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Sturlugötu 7
101 Reykjavík

Vestmannaeyjum 14. júlí 2017
UST201605-001/P.V.B.

Subject: SUSTAIN project-permitt

The Environment Agency of Iceland has received a request from Marie Jackson and Magnús Tumi Guðmundsson on behalf of SUSTAIN drilling program, dated April 29th 2016, with a request for permission to drill two boreholes in Surtsey for scientific purposes.

Surtsey was declared a nature reserve in 1965. Since then human visits have been restricted to prevent biological contamination and to protect Surtsey's delicate environment. Written permission must be obtained from the Environment Agency of Iceland to visit the island Surtsey and dive inside the nature reserve.

Description of the project:

The principal research foci of the SUSTAIN drilling project involve interdisciplinary studies in volcanology, hydrothermal processes, mineralogy and microbiology that integrate scientific investigations by international researches with a broad range of research expertise. The principal global scientific and societal benefits of the research project will be directed towards 1) investigating explosive fragmentation processes of basaltic tephra as a means to refine predictions of hazards associated with sub-aerial explosive eruptions and rapid edifice growth of seafloor volcanoes, 2) describing the chemical-mechanical changes in the Surtsey tephra through hydrothermal rock-water interactions as a means to refine geophysical monitoring of fluid/waste disposal or storage sites and thermal and chemical stimulation of hydrothermal reservoirs in pyroclastic rocks, and 3) determining the role of geochemical and biochemical processes in the development of Al-tobermorite-zeolite mineral assemblages in Surtsey tephra, assessing their cation exchange properties for radionuclides and heavy metals, and transferring this information to applied laboratory studies to reproduce these cementitious fabrics in innovative pyroclastic rock concretes in the built environment and, potentially, encapsulations of wastes using basaltic tephra investigating. The plan is to make two new drill holes in Surtsey which will replace older one from 1979. The new drill holes will be situated within 5-10 m from the 1979 hole. The 1979 hole is located 200 meters from the hut Pálsbær and the helicopter platform.

Hole 1 is an oriented, continuously cored (HQ initially - 96 mm hole size) vertical hole, that will attempt to reach sediment of the pre-eruptive seafloor beneath the volcano, thereby recovering the earliest and, as yet, unsampled phase of the Surtsey eruption. During drilling, samples for pore water and microbiological analyses will be collected on a 30 cm core segment every 10 m; down-hole water samples will be collected after drilling is complete. Estimated total depth is ~210 m. The design of Hole #1 is intended to provide a future laboratory for in situ studies of water chemistry, microbiology, and mineralogy in the Surtsey Subsurface Observatory.



Hole 2 is an oriented, continuously cored (HQ possibly to NQ - 75.5 mm hole size) hole at a 50° angle from horizontal, inclined towards the SE tephra crater with the intent to (1) intersect additional dikes and intrusions beneath the crater, (2) gain additional information on stratigraphy and structure, and (3) investigate the higher temperature portions of the hydrothermal system. The estimated total depth will be ~300 m. Regarding the temporary drill site structure no concrete or gravel pad or other permanent construction will be installed at the proposed drill site. Rather, the drill will be set on a level pad excavated from the volcanic substrate adjacent to the 1979 drill site. The drill site layout will have dimensions 7.5 by 4.5 meters (25' X 15'). Alternative methods are foreseen to fasten the drill platform securely to the ground. If tephra thickness is <0.5 m: The platform will be fastened to the ground by drilling ~50 cm deep, 2-3" wide holes into the lava surface after removal of the uppermost layer of tephra. Iron rods will be cemented into the holes and the platform fastened onto these foundations by welding or in some other acceptable way. If tephra thickness is >0.5 m: A closed, elongated 0.5 m wide and about 0.5 m thick sandbag-like closed gabion filled with tephra from the site. It will be made of chicken wire and sturdy plastic. Iron rods will be founded within the gabion and the frame of the drilling platform fastened to the rods. In both cases foreign parts (rods, gabions etc.) will be removed after drilling and the tephra used in the gabion left in its original location, leaving only the two drill heads 50-70 cm above ground.

