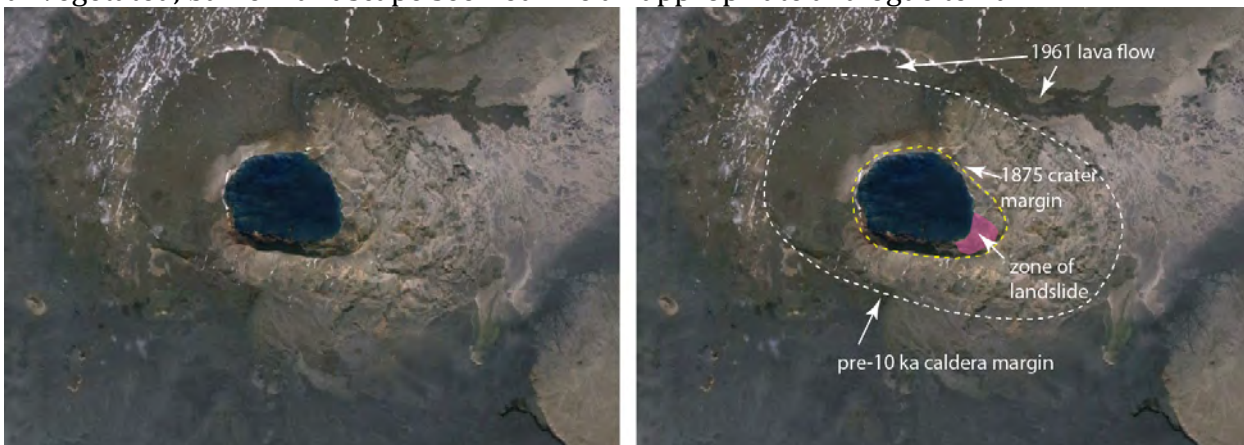


Three days at Askja volcano, east-central Iceland

After two days exploring the tephra cones, lava flows, fumaroles, geothermal power generation, and base-surge deposits in tephra layers (enveloping a forest that was blown down by the velocity of the plume collapse!), we drove to Askja volcano which lies quite close to the huge central icecap (Vatnajökull Glacier). The route has been swept by huge outburst floods over the past 10,000 years that result from volcanic eruptions beneath the ice cap. In fact, many of Iceland's volcanoes have steep slopes of 25-35°, despite being of basaltic composition: a composition that usually produces gently sloping lavas. The steepness results from them having been erupted subglacially into a vault of melted ice where the lavas produce pillows (if the water pressure is high enough) or are brecciated in explosive, glassy sub-ice eruptions. Askja is one such "central" volcano that is typified by subglacial eruptions during much of its growth.

Today Askja has a >10,000 year old outer caldera that is about 8 km across, and a 3-km long crater that is nested within the older one. This young crater formed during a suite of eruptions in 1874-5 that produced long lava flows (>10 km) and large tephra eruptions that blanket the region with pumice fragments. Today the crater hosts a beautiful lake and snow fields extend down to the lake edge in many places – a bit similar to Crater Lake in the spring. In the mid '60s, US astroanauts came to Askja to "train" for the Apollo missions: the volcanic, unvegetated, barren landscape seemed like an appropriate analogue terrain.



Askja caldera-crater with 1875 crater, 1961 flow, and July, 2014 landslide collapse.

Our first afternoon at Askja, we descended into the crater to get a general orientation and look at the suite of airfall deposits created by the 1875 eruption. After taking a group photo on a point in front to the beach cliff, we left about 8 PM to return to our base camp. About 4 hours later, a small eruption occurred along the crater margin, and a large segment of the crater wall collapsed from the 300-m-high rim. Some of this landslide slid catastrophically into the crater lake and created a tsunami that swept across the lake and reverberated for many hours.

When we learned of this event, we abandoned our mapping of lava flows in order to head into the crater in an effort to document the effects of the eruption and landslide/tsunami. We were lucky to be with a Univ. of Iceland volcanologist (as our guide), because most tourists were prohibited from entering the crater. But with our hardhats and fluorescent vests and his persuasive conversations with the park managers, we were allowed to work there for two days.

As far as we could tell, no significant ash was produced by the eruption (which someone had captured in a midnight photo: one of the benefits of the 24 hours of daylight here). In contrast to the lack of recognizable juvenile volcanic detritus, the tsunami deposits were



Phil Gans standing by a stranded ice block, 50 meters above the lake



Chris Older standing at a strandline on snow comprising a ridge of pumice 30-cm high

spectacular! As the main waves crashed into the NW edge of the crater (where we and tourists generally enter), they split around the coastal topography and swept inland. They stranded blocks of ice/snow that were ripped out of snowbanks bounding moats adjacent to the bedrock. Some of these blocks were 50 m above the lake level!! The upper level of the onrushing wave was marked by a strandline of pumice, sometimes 50 cm high and comprising hundreds of clasts the size of ping-pong or tennis balls. We were able to document at least 3-4 waves that swept ashore and rose anywhere from 10 to 50 meters. The “sea” cliff where we had struggled to see the pumice sequence and the underlying lava flows a day earlier was now swept completely clean to show stunning details of that older stratigraphy. Lava flows that had erupted in 1875 in the crater and flowed down into the lake were scoured clean so that we could see precisely how the flows divided and poured over the “sea” cliff into the ocean. We searched for the rocky headland where we had stood for the group photo a day earlier and couldn’t find it.

After surveying the strandlines from the tsunami waves, we spent a day walking around the far margin of the crater to measure high-water marks from the tsunami – up to 37 m in other places. Some of hiked to a distant overview where we could get excellent images of the landslide – a remarkable sight with stunning vertical scarps 100 m high, intermittent rockfalls, a huge mass of collapsed rock extending into the lake, and snow avalanches covered by rockfall deposits. Parts of the rockfall were “steaming” as fumarolic gasses emerged from the newly exposed surfaces.



Head scarp of the landslide. Note the stranded blocks on the slide face. Some of these collapsed each day.

Subsequent surveys of the lake surface suggest rose about 5.5 meters (~18 feet) as a result of the slide into the lake – no wonder we couldn't find our old photo site: it was underwater! That displaced mass of water is equivalent to ~60 million cubic meters of landslide deposits that now sit in the crater lake! Some of the fumaroles around the crater seemed

particularly active, even ones far from the landslide (see image). We had a great time exploring this very active and recently perturbed landscape!



Very active fumaroles along the crater margin with abundant sulfur being precipitated. Group of UCSB students with the hard hats and bright safety vest for scale.

As you can imagine, this event provided a fantastic learning opportunity. The students were fully engaged in collecting key data and in helping interpret what we saw. They heard the arguments/discussions among us as we tried to figure out how waves were routed, why we saw cross-cutting trends in the pumice lines and what they meant, whether the water receded rapidly or slowly, where the transported ice/snow blocks had originated and how far they had moved, why some of the inundated slopes and snowfields were covered with mud, but others were not, why the huge rafts of pumice on the lake surface were still moving up and down on the shoreline at intervals of several minutes, even a day after the eruption (an internal wave or seiche), whether the fumarolic activity had increased, etc. Whereas there is still lots to do, the students helped generate an invaluable data set that will be used to analyze the event. Moreover, after the next rainstorm, the pumice lines will start to be moved around and become discontinuous or invisible, whereas the subtle mud ridges marking various encroaching waves and the stranded ice blocks will all disappear. So, all in all, we experienced a very timely and exciting visit to a very active volcano that had a lot to teach us!

What a treat to be here, to have expert Icelandic volcanologists guiding our trip, and to have an enthusiastic group of students who dove into this new opportunity with energy and insight!