# A Glacial Origin of Polygonal Networks of Double-Ridged Grooves in Western Jezero Crater during the End of an Ice Age on Mars

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Abstract
HiRISE mapping reveals development of networks of polygonal grooves. In this study we show two possible formation mechanisms: deglaciation induced and periglacially induced formation mechanisms.

Introduction:
The hosting plains were interpreted as lava flow and delta. However, these models do not explain the formation of the groove networks.

Data and Methods:
We use HiRISE image ID # ESP_037330_1990_RED to conduct detailed mapping using JMARS tools.

Discussion:
The model we have is a deglaciation model; but we do not rule out periglacial mechanism for groove formation. It is also possible that the grooves formed under both settings sequentially. The larger grooves may have formed during deglaciation while the smaller ones formed during periglacial setting.
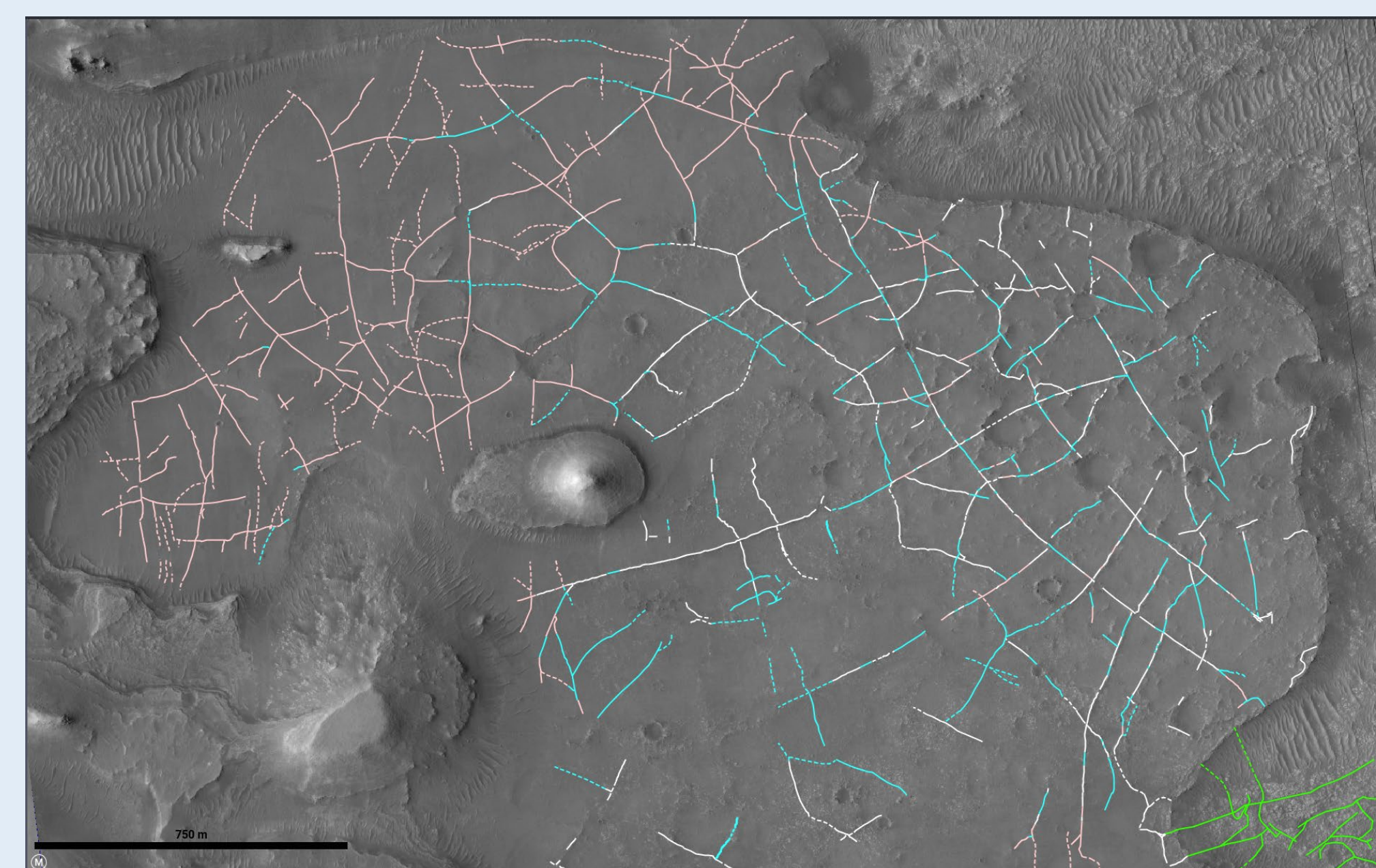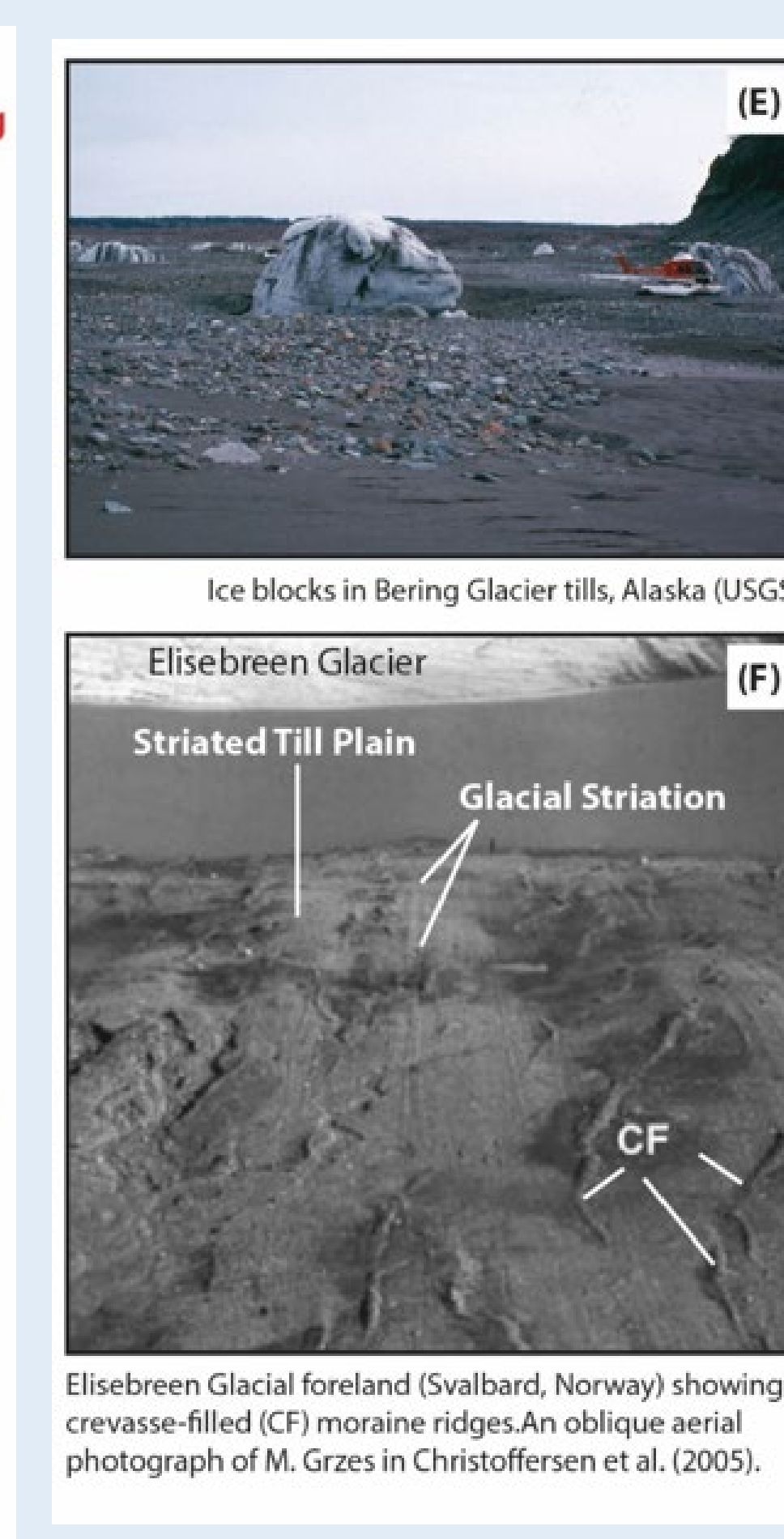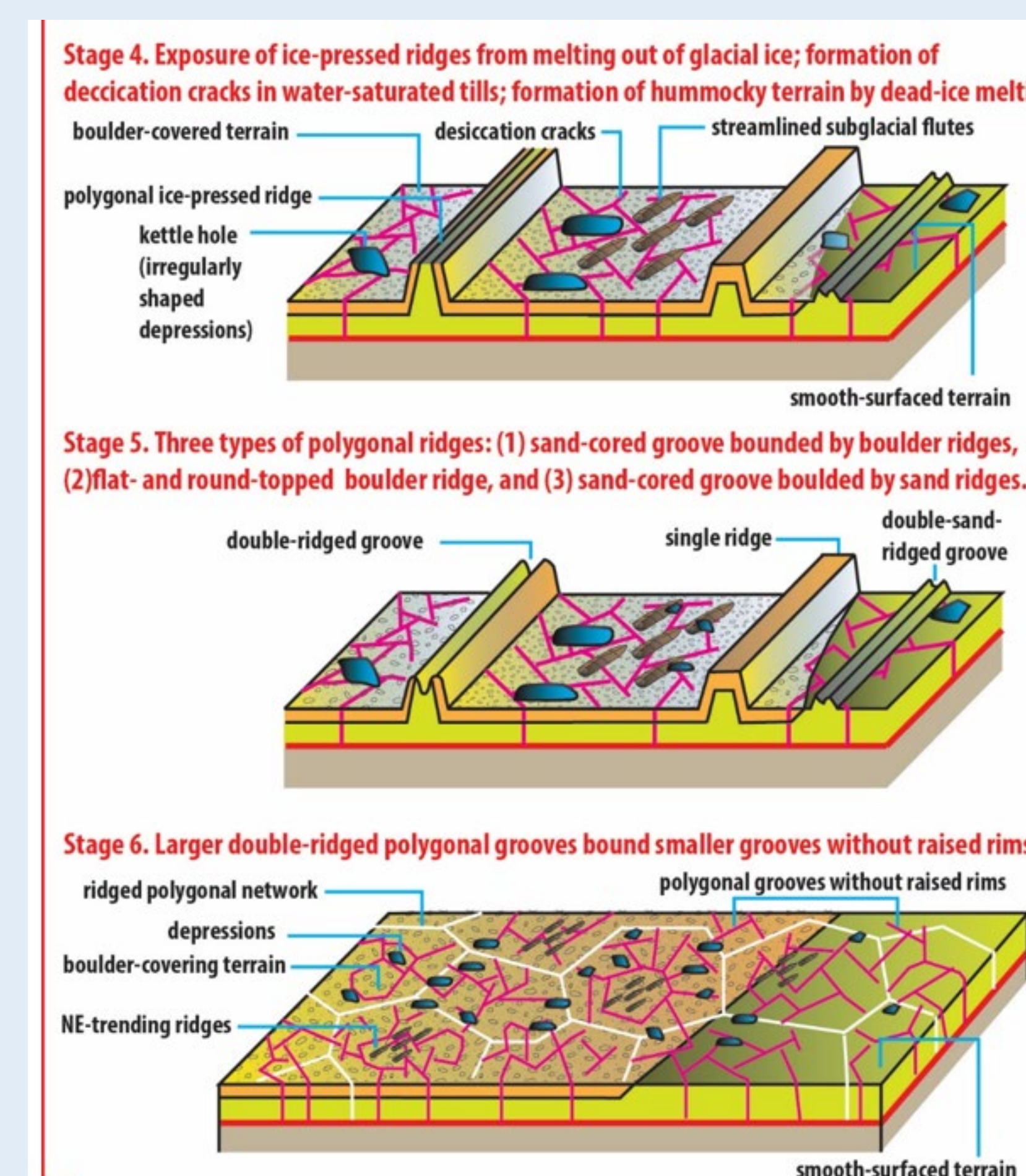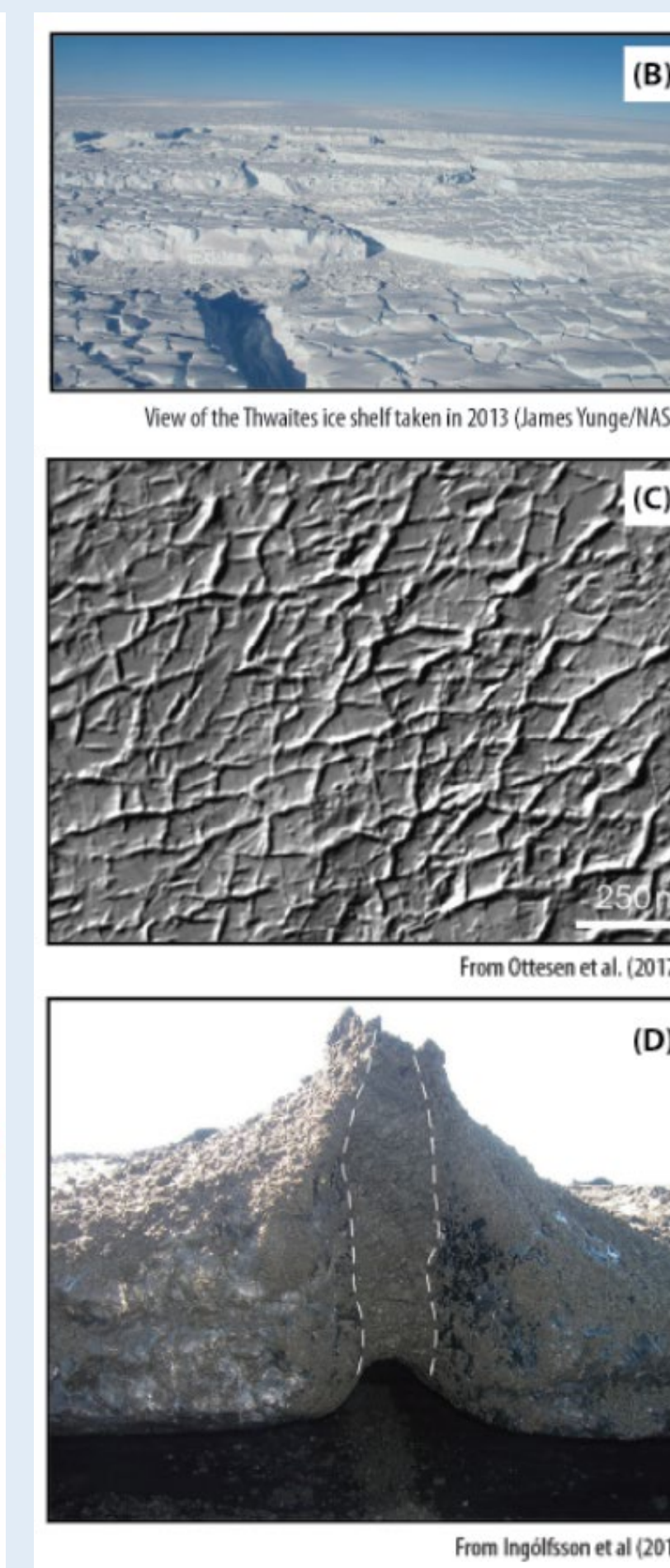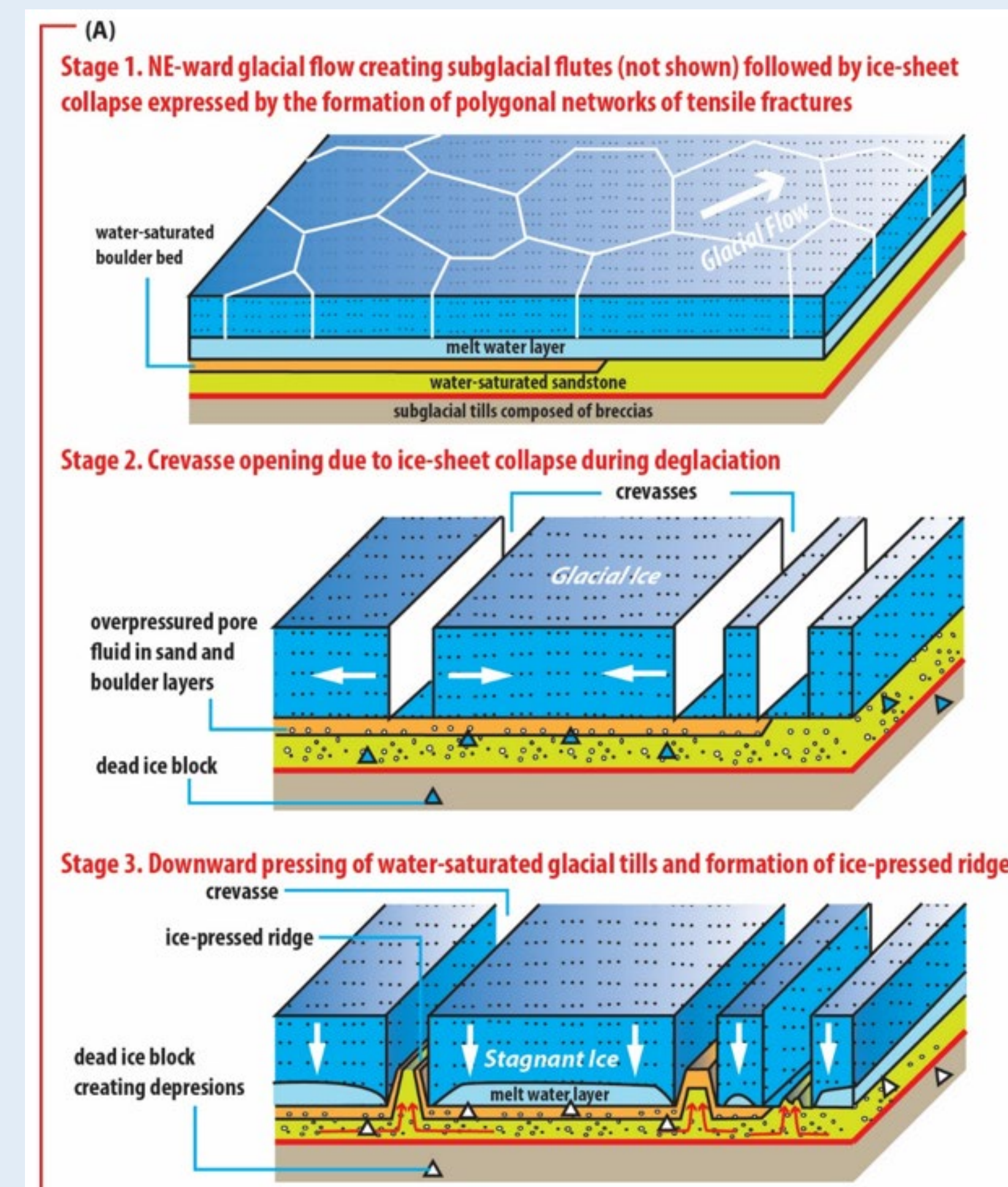
Guided by Earth analogues, we interpret:

