SUPPLEMENTARY MATERIAL

"Long Runout Landslides with Associated Longitudinal Ridges in Iceland as Analogues of Martian Landforms."

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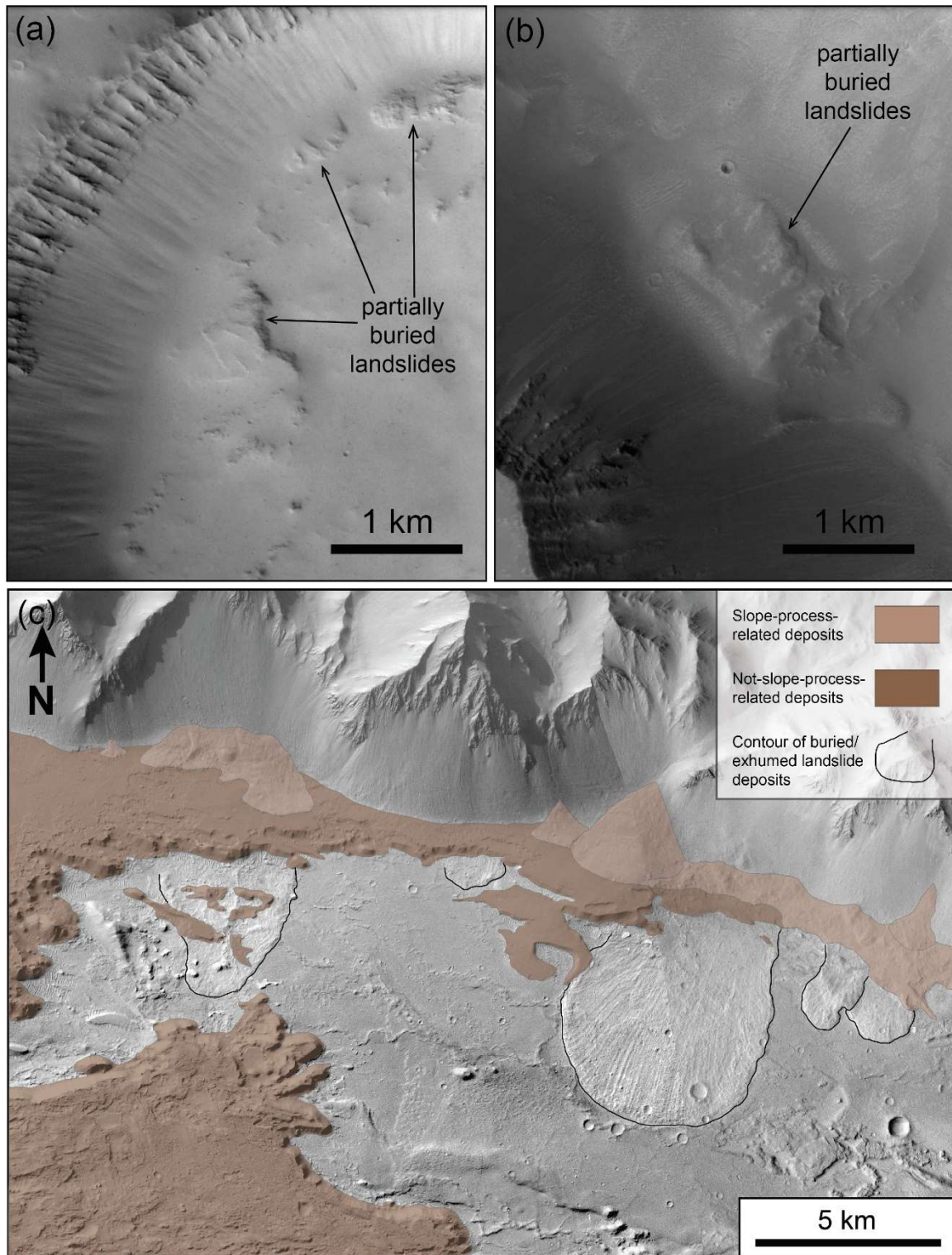
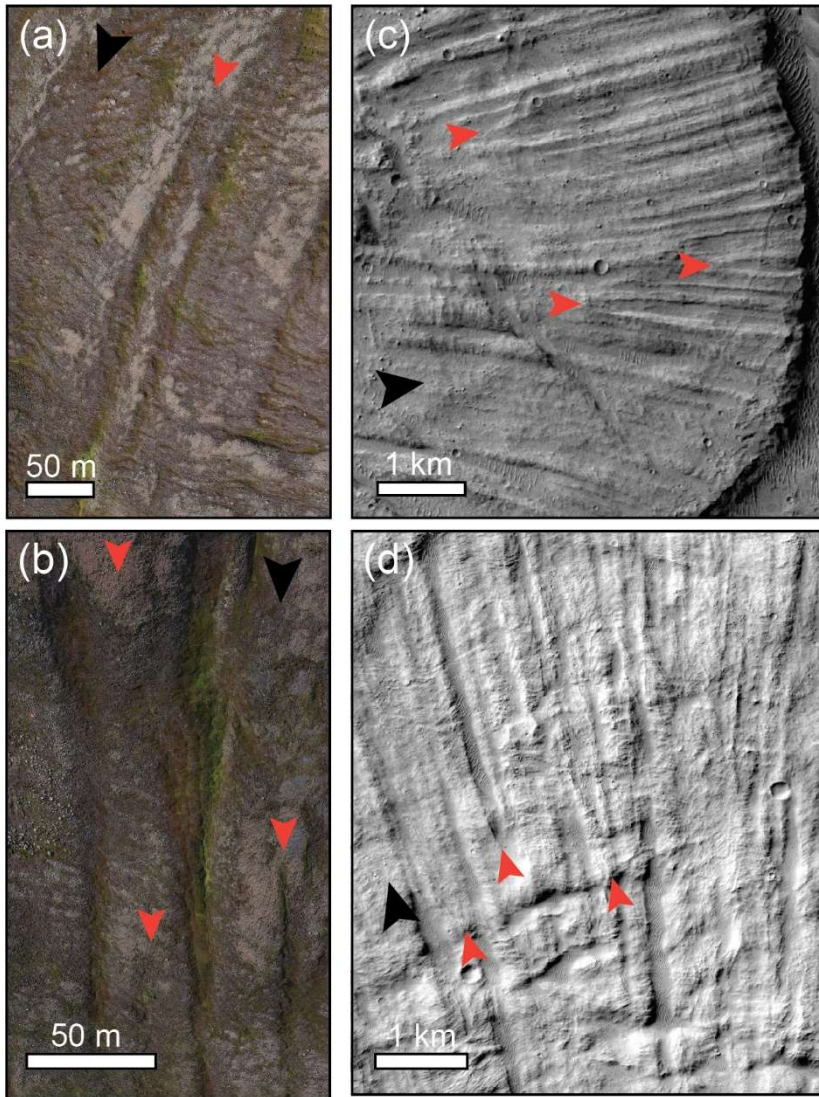
Supplementary Figures S1 to S2.

Supplementary Table T1 to T4.

Visual catalogue of small-scale martian long runout landslides with longitudinal ridges.

Supplementary Figures.

Supplementary Figure 1: Examples of buried and exhumed long runout landslides with longitudinal ridges on Mars. a) location is east of Uranius Patera, unnamed crater: longitude -91.529 latitude 26.274 (CTX image P11_005426_2069_XN_26N091W). b) location near Noc Cavus, longitude -96.337 latitude -13.78 (CTX image P08_004055_1659_XN_14S096W). c) The figure shows a sector of Coprates Chasma, in Valles Marineris, where sediments have buried landslide deposits, which have been subsequently exhumed. Base image is CTX image J09_048254_1668_XN_13S063W.

Supplementary Figure 2: Ridge splitting. The red arrowheads show the locations where ridges split and two ridges develop from the parent ridge. Panels a) and b) show examples of ridge splitting in the Dalvík landslide deposit in Iceland. Panels c) (CTX image: P20_008906_1685_XN_11S067W) and d) (CTX image: B21_017688_1685_XN_11S067W) show examples of ridge splitting in the 63 km long Coprates Labes landslide deposit on Mars.

Supplementary Tables.

Supplementary Table 1: List of long runout landslides with longitudinal ridges in Iceland. H is the elevation drop and L is the horizontal length of the landslide. H and L are calculated from the furthest upslope point of the headscarp to the furthest downslope point of the landslide deposit. The elevation data used come from the ArcticDEM. The landslide marked with the asterisk and bold font is the Dalvik landslide, which is used as a case study in this work. X stands for 'not present'; Y stands for 'present', and the 'line' symbol is used when identification was uncertain.

I-Landslide ID	Latitude	Longitude	H (m)	L (m)	H/L	Toreva block	Lateral Levees	Headscarp
1	66.145	- 23.214	302	634	0.476	X	X	Top-slope
2	66.166	-23.307	285	757	0.376	X	X	Top-slope
3	65.883	-23.357	532	1390	0.382	X	X	Top-slope
4	65.777	-23.45	343	897	0.382	X	X	Top-slope
5	65.94	-21.564	155	466	0.332	X	X	Top-slope
6	65.602	-21.646	352	993	0.354	X	Y	Top-slope
7	65.596	-21.646	345	968	0.349	X	X	Top-slope
8	65.512	-22.281	374	1041	0.359	X	X	Top-slope
9	65.513	-22.261	408	1065	0.383	X	X	Top-slope
10	65.483	-22.133	391	1922	0.203	X	X	Top-slope
11	65.451	-21.85	337	1464	0.230	X	X	Top-slope
12	65.481	-21.506	120	551	0.217	X	X	Top-slope
13	65.442	-21.486	271	686	0.395	X	X	Top-slope
14	65.366	-21.746	479	1064	0.450	X	X	Top-slope
15	65.243	-21.823	180	1030	0.174	X	X	Top-slope
16	65.237	-21.799	156	744	0.209	Y	X	Top-slope
17	65.24	-21.792	209	1328	0.157	X	Y	Top-slope
18	64.9	-23.064	196	1310	0.149	X	X	Top-slope
19	64.867	-22.959	243	987	0.246	X	X	Mid-slope
20	64.991	-22.591	274	930	0.294	Y	X	Top-slope
21	64.974	-22.604	204	514	0.396	X	X	Top-slope
22	64.985	-22.582	221	717	0.308	X	X	Top-slope

-23	64.898	-22.075	295	1160	0.254	-	X	Top-slope
24	64.895	-22.047	261	806	0.323	-	X	Top-slope
25	64.959	-21.757	450	1401	0.321	X	X	Top-slope
26	64.891	-21.513	99	347	0.285	X	X	Mid-slope
27	64.845	-21.73	300	1230	0.243	Y	X	Top-slope
28	64.839	-21.734	348	1534	0.226	Y	X	Top-slope
29	65.061	-21.305	226	843	0.268	X	X	Top-slope
30	64.211	-21.695	318	1540	0.206	X	X	Mid-slope
31	65.396	-20.433	522	2130	0.245	X	Y	Top-slope
32	65.414	-20.743	460	2279	0.201	X	-	Top-slope
33	65.536	-20.669	365	1443	0.252	X	X	Top-slope
34	65.452	-20.222	401	1720	0.233	X	X	Top-slope
35	65.521	-20.325	220	726	0.303	X	X	Mid-slope
36	65.575	-19.998	226	849	0.266	-	N	Mid-slope
37	65.583	-20.028	251	874	0.287	-	N	Top-slope
38	65.597	-20.069	452	1243	0.363	X	X	Top-slope
39	65.606	-20.083	527	1194	0.441	X	X	Top-slope
40	65.58	-20.013	317	1178	0.269	-	N	Top-slope
41	66.138	-19.052	438	1738	0.252	X	X	Top-slope
42	66.091	-18.719	486	831	0.580	X	X	Top-slope
43	66.031	-18.7	810	2469	0.328	-	N	Top-slope
44	66.094	-19.051	243	834	0.291	N	Y	Top-slope
45	66.07	-18.996	245	1131	0.216	Y	N	Top-slope
46	66.066	-18.964	288	1033	0.278	Y	N	Top-slope
47*	**65.981**	**-18.56**	**480**	**1210**	**0.396**	**Y**	**N**	**Top-slope**
48	66.024	-18.931	232	1307	0.177	Y	N	Top-slope
49	66.015	-18.994	283	1188	0.238	X	X	Top-slope
50	65.984	-19.162	415	965	0.430	-	N	Top-slope

