Cosmogenic Modeling ^{10}Be with UAV terrain analysis to determine Little Ice Age subglacial abrasion:quarrying ratio at Jakobshavn fore-field

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John T. and Carol G. McGill Research Award

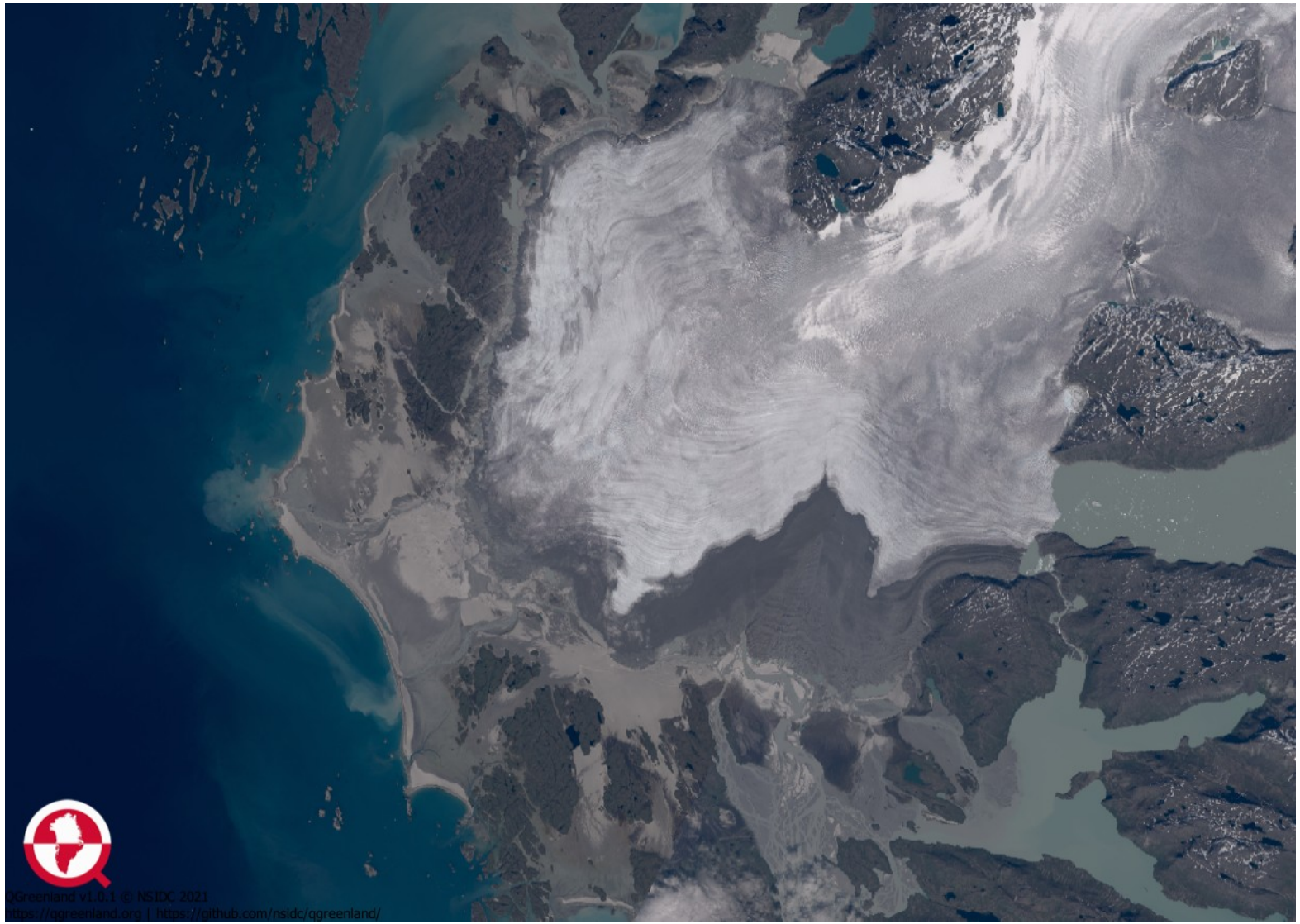
What we're doing

- Quantifying sub **glacial erosion rate**
- How much **erosion** occurs from **abrading** vs **quarrying**
- Taking **cosmogenic nuclide exposure** to the next level

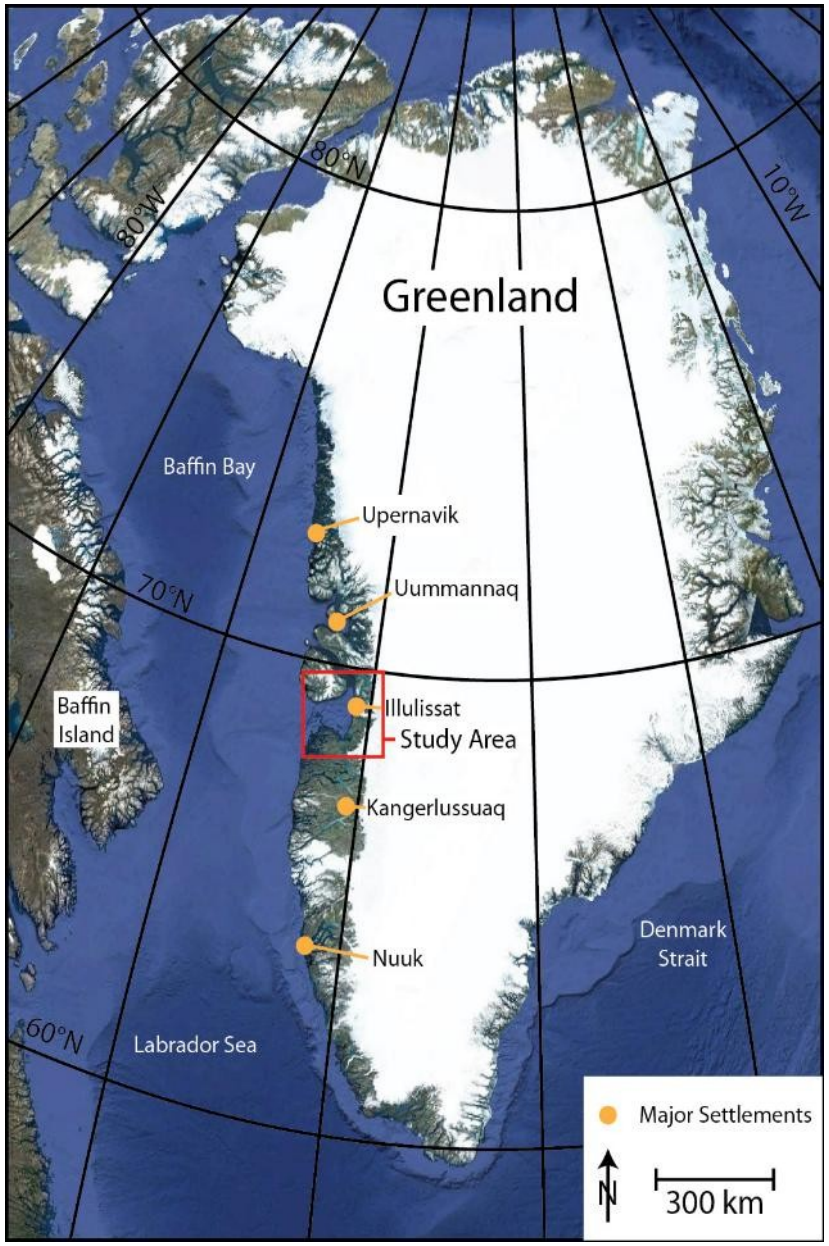
Why we're doing it

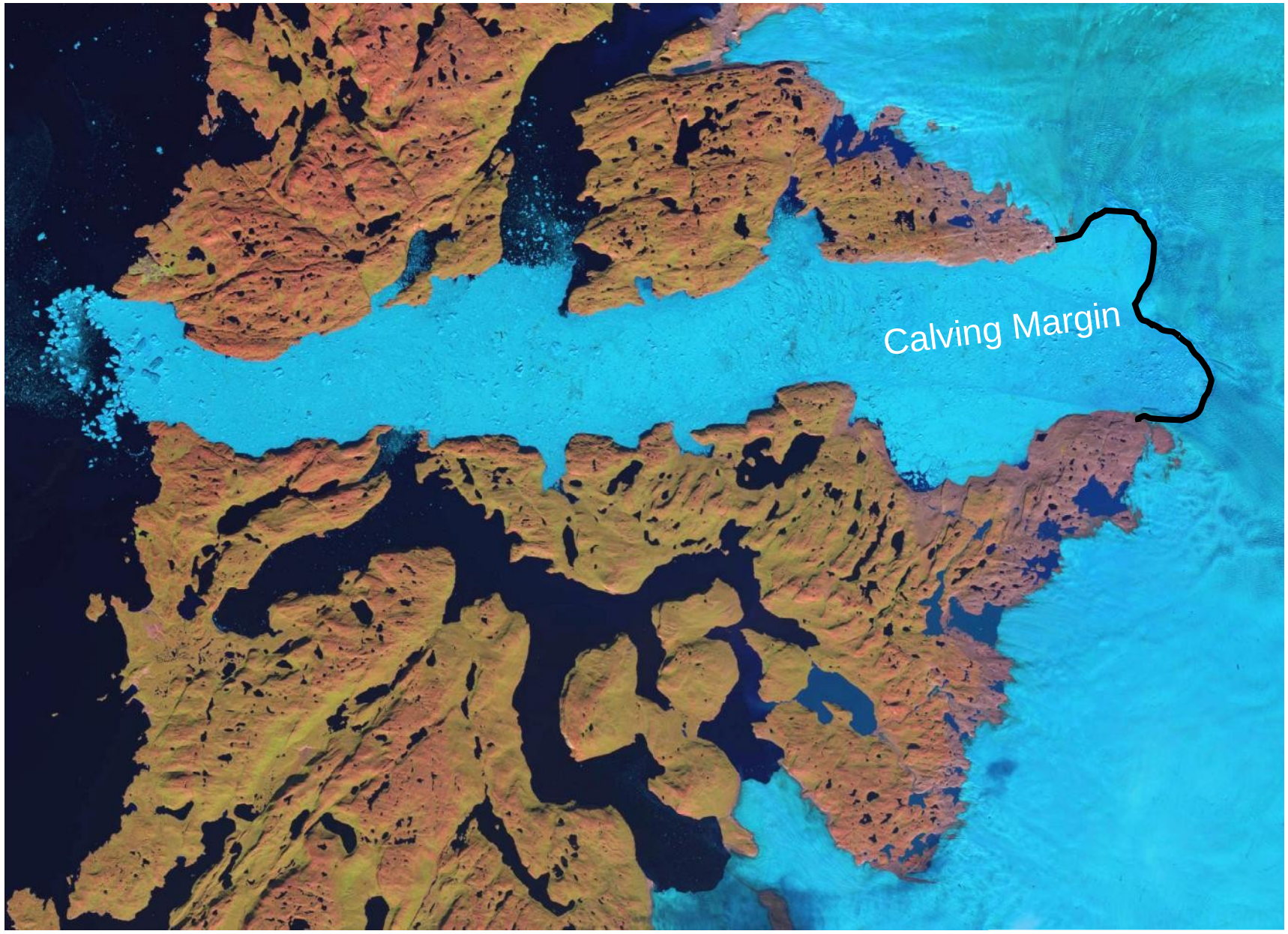
- Economic use of aggregates
- Bio-available fertilizer
- Improve constraints for process models
- Push the utility of Cosmogenic exposure methods

- The Greenland Ice Sheet exports a significant volume of sediment
- The rate of erosion is poorly constrained worldwide, but constantly being improved.
- Models based on experimental constraints.
- Abrasion vs Quarrying?



