Vertical surface deformation monitoring during 2014 and 2015 using precise leveling around Soultz-sous-Forêts and Rittershoffen geothermal exploitation sites, Rhine Graben, France

Gilbert Ferhat[1,2], Monica Lopez Barraza[3], Emmanuel Clédat[1]

1 Institut de Physique du Globe de Strasbourg, UMR7516 CNRS/Université de Strasbourg

2 INSA de Strasbourg, France

3 UniversidadAutonoma de Sinaloa, Mexico

Contact : gilbert.ferhat@unistra.fr

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ABSTRACT

In order to monitor the surface deformation around the two geothermal exploitation sites at Soultz-sous-Forêts and Rittershoffen, France. We established a high precision leveling network in May 2014. A large leveling network (about 38 km) surrounding the two sites was observed in May 2014 and June/July 2015. A small loop (about 3.5 km) around the Rittershoffen site was measured several times in May, June, July, November 2014 and July 2015. This network is monumented by 43 leveling benchmarks, some theses markers are located close to 13 relative gravimetric sites or some permanent cGPS antennas. Preliminary comparisons between 2014 and 2015 altitudes obtained by leveling do not reveal significant signal. These two epochs of measurements serve as a vertical reference vertical before exploitation planned in 2016 at the two sites. The leveling network is planned to be re-observed in May 2016.

1 LEVELING NETWORK

The leveling network was designed for two purposes: 1) for the vertical control of a relative gravimetric network (Hinderer et al. 2105, 13 sites on figure 1) and 2) for the vertical control around the 2 exploitation sites. The leveling network is made of five loops (figure 2). Each loop was observed using a digital level (Leica DNA03) and standard leveling staff. The leveling lines include some National leveling benchmarks installed by the French Mapping Agency (IGN, *Institut National de l'InformationGéographiqueetForestière*) in order to tie the altitudes to the national vertical reference. The loop 5 was observed several times using the same digital level, but this time using invar staffs. By fixing the altitudes of three leveling benchmarks at IGN values, we computed the altitudes of all other benchmarks. Uncertainties on these altitudes are about 2 to 5 mm. We plan to re-observe this network in May 2016.

