



ISLANDIA.

ILLYSTRISS. AC POTENTISS.
 REGI FEDERICO II DANIAE,
 NORVEGIAE, SLAVORVM, GO
 THORVMQVE REG. ETC. PRIN-
 CIPi SVO CLEMENTISSIMO.
 ANDREAS VELLEIVS
 DESCRIB. ET DEDICABAT.



Icelandia, 1585, by Abraham Ortelius. Hand-colored engraving, printed in Theatro d'el Orbe de la Terra, Antwerp, 1602, originally titled Theatrum Orbis Terrarum ("The Terrestrial Globe"), Polar bears still drift to Iceland on ice floes, as seen in the upper right-hand corner. More map details are in the article. Courtesy of the Osner Map Library, University of Southern Maine (oshermaps.org/map/7348-0224)

← Reykjavík Norway →

View of the Mid-Atlantic Ridge, taken between the Námafjall Geothermal Area and Krafla in 2000. Photo by Ronald DiPippo

The Vikings & Geothermal Iceland

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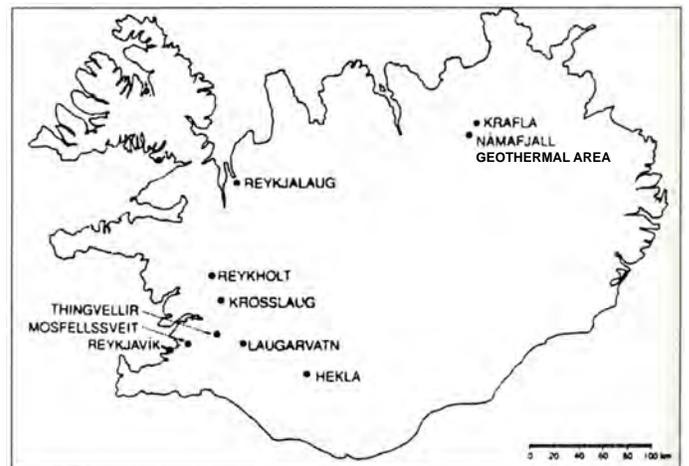
Why and when did the Vikings come to Iceland—the land of fumaroles, geysers, thermal waters, and volcanic eruptions? And what happened next? It's quite a story.

Did the Vikings ever imagine so much heat lay beneath the snow and ice around them—although the climate was a bit warmer back then? Probably not, but why should they? Most of them hailed from Norway, a country with geological stability; a land of ancient metamorphic and sedimentary rocks; and one with no signs of heat but for a tiny spot in the far north and another on the ocean floor. Sure, earthquakes rumbled through occasionally and a few warm springs bubbled in that Arctic archipelago, but the pools of water in the quiet Norwegian woods were cold, and the forested mountains didn't spew vast clouds of steam, ash, and rock high into the sky; turn snow and glaciers into roaring rivers; or extrude flowing, fiery ropes and sheets of immolating lava. The Norwegian mountains were tree-covered and still; they weren't volcanoes.

Beginning around 863 A.D., or a bit earlier, Viking ships, many from Norway, began making

short Icelandic stopovers. The trip from Norway took about four days in good weather.

In about 871 A.D., a large volcanic eruption dusted most of Iceland in a thin layer of volcanic debris, today called the Landnám tephra. (*Tephra is a mixture of fragmented, volcanic products, like ash and cinder.*) The tephra layer helps to date Icelandic settlements around the island, for no indications of Viking life have ever been found beneath this layer—except for one grain of barley pollen near the capital city, Reykjavík.²



Map of Iceland with the geothermal localities mentioned in the text.

The Icelandic *Age of Settlement* dates from 874 to 930 A.D., a time of great change. In 874 the first group of Viking farmers moved permanently to Iceland. They came from Norway, and their leader, Ingólfur Arnarson and his wife Hallveig Fróðadóttir, brought along family members, farmhands, and seasick sheep and cattle. On reaching the shore, they climbed freezing from the cargo ship, called a *knarr*, to begin their new lives.