Jakobshavn Isbræ

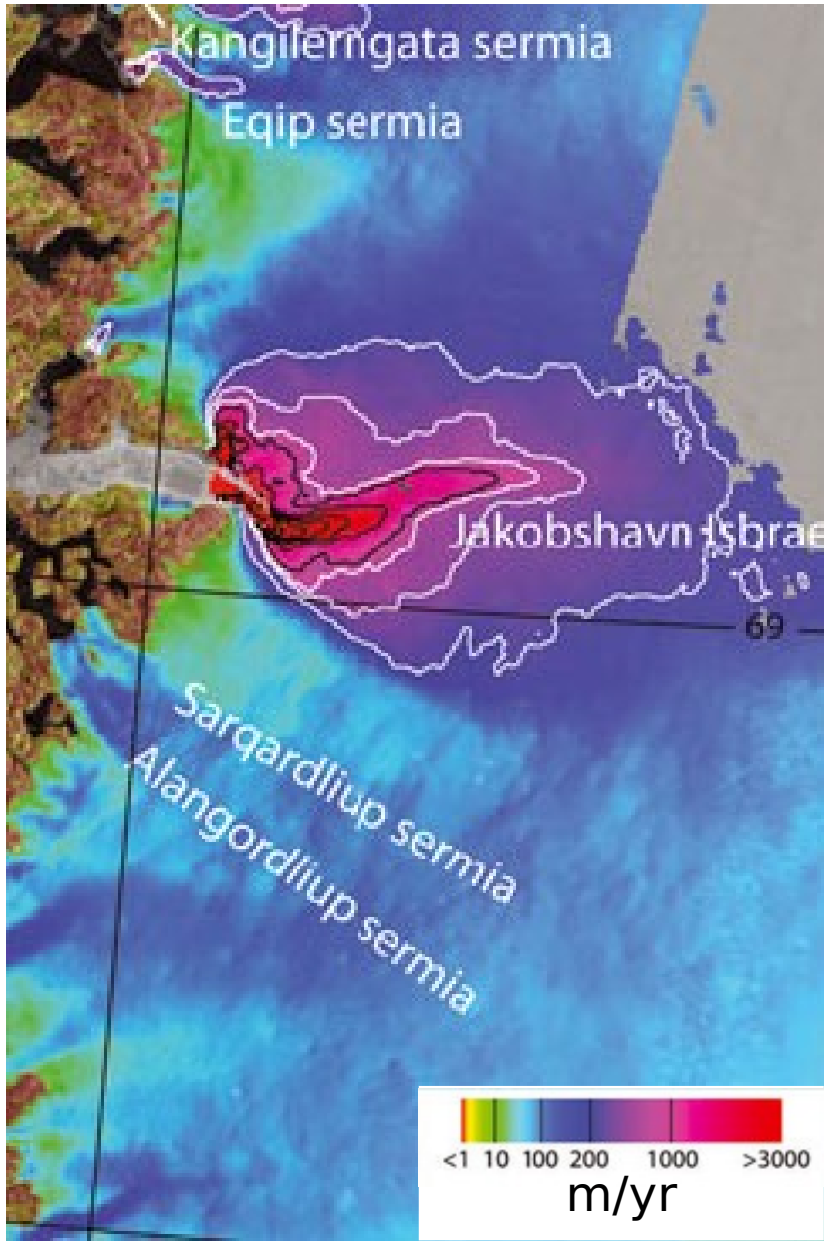


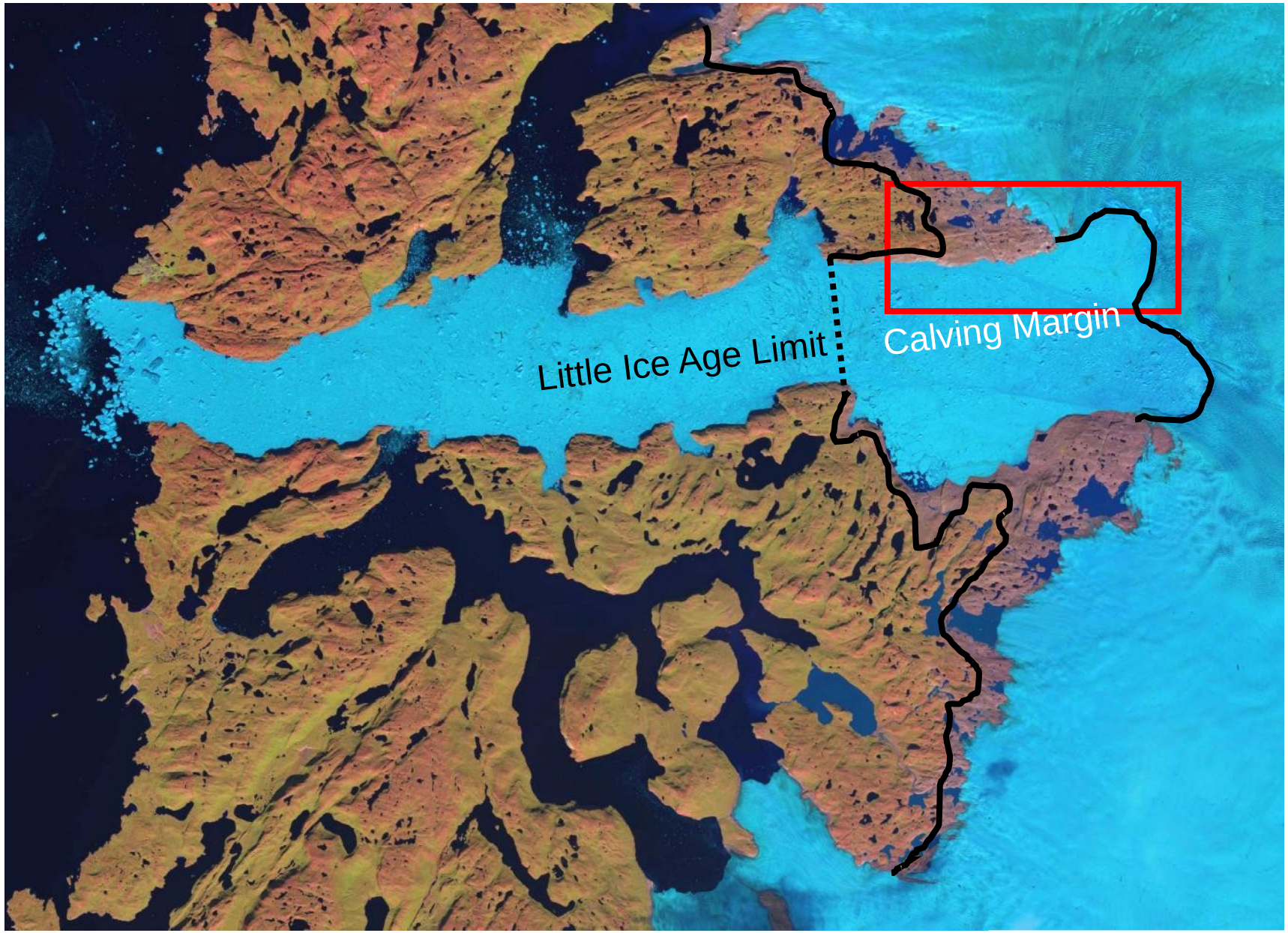


Google Earth: IBCAO, SIO, NOAA, USN, NGA, GEBCO, USGS

USGS Landsat 8 08/22/2018