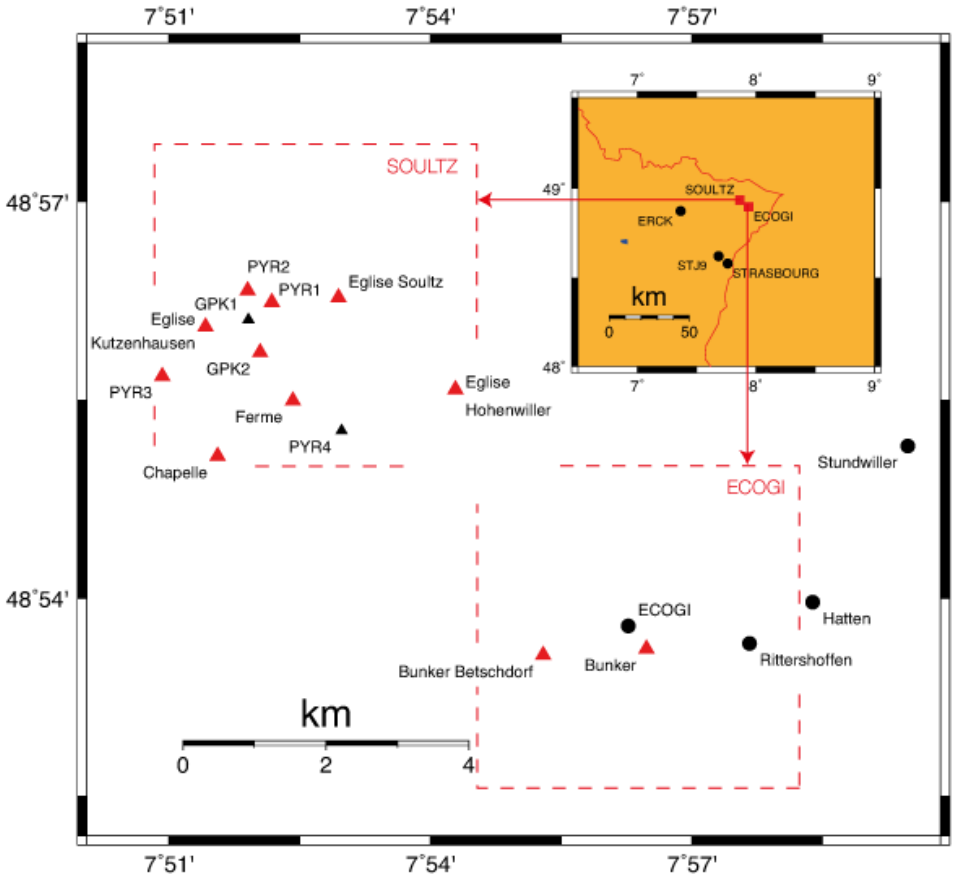

Figure 1: Location of the relative gravimetric measurement site (red or black triangles): 11 surrounding Soultz-sous-Forêts (GPK1 and GPK2) and 2 sites close to Rittershoffen (ECOGI site). Permanent GPS stations are indicated by black triangles or black circles.

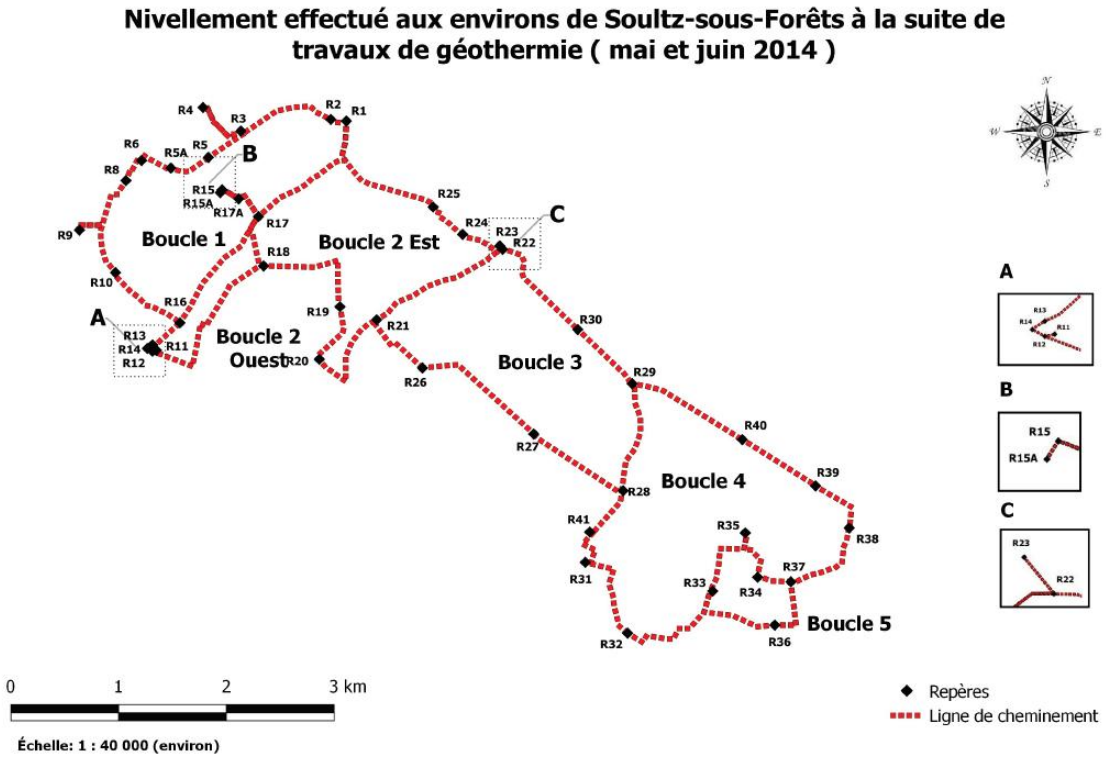

Figure 2: Leveling network around Soultz-sous-Forêts and Rittershoffen sites.

2 LOCAL STABILITY ESTIMATESBETWEEN 2014 AND 2015

In order to evaluate potential vertical deformation, we compute the height difference between two consecutive benchmarks at the two epochs (2014, 2015). Figure 3 shows these differences. For most height differences, values are lower than 10 mm, except for some line sections. A large value of 30 mm on a section of loop 3 is to be linked to soft monumentation in the field. No hard bedrock or concrete structure could be found in the field. Loop 5 (about 3.5 km long) surrounding the ECOGI site shows a relative stability, with maximum value of 3 mm.