(1) polygonal networks of double-ridged grooves as crevasse-filled ice-pressed moraine ridges and the polygonal pattern was inherited from the fractured glacier,
(2) reticulate grooves as desiccation cracks during the final drying of glacial deposits at the end of a Martian ice age,
(3) depressions including most circular pits with raised rims as kettle holes and/or thermokarsts, and
(4) the streamlined boulder ridges as subglacial flutes.

Conclusions:
The mapped features were generated by ice-present geological processes.

Ice-present either deglaciation or periglacial processes have not been documented in this equatorial regions before.



(A) Stage 1. NE-ward glacial flow creating subglacial flutes (not shown) followed by ice-sheet collapse expressed by the formation of polygonal networks of tensile fractures

Stage 2. Crevasse opening due to ice-sheet collapse during deglaciation

Stage 3. Downward pressing of water-saturated glacial tills and formation of ice-pressed ridges

(B) View of the Thwaites ice shelf taken in 2013 (James Yunge/NASA)

(C) From Ottesen et al. (2017)

(D) From Ingólfsson et al (2016)

Stage 4. Exposure of ice-pressed ridges from melting out of glacial ice; formation of deciccation cracks in water-saturated tills; formation of hummocky terrain by dead-ice melting

Stage 5. Three types of polygonal ridges: (1) sand-cored groove bounded by boulder ridges, (2) flat- and round-topped boulder ridge, and (3) sand-cored groove boulded by sand ridges.

Stage 6. Larger double-ridged polygonal grooves bound smaller grooves without raised rims

(E) Ice blocks in Bering Glacier tills, Alaska (USGS)

(F) Elisebreen Glacial foreland (Svalbard, Norway) showing crevasse-filled (CF) moraine ridges.An oblique aerial photograph of M. Grzes in Christoffersen et al. (2005).



Polygonal networks of double-ridged grooves

GRV$_{1R}$ — Double-ridge groove 1 - Rough surface: Most prominent grooves. Well defined and containing boulder on both sides.

GRV$_{2R}$ — Double-ridge groove 2 - Rough surface: Grooves that are defined. The doubled-ridge only contains a few boulders.

GRV$_S$ — Double-ridge groove - Smooth undifferentiated: Grooves with very smooth ridges. No boulders are visible.

• Earth analog: crevasse-filled ice-pressed moraine ridges from fractured glacier

Reticulate networks of grooves

GRV$_{TB}$ — Channel-like grooves - Trench and breccia: Grooves in the boundary of the mapped area located down the trench and into the sand dune and breccia terrain.