Ingólfur Arnarson most likely used a *knarr*, shown here, for his trip to Iceland. The *knarr* is a type of Norse merchant ship the Vikings built for long Atlantic voyages. In fact, *Knerrir* (the still-used plural of *knarr* from Old Norse) routinely crossed the North Atlantic delivering livestock, like sheep and horses, and other items to the Norse settlers in Iceland. The model is on display at the Hedeby Viking Museum in Germany. *Caption and photo from Modell Knorr, Wikimedia Commons*



Was this what Ingólfur Arnarson saw when he arrived in Iceland? *Courtesy of Promote Iceland*

As they stepped on Icelandic soil, they were standing not only on an island with nine active volcanoes, but one with five of the volcanoes close by, arrayed along the southern coastline. From 874 to 930, the Vikings would build many settlements among the five volcanoes—including Ingólfur and his family, who settled down in a place he called Reykjavík.

Ingólfur chose Reykjavík for his home in an unusual way. Before landing in Iceland, but with land firmly in sight, he tossed his pair of carved, sacred, high-seat pillars overboard—vowing to settle wherever they washed ashore. According to legend, after three years of searching he found the pillars at the edge of a bay he named *Reykjavík* (“smoky bay”, from the Old Norse) for the active hot springs and fumaroles around it.⁴ Eventually many other Icelandic sites were given geothermal names, as well.



Ingólfur Arnarson commands his men to erect his high-seat pillars in present-day Reykjavík. The painting, by Johan Peter Raadsig, was a gift to the City of Reykjavík from the Eimskipafelag Islands. From “*Ingólfur by Raadsig*,” *Wikimedia Commons*

It turns out the Vikings weren’t the first to settle in Iceland. Christianity arrived before them, brought to the island by hermitic Irish monks who lived in caves—possibly inside the lava tubes. Commenting on the long Icelandic days and short midsummer nights, a monk once wrote, “... whatever task a man wishes to perform, even to



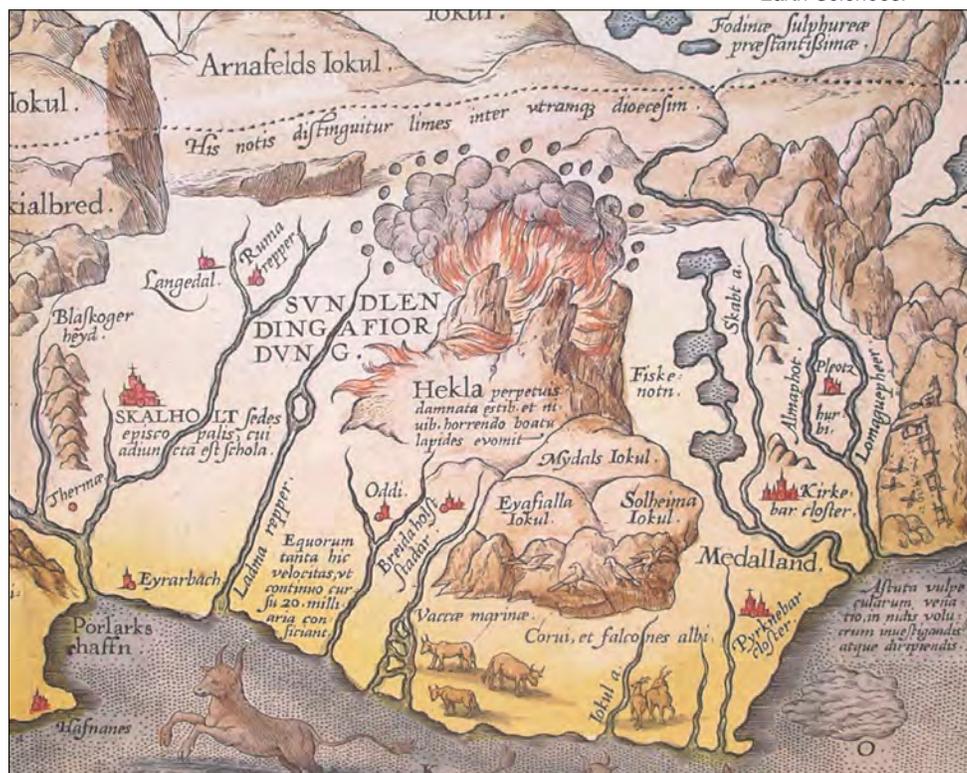
Stöng, a reconstructed Viking longhouse in the Tjórásadalur Valley, east of Laugarvatn. Such longhouses were the farm centers for Viking chieftains in the Middle Ages and were used to store food. This replica was rebuilt as closely as possible to the original longhouse specifications. You can see portions of the basic wooden frame, a stone base, and the turf walls and roof. The original building was buried in volcanic ash during an eruption of Mount Hekla in 1104. The site is open to the public. *Courtesy of The Commonwealth Farm, www.thjodveldisbaer.is*

picking the lice from his shirt, he can manage as precisely as in broad daylight.”⁴ When the Vikings arrived, the monks fled in a hurry, leaving behind many personal effects in the rush to get away.

