The Dynamic Albedo of Neutrons Experiment on MSL: Geant4 Modeling Results

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Brief History of Water on Mars

Morphological Evidence

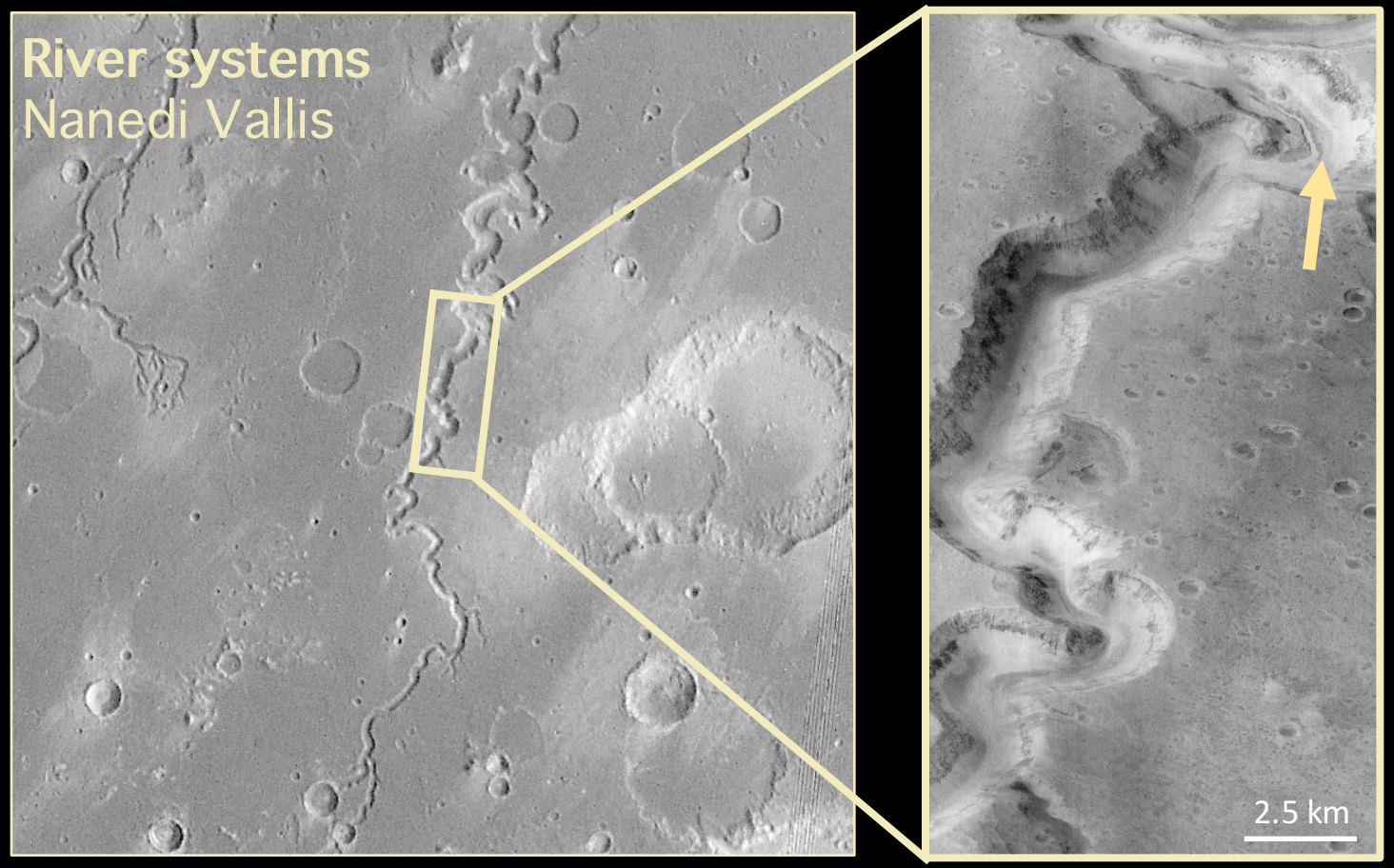
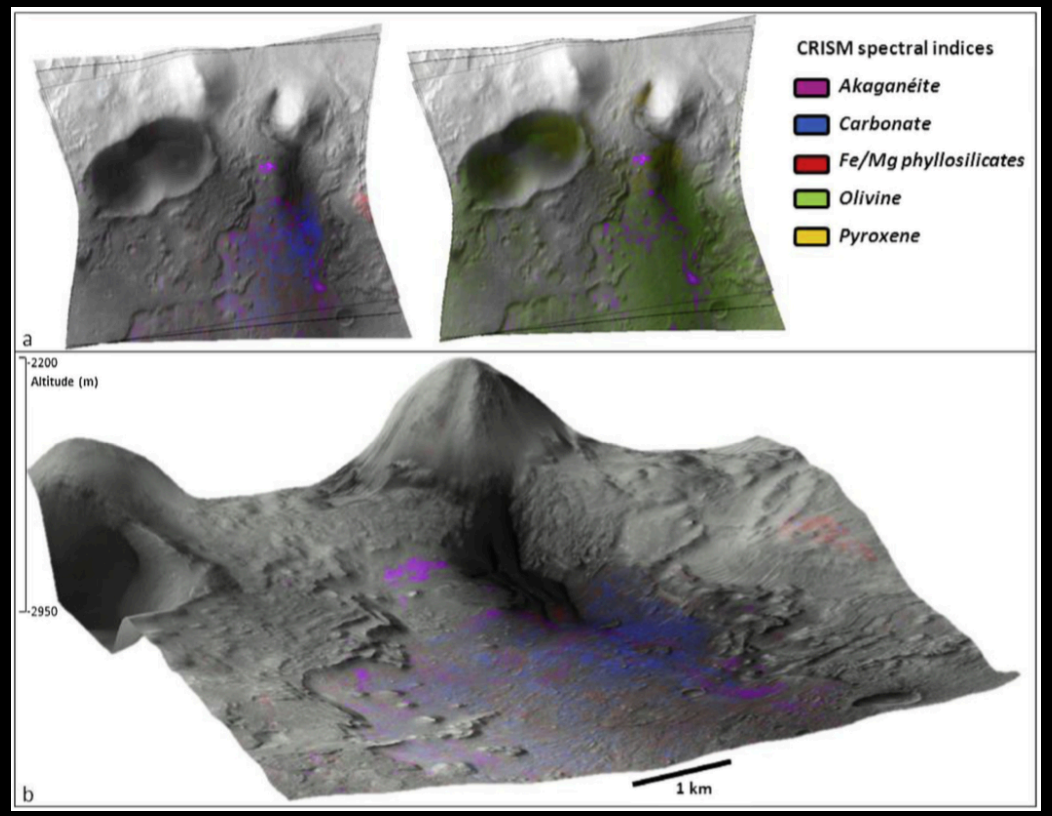