51	66.078	-18.843	167	707	0.236	X	X	Mid-slope
52	66.083	-18.837	103	412	0.250	X	X	Mid-slope
53	66.033	-18.934	115	468	0.245	X	X	Mid-slope
54	66.002	-18.982	273	786	0.347	X	X	Mid-slope
55	66.005	-19.127	307	921	0.333	-	N	Top-slope
56	65.945	-19.083	516	1208	0.427	Y	N	Top-slope
57	66.02	-19.17	317	981	0.323	N	N	Mid-slope
58	65.949	-18.088	548	1444	0.379	N	Y	Top-slope
59	65.946	19.015	203	1290	0.157	N	N	Mid-slope
60	65.941	-19.001	198	865	0.228	N	Y	Mid-slope
61	65.945	-18.83	175	966	0.181	-	Y	Mid-slope
62	65.948	-18.768	396	1781	0.222	N	N	Top-slope
63	65.929	-18.755	328	853	0.384	Y	-	Mid-slope
64	65.94	-18.762	418	1592	0.262	N	Y	Mid-slope
65	65.937	-18.767	455	1037	0.438	N	Y	Top-slope
66	65.915	-18.96	575	1484	0.387	Y	N	Top-slope
67	65.933	-19.381	361	1080	0.334	-	N	Top-slope
68	65.922	-19.364	358	1025	0.349	N	N	Mid-slope
69	65.956	-19.401	235	678	0.346	-	N	Mid-slope
70	65.885	-19.153	526	1511	0.348	-	N	Mid-slope
71	65.78	-19.216	576	2409	0.239	Y	Y	Top-slope
72	65.946	-18.637	270	886	0.304	Y	Y	Mid-slope
73	65.941	-18.638	377	786	0.479	N	-	Mid-slope
74	65.902	-18.536	434	1532	0.283	Y	Y	Mid-slope
75	65.869	-18.68	298	850	0.350	Y	Y	Mid-slope
76	65.9	-18.677	355	1057	0.335	N	-	Mid-slope
77	65.9	-18.667	479	1374	0.348	-	-	Mid-slope
78	65.917	-18.514	377	1455	0.259	N	-	Mid-slope

79	65.869	-18.7	452	1034	0.437	N	N	Mid-slope
80	65.868	-18.69	310	894	0.346	N	N	Mid-slope
81	65.674	-19.331	513	1487	0.344	-	-	Mid-slope
82	65.587	-18.765	302	674	0.448	-	N	Mid-slope
83	65.48	-18.67	180	523	0.344	-	N	Mid-slope
84	65.521	-18.47	229	666	0.343	-	N	Mid-slope
85	65.473	-18.696	226	472	0.478	-	N	Mid-slope
86	65.578	18.7	245	807	0.303	N	N	Mid-slope
87	65.678	-18.327	323	1057	0.305	N	N	Mid-slope
88	65.515	-18.204	437	1162	0.376	-	N	Top-slope
89	65.668	-18.374	738	2258	0.326	N	N	Top-slope
90	65.559	-18.191	112	573	0.195	N	N	Mid-slope
91	65.546	-18.181	564	1542	0.365	-	Y	Mid-slope
92	65.503	-18.315	225	620	0.362	Y	N	Mid-slope
93	65.503	-18.276	541	1547	0.349	-	N	Top-slope
94	65.506	-18.257	257	659	0.389	Y	N	Mid-slope
95	65.547	-17.936	221	566	0.390	N	N	Mid-slope
96	65.608	-17.829	103	379	0.271	Y	N	Mid-slope
97	65.561	-17.76	240	969	0.247	Y	N	Mid-slope
98	65.832	-17.861	516	1703	0.302	Y	N	Top-slope
99	65.83	-18.052	518	1669	0.310	Y	-	Top-slope
100	65.889	-17.811	436	1607	0.271	Y	N	Mid-slope
101	65.986	-17.822	437	1937	0.225	Y	-	Top-slope
102	65.897	-17.824	615	2573	0.239	Y	N	Mid-slope
103	65.678	-14.81	763	2629	0.290	Y	N	Top-slope
104	65.669	-14.813	274	827	0.331	Y	N	Mid-slope
105	65.581	-13.966	340	1159	0.293	N	Y	Top-slope
106	65.549	-13.967	444	1851	0.239	N	N	Top-slope

107	65.532	-13.727	173	1008	0.171	-	-	Top-slope
108	65.513	-13.772	491	1839	0.266	N	Y	Top-slope
109	65.51	-13.706	357	1673	0.213	N	Y	Top-slope
110	65.168	-14.267	167	601	0.277	Y	N	Mid-slope
111	65.128	-13.907	272	1744	0.155	N	Y	Mid-slope
112	65.118	-13.562	214	854	0.250	N	N	Mid-slope
113	64.863	-14.207	361	1133	0.318	Y	N	Top-slope
114	64.959	-14.072	189	605	0.312	Y	Y	Mid-slope
115	64.993	-14.951	442	1443	0.306	N	Y	Mid-slope
116	64.404	-15.288	267	900	0.296	N	Y	Mid-slope
117	65.871	-19.834	544	1936	0.280	-	Y	Mid-slope
118	65.984	-19.395	372	1817	0.204	N	N	Top-slope
119	66.028	-19.318	106	373	0.284	N	N	Mid-slope
120	66.036	-19.321	429	1445	0.296	N	Y	Top-slope
121	65.429	-20.183	188	859	0.218	N	N	Top-slope
122	65.429	-20.166	302	828	0.364	-	Y	Mid-slope
123	66.433	-20.156	287	1265	0.226	Y	N	Mid-slope
124	65.502	-13.711	430	1318	0.326	N	N	Top-slope
125	65.94	-18.826	549	2308	0.237	N	N	Top-slope
126	65.578	-13.999	169	655	0.258	Y	-	Mid-slope
127	65.167	-14.25	91	287	0.317	Y	Y	Mid-slope
128	65.136	-13.946	328	971	0.337	-	-	Mid-slope
129	65.574	-13.996	234	585	0.400	Y	N	Top-slope

Supplementary Table 2: List of Ground Control Points (GCPs) used to georeference drone-acquired images of the landslide near the town of Dalvík (landslide ID 47). The height above the geoid [H] corresponds to the elevation above sea level and it is obtained by subtracting the geoid height above the ellipsoid at the given location [N] to the height above the ellipsoid [h], which is elevation provided by the dGPS.

Point Id	Latitude	Longitude	Height above the ellipsoid (m) [h]	Geoid height above the ellipsoid (m) [N]	Height above the geoid (m) [H]
GCP01	65° 58' 50.58" N	18° 33' 07.09" W	157.2471	66.2095	91.0376
GCP02	65° 58' 46.39" N	18° 33' 21.90" W	176.1410	66.2204	109.9206
GCP03	65° 58' 46.10" N	18° 33' 39.24" W	230.5178	66.2271	164.2907
GCP04	65° 58' 54.19" N	18° 33' 22.74" W	217.9408	66.2106	151.7302
GCP05	65° 58' 56.11" N	18° 33' 10.49" W	195.1588	66.2036	128.9552
GCP06	65° 59' 00.39" N	18° 33' 19.87" W	230.7915	66.2016	164.5899
GCP07	65° 58' 54.69" N	18° 33' 34.43" W	245.3430	66.2142	179.1288
GCP08	65° 58' 47.43" N	18° 33' 52.50" W	250.1690	66.2301	183.9389
GCP09	65° 58' 54.89" N	18° 33' 57.50" W	307.8761	66.2221	241.6540
GCP10	65° 59' 03.12" N	18° 33' 44.07" W	322.9035	66.2066	256.6969

Supplementary Table 3: List of long runout landslide less than 5 km long with longitudinal ridges on Mars. H is the elevation drop and L is the horizontal length of the landslide. H and L are calculated from the furthest point of the headscarp to the furthest point of the landslide deposit. The elevation data used come from HRSC MOLA-Blended global DEM. The landslides marked with an asterisk and in bold font are the landslides for which we have built DEMs and orthoimages. X stands for 'not present'; Y stands for 'present', and the 'line' symbol is used when identification was uncertain.

M-Landslide ID	Latitude	Longitude	H (km)	L (km)	H/L	Toreva block	Lateral levees	Headscarp
1	-11.218	-177.694	0.346	2.022	0.171	X	-	Mid-slope
2	36.377	-104.794	0.566	1.566	0.361	X	Y	Mid-slope
3	36.818	-104.483	0.106	0.508	0.209	X	-	Mid-slope
4	-6.386	-101.555	0.527	1.285	0.410	X	Y	Mid-slope
5	-5.585	-89.658	0.286	1.242	0.23	X	Y	Top-slope
6	-6.194	-89.68	0.902	4.048	0.222	X	Y	Top-slope
7	-4.647	143.78	0.157	0.985	0.159	X	Y	Mid-slope
8	-8.287	149.217	0.304	1.383	0.219	X	Y	Mid-slope
9	-3.595	137.593	0.383	2.886	0.132	X	Y	Top-slope
10	19.115	173.191	0.682	2.492	0.273	X	Y	Mid-slope
11	19.079	173.174	1.341	4.204	0.318	Y	Y	Top-slope
12	-3.519	-60.348	0.845	1.805	0.468	X	Y	Mid-slope
13	-3.681	124.201	1.110	3.344	0.331	Y	Y	Top-slope
14	-14.725	-179.832	0.174	2.287	0.076	Y	-	Mid-slope
15	-14.723	-179.846	0.315	2.111	0.128	X	Y	Mid-slope
16	-17.844	-171.051	0.399	2.904	0.137	X	X	Top-slope
17	-34.076	-156.802	0.408	2.853	0.143	X	X	Top-slope
18	-10	-95.096	1.165	3.327	0.35	X	-	Top-slope
19	-10.02	-95.085	1.151	4.33	0.265	X	-	Top-slope
20	-27.828	155.411	0.576	3.251	0.177	Y	Y	Top-slope
21	37.888	-103.872	1.252	3.371	0.371	X	Y	Top-slope
22	37.858	-103.896	1.341	3.734	0.359	X	X	Top-slope
23	-4.619	-72.68	0.685	3.069	0.223	X	-	Top-slope

24	-4.634	-72.765	0.908	3.512	0.258	X	-	Top-slope
25	-19.336	165.727	0.61	3.951	0.154	X	X	Top-slope
26	-19.969	172.27	0.78	3.373	0.231	Y	-	Top-slope
27	-19.952	172.244	0.671	4.185	0.16	Y	-	Top-slope
28	-4.889	-63.237	1.038	3.144	0.33	Y	X	Top-slope
29	23.618	-67.337	0.964	3.528	0.273	X	Y	Top-slope
30	-11.974	-68.539	0.877	3.337	0.262	X	X	Top-slope
31*	**-4.526**	**-84.365**	**0.943**	**3.461**	**0.272**	**-**	**Y**	Top-slope
32	-4.43	-84.357	1.388	4.746	0.292	Y	Y	Top-slope
33	-4.641	-63.239	0.987	3.356	0.294	X	Y	Top-slope
34	-7.935	-96.229	1.110	3.284	0.338	X	Y	Top-slope
35	-25.854	-139.877	1.369	3.566	0.383	X	-	Top-slope
36	-9.287	123.352	0.693	3.286	0.210	Y	Y	Top-slope
37	0.364	120.835	0.384	3.888	0.098	Y	X	Top-slope
38	-3.87	-74.366	1.708	4.210	0.405	X	Y	Top-slope
39	3.82	131.804	0.804	4.080	0.197	Y	Y	Top-slope
40	-7.475	-89.117	1.336	3.962	0.337	X	Y	Top-slope
41	-5.048	-71.978	1.684	4.468	0.376	X	-	Top-slope
42*	**28**	**-71.876**	**1.172**	**3.868**	**0.302**	**Y**	**Y**	Top-slope
43	-4.089	-88.594	1.579	4.902	0.322	X	X	Top-slope
44	-21.645	169.313	0.809	4.552	0.177	X	X	Top-slope
45	-3.551	134.13	0.797	4.373	0.182	-	Y	Top-slope
46*	**-13.546**	**-65.321**	**0.657**	**4.159**	**0.157**	**X**	**X**	**Mid-slope**
47*	**-13.553**	**-65.277**	**0.8**	**4.256**	**0.187**	**X**	**X**	**Mid-slope**
48	-0.674	-60.672	0.844	3.728	0.226	X	Y	Top-slope
49	16.064	-52.719	0.415	2.076	0.199	-	Y	Mid-slope
50	8.811	-56.122	0.413	3.492	0.118	Y	Y	Top-slope
51	0.377	-45.565	0.284	1.278	0.222	X	Y	Top-slope
52	0.345	-45.529	0.437	1.190	0.367	X	Y	Mid-slope