The two SUSTAIN holes will be drilled using a helicopter-transportable CS-500 diamond core rig. All components of the drill will be washed and sterilized prior to shipping to Iceland. Rubber rig mats weightening down the drilling equipment would surround the drill site, and the volcanic substrate would be protected from disaggregation and erosion. Rig mats, anchored to the drilling platform, will also underlie a temporary drilling support shelter, which will be held stationary for the drilling of both holes. A separate area for core processing will be designated closer to the Pálsbær hut. The drill rig is going to be around 105 db-115 db loud while drilling. The primary drill string will be HQ with an NQ string as back up. Both proposed holes will be drilled in a similar fashion: 1) rotary drill 6-3/4 inch hole to a depth of 10 m; 2) run in hole with 4-1/2 inch casing and cement to surface; 3) run in hole with HQ coring string and core to total depth (TD). If conditions require, the string will reduce to NQ. Upon reaching TD, the holes will be logged using a suite of slim hole logging sondes deployed from a motorized winch to the base of the holes at 200-300 m depth. Hole 2 will be completed with 2-3/8 inch steel liner that will preserve it for subsequent temperature logging and monitoring, similar to the 1979 hole. Hole 1 will be fitted with anodized aluminum casing (6061-T6, solutionized and artificially aged), with 1.2 m long perforated intervals installed with the rest of the casing, immediately after drilling.

The holes will be cored using seawater as drilling fluid, as was done in the 1979 drilling project. A diesel-powered generator will pump the seawater upslope to the drill site. The pump will be around 96 db but sound walls can be constructed to reduce the noise pollution. Water will be pumped from the sea, either on the NE-shore or on the western side of the northern peninsula. The location will be chosen on the basis of the least chance of wave action damaging the intake pipe. The NE-option calls for about 800 m long pipe traversing the Surtsey substrate. For the NW-shore option the pipe would be about 1200 m. The pumps will be running continuously with breaks only happening to check the oil and fuel which is every 12 hours.

The inlet for seawater will be at >20 to 30 m depth, and >50 m from the coastline. The hose for the inlet will be wheighted down with weights at the end. Steel cable will be attached at the end and a float at the surface to mark the spot. A nylon rope will also be placed at the inlet in case the float is released by accident in bad weathers. A >50 m-long plastic pipe will be securely mounted at the shore, with weights attached at the seawater intake and along the pipeline to prevent movements. A mesh screen will cover the pipe opening to prevent the influx of fine-gravel-sized particles. Small buoys attached to the midsection will mark the underwater path of the pipe. The pipeline will be checked on a daily basis to make sure that it does not become unmoored or break off in stormy weather. The seawater will be held in a secondary container tank at the drill site and sterilized by UV light to minimize contamination of Surtsey subsurface deposits with surficial marine organisms. A 1'' "Oroflex" hose wich is flat style fire hose will transport the drill fluid (sea water with drill cuttings) to the coast through a pipe, releasing the fluid by the northern end of the sea cliff. The residual solids from the drill fluid would be transported off Surtsey to Heimaey during helicopter resupply trips to prevent spilling of polymer onto Surtsey substrate. It is anticipate that polymer may be required to effectively clean both holes below 138 m depth, where unconsolidated tephra was intersected in the 1979 hole. The polymer would be used only if necessary and in small quantities, in order to increase the viscosity of the drilling fluid and lift the cuttings more efficiently so that drilling can proceed downsection. The polymer used is GS-550. This is a water-soluble polymer/polyacrylamide powder with a high molecular weight. This is a non-biodegeradable product. At Hole 2 additional mud-polymer beyond GS-550 may be needed to continue drilling to the seafloor. The preferred material is attapulgit, a needle-like clay mineral or "fullers earth" that has been employed in scientific drilling for >50 years. This is a non-swelling material that would have minimal impact on the Surtsey basaltic deposits. This is a non-reactive, non biodegradable attapulgit clay. In both holes a mix/storage tank with seawater would be used so that the material could be re-circulated, reducing the amount required for the drilling. If used, the maximum amount would be about 500 kg for each hole. About 250 kg of each polymer would be transported to Surtsey and a reserve held on Heimaey, to be used only if necessary to deepen the angled hole through unconsolidated deposits. The products of polymer proposed for use in the Surtsey drilling operation are the most environmentally benign materials presently available for scientific drilling. During use in the drilling operation, product containers will be placed on plastic boxes and sheeting mounted on rig mats immediately adjacent to the "mud" tank. Any spillage will be immediately managed with absorbent and then transported to a garbage receptacle for transport to the waste treatment facility on Heimaey via helicopter.