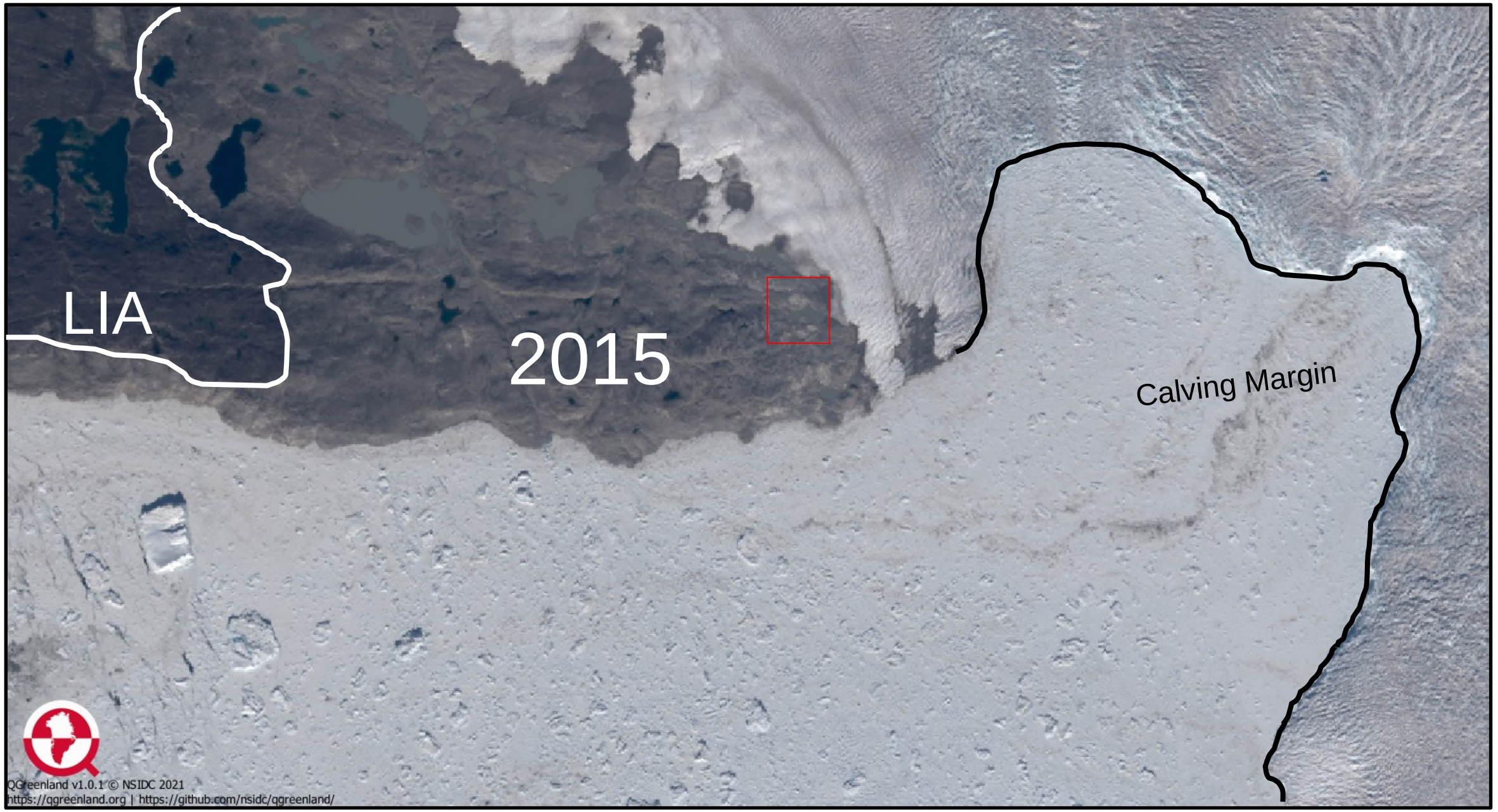
Jakobshavn Isbræ

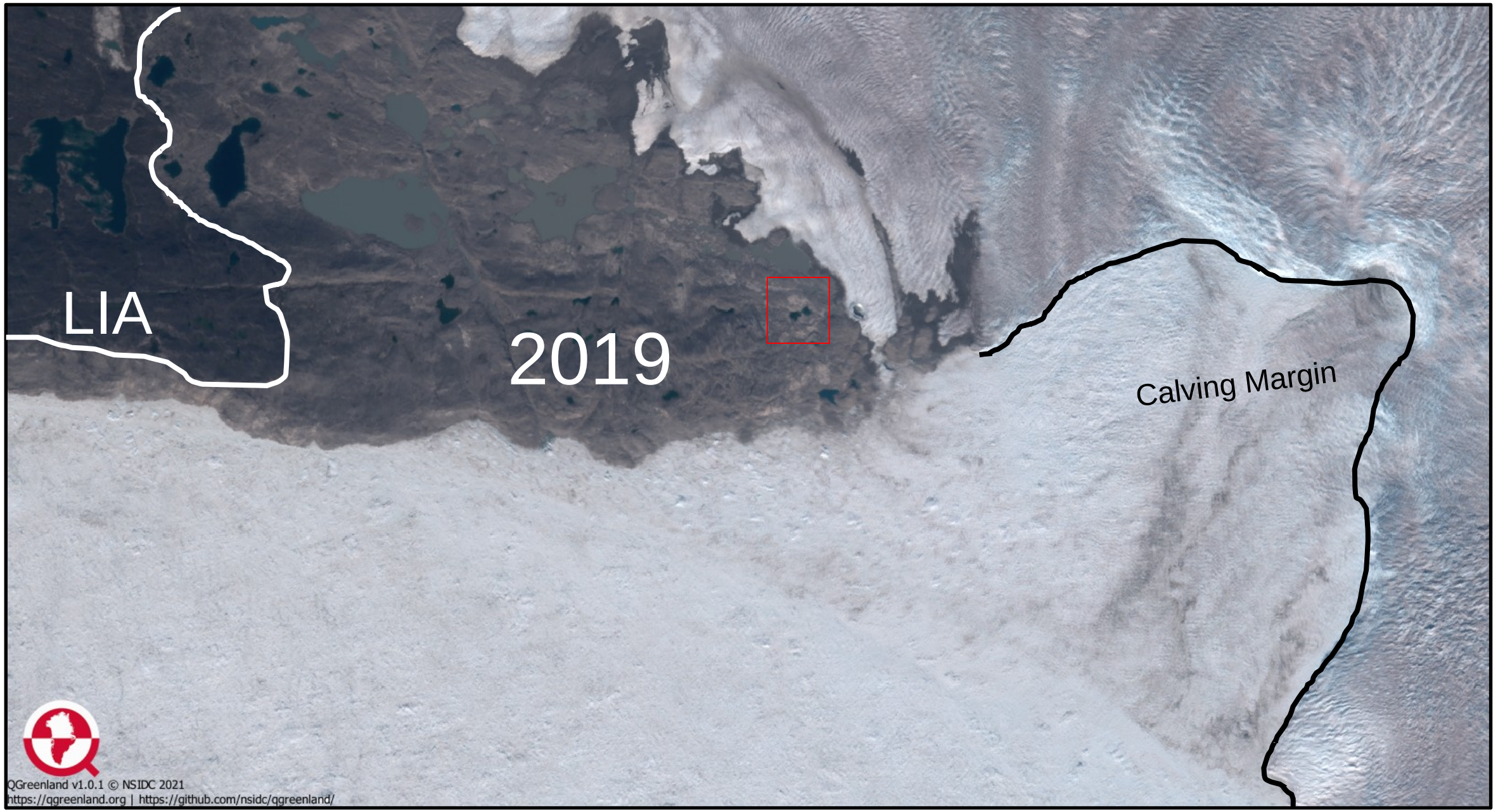




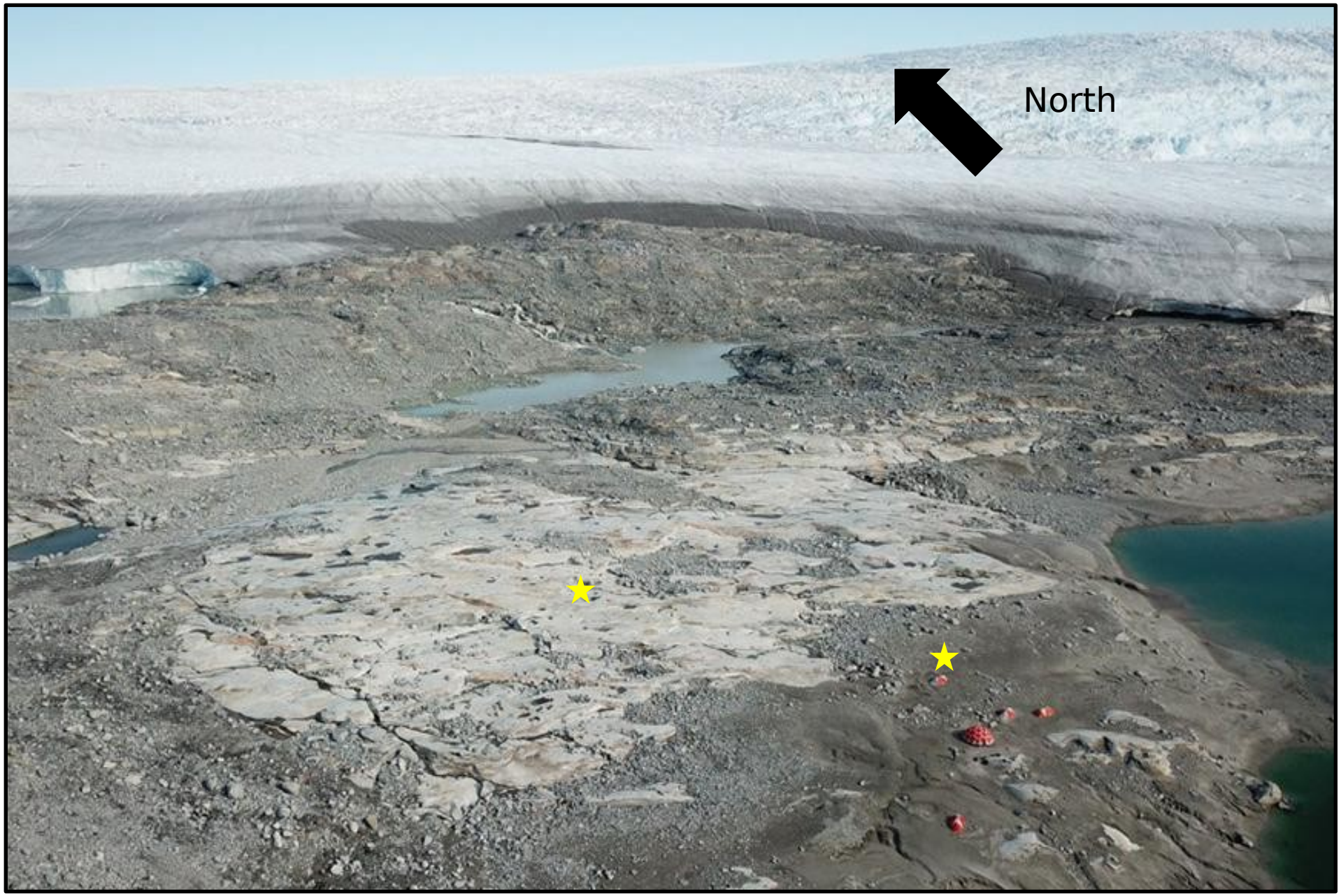
Joughin et al. (2010)