• Earth analog: desiccation cracks
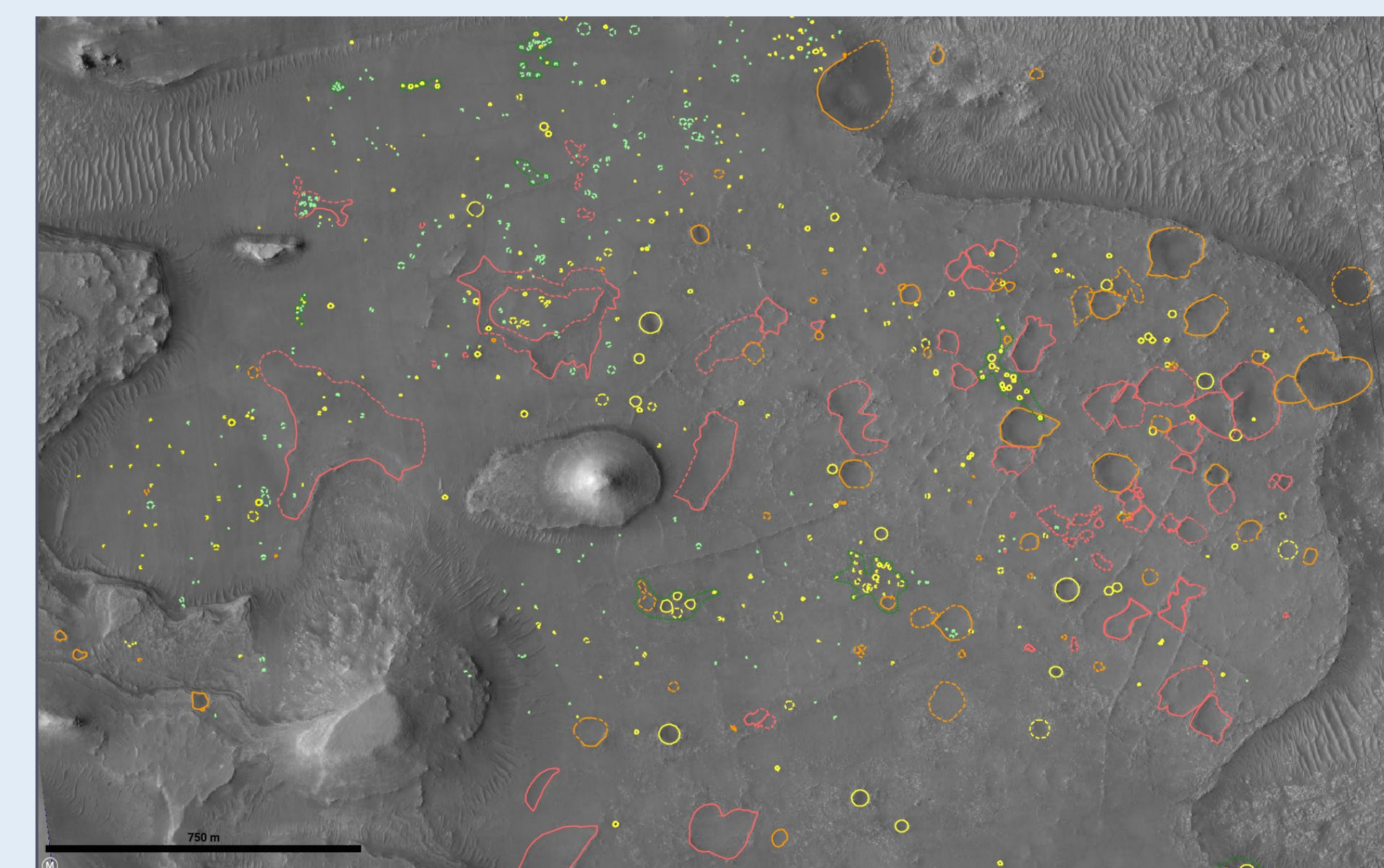


Undulating surfaces hosting variously shaped depressions

CDp$_{RR}$ — Circular and oval crater-like depressions with raised rim

CDp$_{SR}$ — Circular and oval crater-like depressions with smooth rim

PDp — Polygonal-shaped depressions

IDp — Irregular-shaped depressions

PF — Pit field. A collection of depression in a small area