On site logging of drill core will provide labeling and initial observations of rock type, consolidation, and structural features, with detailed lithological logging to take place on Heimaey. A series of reference samples will be designated at about 4 m intervals through the two holes above and below sea-level, giving about 50–60 samples per hole. The study of the subsurface microbiology and water geochemistry will involve three stages: 1) on-site pore water and microbiological sampling during drilling, 2) downhole water and microbiological sampling after drilling, and 3) preparation of the eventual Surtsey Subsurface Observatory. Subsequent to downhole logging, microbial incubation chambers and plugs would be installed for present and future tephra alteration, mineralogy, fluid geochemistry and microbiology studies. The plan is leaving the first incubation experiment inside the borehole for two years.

The experiment chambers could be retrieved during the annual Surtsey Research Society visits. After the experiment is complete, the cylinders would be removed from the rope. For each substrate type and depth interval, one cylinder would be dedicated to microbiological studies involving potentially indigenous bacteria and archaea from the hydrothermal waters and the other one will be used for mineralogical studies. When the HTMTL data is downloaded the data will provide a two-year record of temperature evolution. They would show how quickly the hole temperatures rebounded to its natural state. Subsequent incubation experiments would be proposed based on the findings of the first experiment installed in 2017.

The fuel for the drill rig should be sling dropped in standard 210 liter barrels at the drill site. Fuel will be stored in a secondary containment site at the drill site. A berm of volcanic ash will be covered with a thick plastic liner; the fuel drums placed on the plastic liner, and additional volcanic ash bermed around the drums. The secondary container site should be close enough, about 15 m (50') from the rig to fuel the rig using a 12v transfer pump and fuel hose. About 350-400 liters (100 gallons) of diesel fuel per day during 24 hours continuous operation are projected to be used. In order to prevent contamination, open, leakage-proof containers (of a type similar to fiskikar or bigger) will be used as a secure platform for opening of barrels and re-fueling pumps, drill and generators. Full barrels will be stored together at all depots and empty ones fastened with straps to the bundle of filled barrels. About 75 barrels of diesel fuel are projected to be transported to Surtsey. Fuel barrels, when flown to the island, will be wrapped in thick plastic to minimize the risk of holes forming and leakage during transport and subsequent storage on the island. A strict protocol will be developed and used for all fuel handling to prevent contamination and leakage. About $\frac{3}{4}$ of the barrels will be sling-dropped at the drill site onto a secure plastic base and then surrounded by berms of volcanic ash. About $\frac{1}{4}$ of the barrels will be sling-dropped at a depot by the site of the temporary sheds for operating the generator, or at the seawater pumping site on the shoreline. The barrels will be placed on a plastic base, surrounded with thick berms of volcanic ash, and bound together with straps. The type of plastic the barrels will be wrapped in and stored is Americover. It is fluted and does not tear easily. The thickness is 6-mil (0.15 mm) and it is estimated to use it in four layers under the fuel barrels and the ATM. A heavy duty absorbent diesel fuel spill kit will be kept on reserve at the drill site to manage any spill or leakage, and the absorbent materials flown off island with the emptied fuel containers. Diesel fuel will be used for the drill and pumps but generators and ATM will use gasoline.

In order to provide secure accommodation as well as working conditions for both fluid sample and core preparation for transport to Heimaey, two high strength portable shelters will be brought to the Island and placed northeast of Pálsbær. The details of the shelter have not yet been defined. The shelters/tents will have a solid floor to provide stable and dry working environment, preventing contamination and preserving the Surtsey surface substrate. Each unit will weigh at maximum 1000 kg, and consist of a frame structure, a floor and probably walls made of water-proof thick canvas. The shelter/tent will be fastened down by plastic barrels (100-200 liters each) filled with water-saturated tephra. As many barrels as are considered needed from assessment of wind forces will be used. After use, the tephra will be replaced to the surface where it was before. Shower for the drillers will be located within a sturdy tent-unit. This shed will have a wooden floor and it is expected that the shower water will be collected into a tank underneath the shower. This will be arranged in such a way that the changes of shower water being spilled into the ground will be remote.

