COMPARISON OF ICELANDIC AND MARTIAN HILLSIDE GULLIES. (William K. Hartmann, Planetary Science Institute, Tucson AZ, USA; Thorsteinn Thorsteinsson, Univ. of Iceland, Reykjavik; Freysteinn Sigurdsson, National Energy Authority, Reykjavik, Iceland).

Martian gullies discovered by Malin and Edgett [1] are widely regarded as evidence of recent hillside erosion by liquid water on Mars [2,3]. As reported earlier [3,4], Icelandic basaltic talus slopes of hillsides contain gullies that include virtually exact duplicates of Martian gullies in terms of size, morphology, and placement with respect to blocky outcrops. At the 2001 LPSC, Costard et al. [5] and Lee et al. [6] also presented evidence of similar gullies in Greenland and Canada, respectively.

Here we present some results of a survey of the Icelandic features, carried out both on the ground and by air in 2001. The Icelandic features include a range of morphologies, including classic debris flows (initiated by water saturation of talus slopes) and runoff channels from upslope drainages and from snow melt. Some of these resemble the Martian features more than others, though we have not identified a single specific type that best matches Martian features. Figure 1 shows a comparison of “classic” gullies from the Malin-Edgett discovery paper with Icelandic examples. Note in both cases the typical pattern of gullies beginning in talus near the layers of blocky outcropping strata, and sometimes ending in deltaic fans.

We find that both Mars and Iceland display not just simple “classic” gullies of the form discussed by Malin and Edgett [1] but a whole array of evolved forms, involving progressively more erosion. Figure 2 shows cases in which the headward ends of the gullies have widened, carving the talus layer into wedge-shaped remnant segments. This finding implies that Martian gullies include not just single water-release events, but long-term (repeated?) erosion episodes that move large volumes of talus and fundamentally alter some Martian cliff faces.

Hoffman [7] posited that Martian gullies result from release of liquid CO₂, but it is very unclear that such release would produce tidy gullies instead of explosive decompression. Costard et al. [2] find that Martian obliquity cycles may produce eras favoring gully production by melting of ground ice, producing debris flow. The similarities of the features on Mars and Iceland support, but do not prove, that the Martian gullies originate from action of liquid water from some source. Icelandic debris flow scars are very similar to Martian gullies but often start at mid-slope on talus -- a feature not common in the Martian examples. We attempted to establish whether some Icelandic gullies originated from water release through aquifers, as has been posited for Mars [1,3], but were unable to confirm or refute this in this survey.

Figure 3 shows that certain rare, glacier-like features on Mars appear to be related to Martian gullies. Features resembling parts of the glacier-like tongue in Fig. 3a can be seen in many MGS/MOC images of gully systems, as shown in Fig. 3b. We speculate that the same water release which creates gullies can produce perched masses of ice that can break loose and form short-lived glaciers, which sublime and leave the features seen in Fig. 3 (right).

Our further discussion is being submitted to be published in *Icarus*.

**Topics for Future Research:** Further studies are needed of the exact processes of formation of Mars-like gullies in Iceland, Greenland, and Canada. Many questions can be pursued. Does the Costard et al. [2] debris-flow mechanism explain all features of Martian examples, such as formation on colder, anti-sunward slopes? Are other mechanisms plausible for Mars? In particular, are Mars-like gullies ever formed on Earth by release of water from underground aquifers? We were able to find evidence of aquifer water release on Icelandic hillsides, but not in direct conjunction with Mars-like gullies.

Can water release from Martian aquifers saturate soil layers on Martian talus slopes and produce debris flows analogous to the Icelandic debris flows? Much less common and more isolated Mars-like gullies can be seen in many areas on Earth, including the American Southwest. Does the dramatic concentration of Mars-like gullies at high latitudes on Earth betray some fundamental clue to a Mars-like process that is favored there, relative to other environments? Or is it due more to incidental factors, such as lack of vegetation? Why should features reminiscent of arid Mars be concentrated in such a wet region as Iceland?

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Note: a new Mars research volume: We call attention to the hardcover research volume titled *Chronology and Evolution of Mars*. This is a comprehensive set of review papers resulting from a series of small, focused international workshops held at the International Space Science Institute (ISSI) in Bern, Switzerland. The papers were published first in the fall of 2001 as a special issue of *Space Science Reviews*, and immediately thereafter as a hardcover volume in the ISSI series.

The book includes fundamental reviews on ages of Martian meteorites and lunar samples (Nyquist *et al.*), cratering histories (Neukum, Ivanov, Hartmann), evidence for water alteration assemblages in Martian meteorites (Bridges *et al.*), overviews of geology and fluvial features (Head *et al.*, Masson *et al.*), the Martian atmospheric history (Encrenaz *et al.*), and other topics. The book is available at a special reduced price through the ISSI web site at [http://www.issi.unibe.ch/](http://www.issi.unibe.ch/).

![Figure 1](image1.png)

**Figure 1.** Comparison of "classic" Malin-Edgett Martian gully features and Icelandic gullies. **Left:** MGS MOC 03-02290, 39W, 30S, on the wall of Nirgal Vallis. **Right:** Similar Icelandic gullies on SE face of Esja Plateau.

![Figure 2](image2.png)

**Figure 2.** Comparison of evolved gully forms on Mars and in Iceland, showing the erosion of the original talus slope into triangular facets. **Left:** MGS MOC M15-01616, 163W, 41S. **Right:** Similar Icelandic features, SE face of Esja Plateau.

![Figure 3](image3.png)

**Figure 3.** Features possibly relating gullies and ice flow morphology on Mars. **Left:** Glacier like tongue-shaped feature running downhill on a crater wall at 247W 38S. Note sharp lateral ridges, forming crescentric ridge at bottom with softer crescentric ridges beyond. **Right:** Martian gullies at 166W and 39S, showing the same kinds of distal sharp crescentric ridge with softer ridges beyond. These images suggest that gullies have some relation to the much rarer glacier like feature.