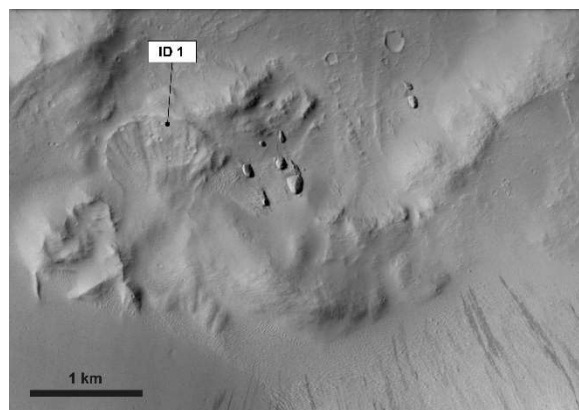
53	0.305	-45.583	0.627	1.922	0.326	X	Y	Top-slope
54	0.022	-45.388	0.881	2.279	0.386	-	X	Top-slope
55	-0.003	-45.388	0.790	1.930	0.409	-	X	Top-slope
56	0.002	-44.916	0.415	2.174	0.190	X	Y	Top-slope
57	-0.025	-44.877	0.664	2.423	0.274	X	Y	Top-slope
58	1.657	-43.837	1.269	3.468	0.365	X	Y	Top-slope
59	6.609	-42.201	1.285	4.599	0.279	X	Y	Top-slope
60	11.442	-41.813	0.82	2.081	0.394	X	-	Top-slope
61	10.024	-41.021	0.715	2.164	0.330	X	-	Mid-slope
62	10.353	-41.266	0.865	2.311	0.374	X	X	Top-slope
63	10.345	-41.215	1.033	3.061	0.337	X	X	Top-slope
64	10.399	-37.866	0.536	3.120	0.171	X	-	Top-slope
65	3.314	-36.009	0.842	2.284	0.368	X	Y	Mid-slope
66	2.19	-36.542	0.997	2.639	0.377	X	-	Mid-slope
67	1.509	-36.287	0.351	1.021	0.343	X	Y	Mid-slope
68	1.198	-36.02	0.409	1.232	0.331	X	Y	Mid-slope
69	0.833	-35.17	0.211	1.148	0.183	X	Y	Top-slope
70	1.184	-34.949	0.742	2.873	0.258	X	Y	Top-slope
71	0.405	-32.5	0.394	0.901	0.437	X	-	Mid-slope
72	0.886	-32.606	0.679	2.902	0.233	X	-	Top-slope
73	5.733	-32.127	0.621	2.243	0.276	X	-	Top-slope
74	11.474	-32.541	0.396	2.011	0.196	X	X	Top-slope
75	1.634	-25.697	0.667	2.075	0.321	Y	Y	Mid-slope
76	2.209	-25.413	1.071	2.724	0.393	Y	Y	Top-slope
77	2.027	-23.319	1.29	4.453	0.289	Y	X	Top-slope
78	2.529	-17.756	1.73	4.633	0.373	X	Y	Top-slope
79	2.71	-17.784	0.741	1.649	0.449	X	Y	Mid-slope
80	2.679	-17.771	0.632	1.403	0.45	X	X	Top-slope
81	1.034	-18.207	0.858	2.429	0.353	X	X	Mid-slope

82	4.211	-17.059	0.813	2.384	0.341	X	X	Mid-slope
83	7.497	-22.434	0.137	1.492	0.091	X	X	Top-slope
84	22.02	77.265	0.58	2.517	0.23	X	Y	Top-slope
85	4.189	81.916	1.006	4.475	0.224	Y	X	Top-slope
86	2.427	88.447	0.898	3.873	0.231	X	Y	Mid-slope
87	-24.735	64.339	1.231	4.123	0.298	X	-	Mid-slope
88	-15.339	83.313	0.491	3.11	0.157	Y	X	Top-slope
89	-3.701	-57.777	0.741	2.813	0.263	X	X	Top-slope
90	-1.033	-42.985	0.816	3.255	0.25	X	Y	Top-slope
91	-1.105	-42.974	0.954	3.112	0.306	X	-	Top-slope
92	-6.433	-48.952	0.975	2.436	0.400	Y	-	Top-slope
93	-6.733	-47.862	1.668	4.433	0.376	-	Y	Top-slope
94	-10.594	-46.425	1.445	4.742	0.304	Y	Y	Mid-slope
95	-8.217	-40.898	0.365	1.305	0.279	X	-	Mid-slope
96	-8.219	-40.911	0.243	0.928	0.261	X	X	Mid-slope
97	-16.067	-45.131	0.406	1.646	0.246	X	X	Top-slope
98	-16.986	-45.148	1.104	3.767	0.293	Y	Y	Top-slope
99	-16.42	-44.02	1.082	3.123	0.346	-	Y	Top-slope
100	-16.25	-43.39	1.118	3.293	0.339	Y	X	Top-slope
101	-14.675	-37.455	0.609	2.074	0.293	X	X	Mid-slope
102	-6.213	-37.651	0.978	2.534	0.385	X	Y	Mid-slope
103	-5.762	-37.895	0.65	1.763	0.368	X	Y	Mid-slope
104	-4.939	-36.084	0.359	2.212	0.162	-	Y	Top-slope
105	-4.908	-36.114	0.299	1.461	0.204	X	X	Top-slope
106	-0.459	-32.403	0.274	0.961	0.285	X	X	Mid-slope
107	-0.321	-32.572	0.295	1.679	0.175	X	Y	Mid-slope
108	-0.294	-22.254	0.645	2.022	0.318	-	-	Mid-slope
109	-0.566	-16.115	1.634	4.856	0.336	X	-	Top-slope
110	-4.931	-18.812	1.177	4.177	0.281	X	Y	Top-slope

111	-18.665	-15.006	1.091	4.864	0.224	-	X	Top-slope
112	0.739	-32.65	0.325	1.285	0.252	X	-	Mid-slope
112	0.739	-32.65	0.325	1.285	0.252	X	-	Mid-slope

Supplementary Table 4: List of CTX image pairs used to generate DEM and orthoimage of two martian landslides.

Landslide ID	Image ID	Pixel size (m)	Incidence angle (º)	Phase angle (º)	Emission angle (º)	Vertical precision (m)
31	D09_030598_1752_ XN_04S084W	5.39	46.83	55.09	8.82	6.16
	D16_033578_1752_ XN_04S084W	5.26	42.72	43.64	1.11	
42	D21_035252_2083_ XN_28N072W	5.73	42.19	45.49	3.42	7.15
	K20_061019_2082_ XI_28N072W	5.75	39.71	34.05	5.71	
46, 47	J16_050944_1665_ XN_13S065W	5.21	41.29	43.27	2.45	2.98
	J16_051089_1665_ XN_13S065W	5.76	42.2	57.88	18.66	

Visual catalogue of small-scale (< 5 km) martian landslides with longitudinal ridges.