Image Credit: JPL

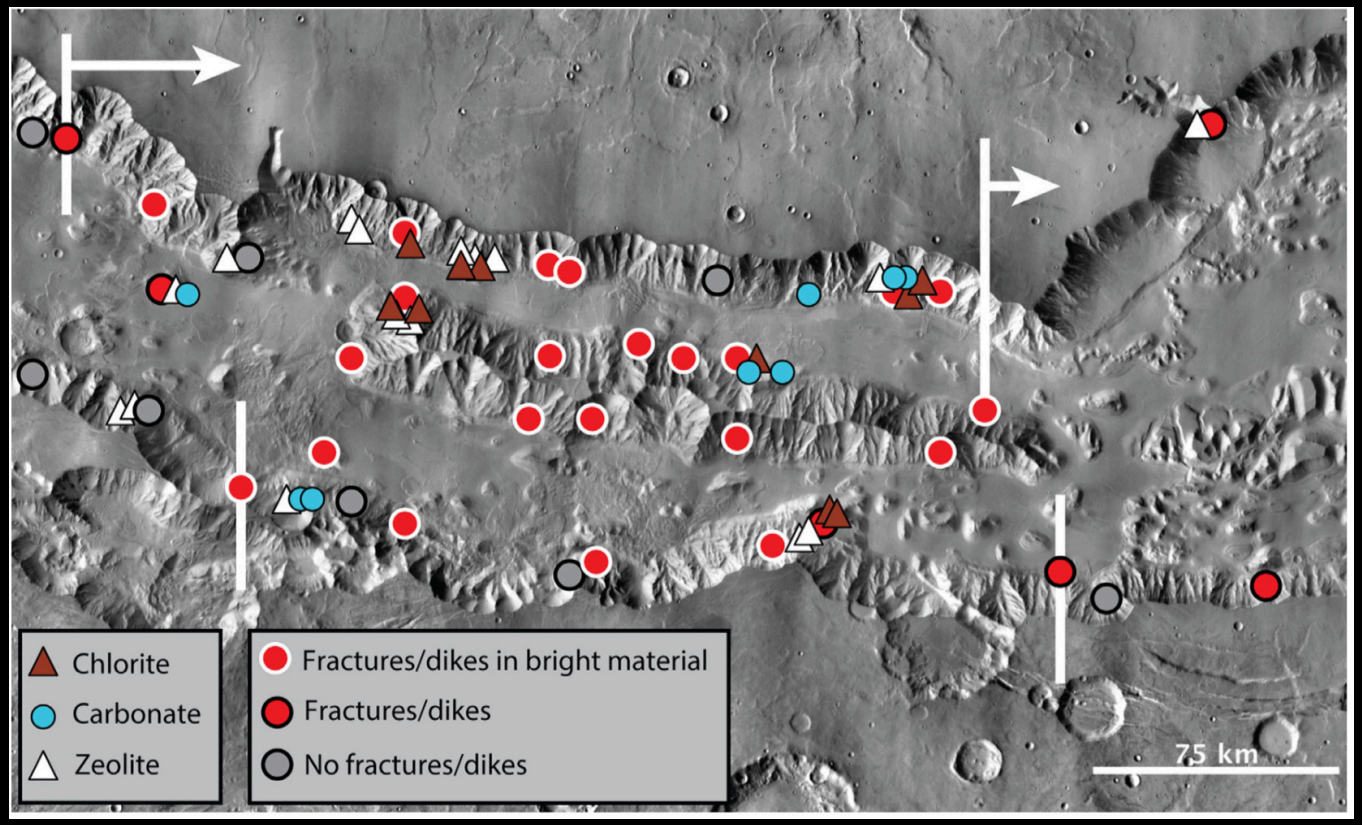
Image Credit: JPL

Brief History of Water on Mars

Chemical Evidence



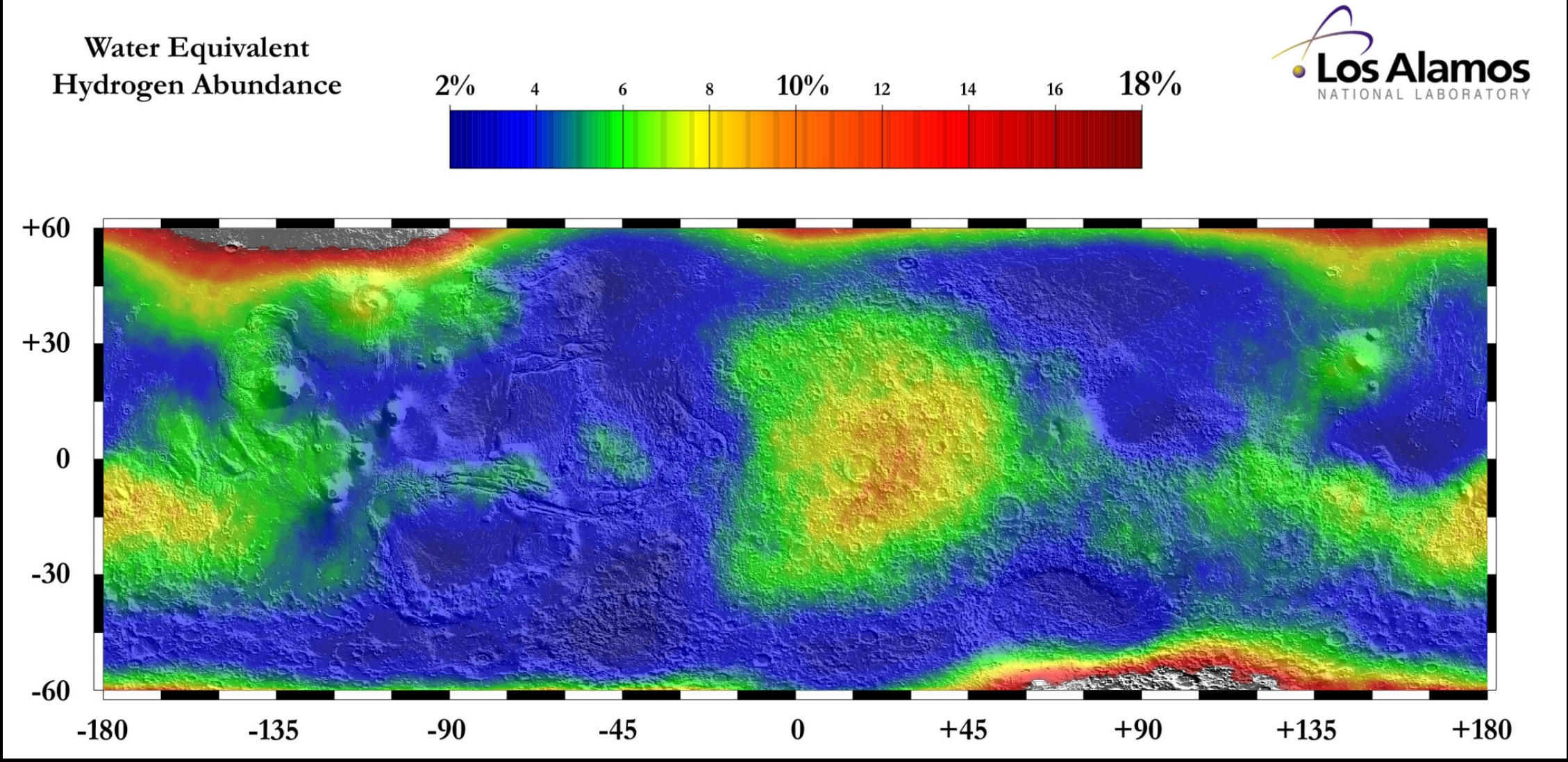
(Carter et al., 2015)



(Viviano-Beck et al., 2017)

Brief History of Water on Mars

Chemical Evidence



Gale Crater

Ellipses indicate MSL landing site

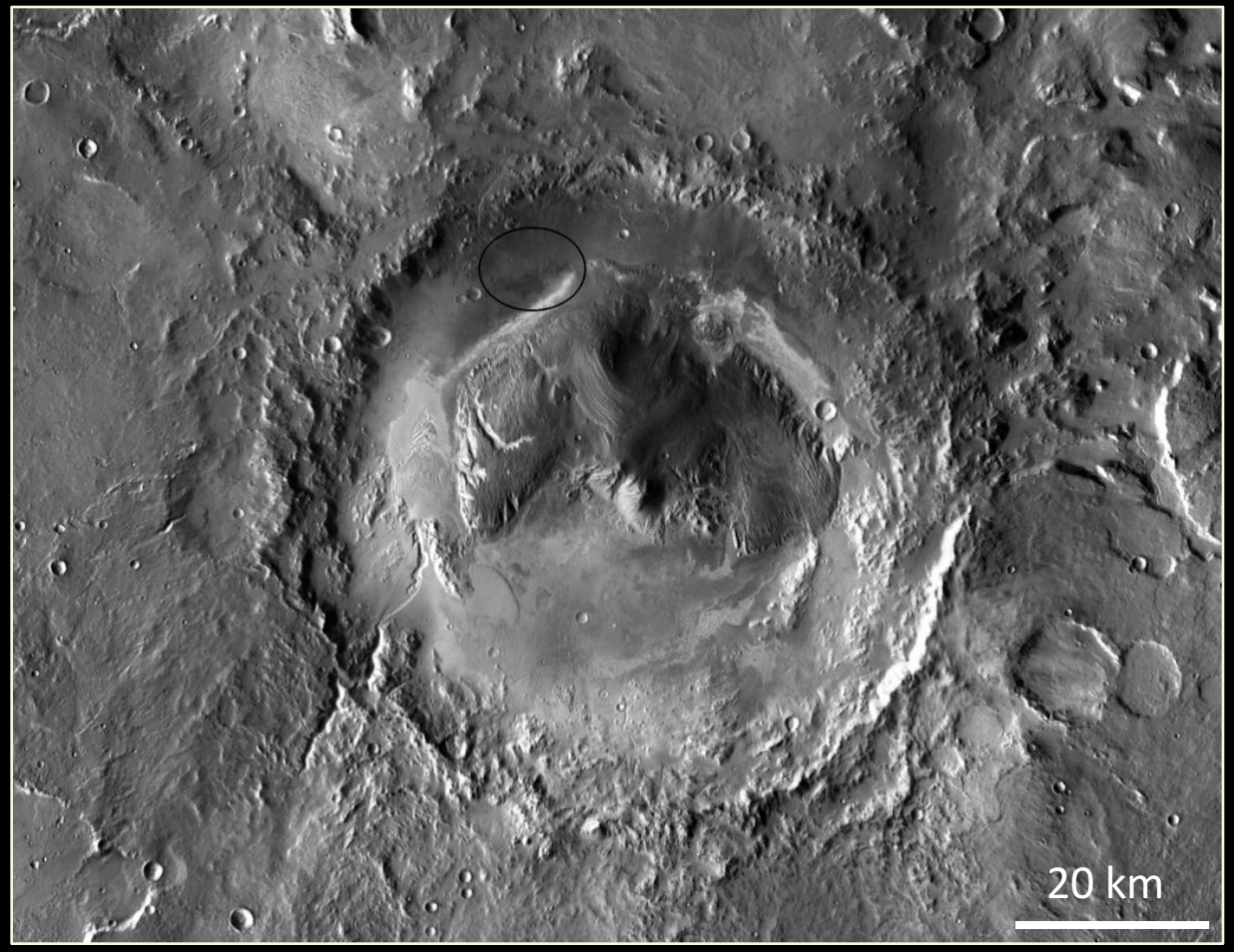


Image Credit: JPL

The DAN–Active Experiment

The Dynamic Albedo of Neutrons (DAN) is an active and passive neutron spectrometer that measures the abundance (*and depth distribution*) of H- and OH-bearing materials in the Martian regolith.