The collection tank will be emptied after use: Either into larger tank that would be connected to the hose leading releasing drilling waste water to the sea, or the tank will be transported with the ATV to the shore where the water will be poured directly into the ocean. To minimize any possible introduction of plant or animal life to Surtsey, all food preparation and consumption will take place in designated areas in or near Pálsbær so that no food scraps or trash (tomato, cucumber or melon seeds, for example) will be dispersed on the Surtsey substrate. Two portable toilets will be installed, one at the drill site and the other at the Pálsbær hut to capture all human waste. The toilets will be fastened down by plastic barrels (100-200 liters each) filled with water-saturated tephra. As many barrels as are considered needed from assessment of wind forces will be used. After use, the tephra will be replaced to the surface where it was before. The same will be done with boxes/containers for samples, equipment and refuse. A strict protocol on handling of refuse and human waste will be followed to minimize the risk of accidental spillage. The waste will be compacted in the liner, placed in a designated receptacle, and then transported by helicopter to Vestmannaeyjar and delivered to the waste treatment facility on Heimaey on a weekly basis. Receptacles will be sanitized on Heimaey and returned to Surtsey in subsequent helicopter flights. All shoes could be dipped in a disinfectant bath, either upon exiting the helicopter at Surtsey or upon entering it at Heimaey, so that no organisms will be brought by foot traffic to the island. A current map of sensitive biological sites will be distributed to each member of the SUSTAIN work teams, and an integral component of the safety training will be to describe the nature and location of these sites, and the care that must be taken to avoid any disruption of these habitats. Prevention of work site injuries and conservation of the Surtsey substrate and surface ecology at the drill site will be a primary concern of the drilling operation. DES drilling staff have extensive safety training, and all scientists working on the island will be required to undertake safety and conservation training on Heimaey before their arrival on Surtsey.

One ATV (6 wheel) be transported to the island and will only be used for the following purposes: a) Transport core from drill rig to camp by hut. b) Transport tools and similar material from camp towards pumps. c) Transport water used in shower, if this way of water disposal will be chosen. d) No trips that are not explicitly needed for the drilling operation will be allowed. Between camp and drill-site and camp and the shore at the end of the lava north of the camp a designated path will be followed – in loose tephra. It is expected that the ATV will always be parked at the same spot between trips. This will either be a wooden platform or a secured designated spot. It is expected that a thick plastic containment will be placed under the ATV at this park site to catch drips and leaks; this also includes a drip containment while fuelling any equipment. Any traces of foot traffic between the drill site, core processing area, and Pálsbær will be removed through raking of volcanic ash after the drilling operation is complete.

Seventeen research projects involving 42 scientists from 10 countries (Australia, Germany, Iceland, Italy, New Zealand, Norway, Sweden, Switzerland, United Kingdom, USA) have been proposed for study of the new cores and geothermal fluids. The overall responsibility for daily management of the project, internal/external communications, and organizational aspects of the drilling campaign rests with M. D. Jackson and M. T. Gudmundsson, supported by DOSECC and University of Iceland. It is anticipated that the entire project should be completed in 6 weeks, including the mobilization and demobilization operations.

It is estimated to start the program on July 22th with a small group of 6 persons to prepare the drill site for equipment drops, prepare foundations for temporary sheds, arranged for the berms of volcanic ash to protect fuel barrel storage, and install the sea-water intake system. In the next few days the equipment will be transported to the island with assistance from the Coast Guard. This should take 1-2 days. The optimum estimated time of completion of each of the two drill holes is 15 days. Approximate 38 people will need to enter the island during the project. Not all of them will stay in the island at the same time. Maximum number of people needed for Hole 1 is 13 persons and 9 persons for Hole 2. The drilling will be done during 12 hours shifts. Only individuals whose work is essential to the logistical and drilling operations will be considered for visits to Surtsey. Safety and conservation training on Surtsey will be required of all individuals before arrival on the island. It is estimated that the drilling project will finish before middle of September and all equipment been packed for transport. The equipment will be packed so it can withstand severe weather. All equipment will be removed after September 5th or when the Coast Guard ship is available. In case the removal of the drill and equipment delays a small group will be sent to the island to secure it more securely and material that might be blown away in winter storms will be moved in the container that is part of the drill equipment. The cores sampled will be stored at the Iceland Institute of Natural History.