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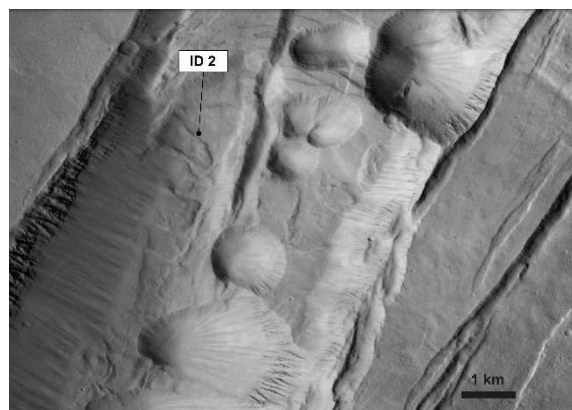
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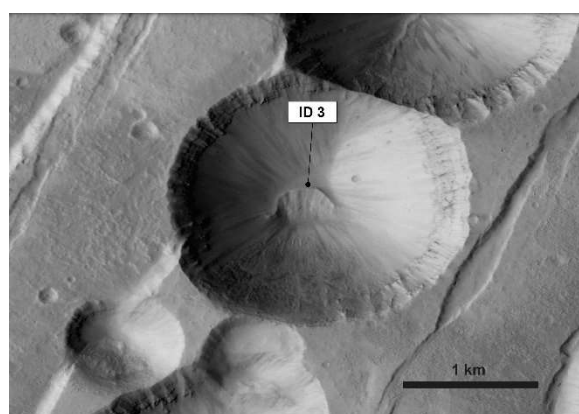
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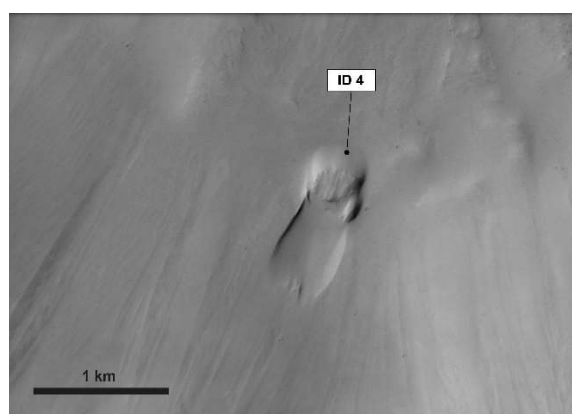
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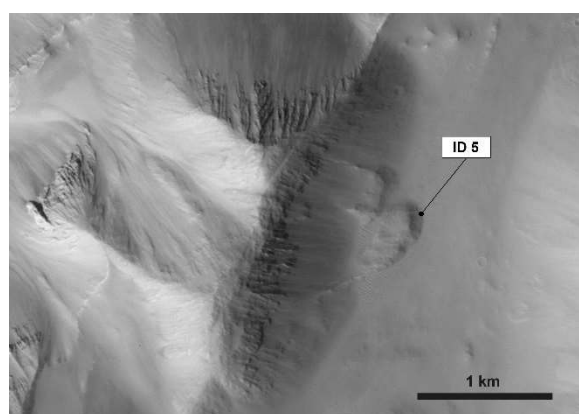
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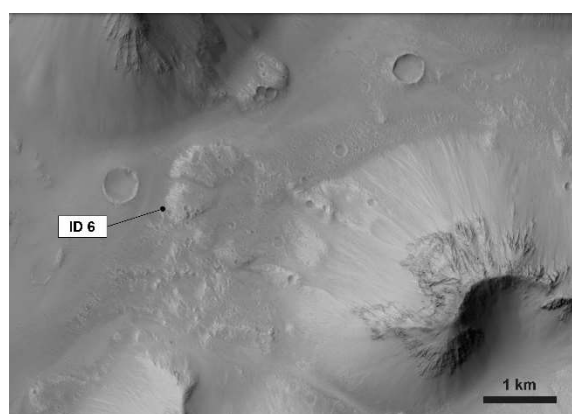
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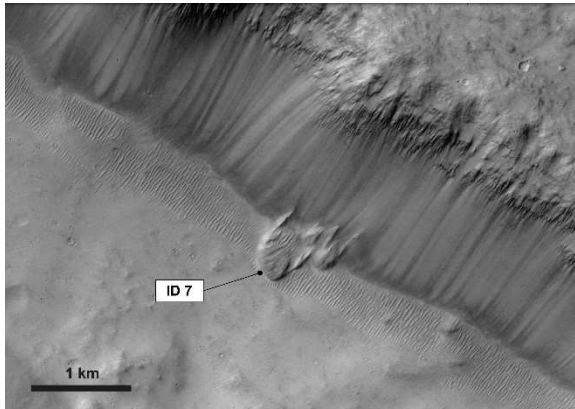
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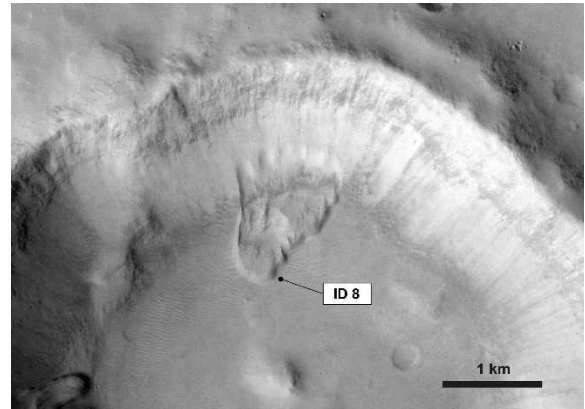
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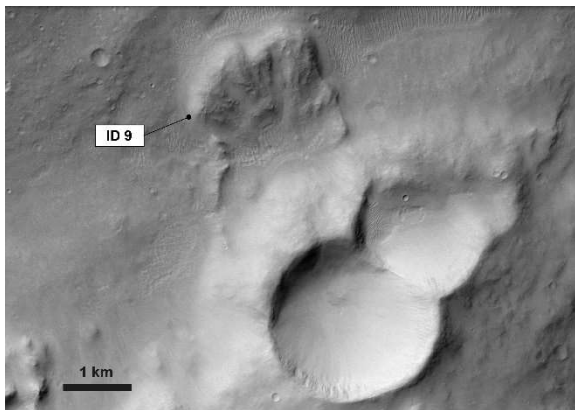
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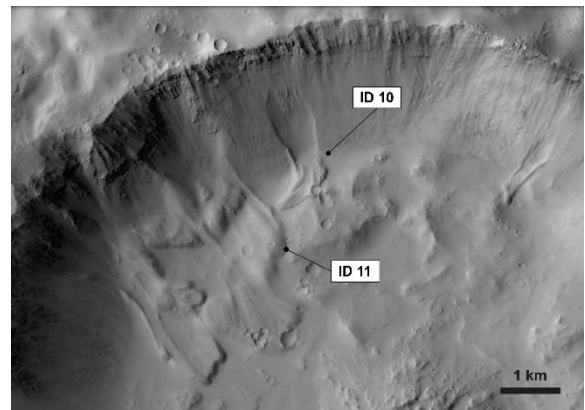
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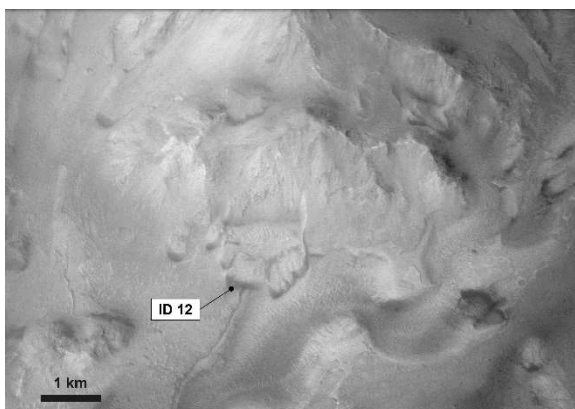
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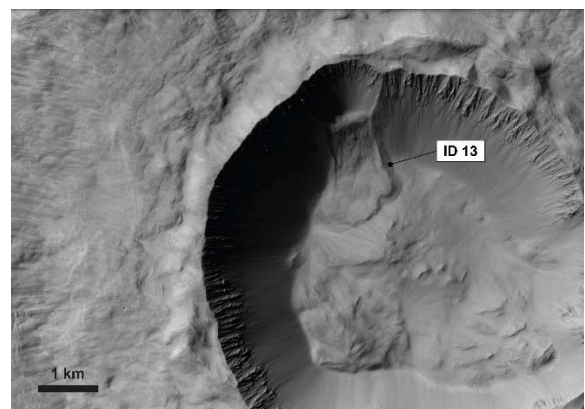
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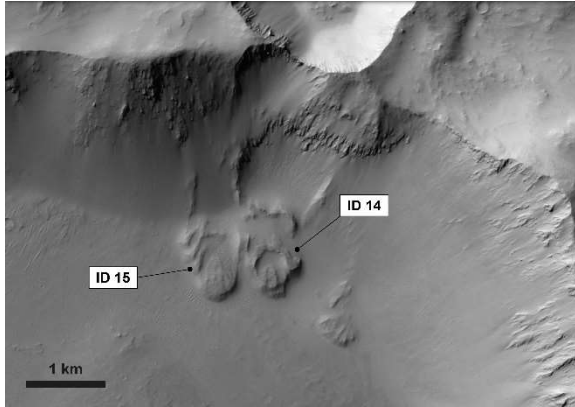
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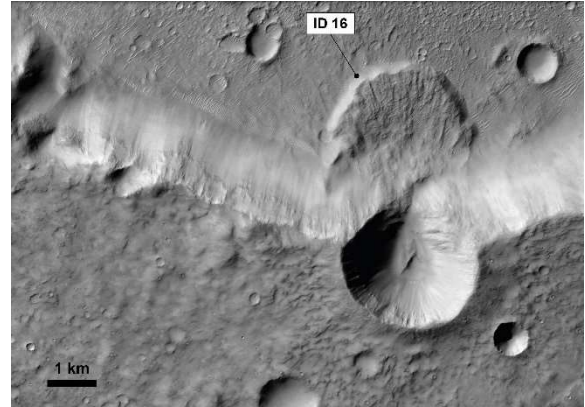
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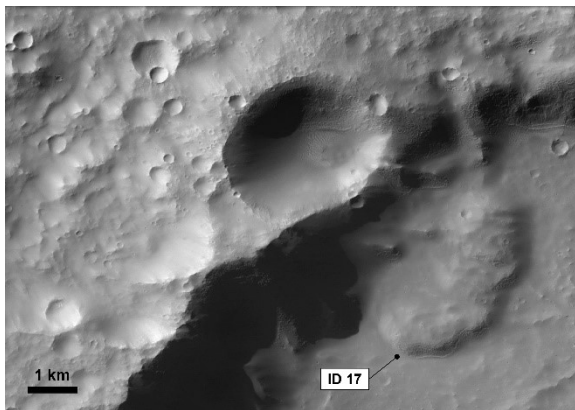
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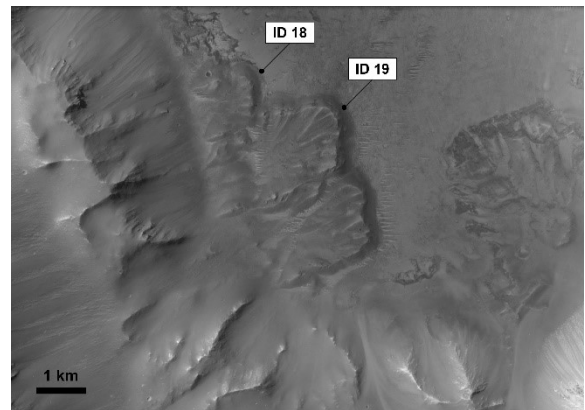
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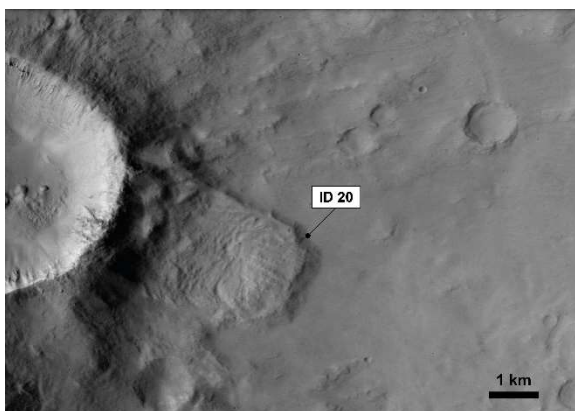
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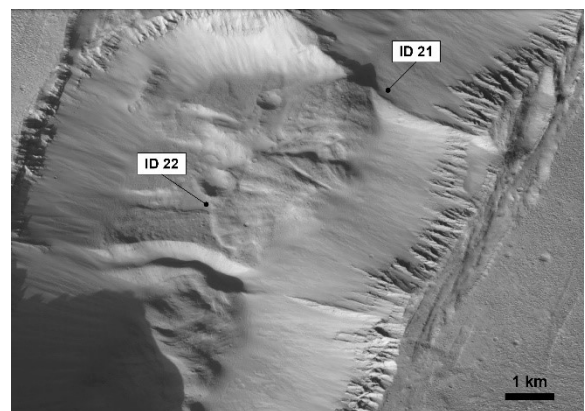
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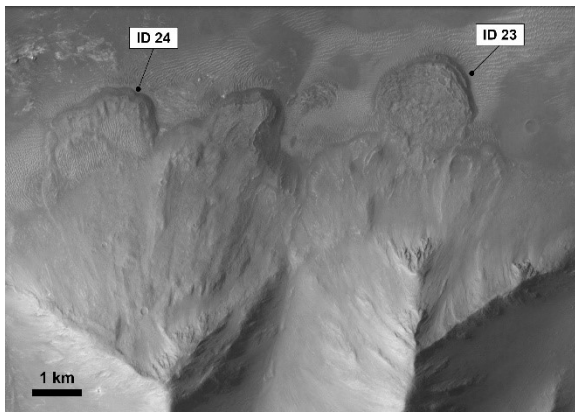
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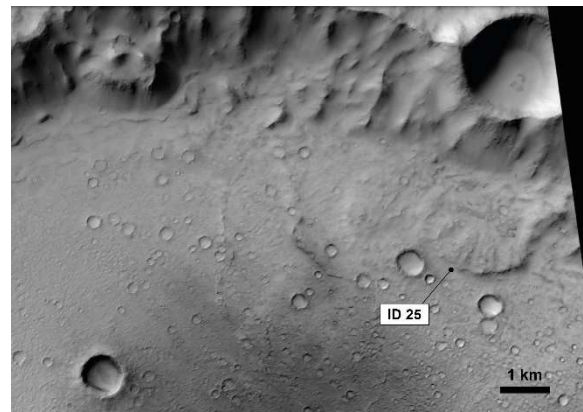