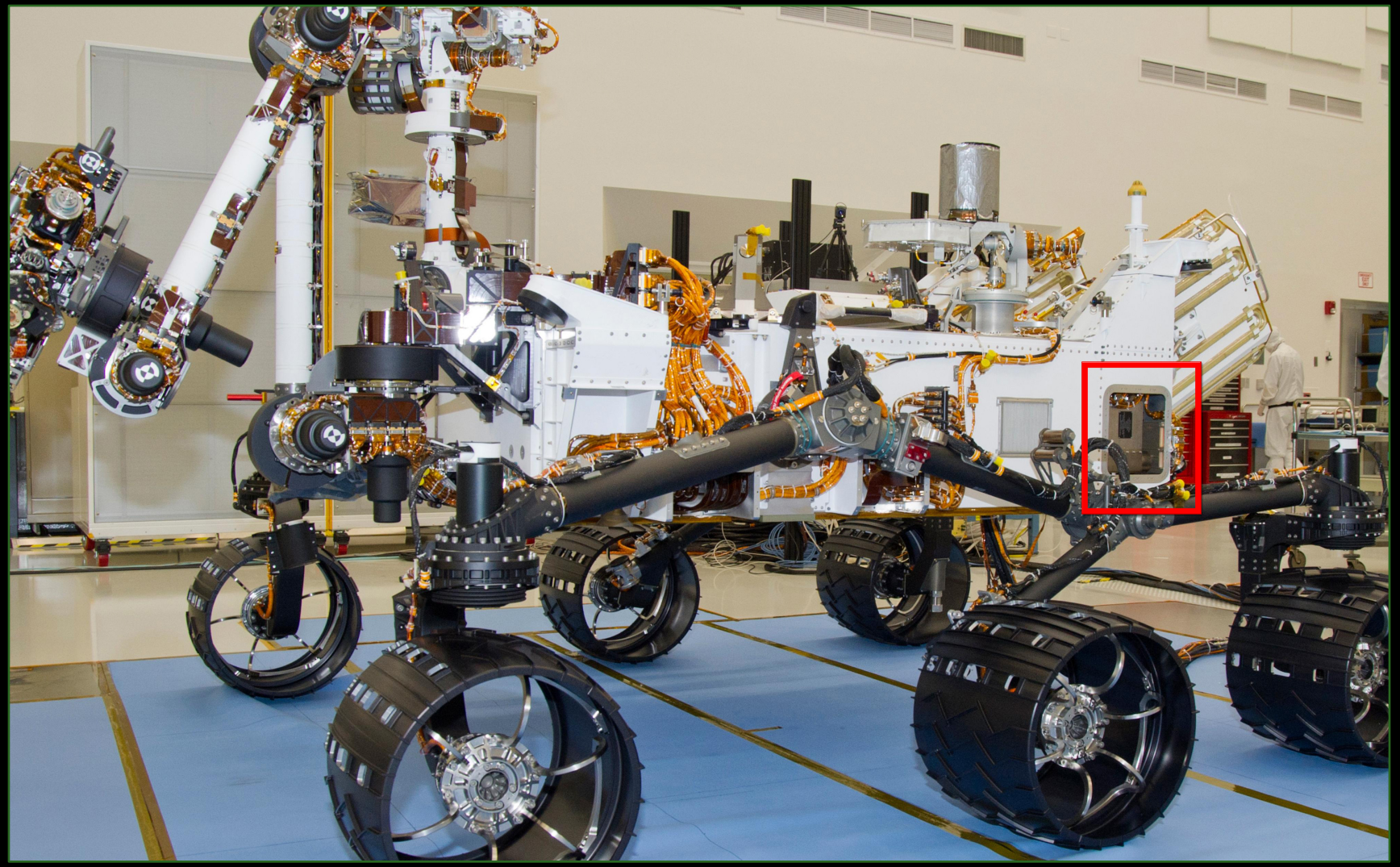


Image Credit: NASA

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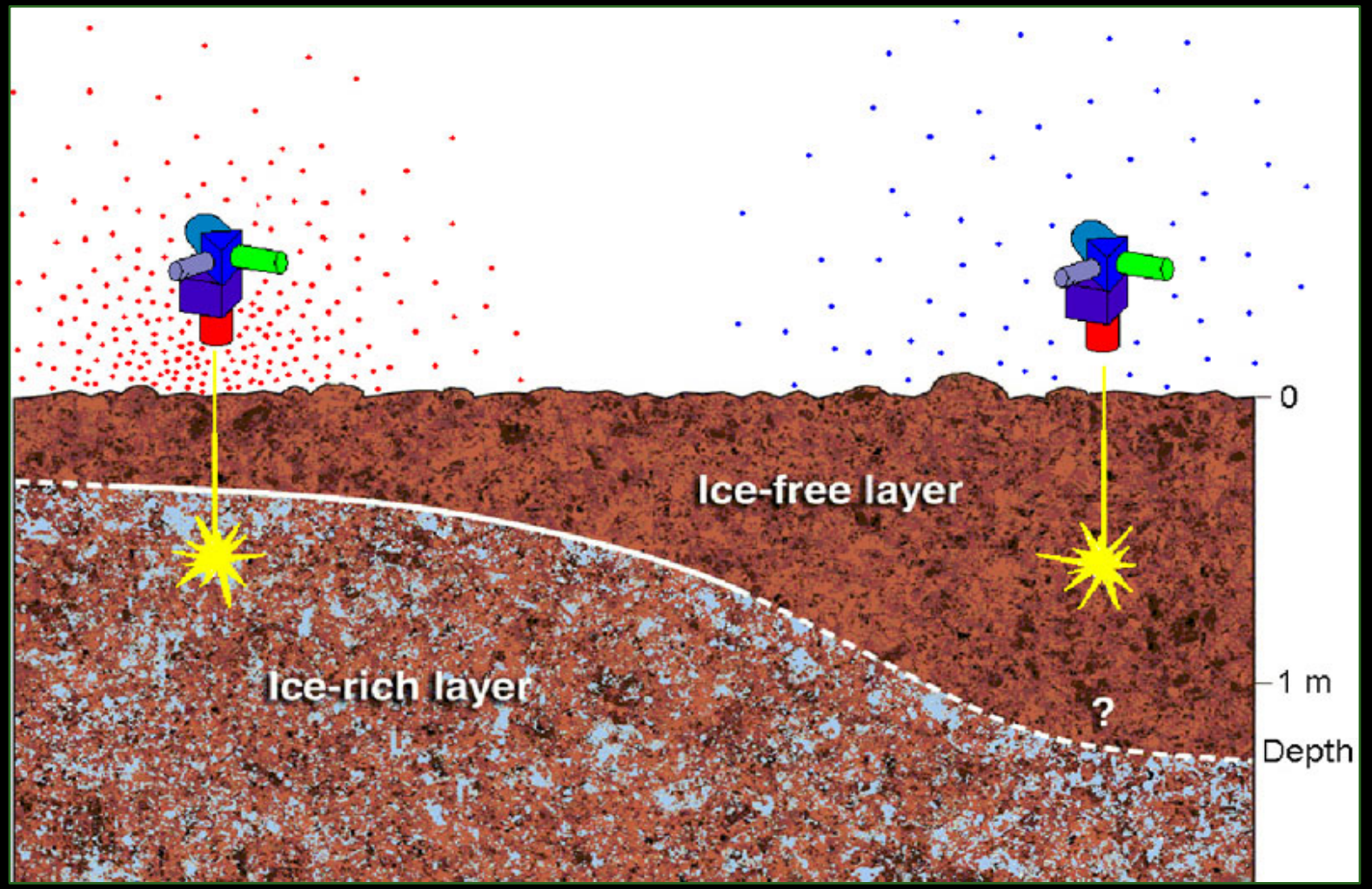