Reviews

The application was sent for a review to agencies conducting research in Surtsey and other stakeholders. Review was received from the Agricultural University of Iceland, Icelandic Institute of Natural History, Marine and Fresh Water research institute and South Iceland Nature Research Iceland. In their reviews there were no objections towards the project. The drilling will take place where there is little vegetation and birdlife. The main concern was that there would be too much disturbance on the peninsula where the grey seal colony is located since they breed in the fall.

Impact assessment

The implementation as such will have a significant impact on the drilling site and vicinity during the period it will take place although it is thought to have little or no negative affect in the long run. The drilling site is outside important bird areas and the vegetation is scattered. The Environment Agency of Iceland, for its part, authorizes the drilling of the two drill holes in Surtsey in the summer of 2017 under the following conditions:

Conditions

- This license is for the drilling and temporal facilities and is valid for the period 22th of July til 10th of September. Travel permits for the staff conducting the drilling, preparation and wrap up will be issued separately since they are given out to individuals.
- The Environment Agency of Iceland must be informed in advance of all changes from the description of the project as described in this permit and must consent to them before they can be implemented.
- All equipment must be thoroughly cleaned before it is transported to the island to make sure no soil, seeds or organism is brought to Surtsey.
- When the drilling is over all traces of the operation shall be removed.
- During the implementation of the project all equipment must be securely fastened or tied down to prevent it from loosening in bad weather.

- In order to minimize environment impact when possible sand anchors are to be used to secure equipment instead of barrels full of sand.
- Use of polymer is to be minimized. Water carrying polymer shall not be discharged on land.
- All waste shall be removed from Surtsey when the project has ended.
- Waste water from showers shall should not be discharged on the Island.
- Environmental certified sanitary and cleaning products are to be used for showers and cleaning.
- Sound from pumps and generators shall be minimized to reduce noise pollution impacts on bird and seal colonies.
- Before August 15th it is not allowed to enter bird nesting areas without permission from the Environment Agency.
- After September 1st traffic on the peninsula on the north side of the island is prohibited without supervision from Environment Agency staff on site to reduce stress in the grey seal colony.
- Oil barrels and other pollution material shall be stored in thick fish tub when in use. Empty barrels and those who are not in use shall be stored on a plastic canvas (Americover) in four layers. Extra care must be taken while handling the barrels.
- The ATM vehicle is to be stored on a plastic canvas in four layers and mats that will absorb oil while not in use near Pálsbæ and the drill site.
- The ATM vehicle is only to be used inside a marked path between Pálsbæ and the drill site. The use of the vehicle is not allowed outside this path.
- The ATM vehicle shall only be used to transport equipment and drivers.
- The speed limit for the ATM vehicle is 15 km/hr.
- Drivers of the ATM vehicle shall have a valid driver's license and have had training using the vehicle.
- During the project adequate oil clean-up equipment shall be at hand in order to handle all possible oil spills during transport, handling or storage.
- The Environment Agency of Iceland wishes to be secured, free of charge, a copy of all reports and scientific articles that result from the research project.

Fees charged

The Environment Agency of Iceland charges a fee of ISK 39.400 for processing and passing permits for construction and activities inside protected areas that may have negative impact on the site.

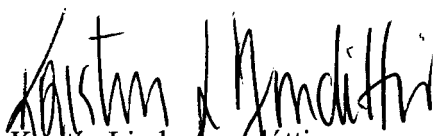
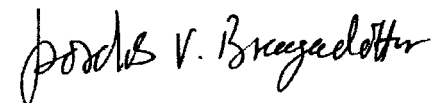
Surveillance

The Environment Agency of Iceland will monitor the project as it sees necessary and charge a fee of ISK 13.200 per hour as well as charging for all expenses related to the surveillance including travel and food for the inspector during the stay in Surtsey, in accordance with the surveillance plan.

Permission from the municipality Vestmannaeyjar must be obtained for this project. The applicant must also receive license from the Environmental and Public Health Authorities of South Iceland.

In order to export any samples taken in Surtey from Iceland permission must be obtained from the Icelandic Institute of Natural History.

Sincerely


Kristin Linda Arnadóttir
Director
Þórdís Vilhelmína Bragadóttir
Advisor