Study visit to northern Iceland, May 2024

On May 27–28, 2024, a study visit to Iceland took place as part of the project *"Optimal Management of Low-Temperature Geothermal Reservoirs – Polish-Icelandic Cooperation on Reservoir Modelling."* The visit included project partners from the Iceland GeoSurvey (ÍSOR) and the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences (MEERI PAS). The purpose of the trip was to visit Akureyri and the low- and high-temperature geothermal fields located in the northern part of Iceland.

On the first day, a meeting was held at the ISOR headquarter in Akureyri, during which ISOR team presented information about the test geothermal fields in northern Iceland, that are of interest to the GeoModel project. Then, participants had the opportunity to visit the Hjalteyri geothermal field, managed by the company Norðurorka. This area is the most productive low-temperature geothermal reservoir in Iceland, considering the productivity from a single well. Currently, there are three production wells: HJ-19, HJ-20, and HJ-21, from which it is possible to obtain over 200 l/s of low-mineralized water at a temperature of 87.5°C with steady long-term extraction. Water from the production wells provides about 60% of the heat demand of the town of Akureyri.

On the second day of the technical visit, we travelled to the high-temperature geothermal fields Hverir – Krafla, located about 80 km east of the town of Akureyri, near Lake Mývatn. This place is the cradle of electricity generation from geothermal resources in Iceland and the site of many pioneering research projects, which will be discussed later in the report. The hosts of study visit emphasized the importance of appropriate surface and borehole investigations for the proper identification of geothermal reservoir conditions, as well as the significance of monitoring for predicting parameter variability during long-term exploitation and locating new

boreholes. The experiences from the Krafla area are universal and also useful in the context of the GeoModel project.

An interesting point on the way to the Krafla area was the Vaðlaheiðargöng tunnel just outside Akureyri, where a very productive geothermal system was encountered during its construction. The 7.4 km long tunnel passes through a fault zone, and during its excavation, a flow of geothermal water with a rate of over 400 l/s and an initial temperature of 50°C was observed. While driving through the tunnel, one can clearly feel the increase in air temperature to as high as 22–26°C. Currently, the hot water drained from the tunnel supplies the Forest Lagoon spa located in Akureyri on the eastern shore of Eyjafjörður.

At the very beginning, it should be mentioned that Lake Mývatn and the Krafla volcanic area are located at a tectonic rift, which is a continuation of the Mid-Atlantic Ridge. Two powerful tectonic plates diverge there: the North American plate towards the west and the Eurasian plate towards the east. The process of plate spreading (rifting) is ongoing, hence this region is characterized by strong volcanic activity with numerous surface symptoms. Before reaching Lake Mývatn, we had the opportunity to admire the beautiful Goðafoss waterfall (Icelandic: Waterfall of the Gods), located about 35 km east of Akureyri.

Near Lake Mývatn, there are two geothermal power plants: Bjarnaflag, with a capacity of 5 MW, put into operation in 1969, is both the oldest and smallest geothermal power plant in the country, and the significantly larger Krafla, with a capacity of 60 MW, launched in 1977. The full rated capacity of the Krafla power plant was achieved in 1996 after additional wells were drilled and a second 30 MW steam turbine was installed. It is worth mentioning that the first geothermal well drilled as part of the Iceland Deep Drilling Project (IDDP-1) is located here. During its drilling, the top of a rhyolitic magma chamber was encountered at a depth of 2,100 meters, which caused equipment failure and the abandonment of further drilling (ultimately, the well was cemented). In 2016-2017, the second well was drilled on the Reykjanes Peninsula (southwestern Iceland) to a depth of 4,659 meters (vertical depth about 4,500 meters), capturing supercritical steam at a temperature of 427°C and a pressure of 340 bar. This was the first successful example in the world of accessing geothermal resources in supercritical conditions (IDDP-2 project).

In the Krafla volcanic area, at the foot of the Námafjall volcanic mountain and 3 km from the Bjarnaflag power plant, Hverir geothermal field is located. This is an extraordinary place where geothermal activity is visible with the naked eye. The area is covered with bubbling mud pools, fumaroles emitting steam and sulfur fumes, and the soil displays a white-yellow-brown colours, resulting from the high concentration of sulfur compounds and hydrothermal transformations.

During the technical tour, we also had the opportunity to walk along the Dimmuborgir lava field, see the inside of the Viti crater up close, and dip our hands in a hot spring in the Grjótagjá cave. The Dimmuborgir lava field was formed about 2,300 years ago during a massive lava eruption from a 12-km fissure. When the lava reached Lake Mývatn, the water boiled and steam explosions formed the characteristic lava structures resembling chimneys and caves. The Viti crater, which translates to "hell" in English, was formed during a volcanic eruption in 1724. The eruption lasted for 5 years and is known as the "Mývatn Fires." Reports state that the Mývatn fires were even visible from the southern coast of Iceland. The diameter of the Viti crater is about 300 meters, and it is most famous for the beautiful blue colour of its water, which during our visit was still covered with ice and snow.

The Grjótagjá cave (one of the fissures in the active rifting zone partially filled with groundwater) was a popular spot for hot baths by locals until 1975, when the Krafla eruption lasting from 1975 to 1984 caused the water temperature to rise to about 60ºC. Currently, the water temperature ranges between 43 and 46ºC; however, bathing is prohibited. At least, it is possible to visit and explore the cave.

It should be emphasized that the Krafla volcanic area has previously been the subject of modelling using Lumpfit software. The Krafla geothermal field is exploited using approximately 30 wells, and thus the new version of the software developed as part of the GeoModel project, Lumpfit++, offers completely new possibilities for more precise modelling of the Krafla geothermal system's response under various exploitation conditions.

More about the GeoModel project:
http://geomodel.pl
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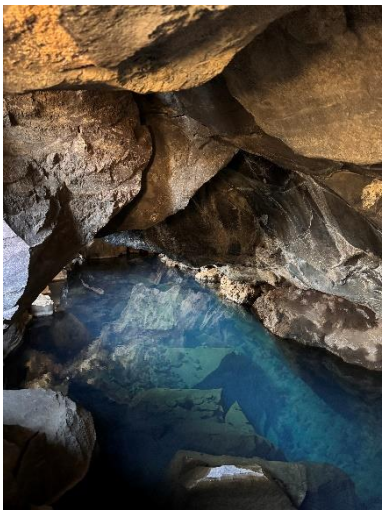





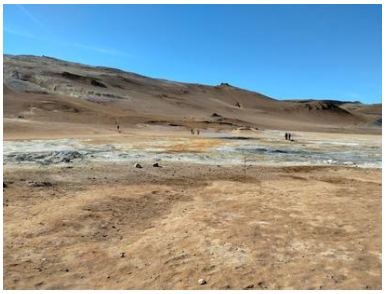


Photos: Aleksandra Kasztelewicz, Maciej Miecznik, Magdalena Tyszer (MEERI PAS)