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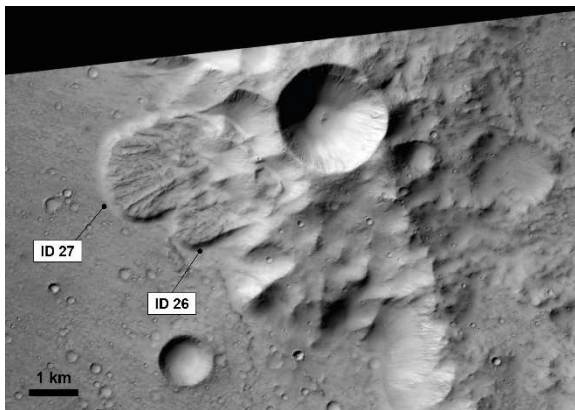
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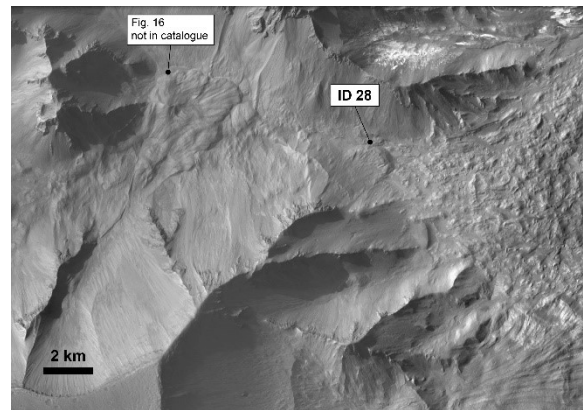
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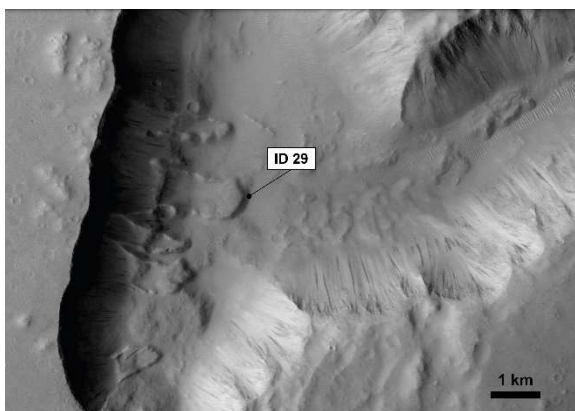
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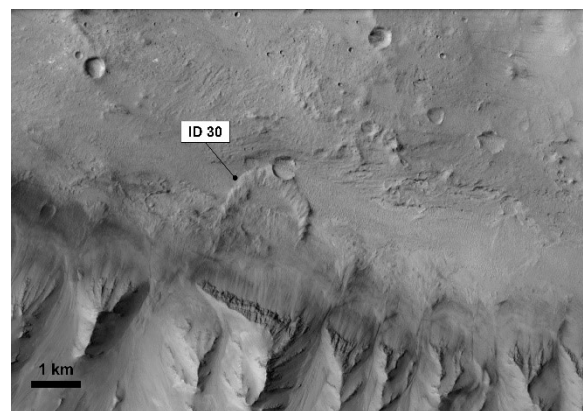
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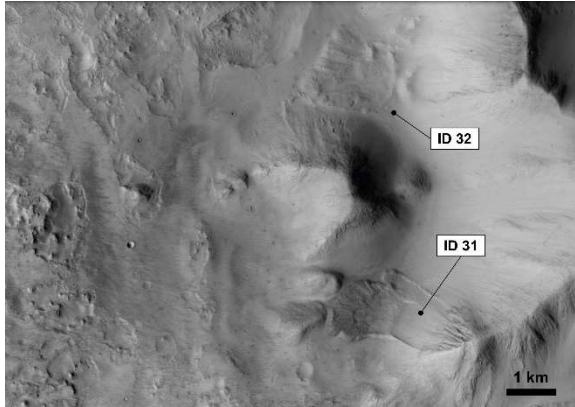
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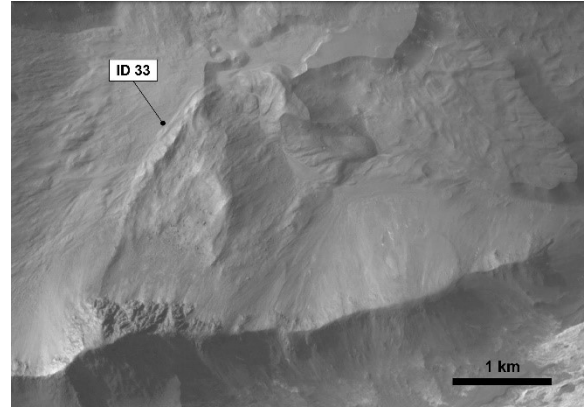
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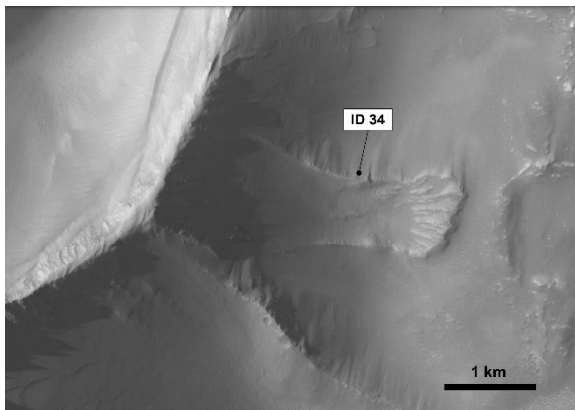
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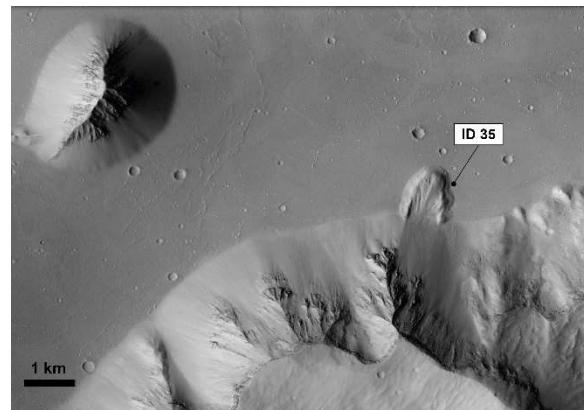
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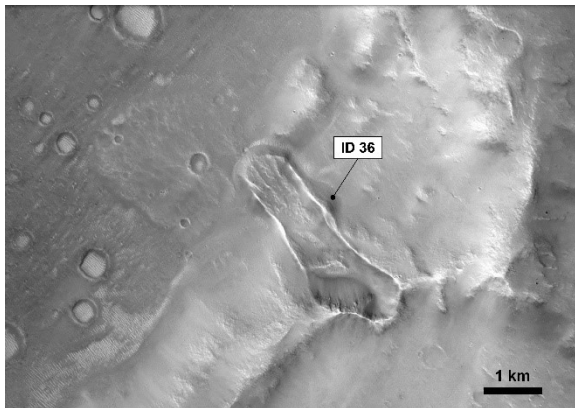
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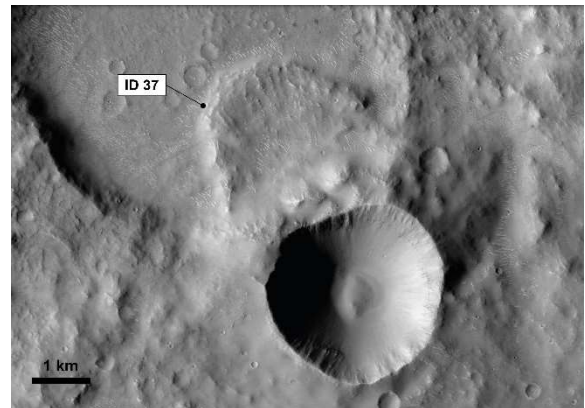
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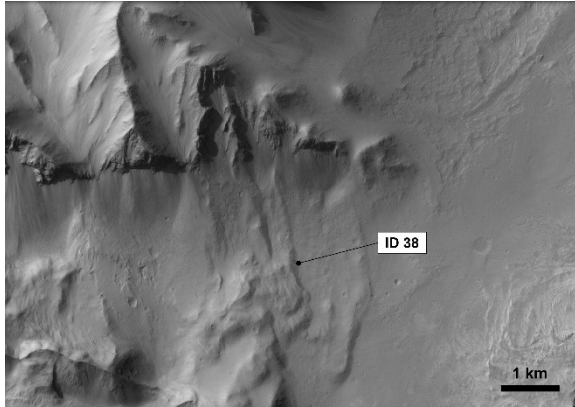
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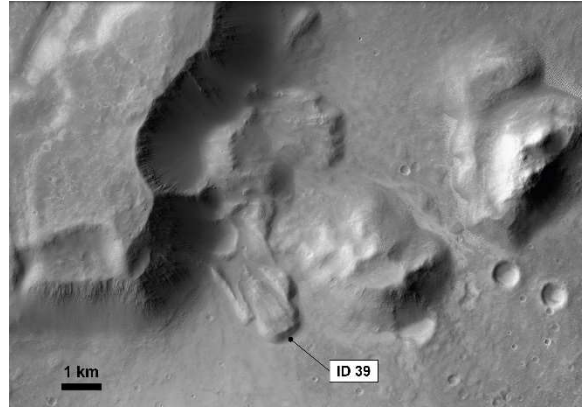
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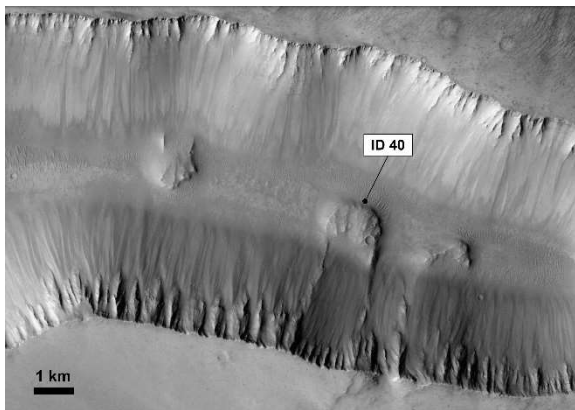
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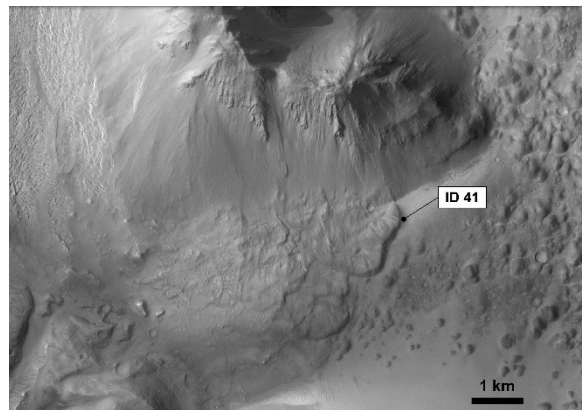
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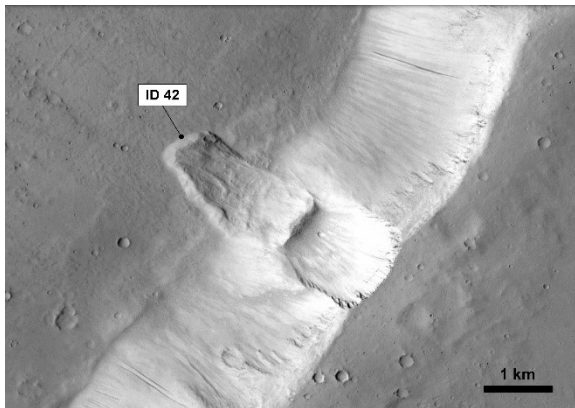
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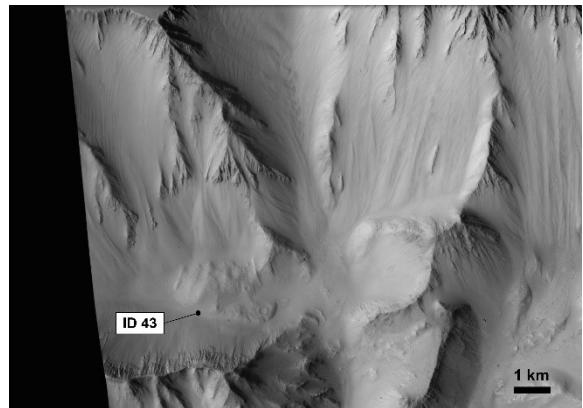
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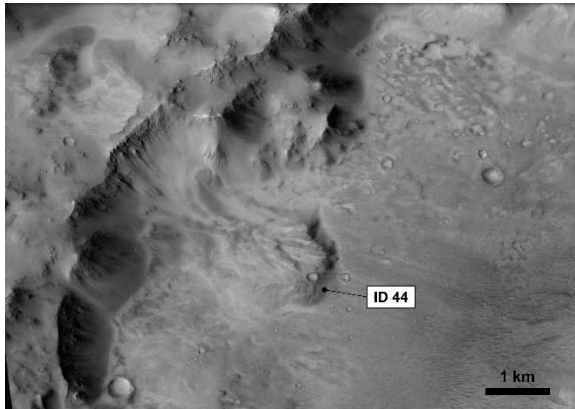
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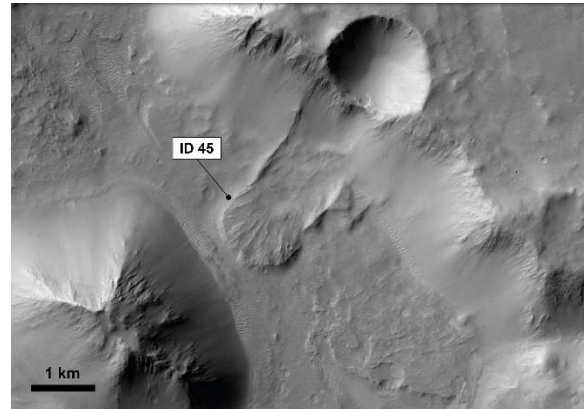
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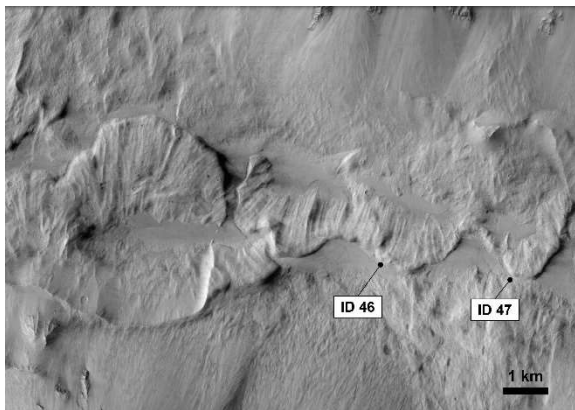