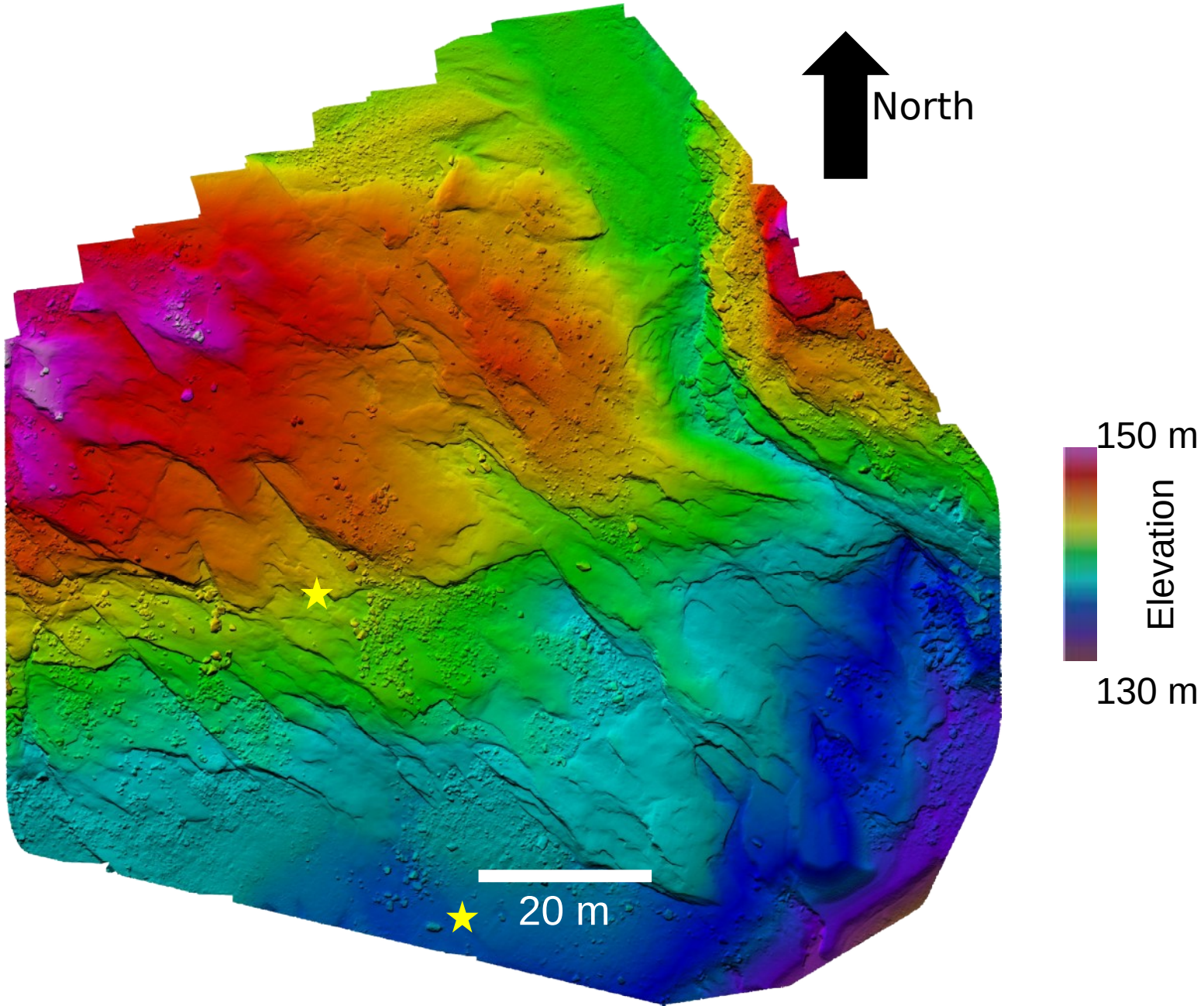
USGS Landsat 8 08/22/2018


LIA
2015
Calving Margin
QGreenland v1.0.1 © NSIDC 2021
https://qgreenland.org | https://github.com/nsidc/qgreenland/

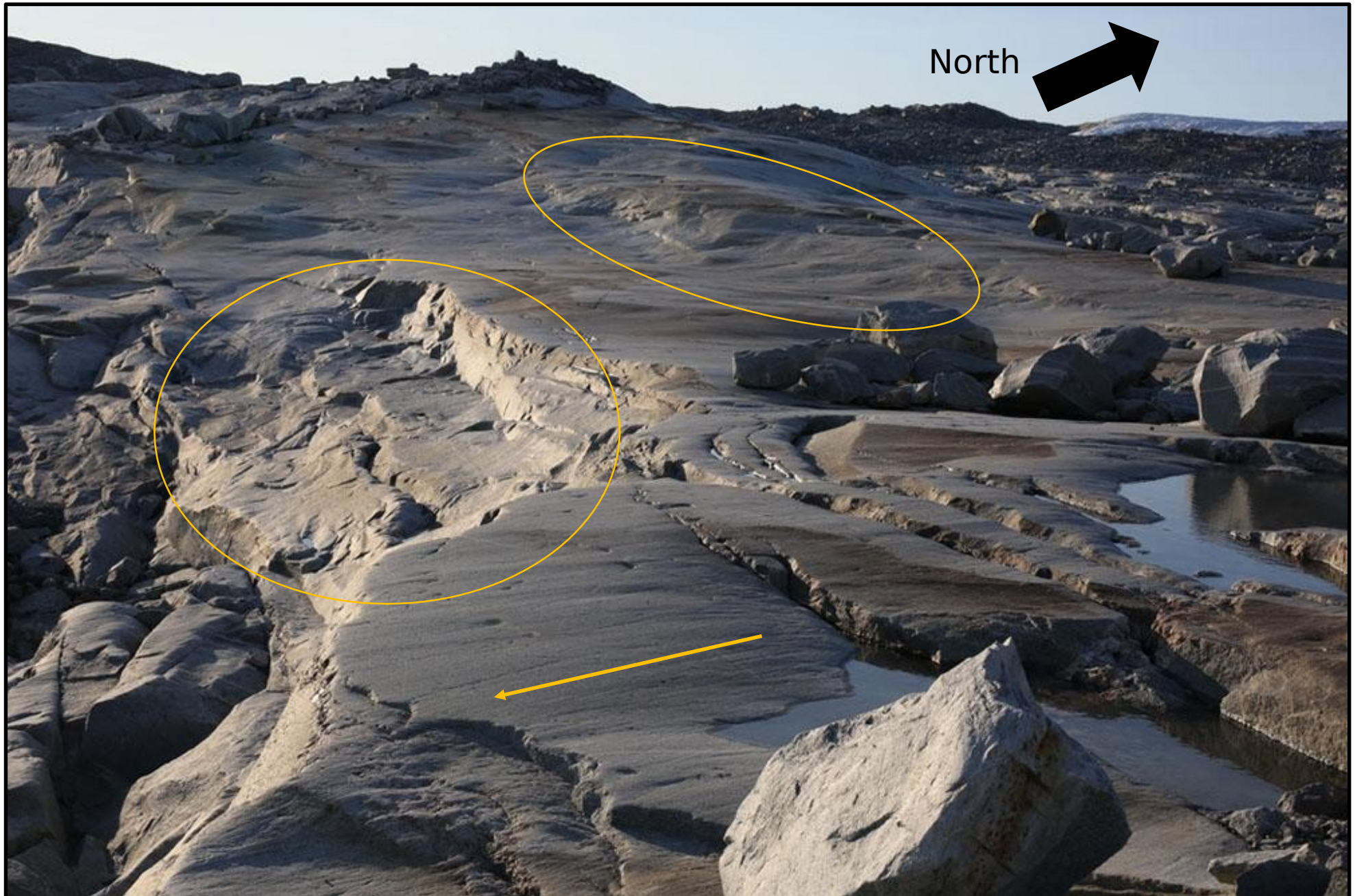

LIA
2019
Calving Margin
QGreenland v1.0.1 © NSIDC 2021
https://qgreenland.org | https://github.com/nsidc/qgreenland/

UAV – Field site imagery




North
150 m
Elevation
130 m
20 m

The Field Site – Erosional Features



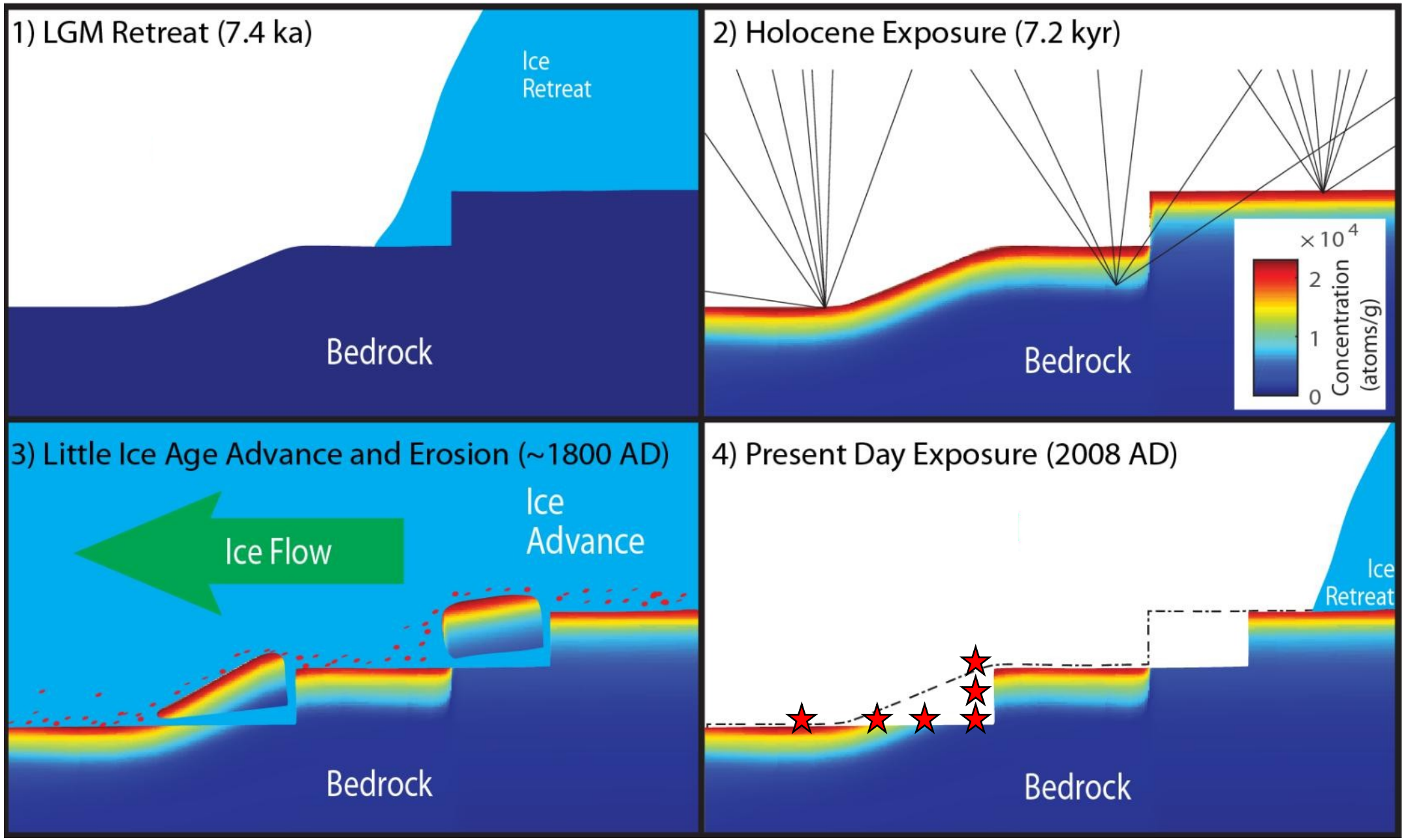
Goals of this study

- How much **abrasion** and **quarrying** occurred during the Little Ice Age?
- Need a way to quantify these parameters?!
- Cosmogenic Nuclide Exposure
  - Used to quantify abrasion depth
  - Can we leverage it to reconstruct a missing block though?