3 FUTURE FULL GEODETIC COMPARISONS

Since the area of the two geothermal sites are surveyed by many techniques, i.e leveling measurements, relative gravimetric measurement, InSAR data and several permanent GNSS stations, future analysis will try to compare and possibly combine all these kinds of different information.

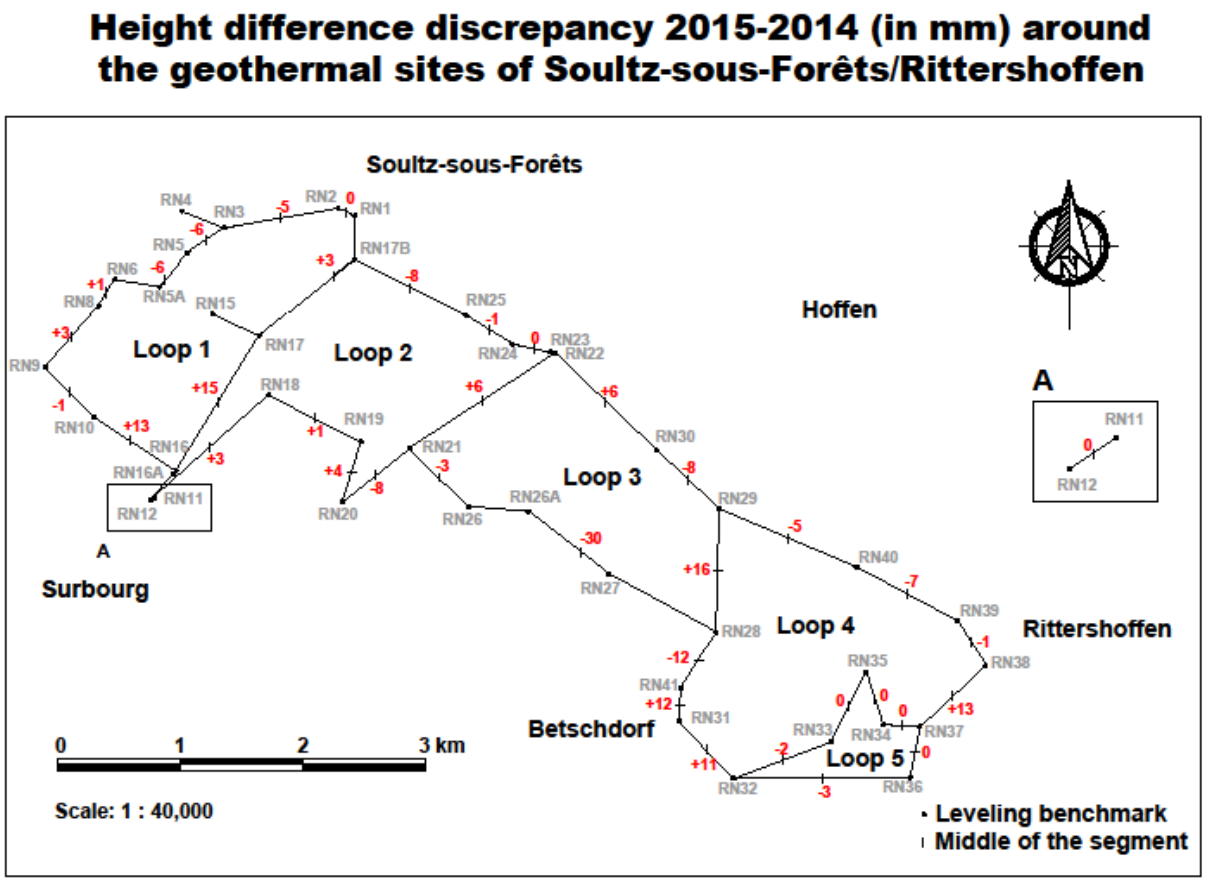

Figure 3: Height differences between consecutive benchmarks of the Soultz/Rittershoffen leveling network between 2014 and 2015

References:

Hinderer, J., Calvo, M., Abdelfettah, Y., Hector, B., Riccardi, U.,Ferhat, G., & Bernard, J.-D., 2015. Monitoring of a geothermal reservoir by hybrid gravimetry; feasibility study applied to the Soultz-sous-Forêts and Rittershoffen sites in the Rhine graben, Geothermal Energy, 3, 16, DOI 10.1186/s40517-015-0035-3