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International Partnership for Geothermal Technology

2011 Newsletter

In this Issue….

Upcoming Events

**

16-18 November, 2011

Australian Geothermal Energy Conference

Melbourne, Australia

**

21-23 November, 2011

33rd New Zealand Geothermal Workshop

Auckland, New Zealand

**

5-9 December, 2011

American Geophysical Union Fall Meeting 2011

San Francisco, California, USA

**

30 January- 1 February, 2012

37th Stanford Workshop on Geothermal Reservoir Engineering

Stanford, California, USA

Letter from the Chairman

Dear Friends,

From the Steering Committee of the International Partnership of Geothermal Technology (IPGT), we hope you enjoy the first edition of the IPGT newsletter.

The IPGT is a forum for government and industry leaders to coordinate their efforts, and collaborate on projects. Partners share information on results and best practices to avoid blind alleys, limit unnecessary duplication, and efficiently accelerate the development of geothermal technologies.

In the past year, the IPGT has been fortunate enough to welcome two new member countries. The IPGT charter was originally signed in 2008 in Keflavik, Iceland by representatives of Australia, Iceland and the United States. In October 2010, Switzerland formally joined the IPGT and I am happy to announce that New Zealand will also be signing the charter this November 16, 2011 in Melbourne, Australia.

Please enjoy this newsletter – I hope it helps to elaborate on why our countries are so committed to geothermal energy and how we can work together to create a better world.

With kind regards,

Gudni A. Jóhannesson, Prof. , PhD
Chairman of IPGT
Director General
National Energy Authority

IPGT Country Updates

Australia

Australia has significant geothermal energy potential. If we harnessed just one per cent of our geothermal resources we could power Australia for 26,000 years.

Recognising this resource base, Australia's current priorities for geothermal are proving the ability to capture the resource through proof of concept projects, attracting private sector financing and developing projects that demonstrate electricity generation. A recent example is MNGI Petratherm Ltd's successful fracture stimulation, which is helping contribute to the understanding and development of geothermal power in Australia.

Current Australian Government support includes the $126 million Emerging Renewables Program, of which at least a third is expected to be available to support geothermal energy, and an immediate tax deduction for exploring geothermal energy sources which will be available from 1 July 2012.

Additionally the introduction of a carbon price package in July 2012 will provide a price signal to improve investment in new clean energy technologies such as geothermal, alongside the $3.2 billion Australian Renewable Energy Agency and $10 billion Clean Energy Finance Corporation, which will provide a more certain future for government support.

Australia recognises the importance of countries working together to pool resources and share lessons to maximise the opportunities for global geothermal success. We are an active participant in the IPGT and IEA Geothermal Implementing Agreements.

Iceland

The Icelandic master plan for environmental conservation and utilization of the remaining larger power plant options which has been on it way since 2007 was finalized as a result of the work of the project and presented jointly by the ministry of industry energy and tourism and the ministry of environment to the Icelandic parliament. The proposal is now out for comments both as a part of the parliamentary process and the legal concerns of the planning law on the environmental impact assessment of national programs. The list of possible power plant options covered 84 alternatives and the proposal now suggests that power plants for 13 TWh will be destined for utilization, 13 TWh will be put on a waiting list for further decisions and a considerable part has been recommended for conservation, more often as they are within areas with unique scenic and environmental qualities. The majority of the possible power plant options are high temperature geothermal sources.

In the beginning of September 90 new MW were added to the Hellisheiði plant. Several geothermal plant options are in the pipeline but it seems that the there is some reconstruction and renegotiation of the sales contracts taking place. The geothermal research cluster GEORG has progressed well and the Icelandic geothermal community is working on an industrial cluster building. The Icelandic Deep drilling project has scored well in finding Magma and water at high temperatures but the depth was too small to reach the necessary conditions to get super critical fluid.

New Zealand

Geothermal resources supply an increasing fraction of New Zealand's electrical energy needs (having risen from 7% to ~13% over the past 5-6 years), with a possibility they could supply over 20% of New Zealand's electricity demand in the next decade.