Image Credit: NASA

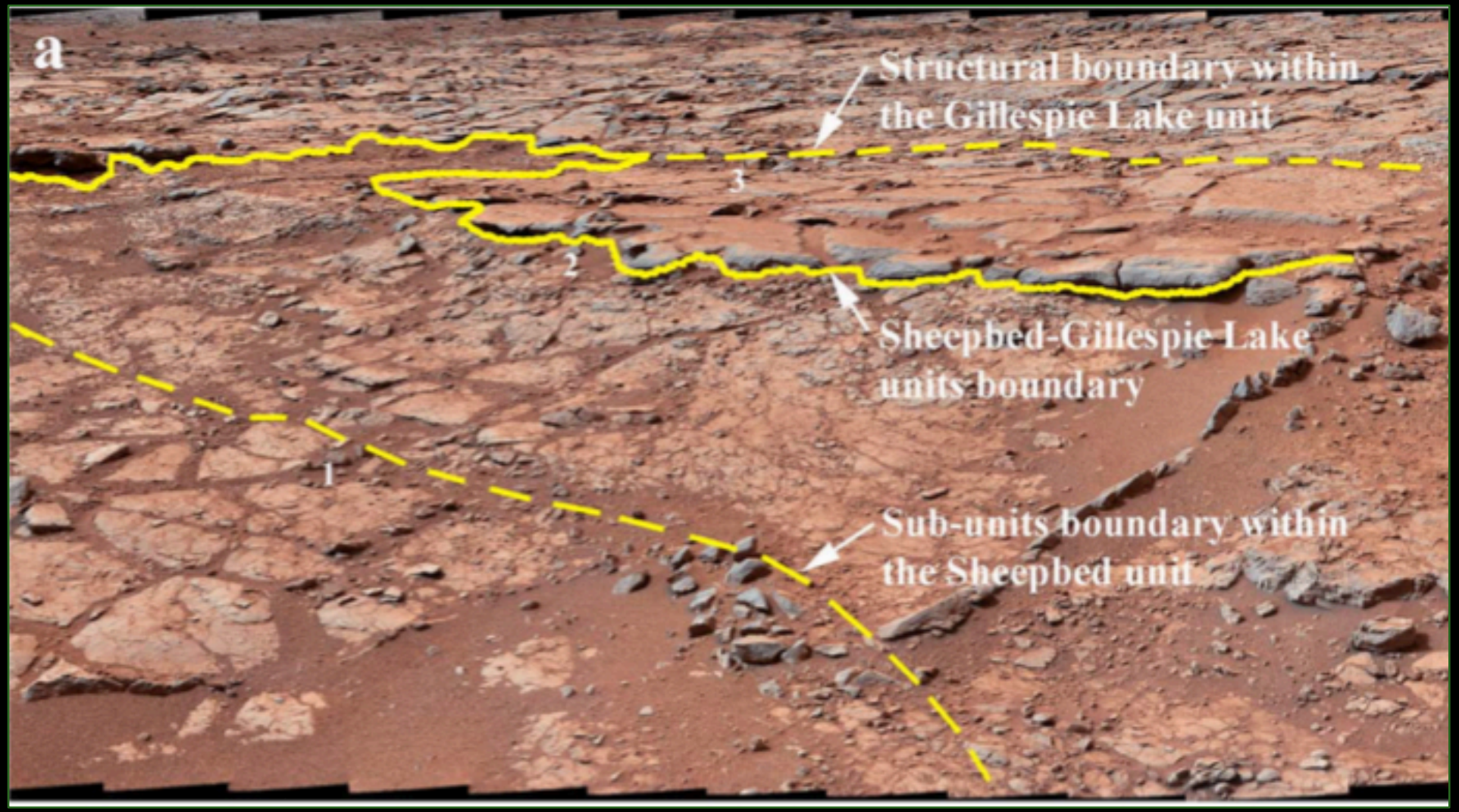
The DAN–Active Experiment

No hydrogen in the soil

The DAN–Active Experiment

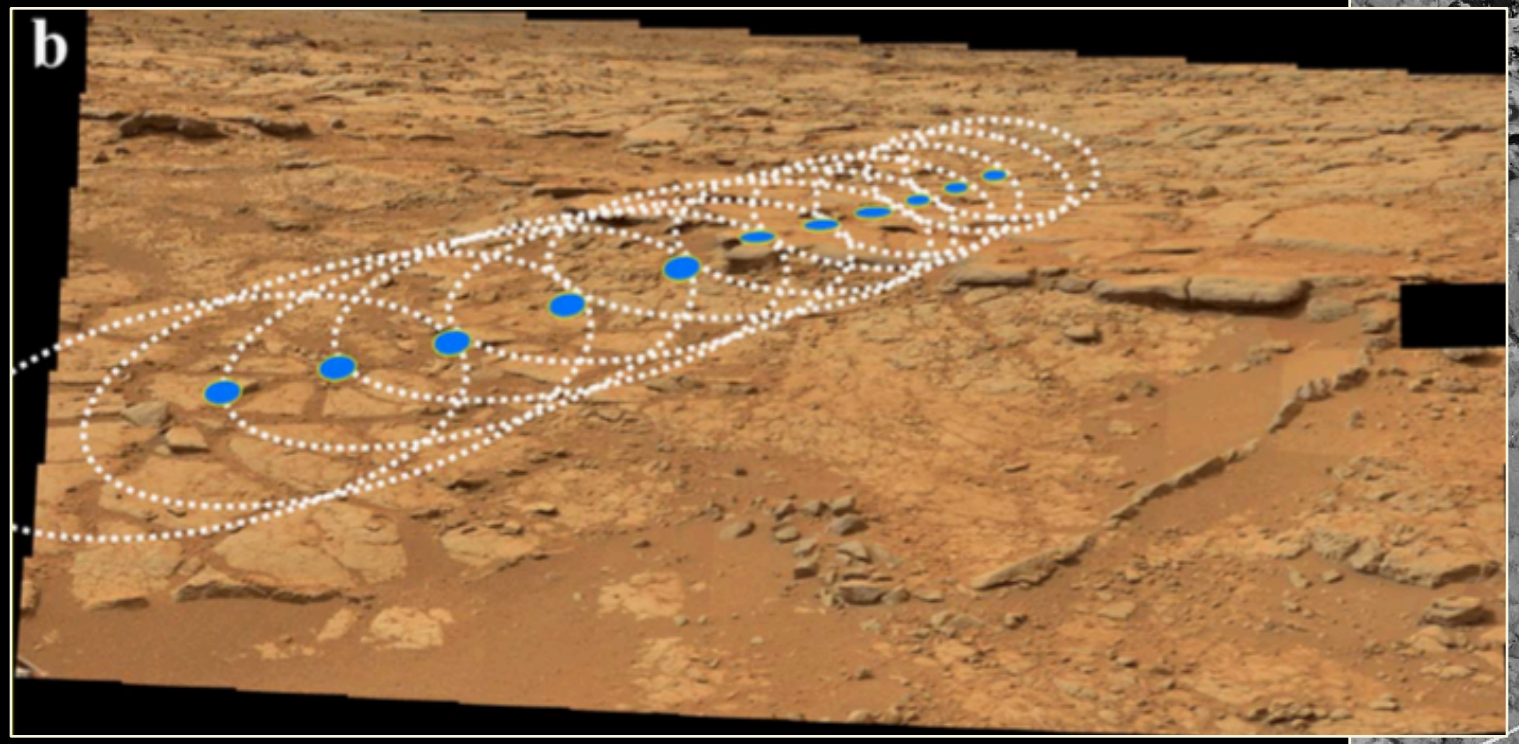
With hydrogen in the soil