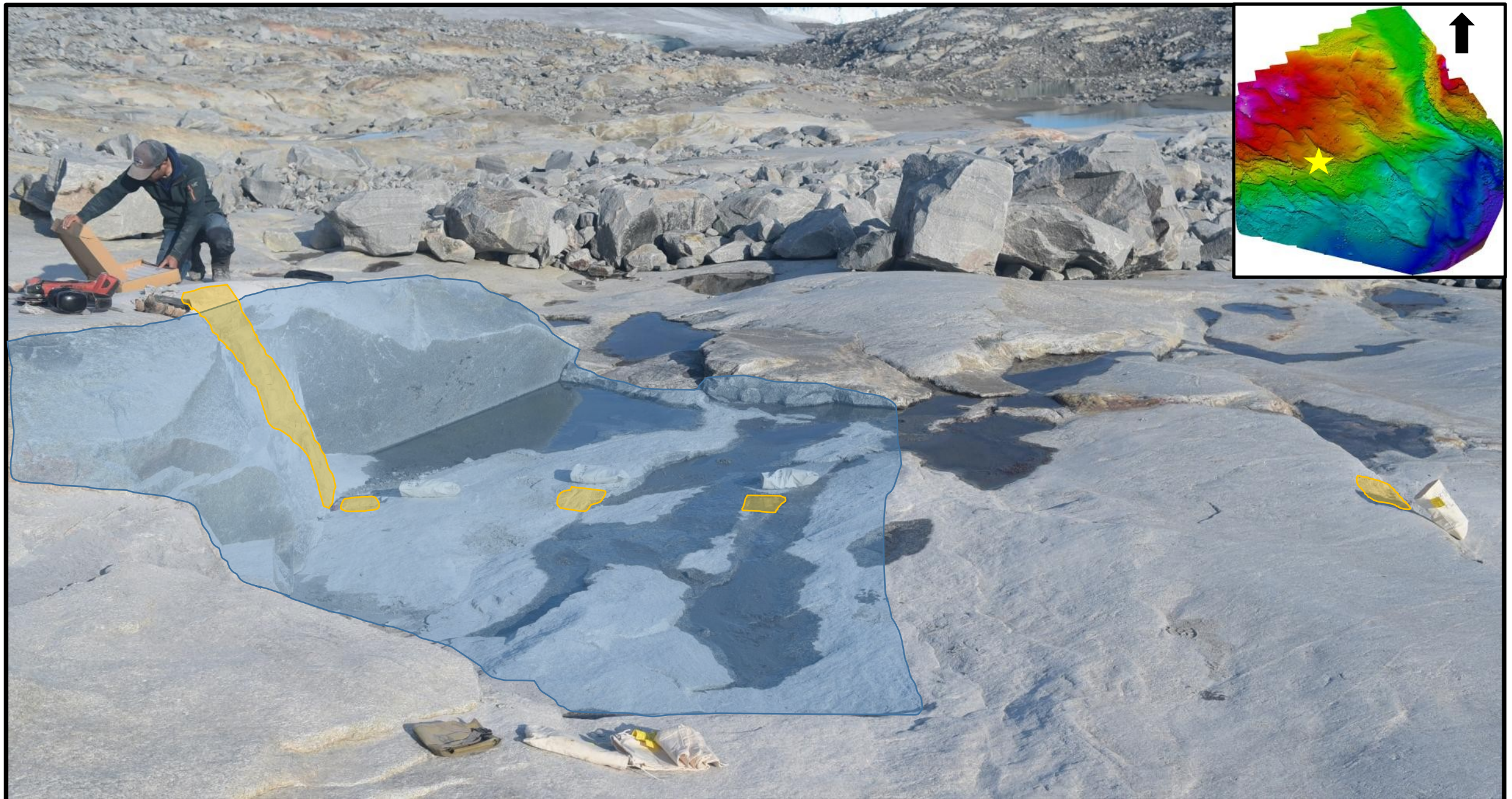
Cosmogenic ^{10}Be

- ^{10}Be - nuclear reaction from high energy neutrons hitting O and Si in quartz
- Does not occur from any other way
- Built up through time due to exposure of cosmic radiation