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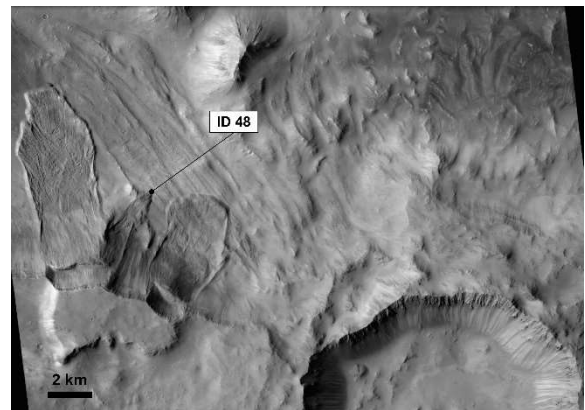
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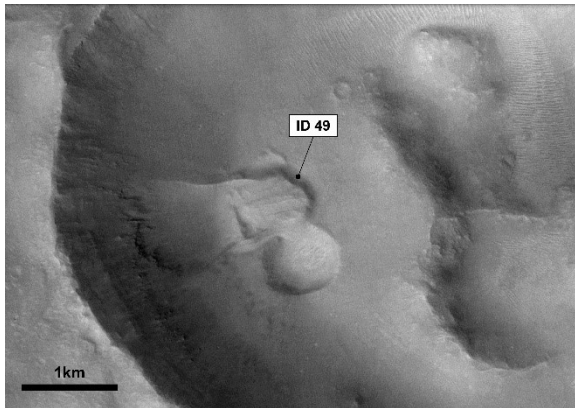
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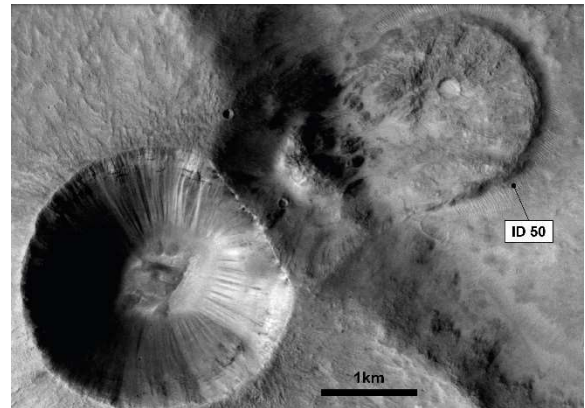
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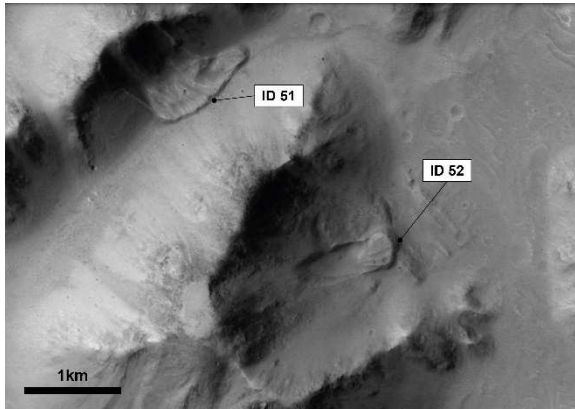
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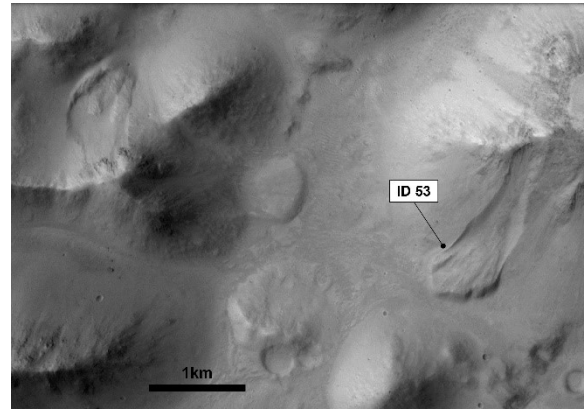
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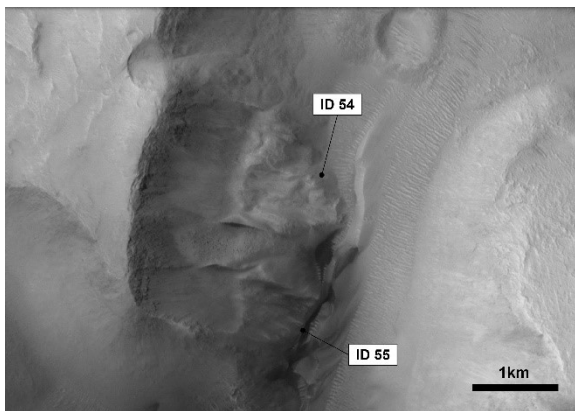
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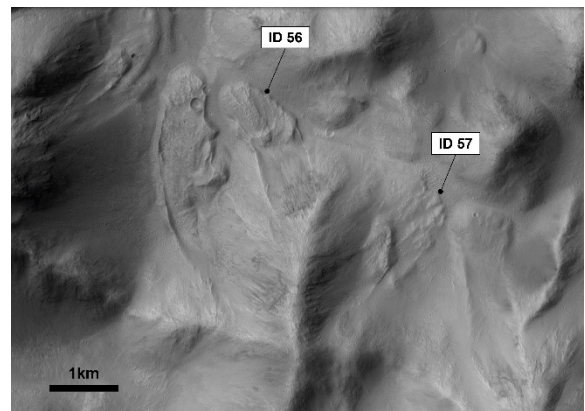
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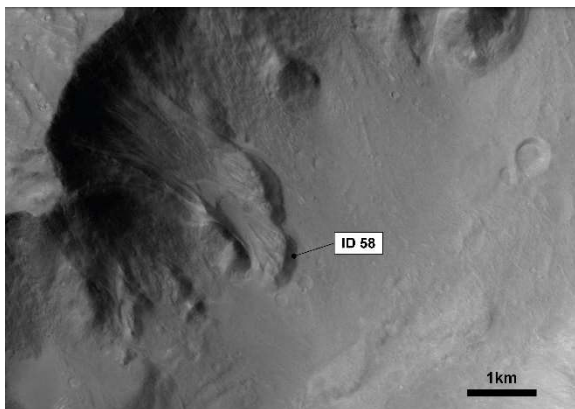
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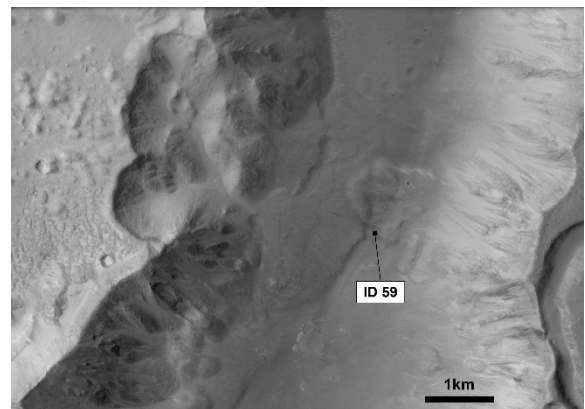
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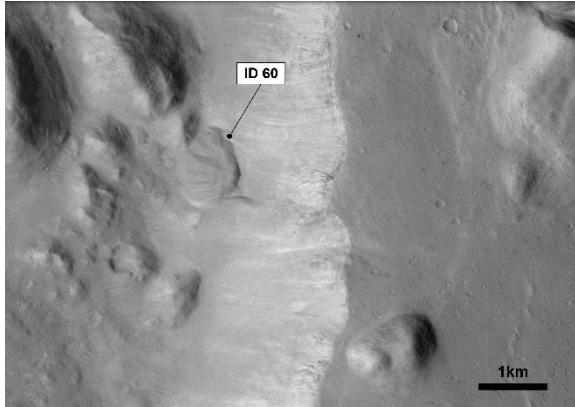
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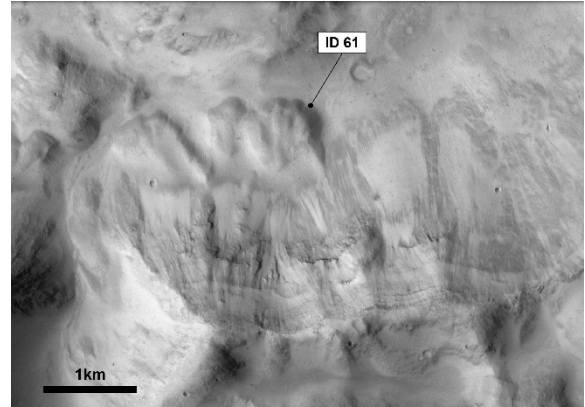
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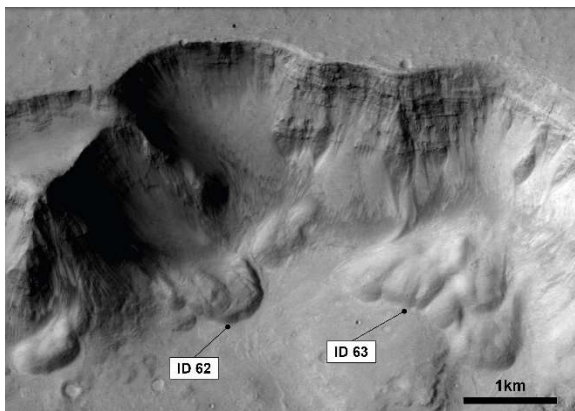
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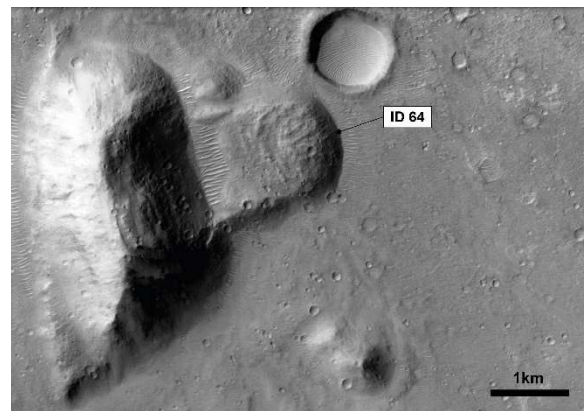
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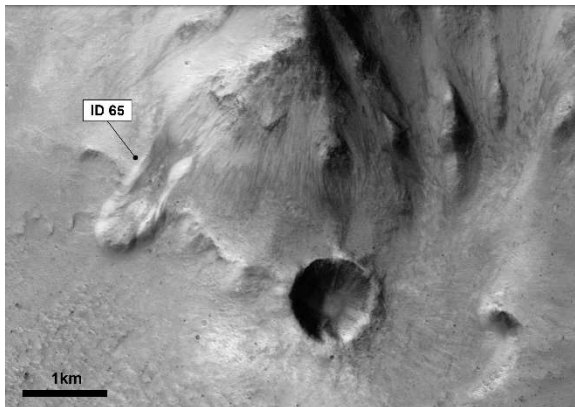
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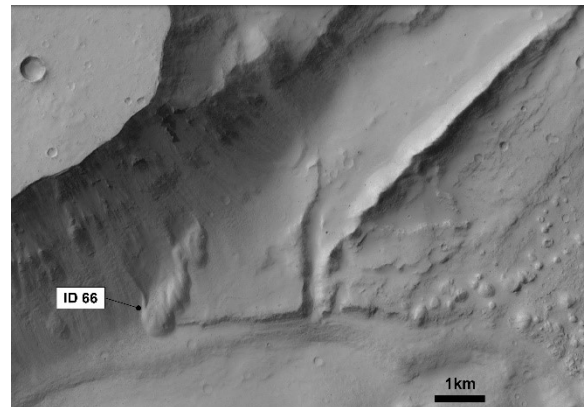
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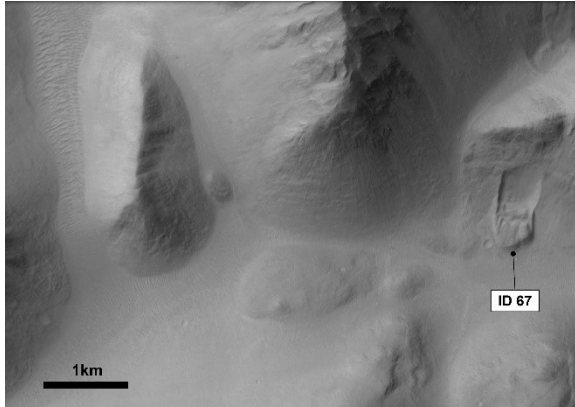
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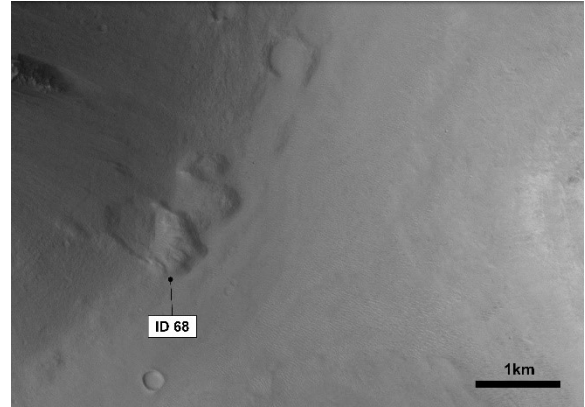
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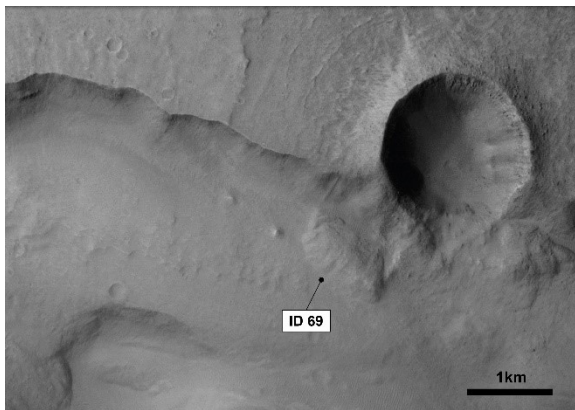
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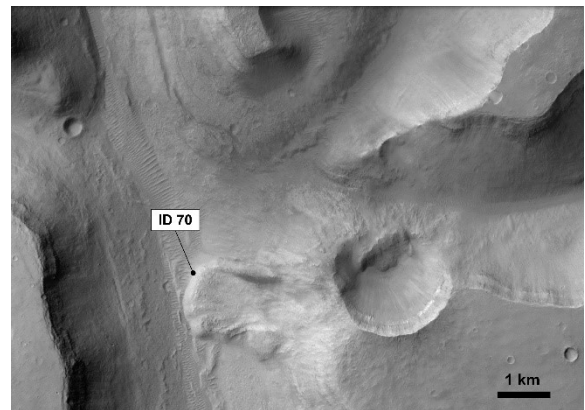
