Snow avalanches hitting natural obstacles in Iceland: The avalanches at Kisárdalur, Sveinsstaðaskál and Upsi in N-Iceland

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ABSTRACT

Several avalanche dams have been built to protect settlements in Iceland during the last 20 years, greatly improving the safety of people and property in the areas below the dams. The dams are both deflecting dams and catching dams, with height in the range 10–22 m. Several of the dams have been hit by snow avalanches, resulting in up to 13 m vertical run-up on the deflecting dams and one case where a catching dam was overrun without anyone coming to harm. No large avalanche, in comparison with the design avalanche, has so far hit the man-made dams to properly test the rather crude avalanche dynamics assumptions used in the design of the dams. However, several large snow avalanches have in recent decades hit natural obstructions in Iceland. Some of them provide indications about the dynamics of avalanche flow against obstructions that may be useful in the context of avalanche dam design. Here we report on three such avalanche paths where simulations with avalanche dynamics models have been used to interpret observations about the extent, run-up and other available information about notable avalanches. Two large avalanches in N-Iceland, at Sveinsstaðaskál in Skíðadalur and Kisárdalur in Fnjóskadalur, have overrun 8–12 and 50–60 m high opposing gully sides respectively that are almost perpendicular to the flow direction. The gullies both have rather steep sidewalls, shaped not unlike catching dams. The paths have 700 and 340 m vertical drop, respectively, from the starting zone to the impact with the opposing gully side. The slope angles from the top of the starting zones to the gullies are 25 and 24 degrees, respectively, and the alpha angles to the tip of the avalanche tongues in the run-out areas below the impact with the gullies are 22 and 17 degrees, respectively. A third location investigated here is the 10–20 m high Upsi landslide deposit in Eyjafjörður, which is formed like deflecting dam with a 27° deflecting angle, and is frequently hit by snow avalanches. Three farms are located in the shelter provided by this landslide and two more farms stand farther down in the run-out zone of the avalanches. Avalanche simulations are used to back-calculate impact velocities of large avalanches at these three locations and investigate to what extent the observed geometry of the avalanche deposit can be reproduced. The simulations of the Sveinsstaðaskál avalanche indicate that avalanches at this location can easily overtop the 8–12 m high obstruction that is nearly perpendicular to the flow direction, which is consistent with traditional design assumptions of catching dams. The simulations of the Kisárdalur avalanches indicate that avalanches traveling at 45 m/s can overtop the 50–60 m high obstruction that is nearly perpendicular to the flow direction, which is also largely consistent with traditional dam-design assumptions.