• Earth analog: kettle holes and/or thermokarsts



NE-trending boulder-bearing ridges

SR$_{SdB}$ — Single ridge on the sand dune/breccia terrain

SR$_P$ — Single ridge on the plateau

SR$_G$ — Single ridge as a continuation of a doubled-ridge groove

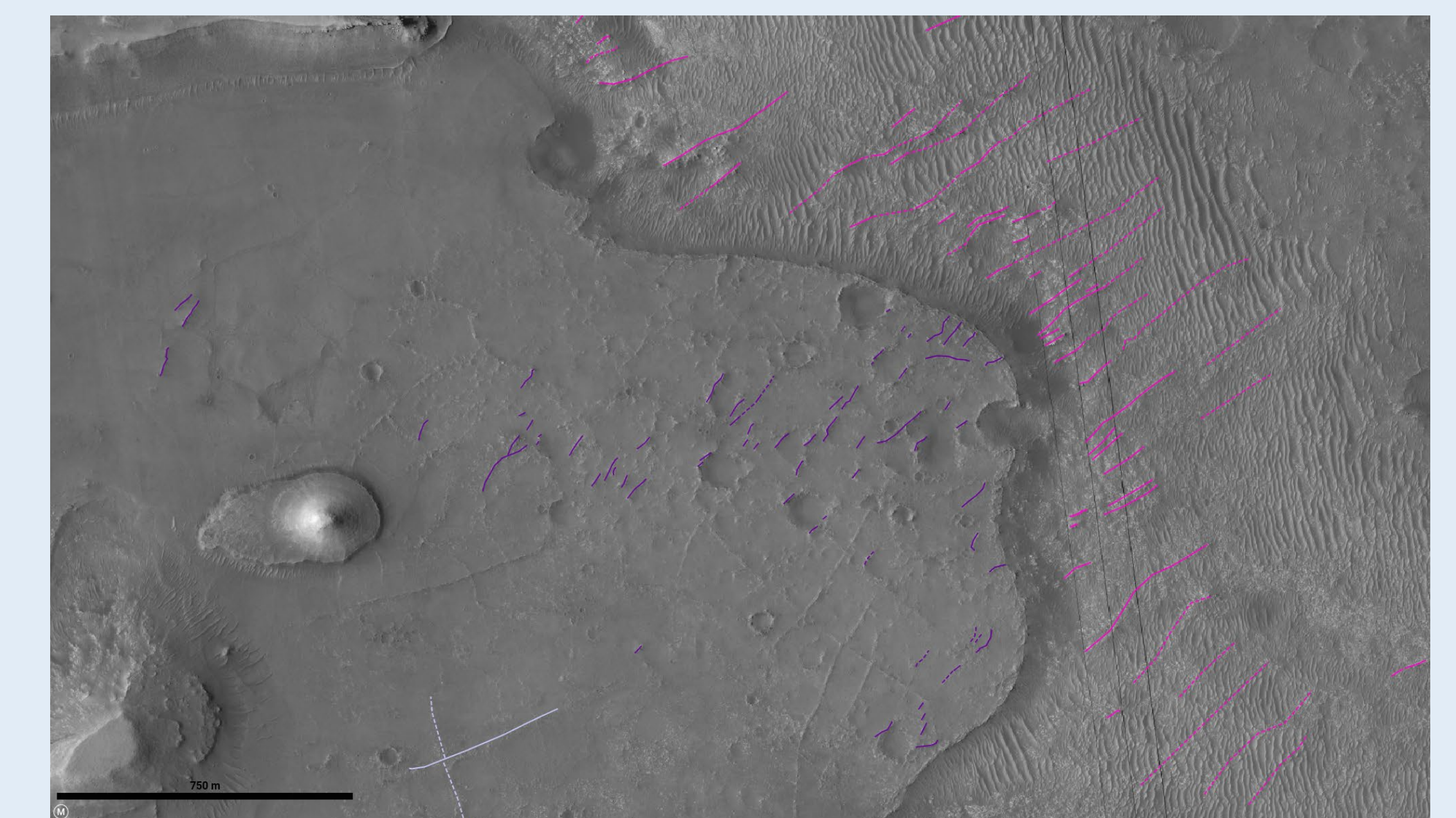• Earth analog: subglacial flutes

References and acknowledgements:
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