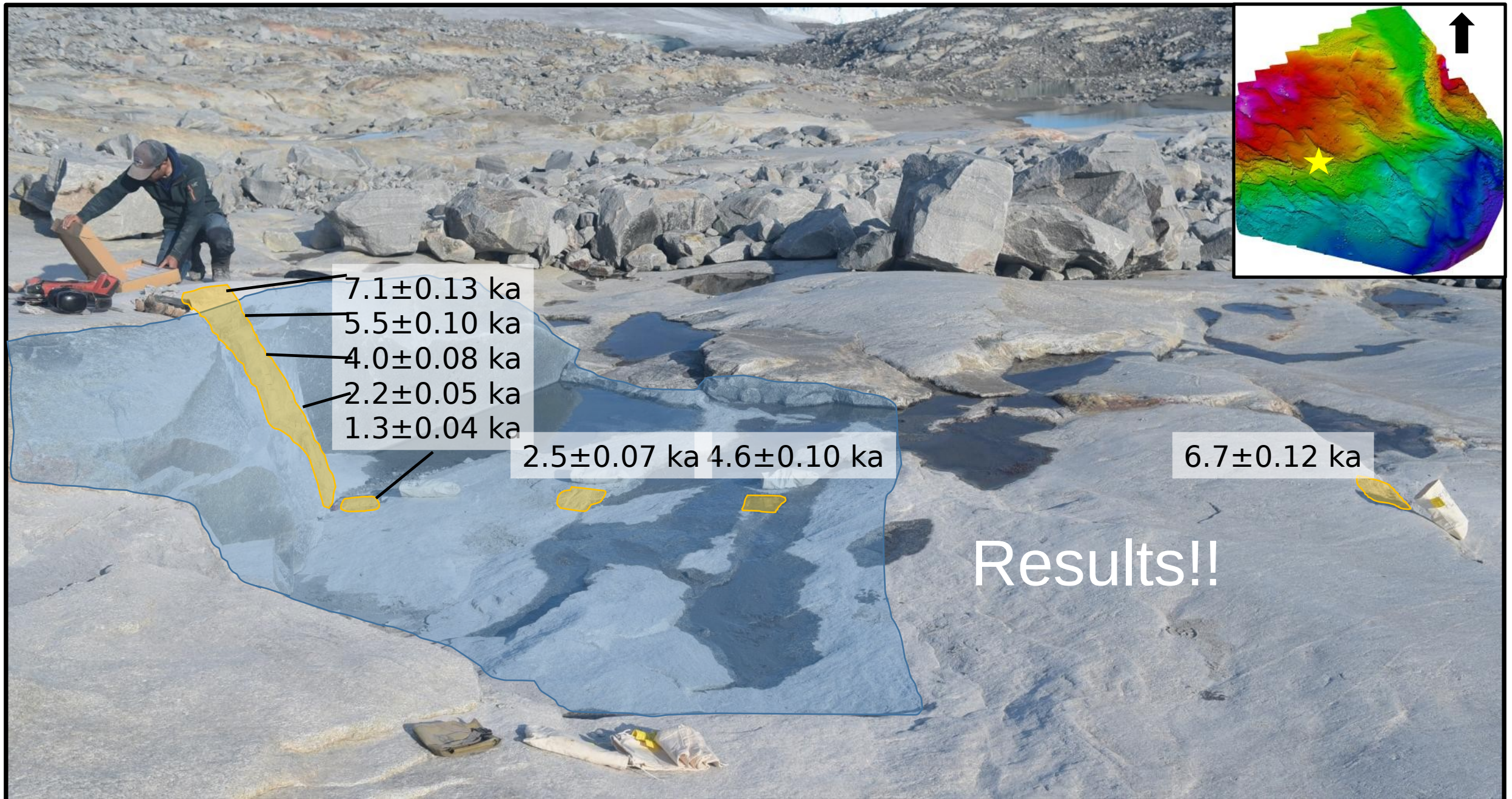
Concept Model



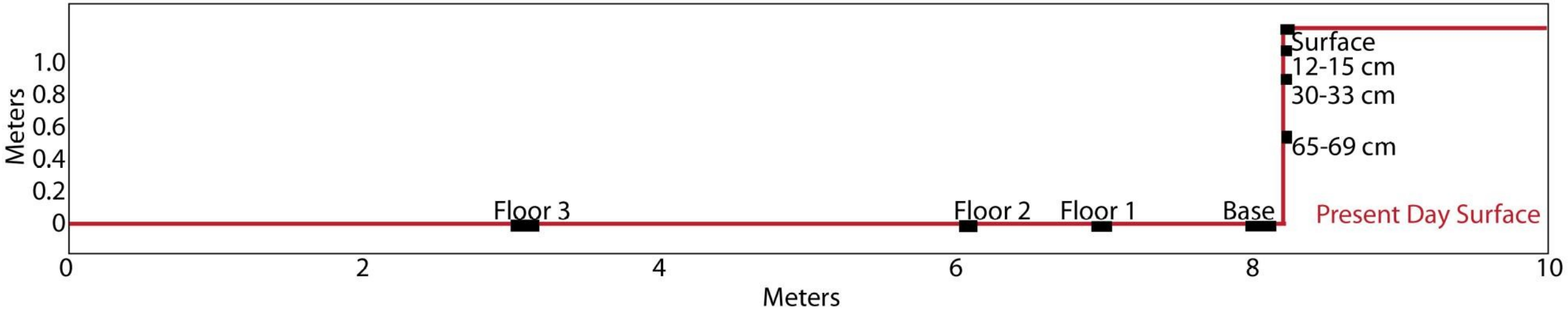
Sampling location

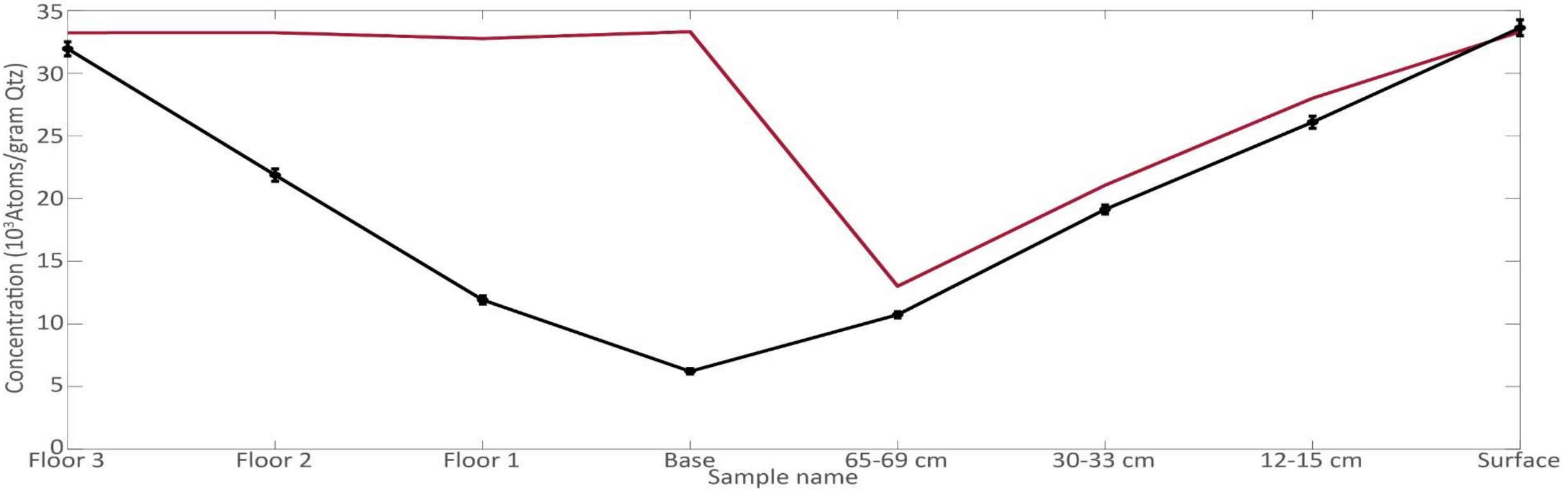


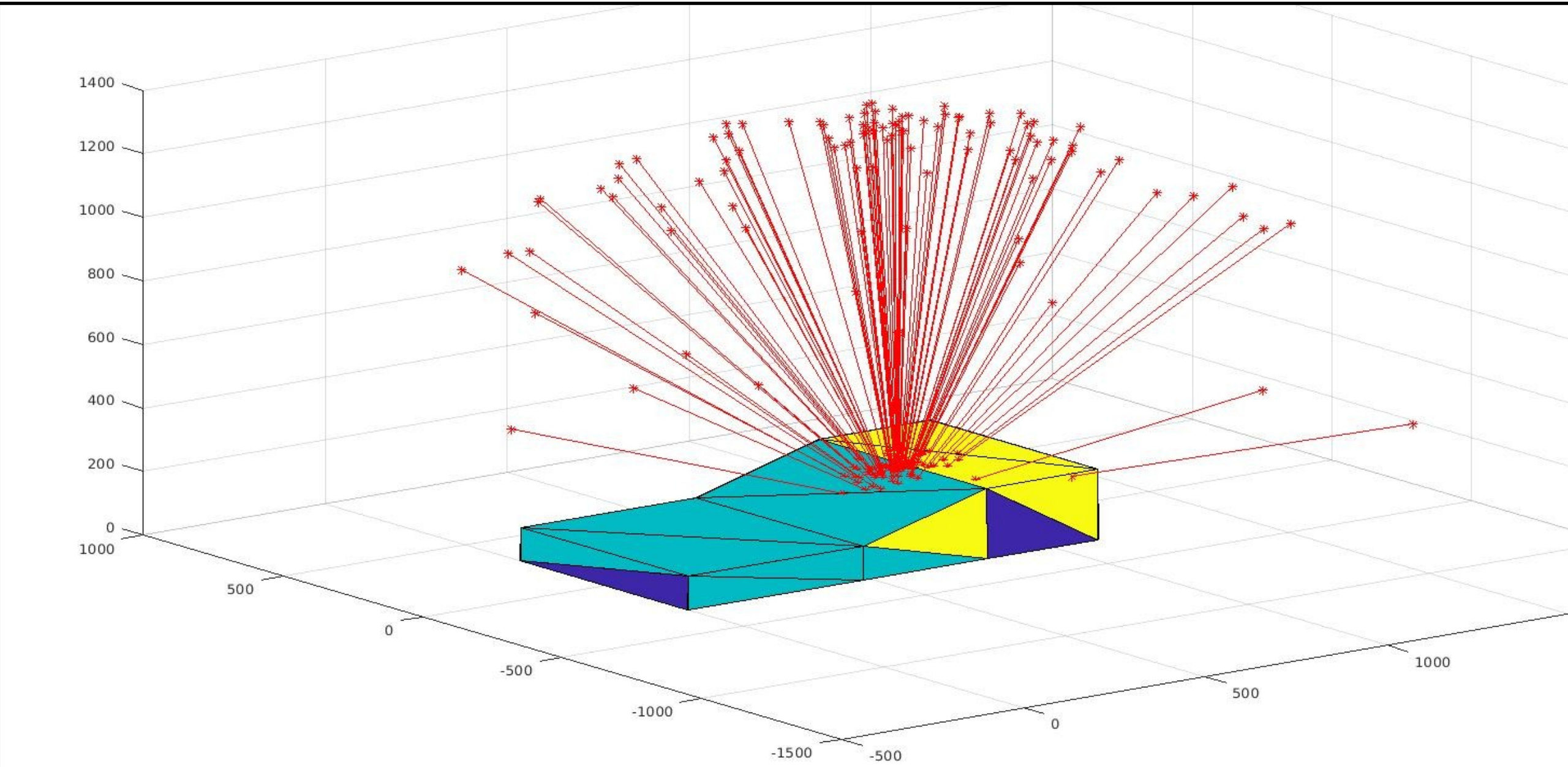
Sampling Location


7.1±0.13 ka
5.5±0.10 ka
4.0±0.08 ka
2.2±0.05 ka
1.3±0.04 ka
2.5±0.07 ka
4.6±0.10 ka
6.7±0.12 ka
Results!!