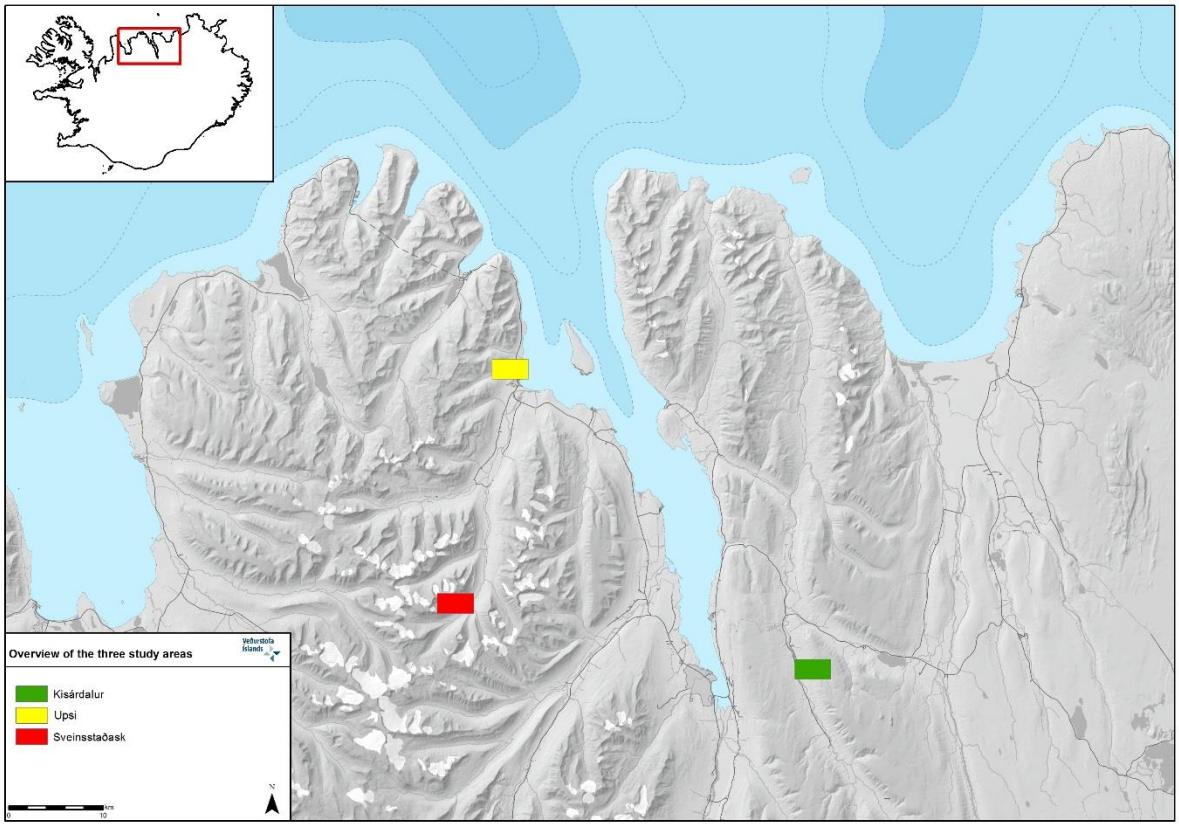

Figure 1. An overview of the three study sites. The terrain at Kisárdalur and Sveinsstaðaskál below the avalanche starting zone is formed like natural catching dams, whereas the lower part of the avalanche path at Upsi is formed like a deflecting dam.