Yellowknife Bay

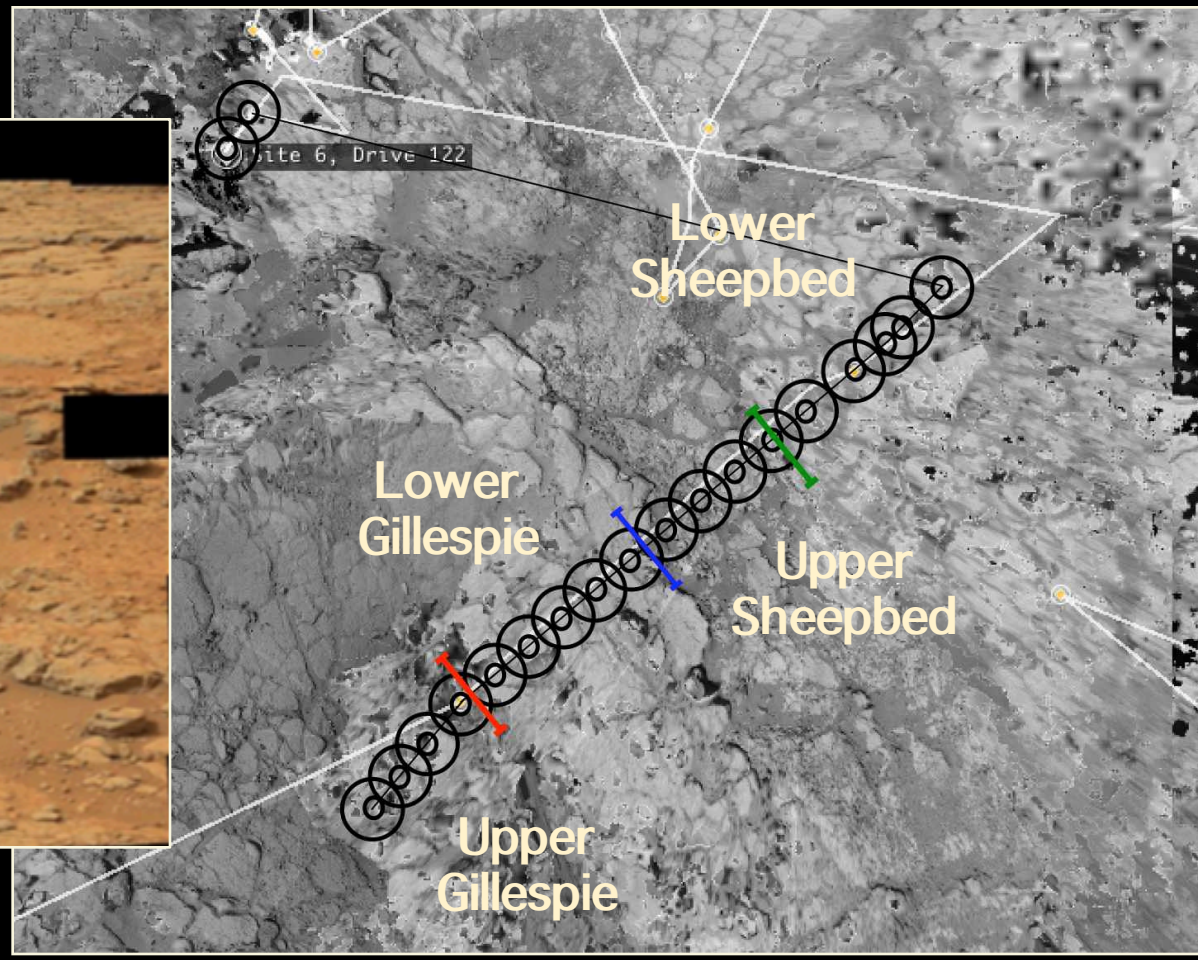


(Litvak et al., 2014)

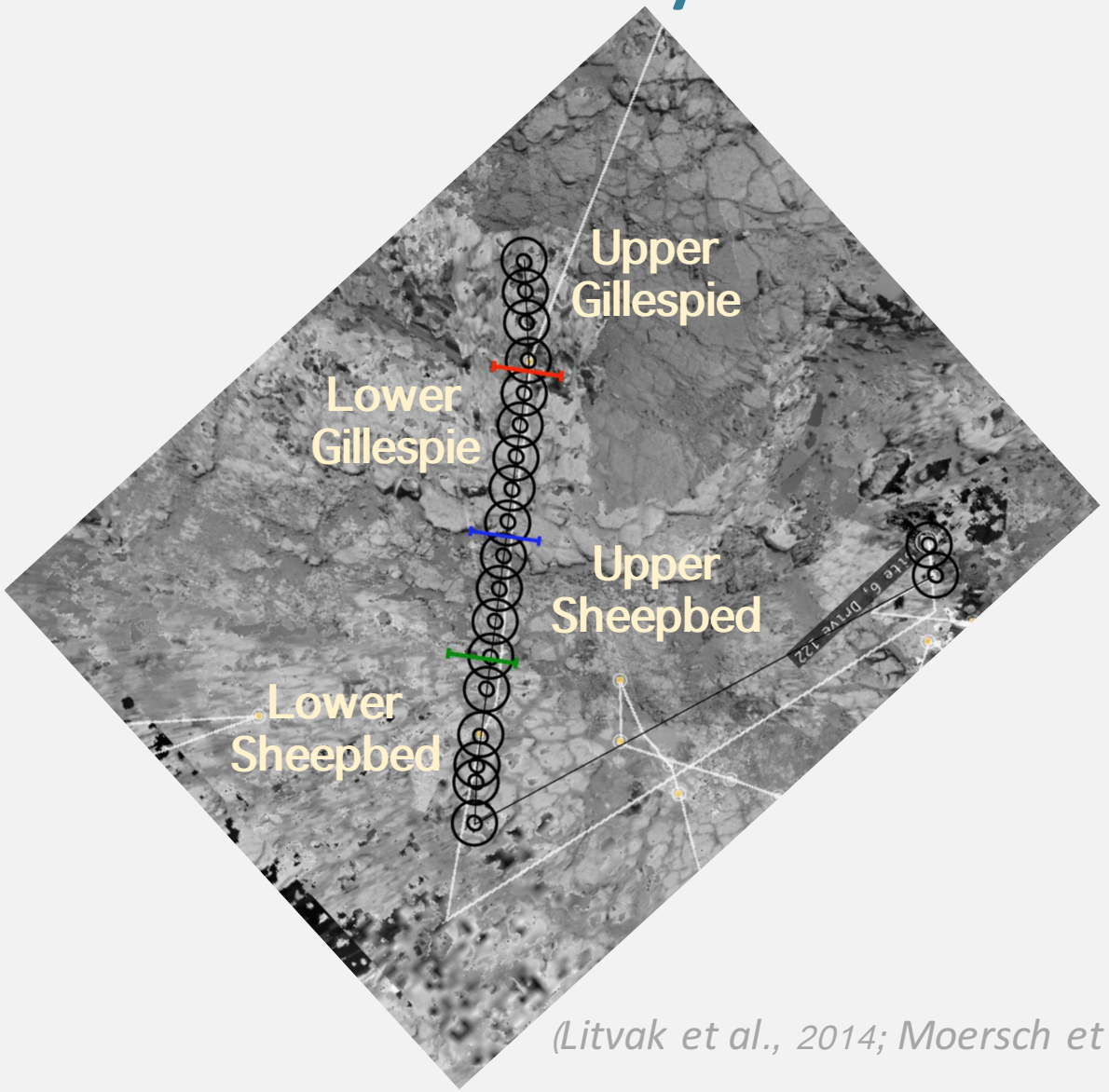
Yellowknife Bay

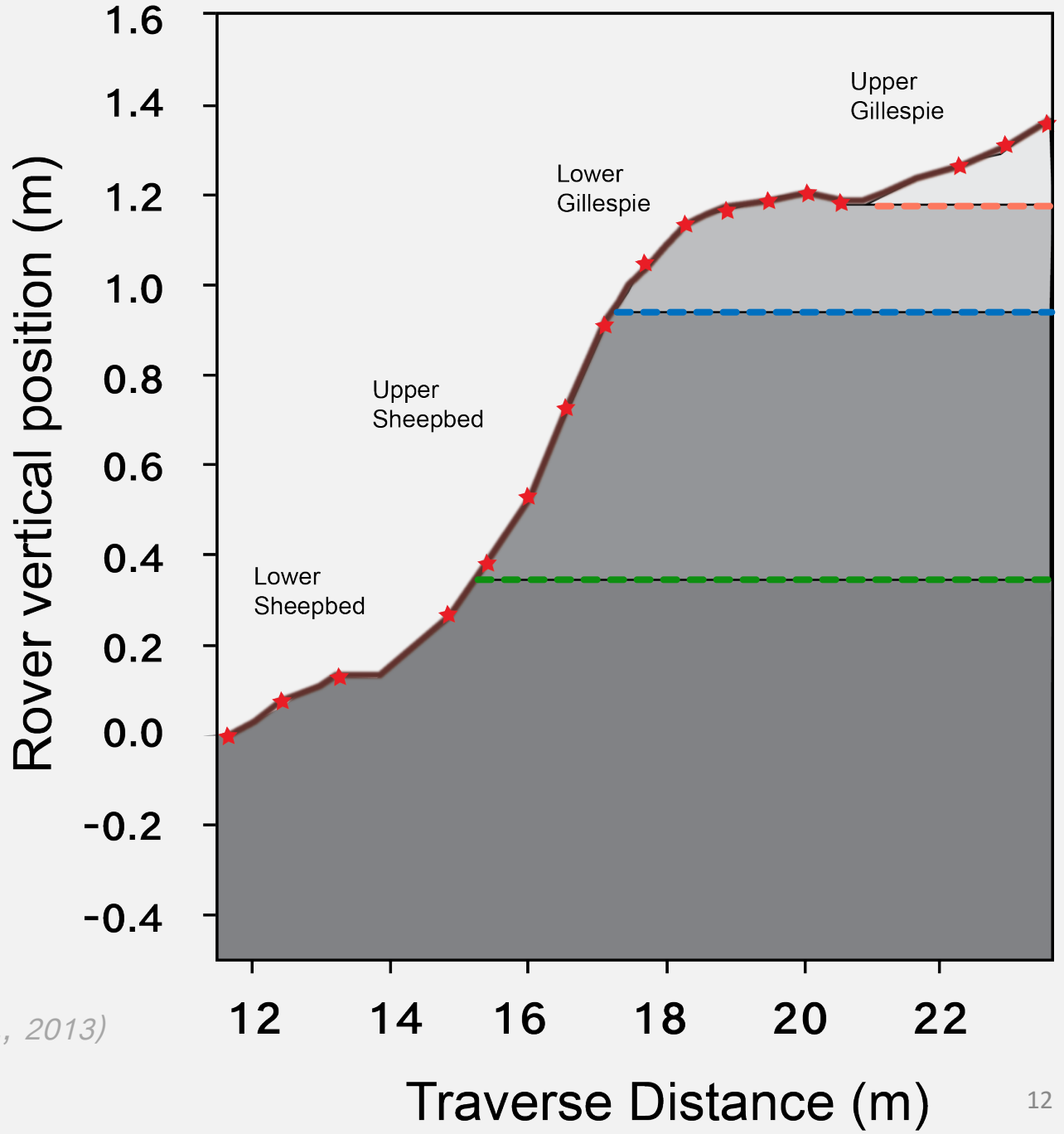


(Litvak et al., 2014)