Mount Hekla, one of the five southernmost coastline volcanoes—and still very active, has erupted well over 20 times since 874 A.D. During the fiery eruption of 1104, huge blankets of tephra destroyed at least 20 farms in southern Iceland. One such farm, named Stöng, has been excavated, rebuilt, and opened to the public. The farmstead is preserved perfectly, like an Icelandic Pompeii. The sod walls were left nearly intact beneath the thick layers of tephra.⁴



Mount Hekla volcano, erupting in 2000. Photo by Sigurjón Sindrason; reproduced courtesy of Dr. Sindrason and the Icelandic Institute of Earth Sciences.



Dr. Sindrason worked for the Nordic Volcanological Institute from 1975 to 1984. During that time, he and others studied Krafla, a volcano mentioned in the hot springs photo caption on page 44.

When I asked Dr. Sindrason about his Viking ancestry, he said it was “a bit too long ago.” He thought I had meant family stories from the last several hundred years, but I’d really wanted him to go back 1,000 years or more. Impossible because he was right; the events were “a bit too long ago.”



View of Mount Hekla covered in snow. From Hekla and gate, Wikimedia Commons

Back in 930, 201 years before the 1104 eruption of Mount Hekla, the first Icelandic national assembly, called the Althing, met at Thingvellir (“Parliament Plains”) about 50

km from Reykjavík. Today Thingvellir is a National Park and an UNESCO World Heritage Site. Its long and incredible expanses of lava form part of the mid-Atlantic ridge.

Inspired by the 1104 eruption, monks began spreading tales throughout Europe that Mount Hekla was a gateway to Hell. This speculation is illustrated dramatically in books and maps from The Middle Ages—as you can see on the 1585 map of Iceland reprinted above and on page 39. Notice how Mount Hekla, the largest feature on the map and one covered in flame, spews dark smoke and volcanic bombs—the arc of black dots above the smoke.

The Vikings created the Althing to establish a common code of law suitable for a republic (not a monarchy) and to settle disputes. Here was where the Law-Speaker spoke to the assembled Vikings in front of the great wall of lava. “The riven wall of lava made a splendid sounding-board for speakers’



Thingvellir National Park, since 2004 an UNESCO World Heritage Site. The distant, dark horizontal lines are extruded basalt walls. The Althing, a small, block-filled cleft in a wall, may be just right of where water spills through the lower wall on the photo upper right. The Althing itself is depicted below in the 19th century painting by Collingwood. *From Thingvellir aerial panorama, Wikimedia Commons*



The Althing in Session. The center of attention at an Althing gathering was the large, basaltic law rock at the top of the cleft filled with boulders. Here is where the presiding official, the Law-Speaker, addressed the assembly. In the painting he is clothed in green and speaking from the far edge of the law rock. The oil painting is by W. G. Collingwood. *From Law-Speaker, Wikimedia Commons*

voices in those days before microphones and amplifiers were invented.”⁴

By the year 1000, just 70 years later, the King of Norway was pressuring Iceland to renounce paganism and accept Christianity. Icelandic political opinion on the matter was polarized into two bitterly opposed factions. War seemed

imminent. Sensing a crossroad, the leader of the Christian party, Hall of Siða, asked the Law-Speaker of the Althing, a pagan named Thorgeir Thorkelsson, to arbitrate. Everyone swore to follow his decision.

After considering the situation for a day and night, and in the interests of peace, Law-Speaker Thorkelsson declared that all unbaptized people in Iceland should become Christians and be baptized — meaning they would be submerged in cold water. Now real trouble arose. The Icelanders agreed to become Christians only if hot water was used in the ceremony.

