Implementation of a probabilistic traffic light system for the reduction of seismic hazard associated with an EGS project using a hydraulic multistage stimulation in the Commune Haute-Sorne (République et Canton du Jura, Switzerland)

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In Switzerland the large geothermal potential for electrical power production can only be used if Enhanced Geothermal Systems (EGS) will be technically feasible. Based on the data of the Deep Heat Mining Project Basel a new concept has been developed which reduces the risks of induced seismicity and promises a better return of energy. In addition the acceptance by the local population and the authorities play an important role. Geo-Energie Suisse Ltd. has started permitting procedures for EGS pilot projects at five sites in Switzerland in order to create a portfolio of projects sites. The sites are located in the communities of Haute-Sorne (Canton Jura), Avenches (Canton Vaud), Etzwilen (Cantons Thurgau and Zurich), Pfaffnau and Triengen (both canton Luzern).

Hydrothermal systems for an electricity production from deep geothermal energy in a larger extent are in Switzerland exceptional areas like fault zones and permeable aquifers in depth of 4,000 to 5,000 m. A large-scale extension of such systems could not be proven up to now. For sedimentary systems in greater depths, whose temperatures also allow an electricity production, only a small zone in the foreland of the Alps can be taken into account. Additionally the situation complicates, as the very good aquifers in the Bavarian Molasse Basin become to the West less permeable with lower flow rates of the groundwater.

Based on these considerations the Geo-Energie Suisse Ltd. decided to focus their activities on the development of EGS-pilot-projects (petrothermal systems). If it is possible to install in the crystalline rocks of the basement an artificial boiler, that technology can be used nearly everywhere in Switzerland. For the first time such a big permeable system could be created in the well Basel-1 in 5,000 m depth, however, the unrequested side effect of induced seismicity occurred.

The Basel results and the ongoing research and development show that the magnitude of such seismic events can be controlled by a series of measures, Therefore, especially the approved techniques from the oil and gas industry shall be included, like the combination of horizontal well with a multitude of stimulated zones.

The stimulation of an Enhanced Geothermal System (EGS) involves the injection of a fluid at high pressure, which induces seismicity and enhances permeability. Although to date there is no recorded instance of a significant danger or damage associated with induced seismicity related to geothermal energy production, induced seismicity is an important topic that needs to be coped with because the occurrence of a large magnitude event causing structural damages cannot be fully excluded. Two pillars for the reduction of seismic hazard are (1) the real-time monitoring of induced seismicity and (2) the application of reactive systems to cease the injection as a response to seismicity, termed “traffic light systems” or simply TLS. Generally, TLS are reactive and deterministic, e.g., the injection is stopped if a pre-defined threshold magnitude is exceeded. Rarely, TLS are probabilistic, e.g., the injection is stopped if

the exceedance probability of a certain magnitude is high. Adding such criteria confers the TLS with forecasting capabilities, thus becoming an Advanced Traffic Light System, or ATLS. Such a system has been developed by the Swiss Seismological Service and has been calibrated using the data from the Basel project.

This presentation reports on the tasks undertaken by Geo-Energie Suisse AG for the implementation of a probabilistic traffic light system for the reduction of seismic hazard associated with the stimulation of a multi-fracture system in the community of Haute-Sorne (Switzerland). An ATLS is used to evaluate the probabilistic seismic hazard associated with the stimulation of a single fracture and with the multi-stage stimulation of a system of parallel fractures. It will be shown that:

1) The implementation of a probabilistic traffic light system (termed here Advanced Traffic Light System) reduces considerably the seismic hazard. The stricter the ATLS criteria are, the greater the risk reduction is.
2) The multi-stage stimulation of a larger number of smaller parallel fractures is proven superior to the massive stimulation of a single fracture zone with equivalent area.