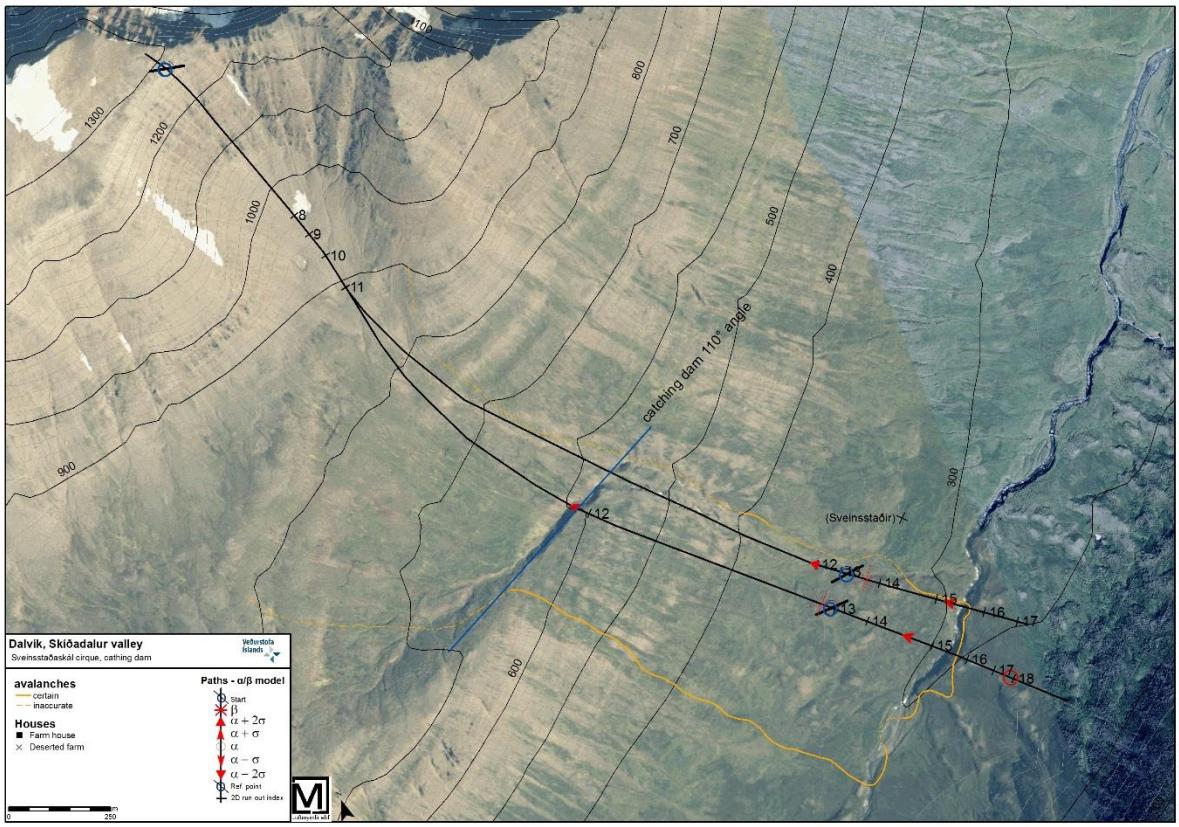

Figure 2. Only one avalanche from the Sveinsstaðaskál cirque in the avalanche database of the IMO is reported to have reached down to the bottom of Skíðadalur Valley but local farmers hold knowledge about more avalanches reaching this far. An avalanche in November 2017, with a fracture line at the rim of the cirque, hit a catching-dam-like, 8–12 m high opposing gully side. The avalanche left almost no snow deposit in the gully but the lower flank was covered with an iced snow surface and fine-grained rock debris indicating high-energy impact. The run-out zone had maximum width of 520 m and was covered with rather thin but even snow debris, typically 10–100 cm thick, with a maximum depth of 300 cm. The abandoned farm Sveinsstaðir, just north of the avalanche tongue, was located in between two large avalanche paths as the run-out zone of another and even more active avalanche path is located just north of the farm. People were living on the farm for some decades during the 19th and early 20th century without any recorded avalanche accidents. That is unfortunately not the case for all farms in the valley. Probably the avalanche danger at Sveinsstaðir was obvious enough for the inhabitants to build the farm at a relatively safe location.

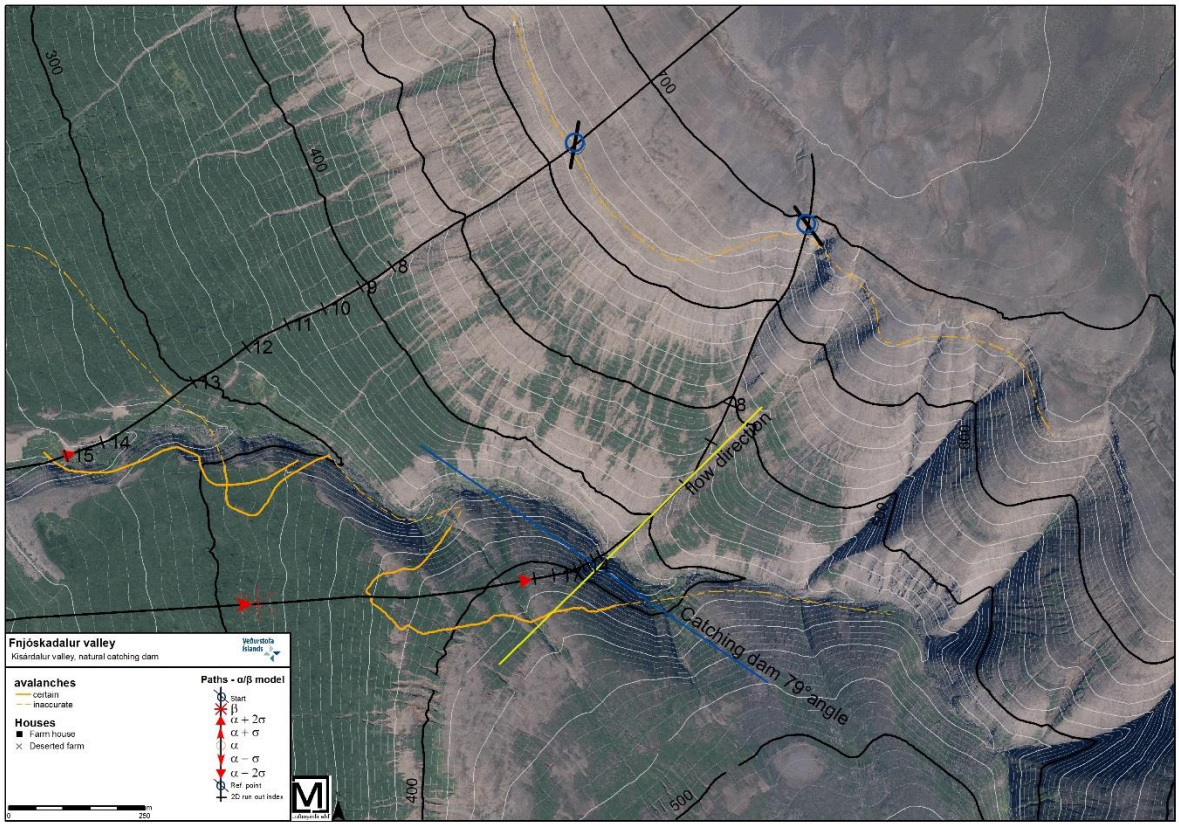

Figure 3. As in Sveinsstaðaskál, only one avalanche is reported having overrun a catching-dam-like opposing gully side at Kisárdalur, Fnjóskadalur Valley. The gully is 50–80 m deep where the avalanche from October 1995 rushed across from a starting zone on the north side of the Kisárdalur Valley. The maximum, vertical run-up of this remarkable 3-km wide slab avalanche was almost 70 m on the south side of the gully. The avalanche tongue was deflected towards west by the south side of the gully which is oriented approximately 11° from perpendicular to the flow direction. Another tongue, coming from the open slope just north of Kisárdalur, reached across the gully farther down where the vertical run-up from the gully bottom is approximately 10 m. The avalanche spread turf and rocks over a large area, making it easy to map the run-out for a long time after it fell.