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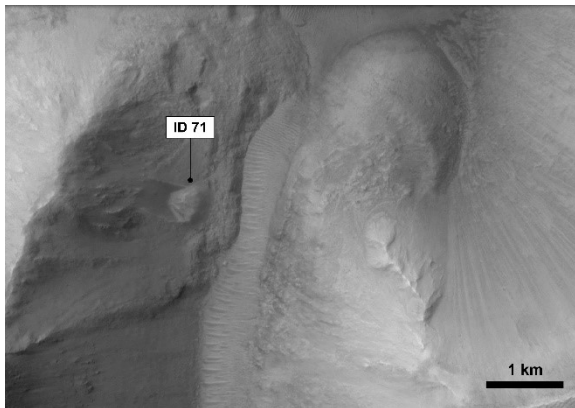
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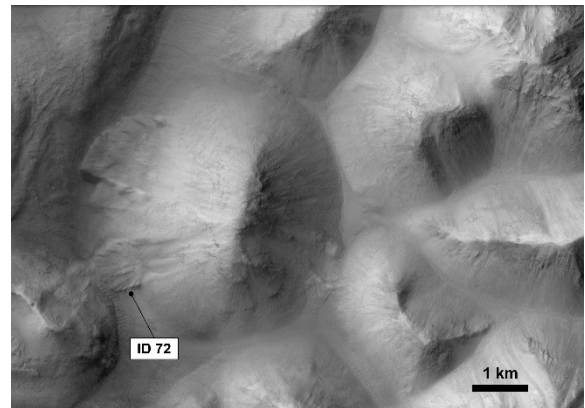
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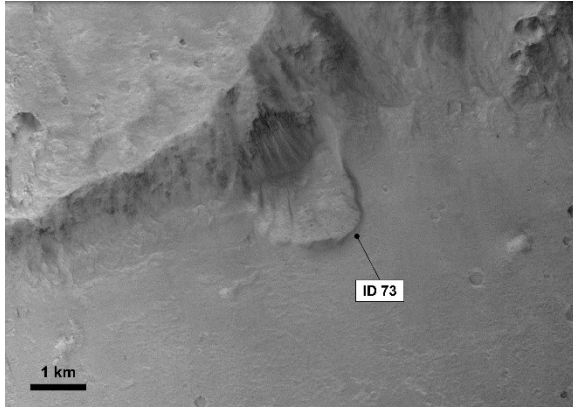
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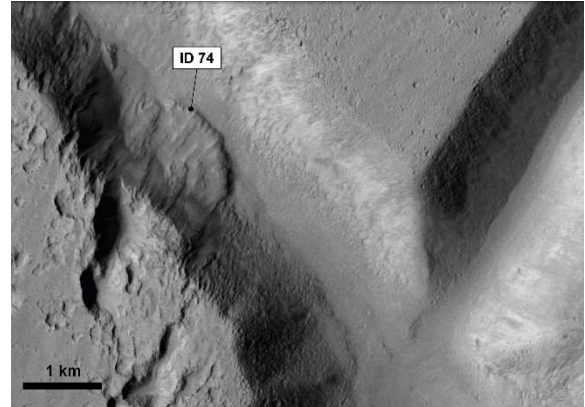
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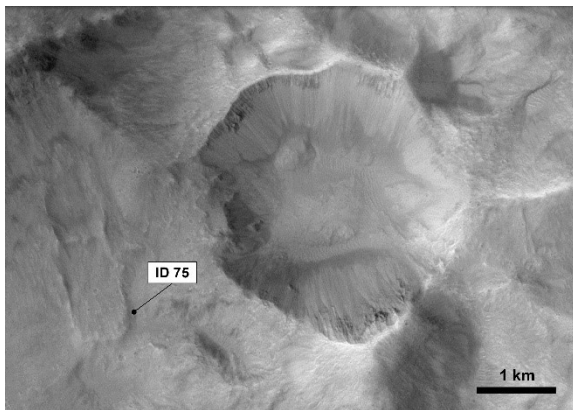
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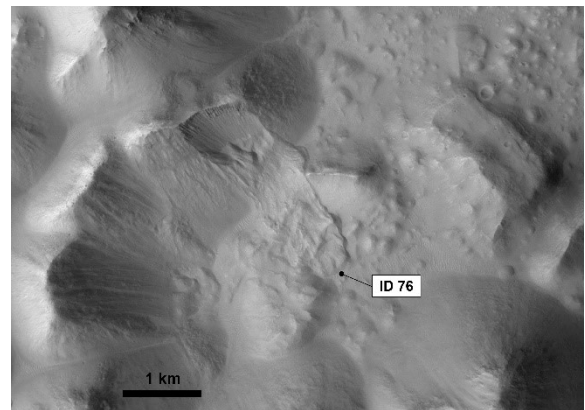
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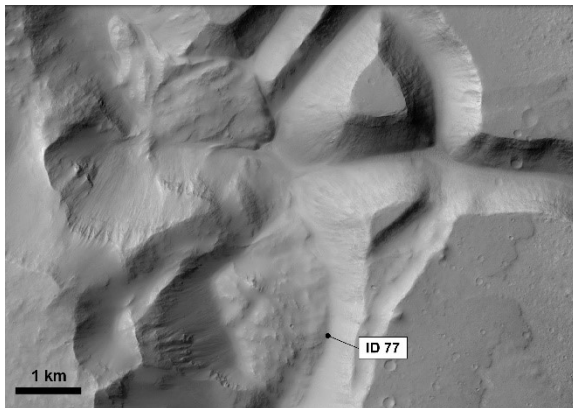
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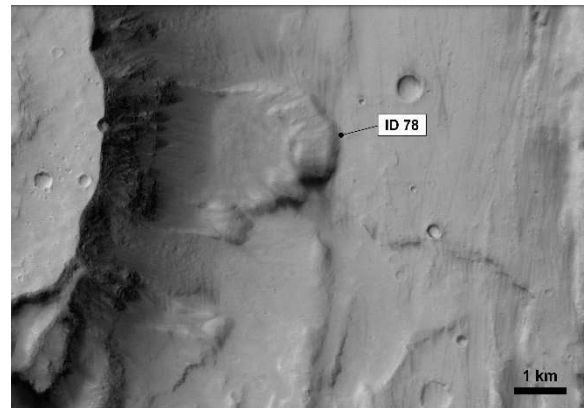
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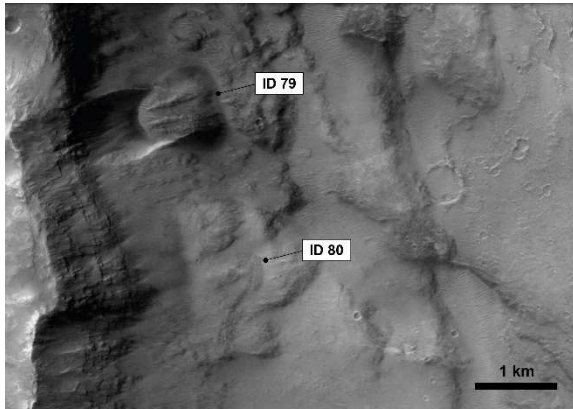
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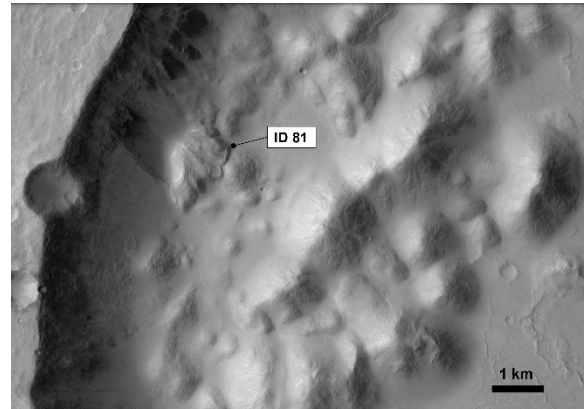
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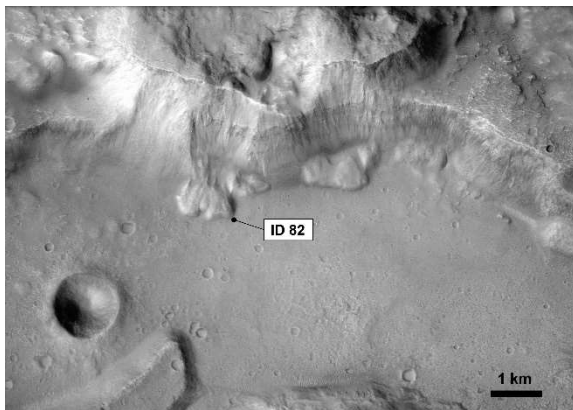
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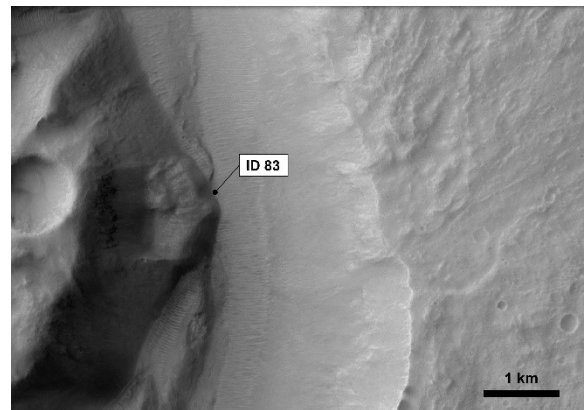
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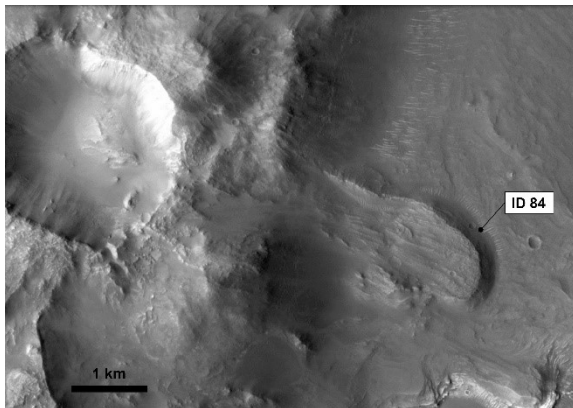
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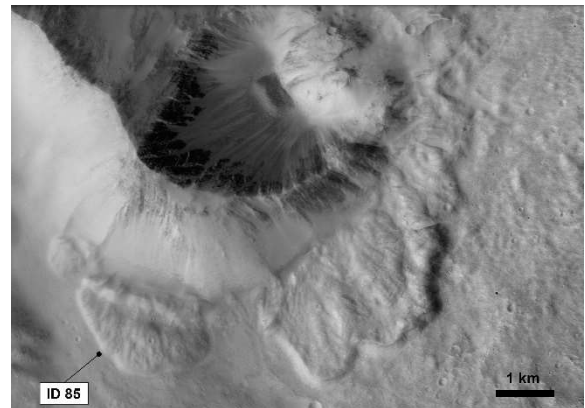
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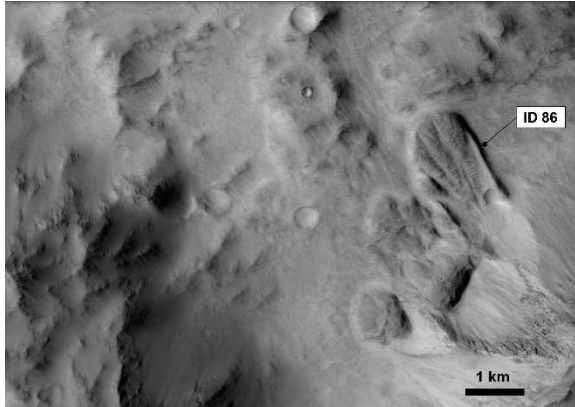
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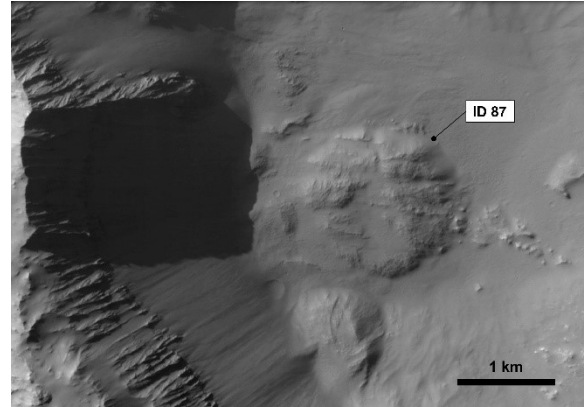
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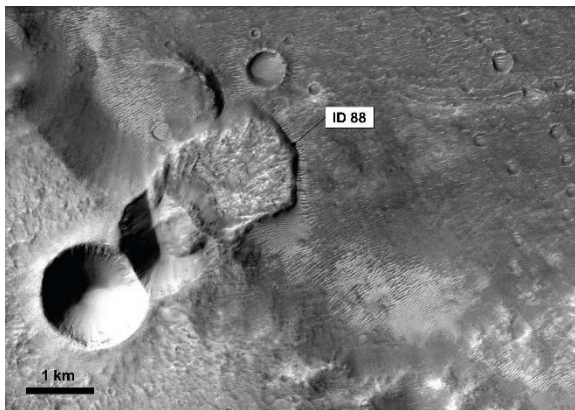
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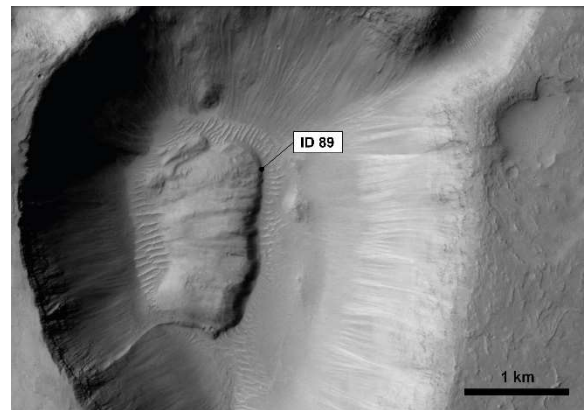
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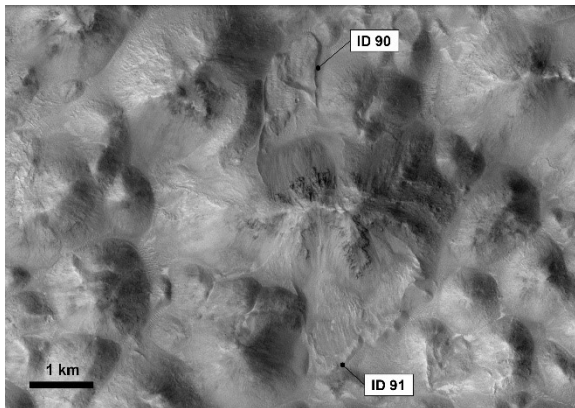