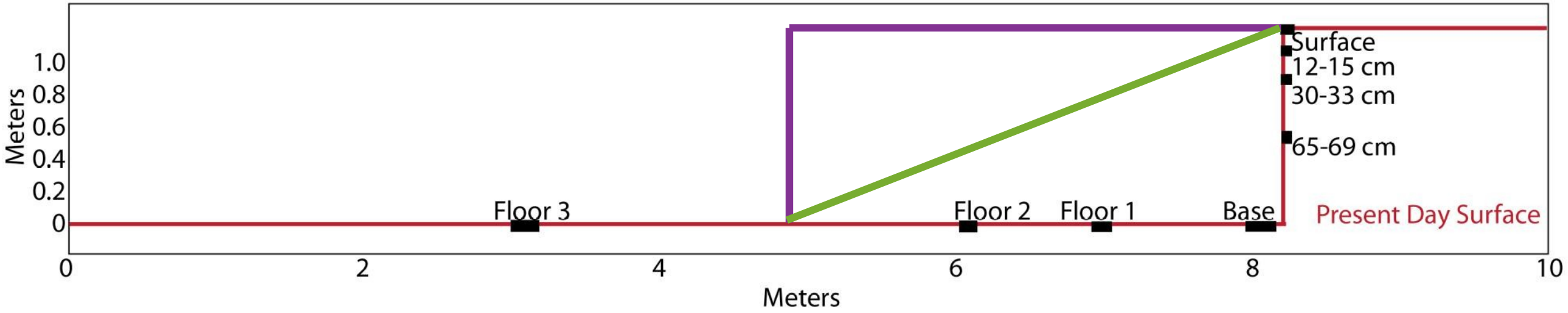
Cosmogenic Nuclide Modeling - Results

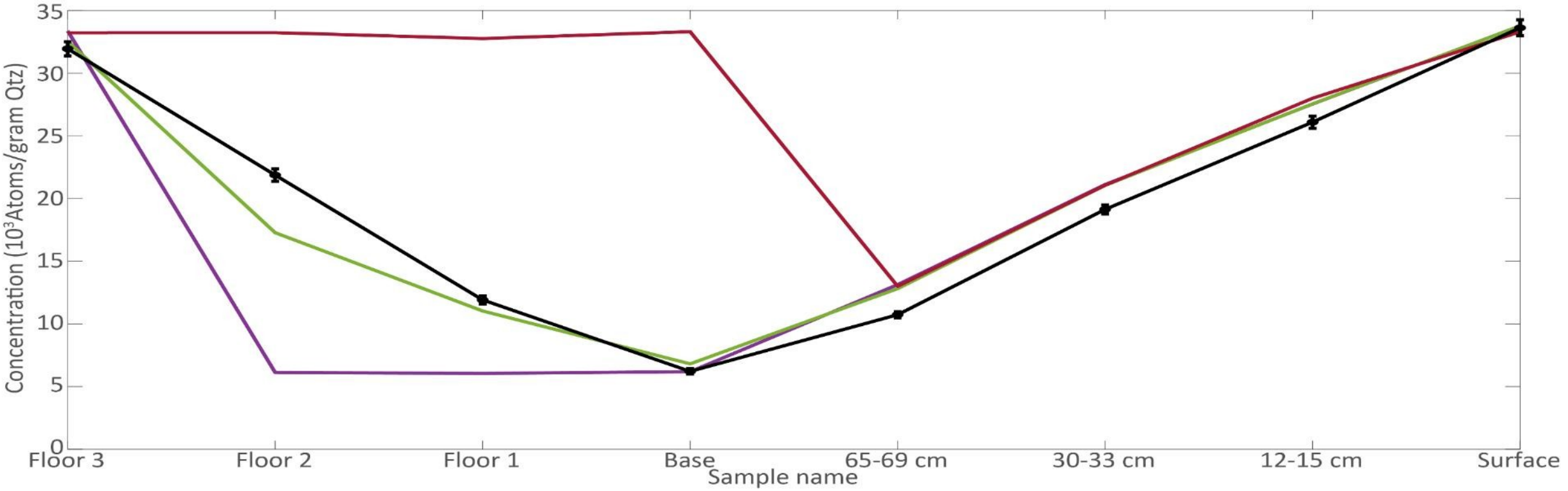




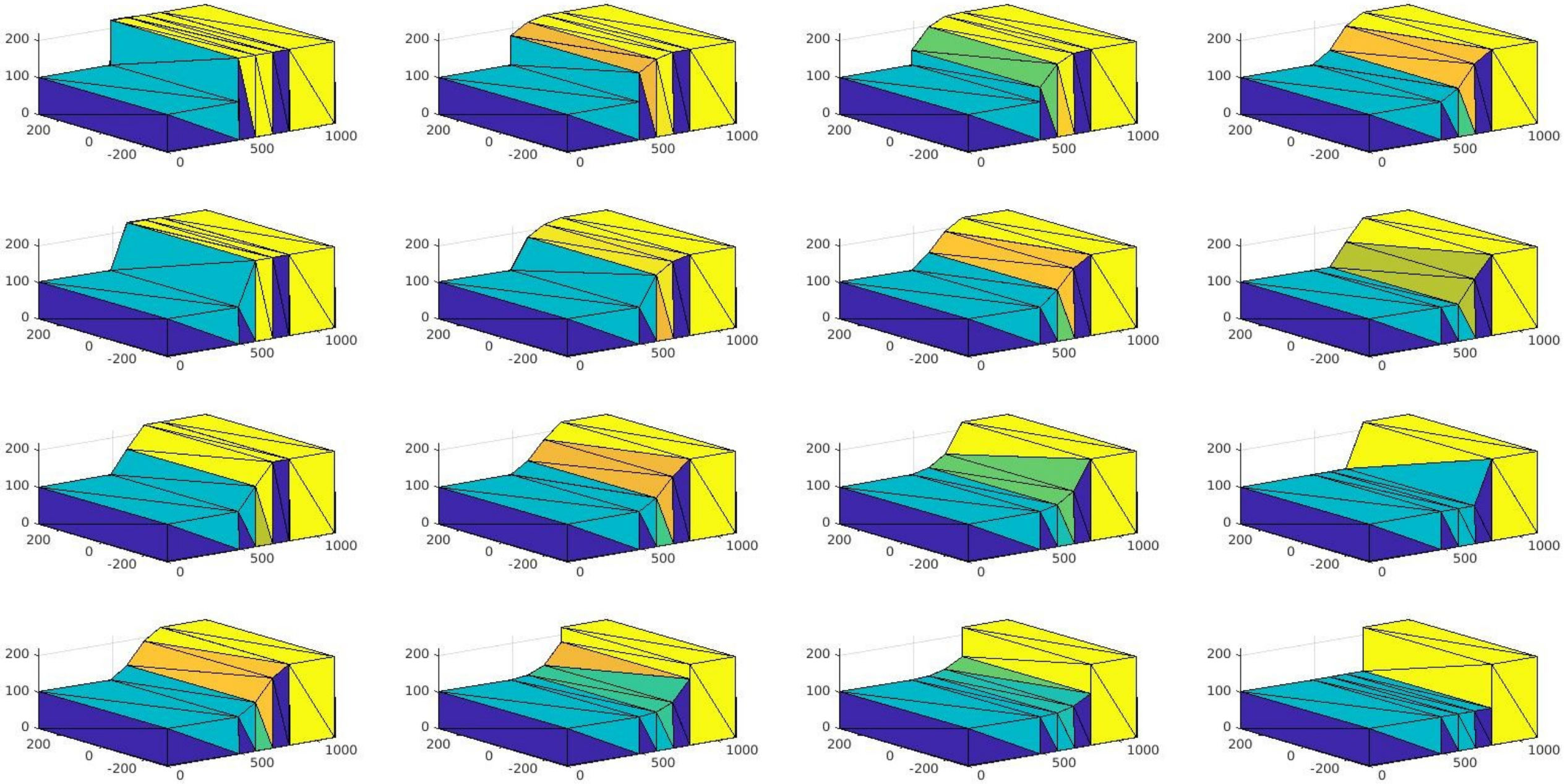

1400
1200
1000
800
600
400
200
0
1000
500
0
-500
-1000
-1500
-500
0
500
1000

Cosmogenic Nuclide Modeling - Results

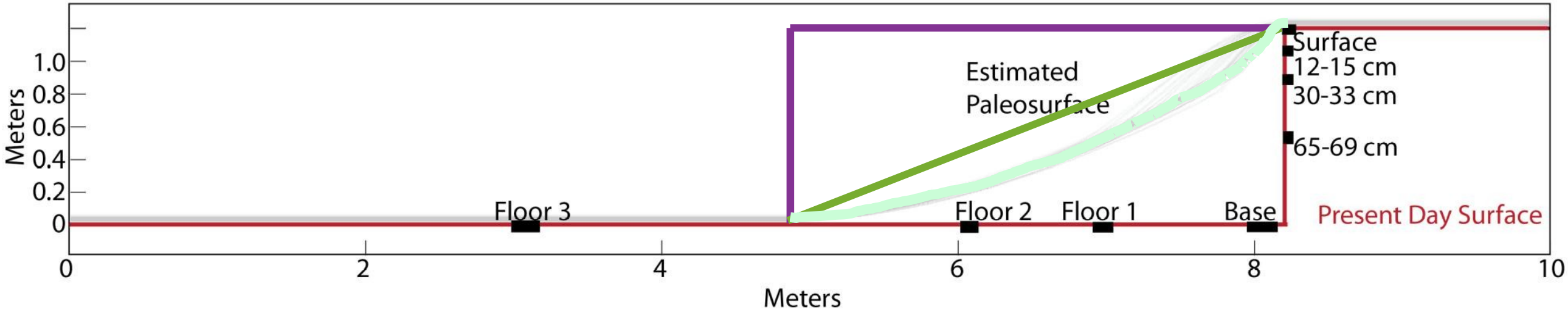


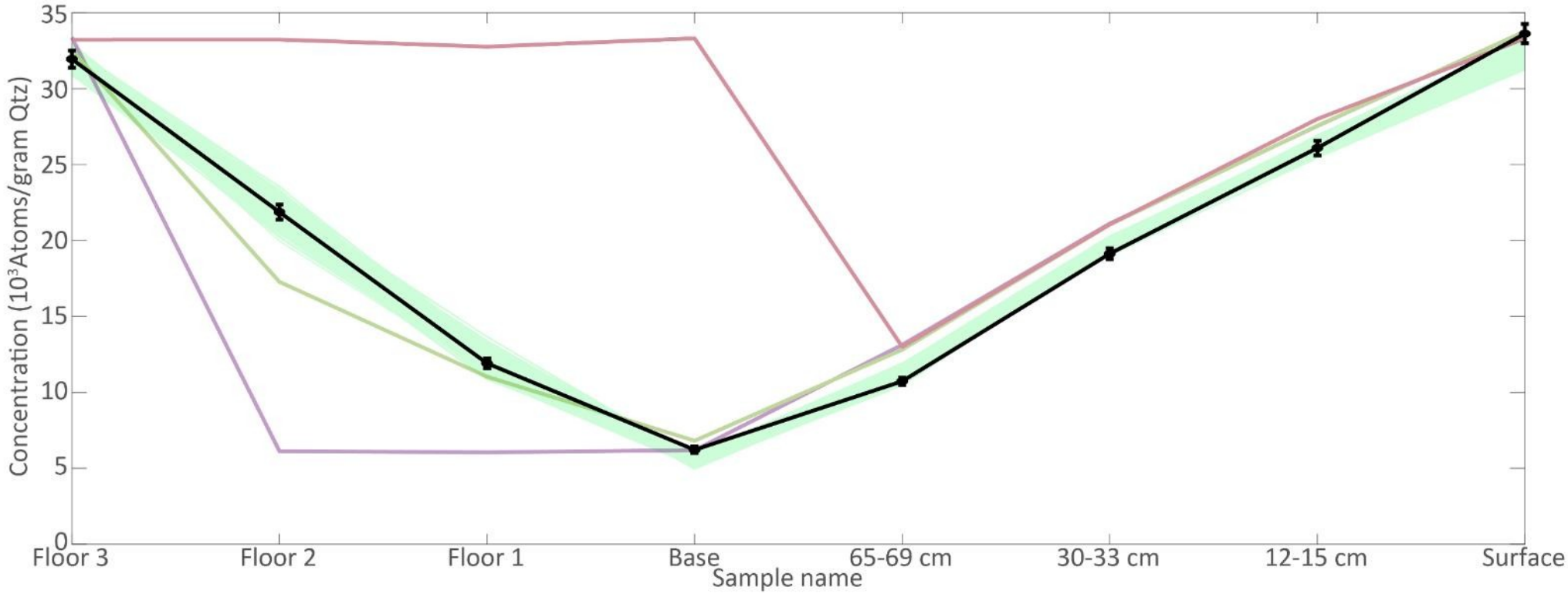


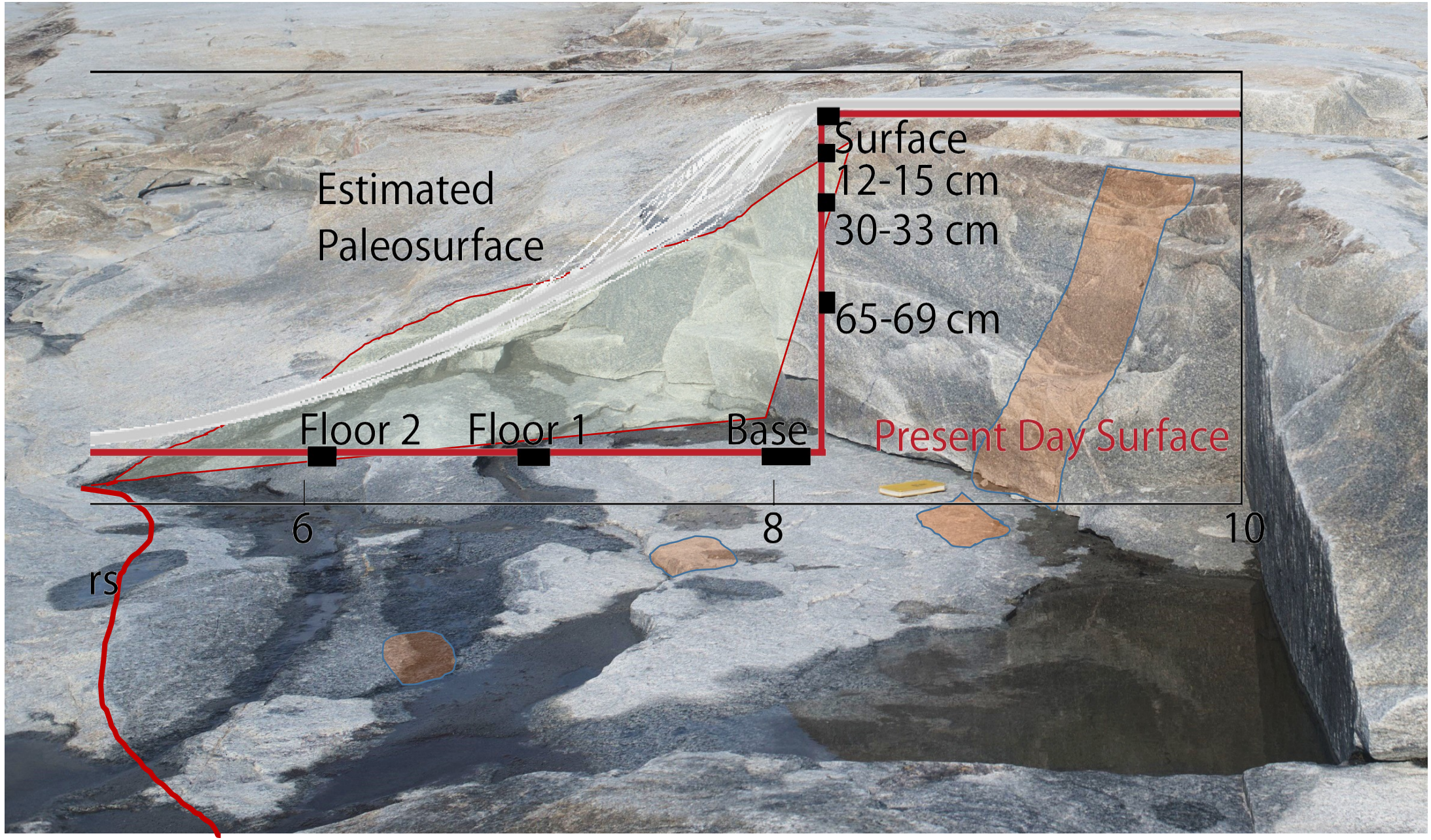
Cosmogenic Nuclide Modeling - MCMC



Cosmogenic Nuclide Modeling - Results





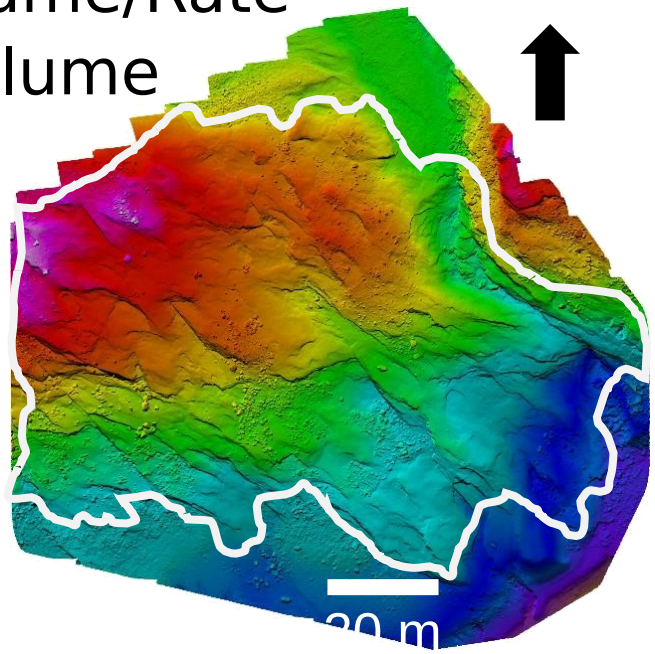

Surface
12-15 cm
30-33 cm
65-69 cm
Estimated
Paleosurface
Floor 2
Floor 1
Base
Present Day Surface
6
8
10
rs