Yellowknife Bay

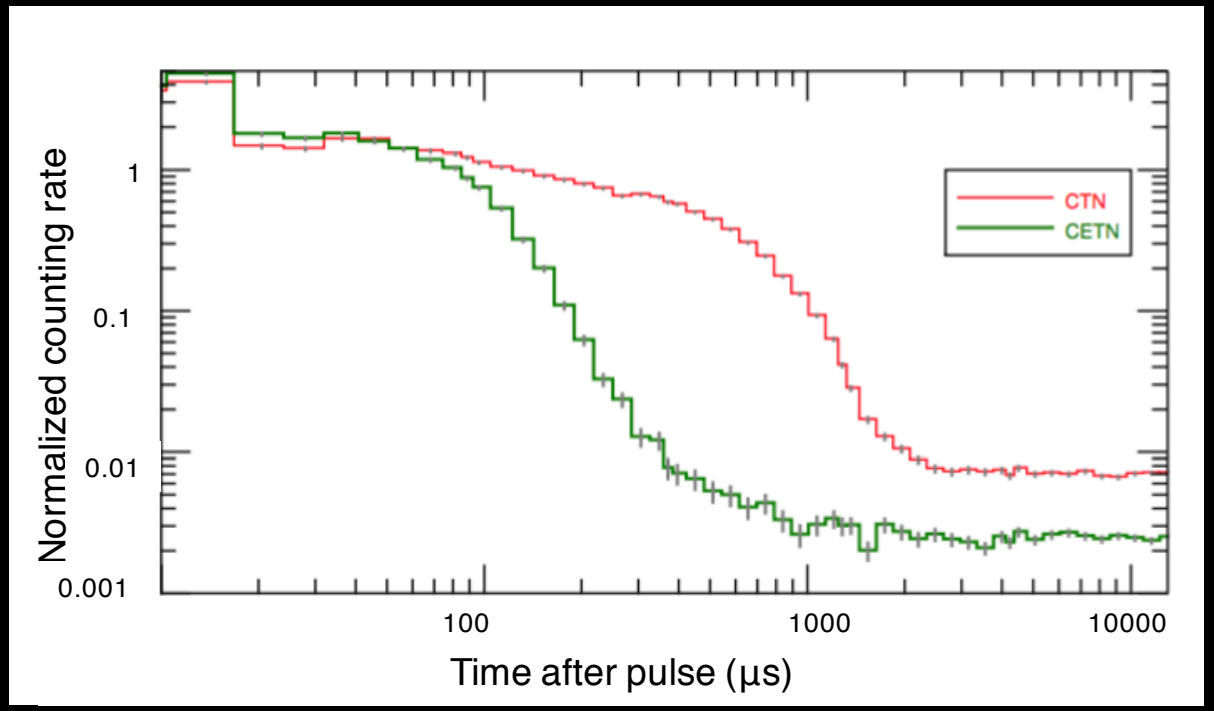




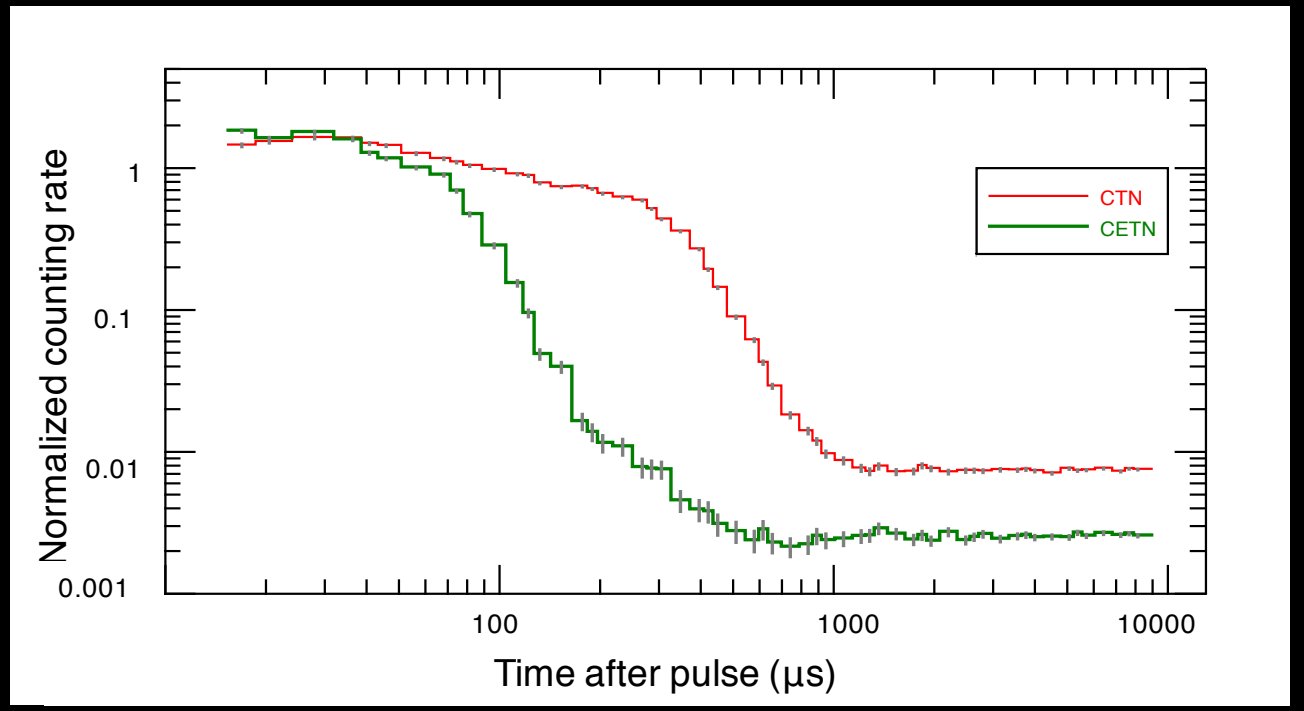
(Litvak et al., 2014; Moersch et al., 2013)

Yellowknife Bay

Unit	Ave Water within 60 cm (%)	Top Water (%)	Bottom Water (%)	Depth to Layer between top and bottom (cm)
Lower Sheepbed	2.4 ± 0.17	1.40 ± 0.14	2.9 ± 0.3	20 ± 3
Upper Sheepbed	2.15 ± 0.15	1.50 ± 0.12	2.8 ± 0.3	30 ± 5
Lower Gillespie Lake	2.50 ± 0.19	1.70 ± 0.16	2.9 ± 0.4	20 ± 4
Upper Gillespie Lake	2.23 ± 0.14	1.40 ± 0.3	2.4 ± 0.3	10 ± 7