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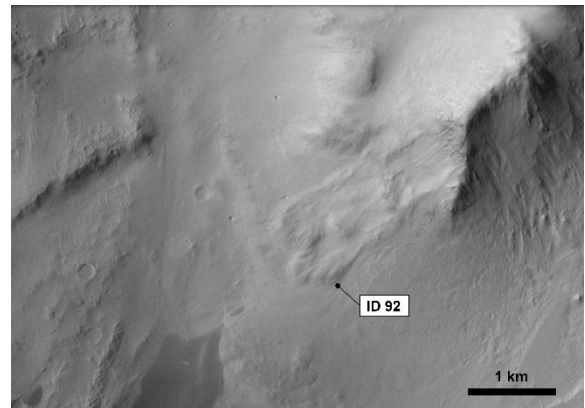
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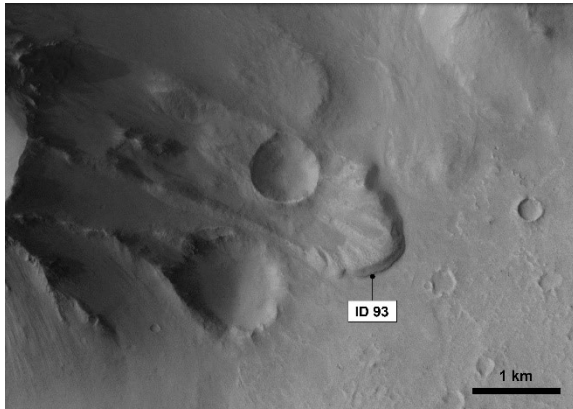
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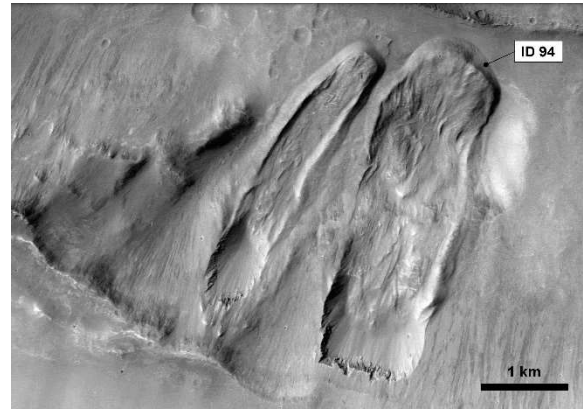
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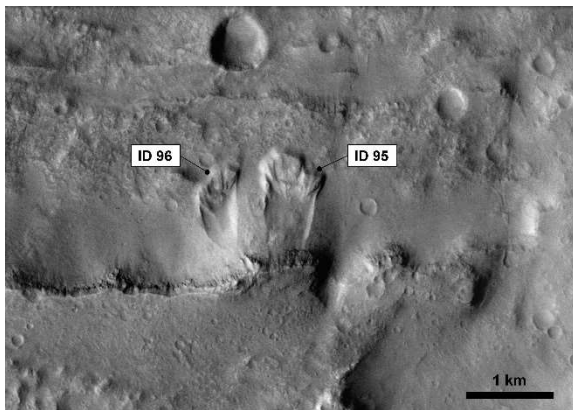
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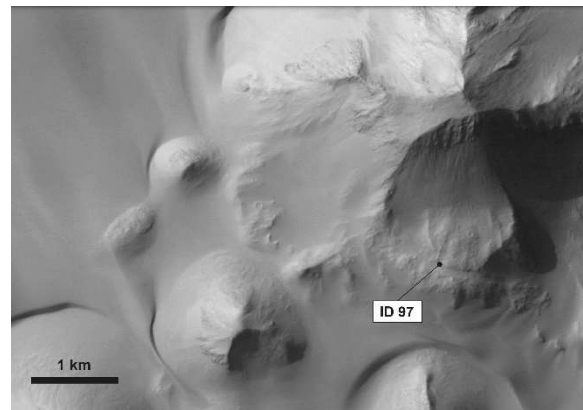
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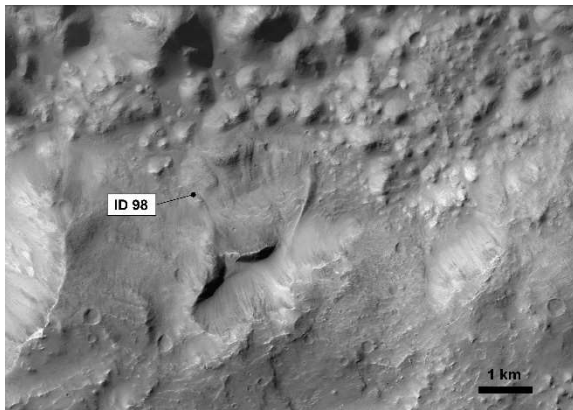
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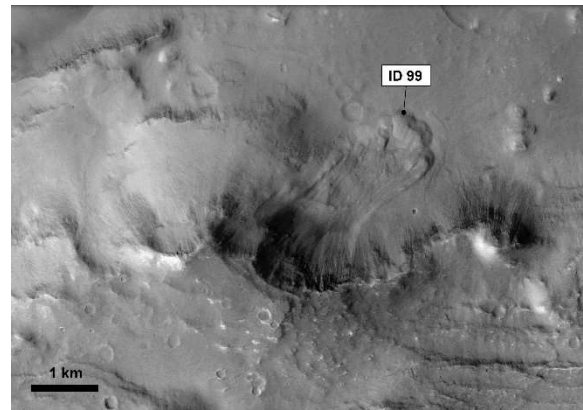
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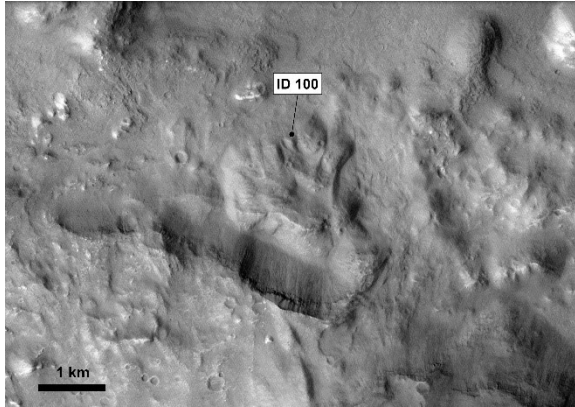
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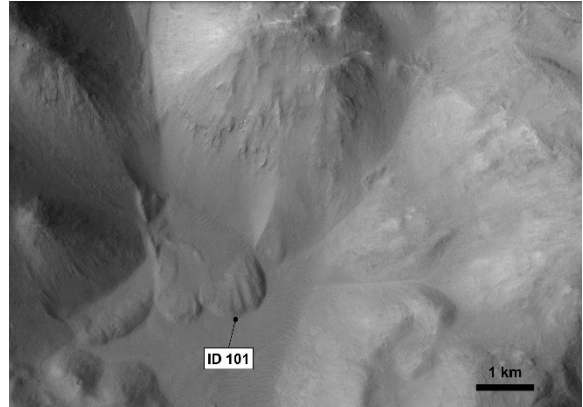
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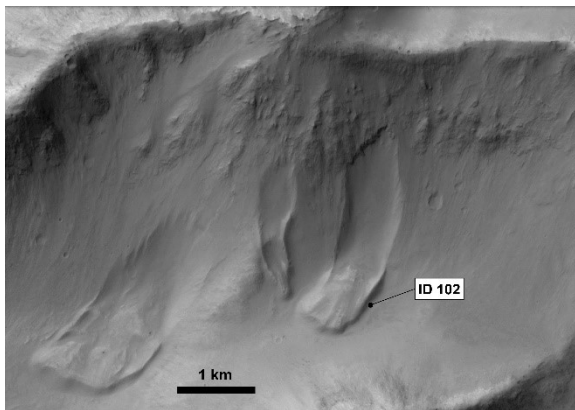
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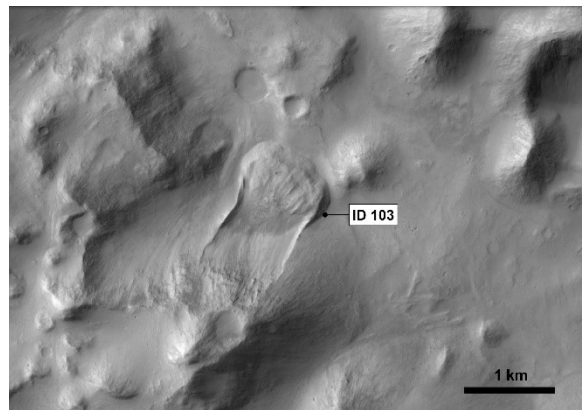
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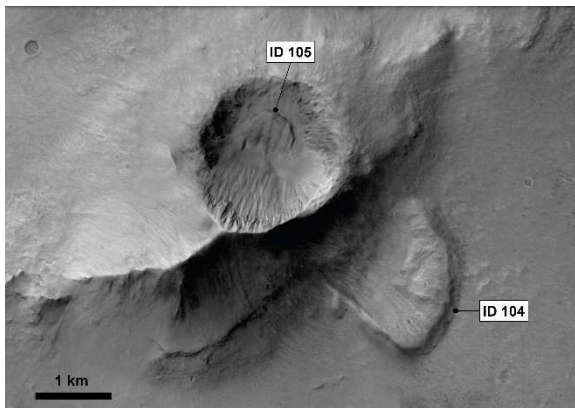
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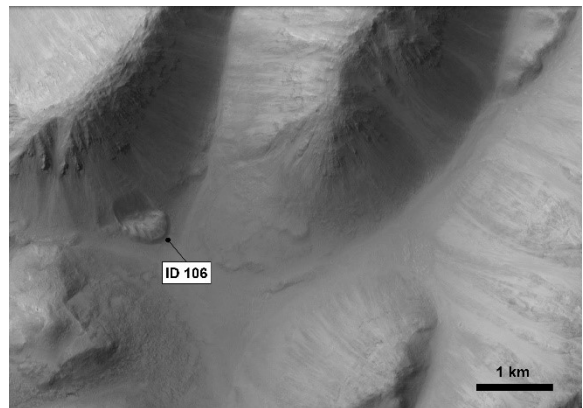
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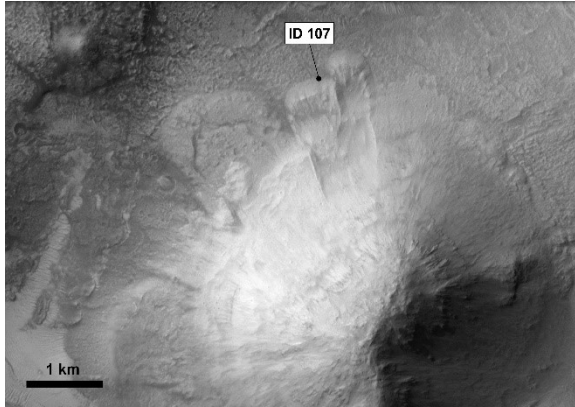
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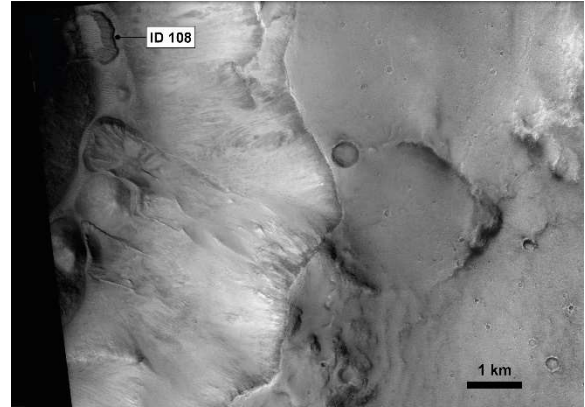
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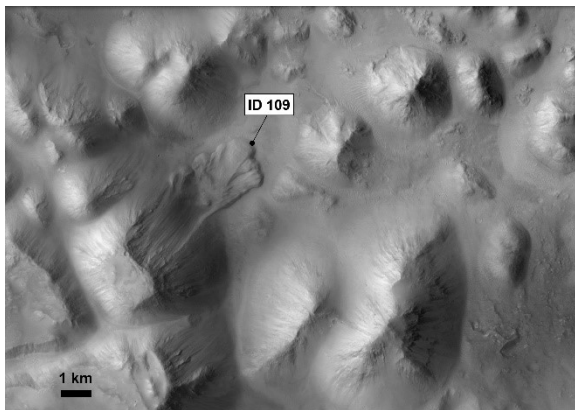
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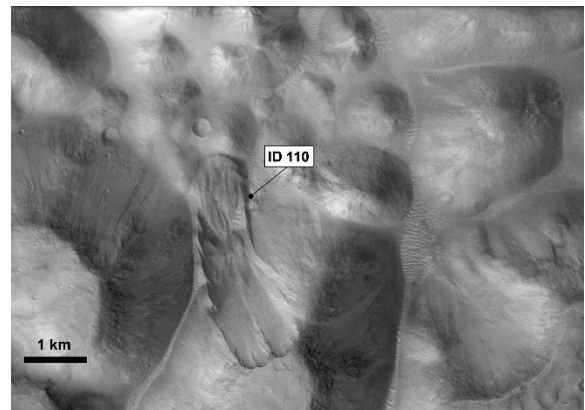
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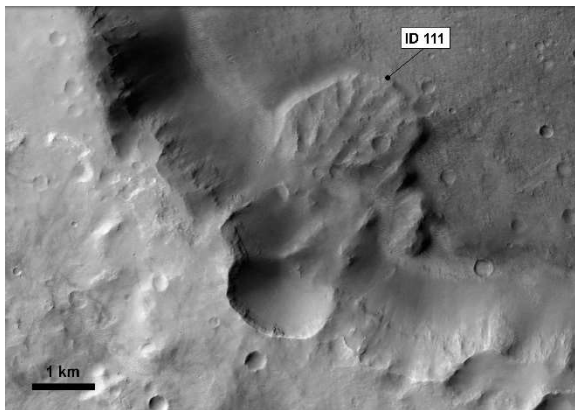
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