In 2011, drilling operations have been undertaken at Wairakei, Tauhara, Taheke and Ngatamariki geothermal fields. The delineation and potential utilisation of *deep* geothermal resources in the Taupo Volcanic Zone is being investigated through a collaborative research programme led by GNS Science, with University of Auckland, IRL and Victoria University of Wellington, involving geological, geophysical (MT, seismic), geochemistry and numerical modelling studies aimed at gaining a greater understanding of the physical and chemical nature of fluids and flow pathways at 3-7 km depth.

As well as contributing to IPGT initiatives, the New Zealand geothermal research programme seeks to give developers a level of confidence for exploration strategies that reduce risks associated with deep drilling, with a goal to have a deep research well drilled in partnership with industry and ICDP in 2013-14. The research programme was initially supported through funding from the Foundation for Research Science and Technology, but from 1 July, 2011 has been incorporated into the GNS Science Core Science Area (CSA) Geothermal Research Programme (contact Greg Bignall (g.bignall@gns.cri.nz), Programme Leader for more information).

Switzerland

In 2010 seven Swiss utility companies have founded GeoEnergie Suisse, a special purpose company to bundle know how for the exploration and development of geothermal resources in Switzerland. The goal of the first phase is not to identify a single site for a pilot plant, but to identify a number of sites to create an entire exploration portfolio for potential pilot plants throughout Switzerland.

The definition of prospective areas should be completed by the end of the year. A detailed assessment of the sites with active exploration, in particular reflection seismic and eventually exploratory drilling, is planned to start in 2013.

Plans are to prove the technical feasibility of geothermal power plants in Switzerland within five to 10 years from now and to achieve a commercially viable power production within the next 10 to 20 years.

Switzerland continues to rely strongly on international collaboration. In addition to participation in the International Energy Agency's Geothermal Implementing Agreement, the Geothermal ERA-NET sponsored by the European Commission, the International Partnership for Geothermal Technology plays a central role. It is Switzerland's aspiration to soon establish joint projects with the partner countries.

The United States

The United States is the world leader in installed geothermal capacity with approximately 3 GWe installed and an additional 1.6 GWe in development.

In the near-term, the U.S. Department of Energy's Geothermal Technologies Program (the Program) will focus on rapid reconnaissance on a regional scale to locate hydrothermal prospects, improve the performance of existing exploration technologies and to develop new exploration tools.

In the long-term, the Program will demonstrate the technical feasibility of creating a 5 MWe Enhanced Geothermal Systems (EGS) reservoir by 2020 that is capable of being sustained for 20 years. Success in EGS will require new and improved tools and technologies to access a hot formation, create a reservoir and sustain the reservoir over time.

The Program is working with the U.S. Geological Survey to expand U.S. geothermal resource assessments to include all 50 states across a broad spectrum of temperatures and resource types, and to develop new geothermal resource classification standards. In addition, the Program is designing, implementing and populating the National Geothermal Data System (NGDS), a national, sustainable, distributed, interoperable network of data and service (application) providers.

The United States recognizes the importance of collaborating internationally to develop effective methodologies and practices, and demonstrates this through participation in the IPGT and the IEA-Geothermal Implementing Agreements.

For more information on geothermal projects in the United States, please visit: www4.eere.energy.gov/geothermal/projects.

IPGT Working Group Updates

Stimulation Procedures

The Stimulation Procedures working group has developed a draft white paper on exploration needs that was released for comment in May, 2011. The current draft of the white paper is available at:

http://www.internationalgeothermal.org/Working_Groups/Stimulation_Procedures.html

Induced Seismicity

The IPGT Induced Seismicity working group was established in October, 2010. The first group meeting was in Paris, France on May 3, 2011 where a series of tasks were developed. The next meeting will be November 14-15, 2011 in Melbourne. The Induced Seismicity working group collaborates with the International Energy Association's Geothermal Implementing Agreement (IEA-GIA) Annex X on Induced Seismicity.

Lower Cost Drilling

The Lower Cost Drilling working group will be working in 2011 to develop a description of technology needs and opportunities for international drilling collaborations.