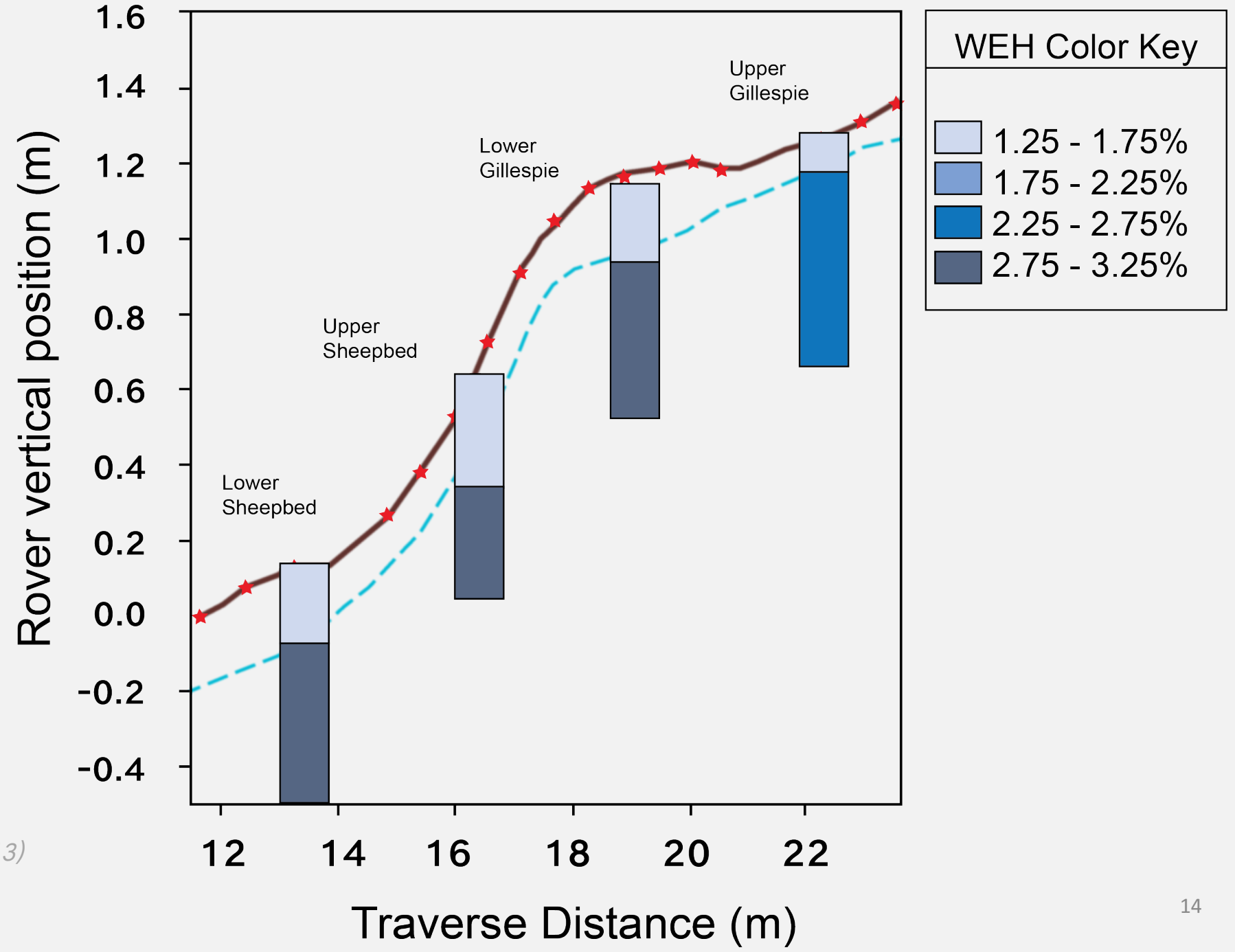


Sheepbed Upper Unit – Stop 9



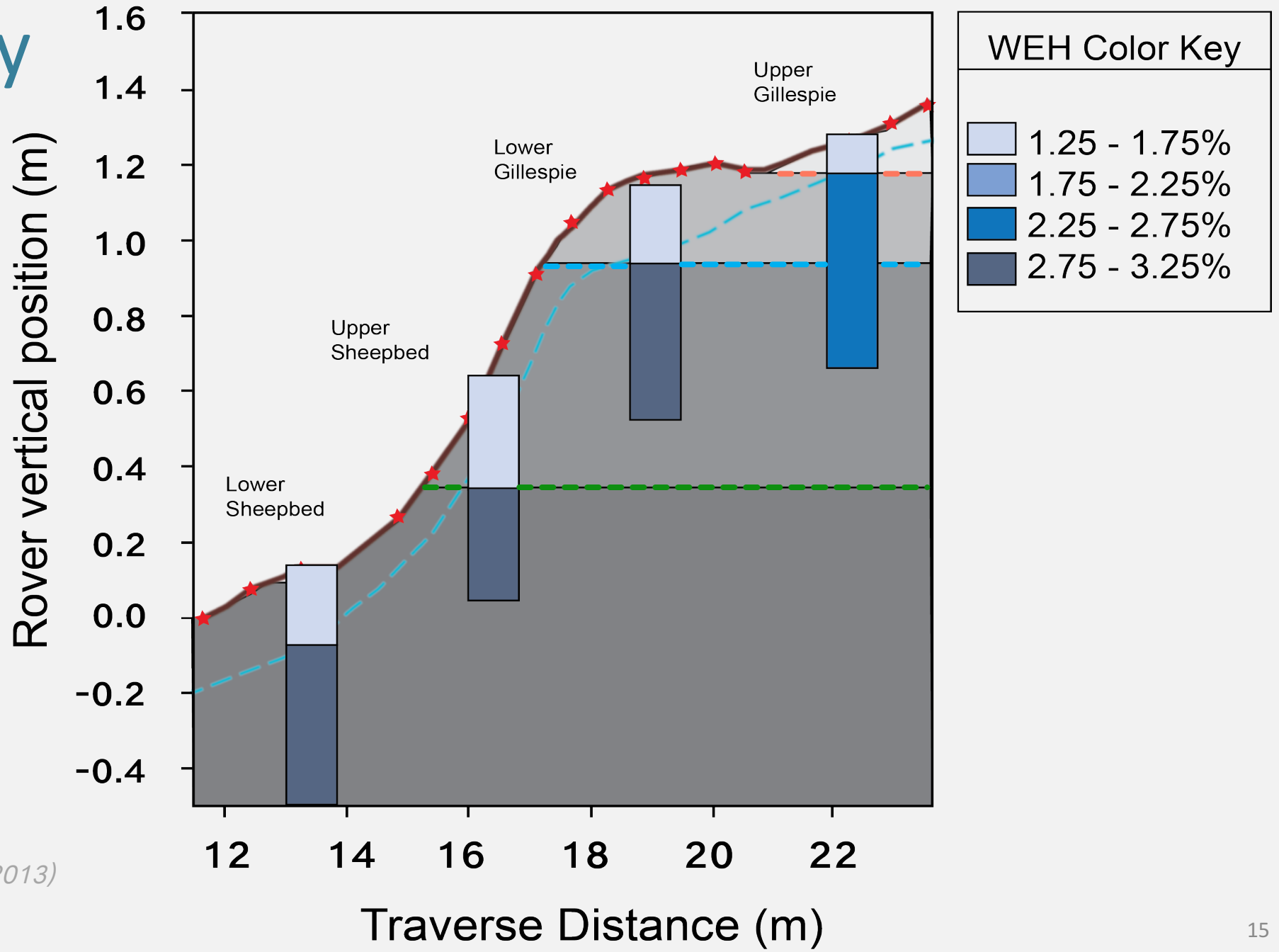
Gillespie Upper Unit – Stop 15

Yellowknife Bay



(Litvak et al., 2014; Moersch et al., 2013)