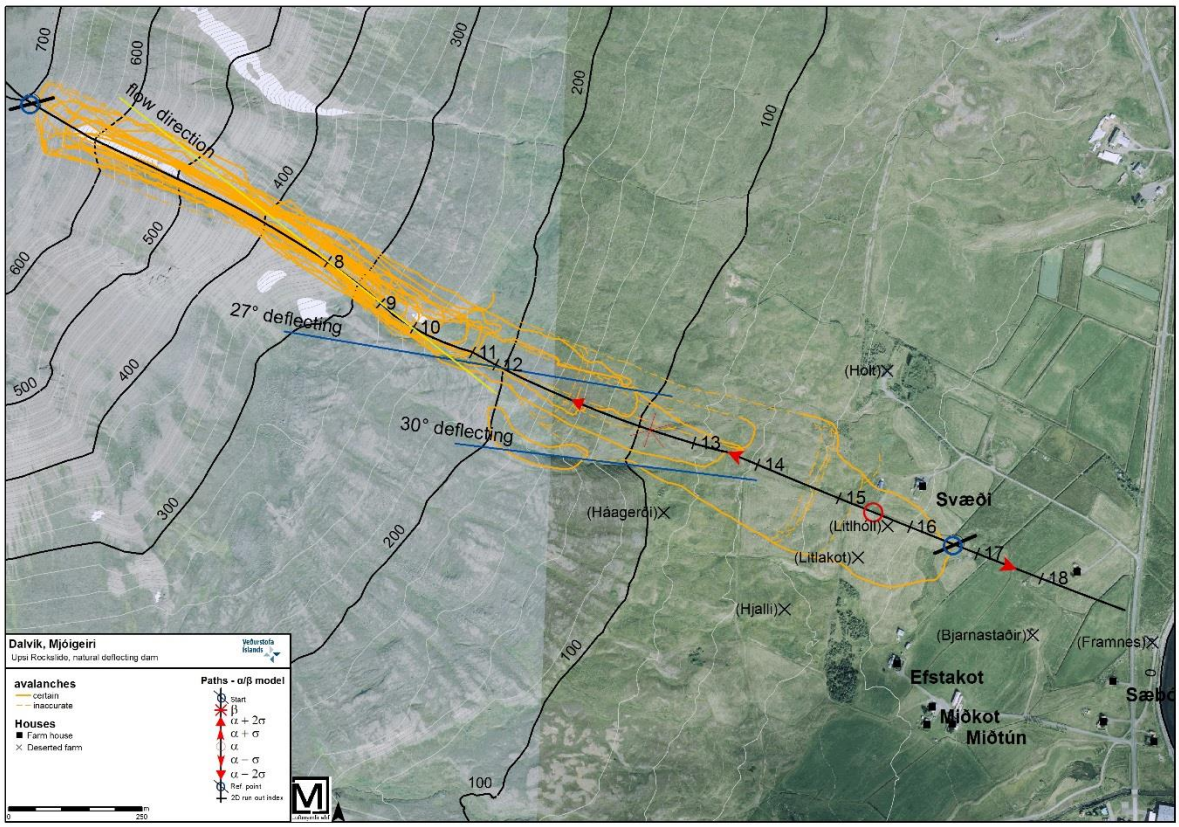

Figure 4. Many avalanches are mapped from the gully Mjóigeiri in the Bæjarfjall Mountain, just north of the village Dalvík. Several of them have damaged the powerline, that used to cross the run-out zone, and fences for livestock many times. The largest recorded avalanche was released in February 1973 and hit the sheep house at the farm Svæði and stopped about 120 m below the farm, only 30 m south of it. The 10–20-m high Upsi landslide deposit lies with an approximately 27° angle from the flow direction of avalanches from the Mjóigeiri Gully. The landslide has several times been observed to deflect avalanches from Móigeiri towards north and is expected influence the hazard at the farms below. The three farms south of Svæði seem to be sheltered by the deflecting effect of the landslide but the Svæði itself seems to be more endangered as the avalanches are deflected towards that farm. There are no indications or records about avalanches overrunning this natural deflecting dam.