Exploration

The Exploration working group has developed a draft white paper on exploration needs that was released for comment in June, 2011. The current draft of the white paper is available at:

http://www.internationalgeothermal.org/Working_Groups/Exploration.html

Reservoir Modeling

The Reservoir Modeling working group held two workshops in 2010 to develop the white paper on a vision for the development of a fully coupled thermo-hydro-mechanical-chemical (THMC) reservoir simulation code by the year 2020. The current draft of the white paper is available at:

http://www.internationalgeothermal.org/Working_Groups/Reservoir_Modeling.html

High Temperature Tools

The High Temperature Tools working group has developed a draft white paper on technology needs that was released for comment in February, 2011. The current draft of the white paper is available at:

http://www.internationalgeothermal.org/Working_Groups/High_Temperature_Tools.html

Zonal Isolation and Packers

The Zonal Isolation and Packers working group has developed a draft white paper on technology needs that was released for comment in February, 2011. The current draft of the white paper is available at:

http://www.internationalgeothermal.org/Worki

How to get involved….

To join a working group, please email: IPGT@ret.gov.au (note that participation in working groups is NOT limited to IPGT member countries)

If your country is interested in joining the IPGT, please contact IPGT@ret.gov.au for more information.

Issue Briefs

Don't stray further than 300 m from your injection zone at Basel:

Stress drops and their spatial distribution from the injection zone

Switzerland's EGS project at Basel has attracted considerable attention from stakeholders in response to the felt induced seismicity during the hydraulic stimulation in December 2006. As a consequence, the project has been terminated and the well shut-in. Under the auspices of the research initiative GEOTHERM, based at the Zurich campus of the Swiss Federal Institute of Technology (ETH Zurich) and sponsored by the Swiss Federal Institutes of Technology, the Swiss Federal Office of Energy and industry, has begun to analyze data and derive lessons learnt. Safe and successful EGS reservoir creation by way of a massive hydraulic stimulation will ensure that operators retain their 'license to operate' and become adept at engineering the reservoir to optimize subsequent heat extraction while reducing exposure and risks to a level as low as reasonably practicable (ALARP).

Owing to the installation of a highly sophisticated microseismic monitoring system, the operators of the Basel EGS Project have collected a data set that illuminates the processes operative during a massive hydraulic stimulation. Within the framework of the GEOTHERM project, ETH Zurich's Bettina Goertz-Allmann and colleagues have analyzed P-wave spectra of about 1000 seismic events to estimate stress drops and their spatial variation throughout the stimulated reservoir. The estimated median stress drop is 2.3 MPa with values varying over 2 orders of magnitude. Small stress drops of around 1 MPa occur close to the casing shoe with higher stress drop events progressively further away from the injection zone. A hydraulic diffusivity model accounts for locally observed transport properties and reveals a close correlation of the spatial distribution of stress drops with a modeled pressure perturbation. The result confirms that observed stress drops are a very good proxy for the pore pressure distribution during a hydraulic stimulation.

Some important insights into possibilities of designing and executing hydraulic stimulation operations have been made in a recently published study described next.

You have 6 hours: Forecasting induced seismicity during and after shut-in of hydraulic stimulation & Tracking the time-evolution of seismic hazard:

ETH Zurich's Corinne Bachmann in collaboration with Germany's GFZ Potsdam have analyzed statistical features of the induced seismicity sequence at Basel and show that the sequence

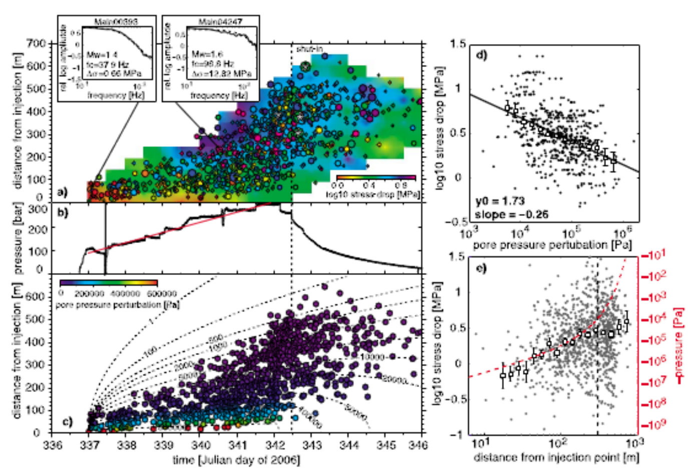

Figure 1: Distance - time plots of induced seismicity and the correlation with injection schedule and modeled pore pressure distribution (Source: Goertz-Allmann et al. Stress drop variations of induced earthquakes at the Basel geothermal site. Geophys Res Lett (Lett (2011) vol. 38 (9) pp. L09308