And so it was. People from northern and southern Iceland were baptized in a hot spring named *Reykjalaug* (later called *Vígðalaug*, “the consecrated spring”) at Laugarvatn. Those from western Iceland were baptized in a hot spring named *Lundarreykjadalur* (later called *Krosslaug*, “the spring of the cross”) at Reykjalaug. Since then, both of these hot springs are said to hold healing powers.³



Native sulfur covers the sides of an Icelandic volcano. *Courtesy of Promote Iceland*

Iceland lost its independence to the King of Norway in 1262 and together with Norway to the Queen of Denmark in 1388. Toward the end of the thirteenth century, the Norwegian Archbishop of what today is Trondheim apparently won exclusive rights to buy and transport native sulfur from Iceland. The sulfur was collected from locations known today to include high-temperature geothermal fields. Exactly what the sulfur was used for is unclear, as gun powder hadn't yet been invented.³ Some say the Catholic Church may have exported the sulfur to European churches so the congregations could grow familiar with the odor of hell.¹ Icelandic sulfur rights—sometimes quite valuable—were controlled by the Danish King for many years until the rights were returned to Iceland in the 1760s.³



The hot springs at Leirhnjúkur date from an eruption through a fissure in the mid-1970s. Note the abundant patches of native sulfur on the surrounding rocks. The hot springs, photographed in 2008, are about 2 kilometers from the Kefla power plant. During the eruption, a string of lava was produced from a geothermal well nearby. *Photo and information by Ronald DiPippo*

How many hot springs are in Iceland? The count includes 250 thermal areas and 600 major hot springs. Surprisingly, geothermal expert Ingvar Fridleifsson finds no correlation between natural hot spring locations and the sites where early Vikings chose to build the farmhouses. Even the first settler, Ingólfur Arnarson, built his own farmhouses about 3.5 km away from the nearest hot spring, apparently preferring a good landing beach for his boats to the luxury of nearby hot waters for things like bathing, laundry, and cooking—not his duties, after all.³ Several years ago, parts of his farmhouse were discovered under the southern end

of Reykjavík's Aðalstraeti ("Main Street") that runs down to the harbor.⁴

In the eighteenth century, hot springs were considered "nuisances" by some farmers who were quoted in a book titled, *Description of the Farmsteads of Iceland, 1703-1714*. One farmer said, "A part of the hay field is spoiled by a hot secretion caused by a nearby hot spring." Another complained, "Storms are fierce so that both houses and haystacks are in danger. The water is warm (*read 'undrinkable'*)."³

Only one pre-twentieth century archaeological structure exists where hot spring waters may have been used for space-heating. This is in the farmhouse (barely seen in the photo) built behind a hot water pool called, Snorrallaug ("Snorri's bath"), in the village of Reykholt. Snorrallaug itself is the only ancient (probably 13th century), man-made bathing structure still standing in Iceland, and it resembles a 4 meter wide, stone-sided, backyard hot tub.

Built by powerful chieftain, famed historian, and writer of sagas, Snorri Sturluson (1178-1241), Snorrallaug was heated with steam and hot waters flowing through two conduits from a nearby hot spring, called Skrifla. A third conduit from the hot spring bypassed Snorrallaug entirely and went straight to the farmhouse in back. Were at least some farmhouse rooms warmed by geothermal heat? Perhaps, yes.



In 13th century Iceland, Snorri Sturluson built a farmhouse and this heated pool, called Snorrallaug. The site was restored in 1858 and 1959. A tunnel dug behind the door allowed Snorri to move quickly from the pool to his farmhouse. The outdoor pool and perhaps the farmhouse were heated by steam and hot water flowing through conduits from a nearby hot spring. The hot water enters the pool from the ditch on the right. *Photo from Snorrallaug, Wikimedia Commons*

We do know that for over a millennium, thousands of Icelanders living in a very cold climate never used the nearby hot waters to warm their houses. In 1908, perhaps the first person to do so was a farmer at Reykir in Mosfellssveit, Stefán B. Jónsson (1861-1928). He brought hot spring waters through a 2.3 km pipeline into his home to heat the radiators. Not long after, in 1911, Erlendur Gunnarsson, from Sturlureykir in Western Iceland near Reykholt, invented a simple mechanism to separate the steam from the hot water in a boiling spring next to his house. He used the steam for cooking and heating.³ The two installations, invented over a century ago, began the modern era of geothermal development in Iceland.

