed at the borehole locating 300m south from the shaft (shown in blue in Fig.4). Precise levelling is also repeating in the nearby area of the shafts as shown in Fig.5.

Subsidence around Shafts in 2012-2015

In 2012, we extend the precise levelling network toward north-east direction. Fig.3 shows the length of levelling route exceeds 30km and we could discuss the vertical deformation over 5km x 5km area. Precise levelling are repeated every year until 2015. As a result of repeated levelling,

1) Leveling error are within ±1mm, shown in Fig.7.
2) A significant subsidence of 6mm for 3 years is detected beside the shaft and in the downstream area of groundwater system, shown in Fig.8.

Drain, Water Level Drop, and Subsidence at Shafts

Draining from shaft lead the ground water level change in Togari borehole and subsidence at BM2 (Fig.6). For 11 years until 2015, discharge of ground water is over 800m3/day, water level drop over 80m is observed at the borehole, and a subsidence over 22mm is detected at BM2 close to the shaft.

1. Sudden water level drop after the flood from 200m depth in shaft in 2005 summer.
2. Water level recovering at the discontinued draining in 2005 fall.
3. Water level after re-draining of 60m3/day in 2006, and reached over 800m3/day in 2013.

In 2011 Togari earthquake, large water level ascends over 15m observed in Togari borehole, and uplift of 2mm is detected at BM2 in 2012.

Consequently, large draining of 600m3/day from shaft cause the water level drop of 40m and subsidence of 3mm.

Cross Section of GW System around the Shaft

Base Structure of Groundwater System

Base rock is granite in the region, and base structures in the groundwater system are estimated using geochemical, geophysical, and seismic surveys by JAEE shown in Fig.9. Base rock distribution is created the groundwater system, and groundwater are following the boundary of granite and sediment.

Additionally, the channels join in the southeast of the shafts, and the altitude of the extraneous area is about 0m above sea level. One groundwater basin is formed with 30 – 100m depth in the entrance area.

1) Excavating 500m depth shafts with discharging of 800m3/day, trigger groundwater drawdown of 80m, and subsidence of 2mm near the shafts. The subsidence also detected 2km far from the shafts.
2) As the field is leaned in mass-mountainous region, groundwater system is not simple. Discharging is intimately related with the groundwater system and groundwater basin. When the test field of mass-discharging is necessary to make monitor by not only groundwater but also the ground deformation using with ground survey.