is well modeled with the Omori–Utsu law following the termination of water injection. Based on this model, the sequence will last 31 (+29/−14) years to reach background levels of seismicity. Bachmann et al. use Epidemic Type Aftershock Sequence (ETAS) models to successfully derive a 6-hr forecast of the seismicity to come, and use the forecast to develop a time-varying evolution of the seismic hazard during hydraulic stimulation. Such a model may in future serve as a valuable tool for designing probabilistic alarm systems for EGS experiments and govern operations in an increasingly controlled manner. Whereas Mohr-Coulomb failure criteria are commonly employed, Bachmann et al. relate their observations to modern rate- and state variable friction laws. Thus new approaches to designing and executing hydraulic stimulations may be developed based on mechanical rate effects, mechanical aging effects, hydrothermal effects on strength and hydrothermal effects on fluid flow (Karner, 2006).

Sources: (1) C. E. Bachmann, S. Wiemer, J. Woessner and S. Hainzl, 2011, Statistical analysis of the induced Basel 2006 earthquake sequence: introducing a probability-based monitoring approach for Enhanced Geothermal Systems, Geophys. J. Int. (2011) 186, 793–807 doi: 10.1111/j.1365-246X.2011.05068.x

(2) Goertz-Allmann, B., A. Goertz and S. Wiemer, 2011, Stress drop variations of induced earthquakes at the Basel geothermal site. Geophys Res Lett (2011) vol. 38 (9) pp. L09308, http://dx.doi.org/10.1029/2011GL047498

(3) Karner, S.L., 2006, Correlating Laboratory Observations of Fracture Mechanical Properties to Hydraulically-Induced Microseismicity in Geothermal Reservoirs, PROCEEDINGS, Thirty-First Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, January 30-February 1, 2006, SGP-TR-179

Paralana EGS Project, South Australia – Fracture Stimulation Completed

Petratherm is a specialist EGS explorer and developer with projects in Australia and Spain. The Company's flagship project, the Paralana Engineered Geothermal Project is located 600km north of the city of Adelaide in South Australia. Petratherm Limited in joint venture with a major oil and gas (Beach Energy) and power industry energy utilities (TRUenergy) are initially seeking to build a 7.5 MWe commercial power development to supply a local off-grid mine, with the long term objective of providing large scale (260 MWe) power through the national electricity grid.

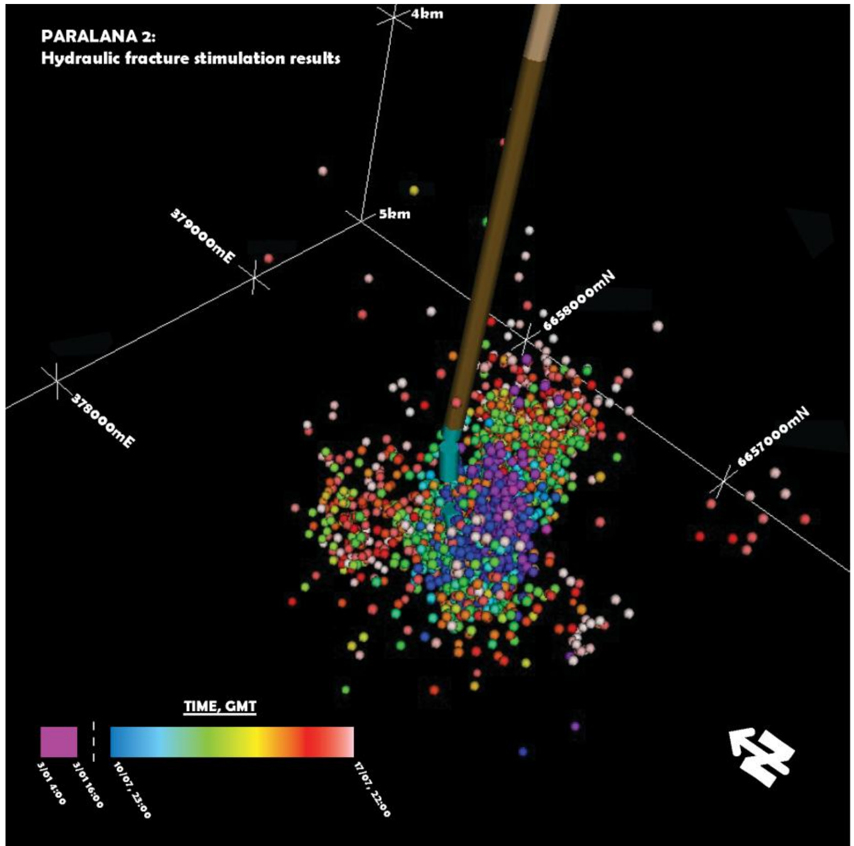

Figure 2 Micro-seismic locations from the Paralana Fracture Stimulation. Oblique view looking down and towards the northeast.