Results

- Abrasion Depth = 4.1 ± 1.9 cm
  - ~0.2 ± 0.1 mm/yr abrasion rate
  - Young et al (2016)
  - Balter-Kennedy et al (*in review*)
- Field Area = 18,000 m^2
- Abraded Volume = 650 ± 300 m^3
- Plucked Volume = TBD
- Quarried site informs other lee surfaces

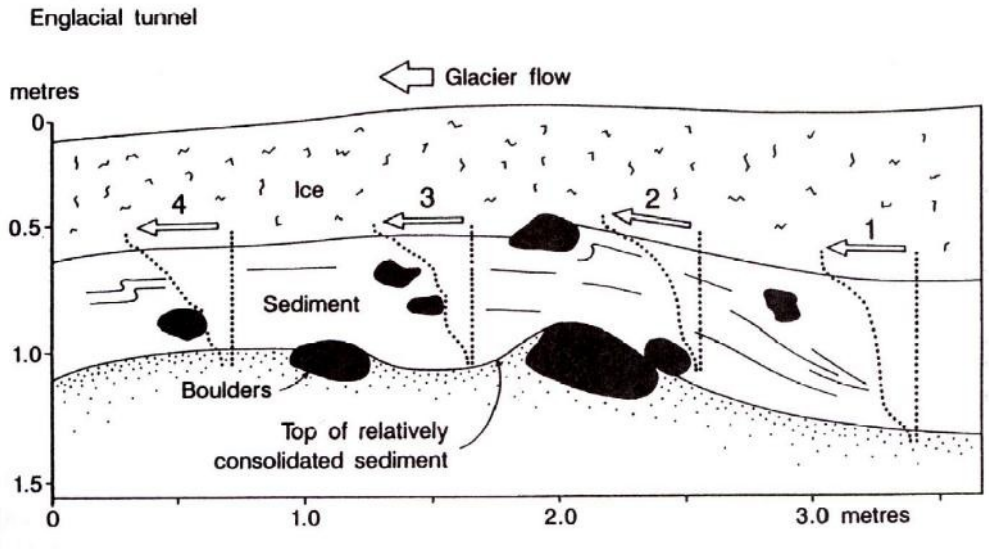
Implications

- Constrain erosion process models
  - Ice velocity
  - Rock Hardness
  - Fracture/Joint orientation
  - Abrasion Volume/Rate
  - Quarrying Volume

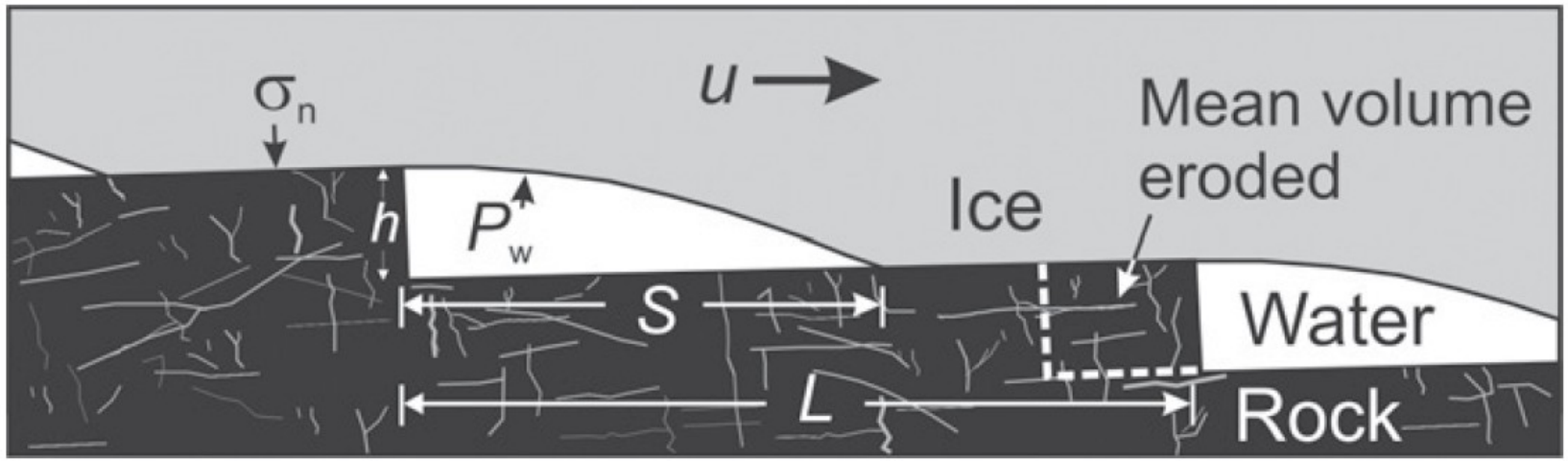


Thank you!

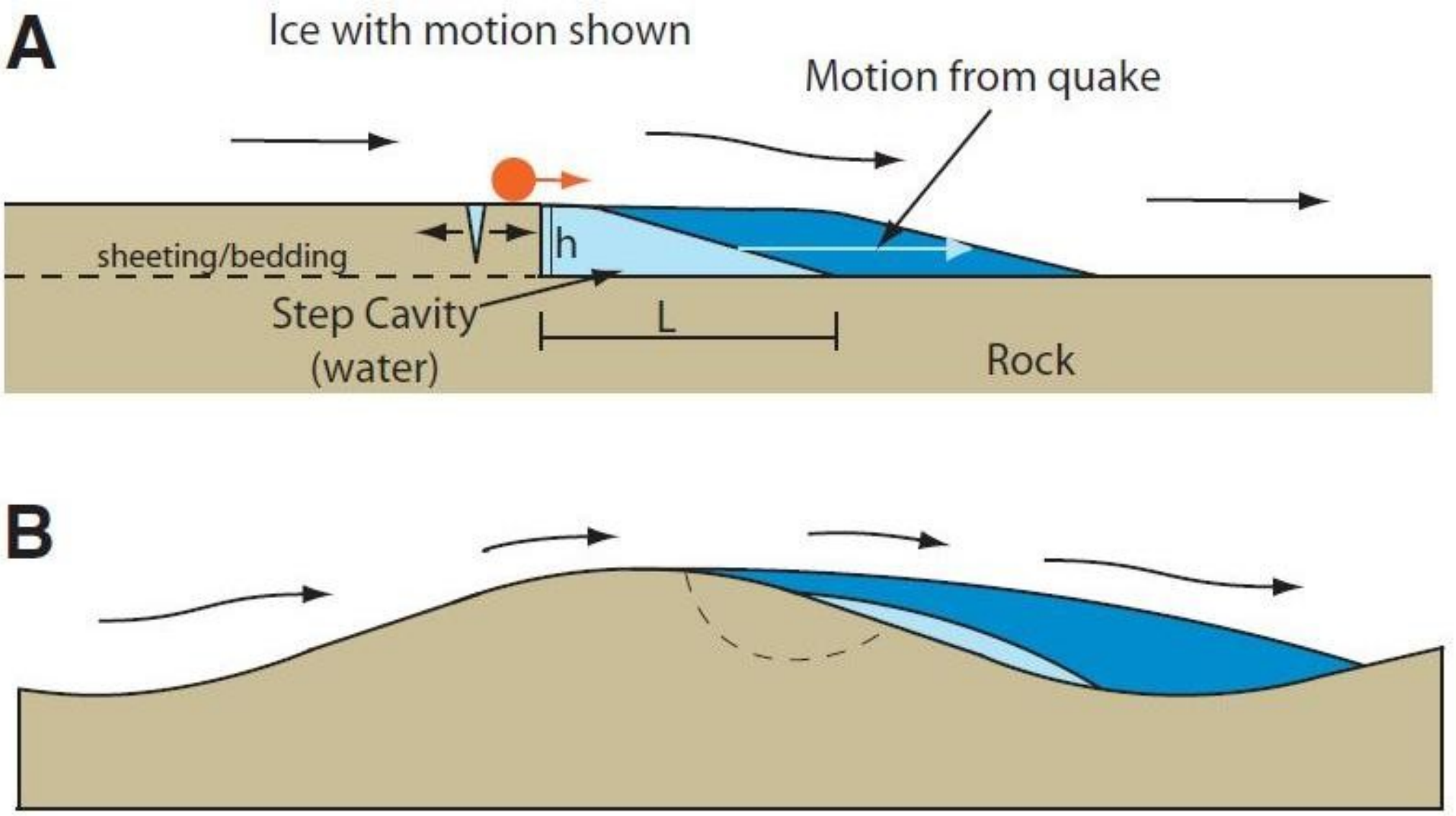
But Wait…



Boulton and Hindmarsh, 1987



Iverson (2012)



Zoet et al. (2013)