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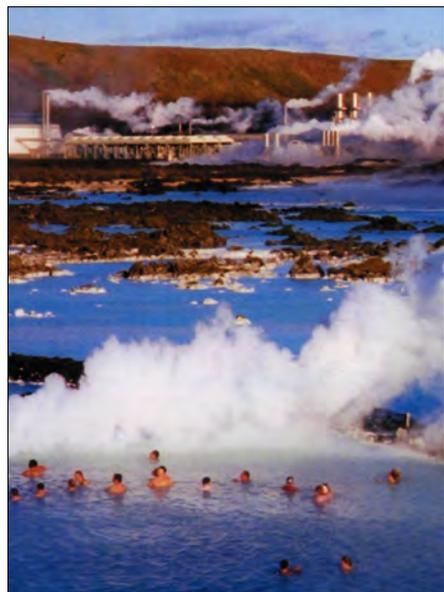
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Acknowledgments

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Addendum: Iceland Today at the GRC

The lineage of modern Icelanders is complex. Perhaps some Icelanders with Viking ancestry are members of the Geothermal Resources Council, and maybe some pictures they've taken of modern geothermal Iceland have been *Bulletin* covers. Here are ones I've found – along with the captions and photographers' names. If there are others, let me know; we'll print them in the next issue.



The Svartsengi Power Plant, in the Sudurnes area, is the world's first geothermal power plant to both generate electrical power (361 MWe and 125 MWt) and produce hot water for district heating. It also provides water to the Blue Lagoon, pictured here, a bathing resort attracting tourists worldwide. *Photo by John W. Lund, March/April 2006*



The Reykjanes Geothermal Power Plant is on the Reykjanes peninsula in southwestern Iceland. To operate the single-flash power plant, brine with the salinity of seawater is extracted from 11 production wells drilled 2700 m deep into a reservoir where the temperatures range from 280 to 316° C.

Continued...

The steam inlet pressure is 18 bars and the tubular condensers are cooled by seawater drawn from 10 wells close to the beach; thus, no cooling towers are needed. The waste brine is mixed with spent cooling water and passed through a concrete canal to the sea.

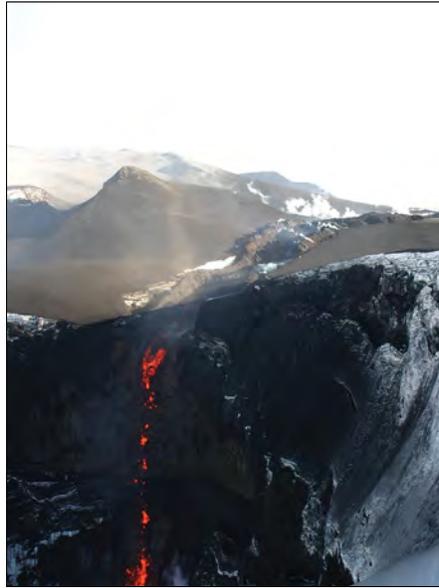
The power plant, generating 100 MWe from two Fuji 50 MWe turbines, is owned and operated by Sudurnes Regional Heating Corporation. The plant began operating in May 2006 and is connected to the national grid with a 12 km long, 220 kV, overhead power line. Much of the power is sold to an aluminum smelter owned by Century Aluminum (Norðurál ehf). *Thanks to Sverrir Thorhallsson for caption information. Photo courtesy of Glitnir Bank; Ragnar Th. Sigurdsson, photographer; Nov./Dec. 2007*



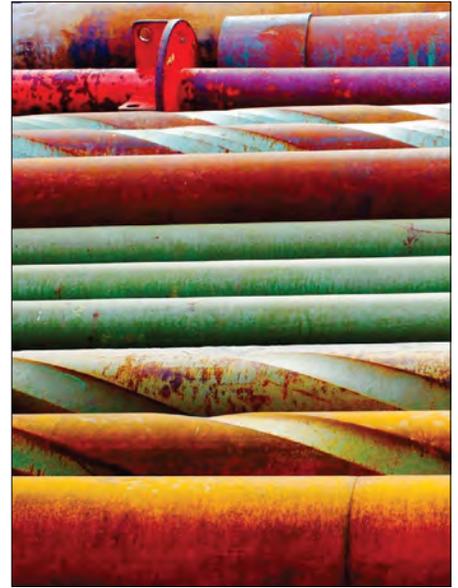
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Well IDDP-1, the first deep well of the Iceland Deep Drilling Project (IDDP), penetrated rhyolitic magma at a depth of 2104 m in the Káfla Geothermal Field in northern Iceland (see map). Pictured is the rig (now removed) used to drill the well. The well overlooks Viti, an explosion crater formed in an eruption in 1724. Photo by G. Ó. Friðleifsson, July/Aug. 2009