In the second half of 2009 a deep geothermal well, Paralana 2, primarily designed to be an injector well, was drilled to 4003 metres (G.L) AHD. During drilling of the well, several zones of over-pressured fluid between 3670 - 3864 metres were encountered. The Paralana 2 well recorded a temperature of 176°C at approximately 3,670 metres with modelled temperatures of 190°C at 4,000 metres.

In July 2011 the large scale fracture stimulation works were successfully completed. Over a five day period, a total of 3.1 million litres of water were pumped into the Paralana 2 well at pressures up to 9,000 psi and with sustained pump rates of up to 27 litres per second. The extensive mirco-earthquake monitoring array detected over 10,000 micro-seismic events.

The stimulated zone extends approximately 900 metres to the north east of the Paralana 2 well at a depth from 3,500 to 4,100 metres. On completion of the stimulation, the calculated stable wellhead pressure was 3940 psi. The encountered over-pressured fluids should assist in the recovery of hot fluids from the reservoir.

US DOE Recent Activities in Monitoring and Understanding EGS Induced Seismicity

The US DOE Geothermal technology Enhanced Geothermal Systems program has two main goals with respect to induced seismicity; to increase the productivity and effectiveness of geothermal energy recovery through research on induced seismicity, while simultaneously informing and ensuring the safety of EGS. This is being accomplished by focusing in two main areas, monitoring and understanding induced seismicity at multiple DOE demonstration sites and developing an up to date protocol and best practices documents.

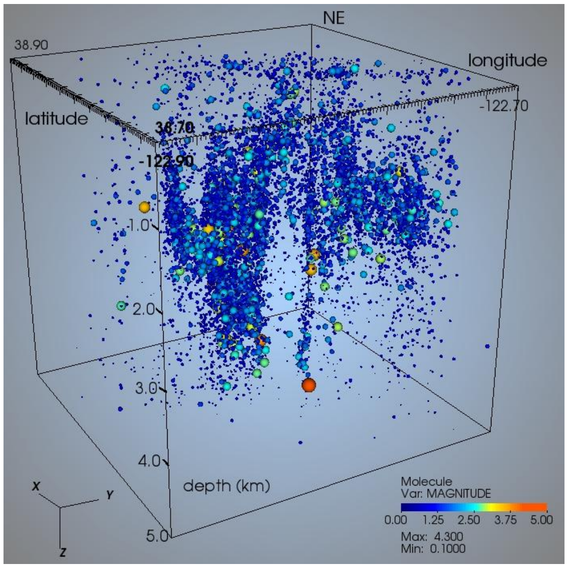

Figure 3: 3D Distribution of Earthquakes at The Geysers. Approximately 9,400 earthquake locations of magnitude 0.1 and higher are shown in this image. Locations are color-coded by magnitude, and the radii of the spheres are proportional to the magnitude. The data were obtained from the Northern California Earthquake Data Center.