View of the 2010 volcanic eruption at Fimmvörduháls, in southern Iceland. For editorial reasons, the image has been reversed. Photo by Helga M. Halgadóttir, courtesy of ISOR, Jan./Feb. 2012



Drill casings for a new geothermal well. Photo by Cari Covell, Reykjavik University, Iceland School of Energy, Reykjavik, Iceland, Nov./Dec. 2015. First place in the 2015 GRC Photo Contest



“Geothermal Mist” at Svartsengi Geothermal Power Plant—near Reykjavik, Iceland. Photo by Pawel Krok, Lubawka, Poland, Sept./Oct. 2016. Second Place in the 2015 Amateur Geothermal Photo Contest



“Northern Lights Reflection” taken at Theistareykir Geothermal Field. Located in northern Iceland, the photo shows the Northern Lights reflected in the hot springs and mud pots associated with geothermal activity. Photo by Bastien Poux, Reykjavik, Iceland, Nov./Dec. 2016. Peoples’ Choice winner in the 2016 GRC Amateur Geothermal Photo Contest



A rig called Thor was used to drill the supercritical well IDDP-2 at Reykjanes, Iceland. Photo courtesy of Wilfred A. Elders, Mar./Apr. 2017



“Midnight Heat.” taken at midnight, July 20, 2016, in the Icelandic, Theistareykir Geothermal Field. The drilling equipment and power stations are in the background. *Photo by Hreinn Hjartarson, Husavik, Iceland, Nov./Dec. 2017. Honorable Mention in the 2017 GRC Photo Contest*



“Power in the Dark.” Early afternoon sunset on a calm late December day over the Reykjanes Geothermal Field. *Photo by Robert Zierenberg, Davis, USA, Jan./Feb. 2018. Honorable Mention in the 2017 GRC Photo Contest*



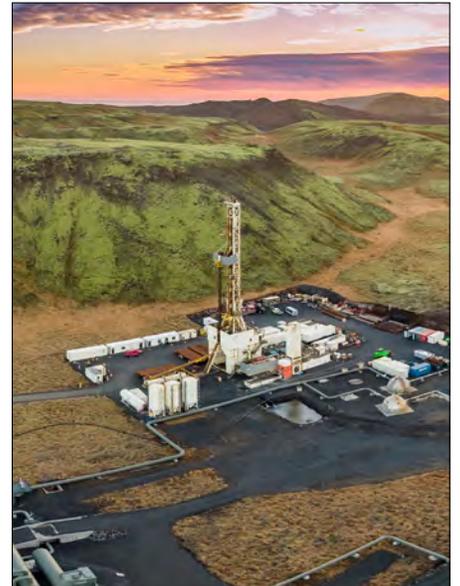
“Flow Test at Theistareykir, Iceland.” The picture was taken in February 2016 during a massive flow test for several wells at the Theistareykir Geothermal Field. *Photo by Bastien Poux, Pontoise, France, Mar./Apr. 2018. Honorable Mention in the 2017 GRC Photo Contest*



“The Power of Thor.” The rig used to drill well IDDP-2 at the Iceland Deep Drilling Project is named Thor. This supercritical drill hole shows the way to the future of geothermal power. At right is the lighthouse on the Reykjanes Peninsula, Iceland, showing the way to safe passage at sea. *Photo by Robert Zierenberg, Davis, USA, July/Aug. 2018. GRC Photo Contest 2017*



“The Stillness of Winter.” Borehole testing at Theistareykir, Iceland, March 31, 2016. *Photo by Hreinn Hjartarson, printed Mar./Apr. 2019. GRC Geothermal Photo Contest 2018*



The most recent Icelandic cover photo is on the cover of this issue.