In terms of monitoring, DOE is installing, operating, and/or interfacing MEQ seismic arrays at multiple EGS sites which are in collaboration with the various operators at the demonstration sites. The overall goal is to gather and understand high resolution MEQ data before, during and after stimulation activities at the EGS projects. This will include both surface and borehole deployments (as necessary and in conjunction with available boreholes). The purpose is to not only use MEQ data for understanding the creation and monitoring of fracture stimulation of EGS reservoirs, but for using both active and passive monitoring of the fracture systems. Current sites include Desert Peak and Brady's Hot Springs, Nevada, (Ormat Inc.) the NW Geysers project (Calpine), The SE Geysers (NCPA), Raft River, Idaho (US Geothermal), New York Canyon/Coyote Canyon (Terragen Inc.) and Newberry Caldera(Alta Rock/Davenport). A possible additional site is Bristol Bay, Alaska. Additional sites will be instrumented as DOE adds projects. A second goal is to process high quality MEQ data, improved processing methodologies to detect and understand fracture and fault mechanics, and supply advanced analysis of the data to the research community in order to develop, test and apply MEQ methods for understanding the performance of the EGS systems, as well as aid in developing mitigation techniques that can be used for a variety of EGS systems in the future. To date two EGS injection have started, the Desert Peak injection and NW Geysers. The seismicity at the Desert Peak site has been relatively low with all seismicity less the magnitude 1. The injection started in the fall of 2010 with very low injections rates and was slowly ramped up. In April a larger injection was undertaken which produced the most seismicity (still small events). A second injection is planned at the end of October 2011 which will occur at higher pressures and rates. At the NW Geysers the injection started on Oct 3, 2011 into the deep high temperature zone under the main production zone. Seismicity started within a few hours at the bottom of the injection well with all seismicity below Magnitude 1.6. This injection will be in stages for the next several months.

In terms of an updated protocol and best practices, USDOE has been developing two companion documents to address both of these issues. The first is the EGS induced Seismicity Protocol and the second is the EGS Induced Seismicity Best Practices. The protocol was developed for all stakeholders involved with EGS, recommending seven critical steps to be considered before, during and after EGS activities. It was written as a guideline, versus a requirement, that would be useful for the public, regulators, policy makers, the public and the operators. The purpose being to gain public acceptance as well outline procedures for dealing with technical issues associated with induced seismicity. The best practices was written mainly for the operators to provide a more detailed description and guidelines with specific recommendations on how to implement such activities as monitoring, risk analysis, and public interaction.

Re-injection triggers up to 3.8 earthquakes in Iceland

Re-injection has been a regular practice in nine geothermal fields in Iceland. These are 5 high temperature fields and 4 low temperature fields. Usually the fluid is injected at low pressure. Until recently, only small seismicity had been observed around the injection wells and not at all felt by people. According to the production licence, Reykjavik Energy has is obliged to re-inject into the reservoir below 800m depth all the return fluid from the 303 MW_e Hellisheidi geothermal power plant, presently around 600 l/s. Initially, the re-injection took place around 3 km south of the power plant in an area called Gráuhnúkar. This has been done during a few years with low observed seismicity. The maximum re-injection at Gráuhnúkar was around 250 l/s.

The reservoir temperature at Gráuhnúkar is very high so the area is rather considered to be a potential production field than a suitable re-injection field. Therefore it was decided to move the re-injection area some 4 km to the north into a known fault zone in an area called Húsmúli. During drilling of an injection well at Húsmúli in early 2011 seismicity was triggered during total circulation loss at 1300m depth. The size of the largest earthquakes exceeded Ml 2. This showed clearly that the differential stress in the bedrock is very close to the failure limits and only a very little increase in pore-fluid pressure triggered the earthquakes.

The re-injection of up to 500 l/s started at Húsmúli in September 2011, followed by high seismicity. Until mid-October around 2000 earthquakes were identified, most of them quite small. However, some larger events did happen. The quakes occurred mainly in swarms with hundreds of events during a few days with periods of low activity in between. The most intensive swarm occurred on October 15th with several events above 3, the largest one was M_l 3.8 in size. These quakes were abnormally strongly felt in the village of Hveragerdi, 12 km east of the injection area and also in Reykjavik. The apparent reason is that the earthquakes are mostly occurring in the uppermost 3 km of the crust where velocity gradients are high causing the energy to be trapped within the surface layers.

In May 2008 the village of Hveragerdi suffered a 6.3 earthquake with epicentre almost within the village. It caused lot of damages on houses and extensive material damage but fortunately no injuries of people. A consequence of this earthquake is that the people are quite sensitive to earthquakes. They have strongly protested against what they call man-made earthquakes and insist the re-injection to be stopped. That is hardly an option without shutting down the power plant or injecting the fluid into the shallower groundwater reservoir which also is of environmental concern.

Since the intensive swarm on October 15th the seismicity has decayed and is negligible now two weeks later. It is hard to predict the evolution of the seismicity but it is likely that the seismicity will mostly disappear when pressure increase due to the injection has stabilized. The authorities are closely observing the development ready to interfere if necessary.