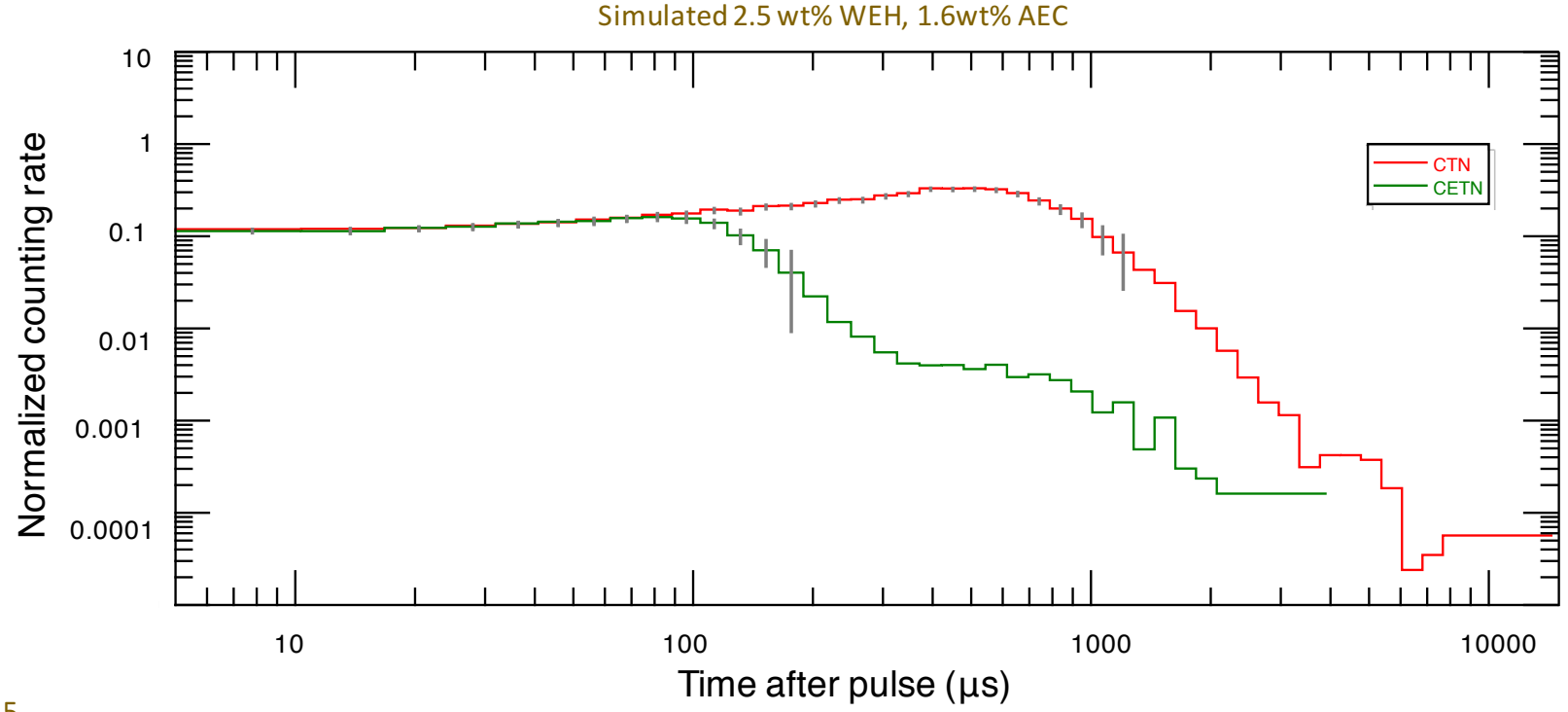
Yellowknife Bay

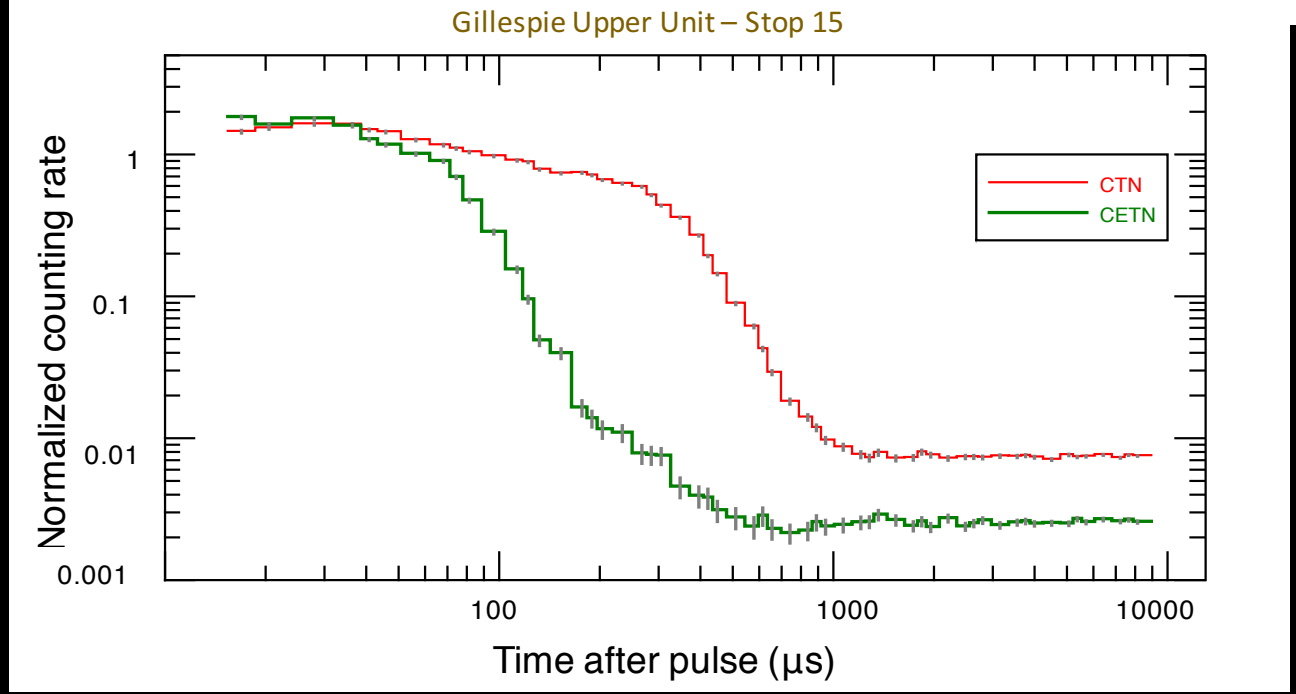


(Litvak et al., 2014; Moersch et al., 2013)

MCNPX

Simulated MCNPX results for 2.50 wt.% WEH and 1.6 wt.% AEC. Green curve is simulated count rate of CETN and red curve is simulated count rate of CTN.





DAN measurement from Upper Gillespie Unit in Yellowknife Bay. Best fit model parameters:
wt.% WEH =1.40 ± 0.3 (TOP), 2.4 ± 0.3 (BOTTOM)
wt.% AEC = 1.3 ± 0.1
Depth to second layer (cm) = 10 ± 7

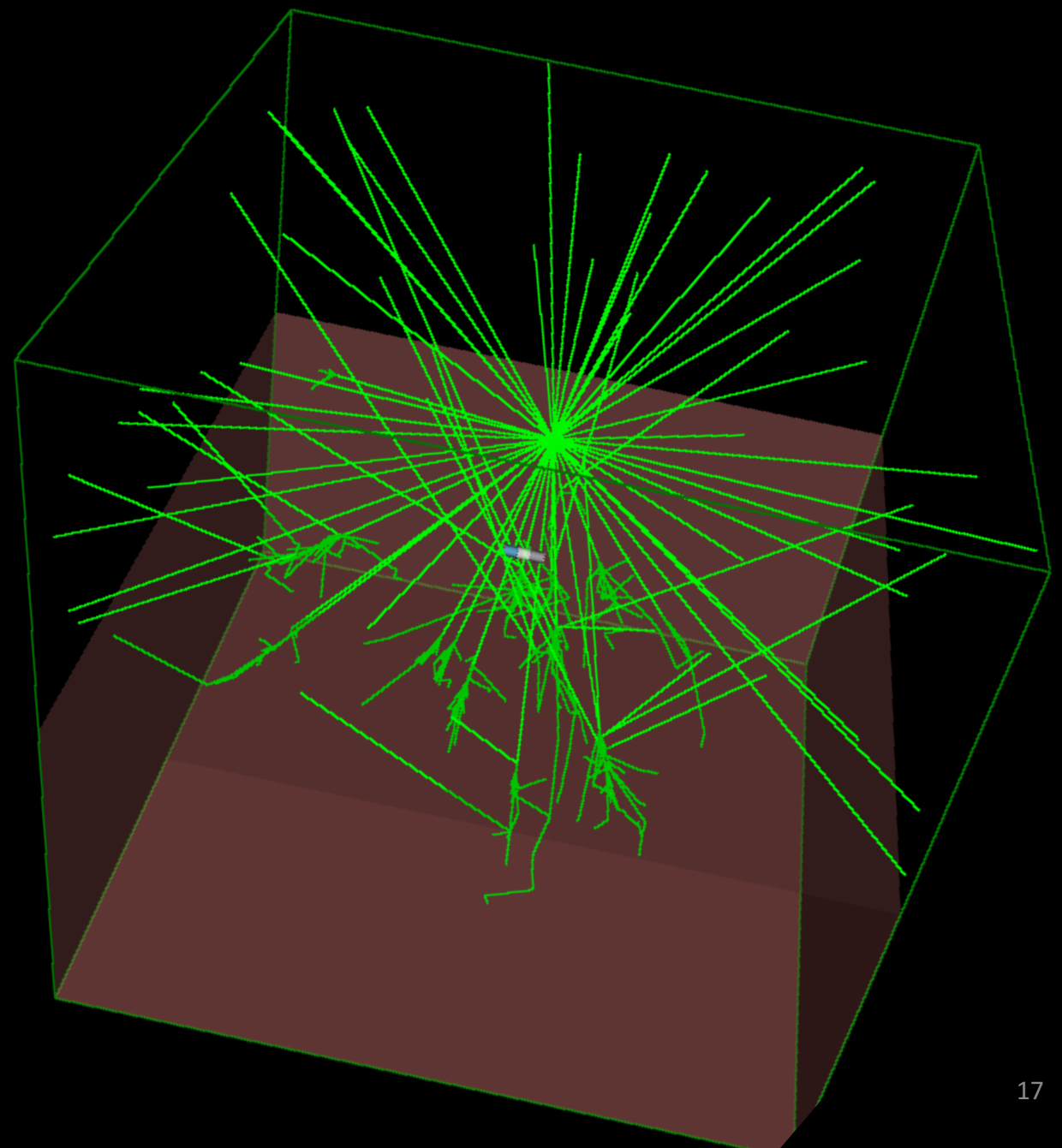
Geant4 Simulations

Overview

Physics: QGSP_BERT_HP

Material & Geometry: Made to mimic the Yellowknife Bay regolith. CTN and CETN are included with the same material and geometry as on MSL.

Event: The primary generator is a simulated PNG.

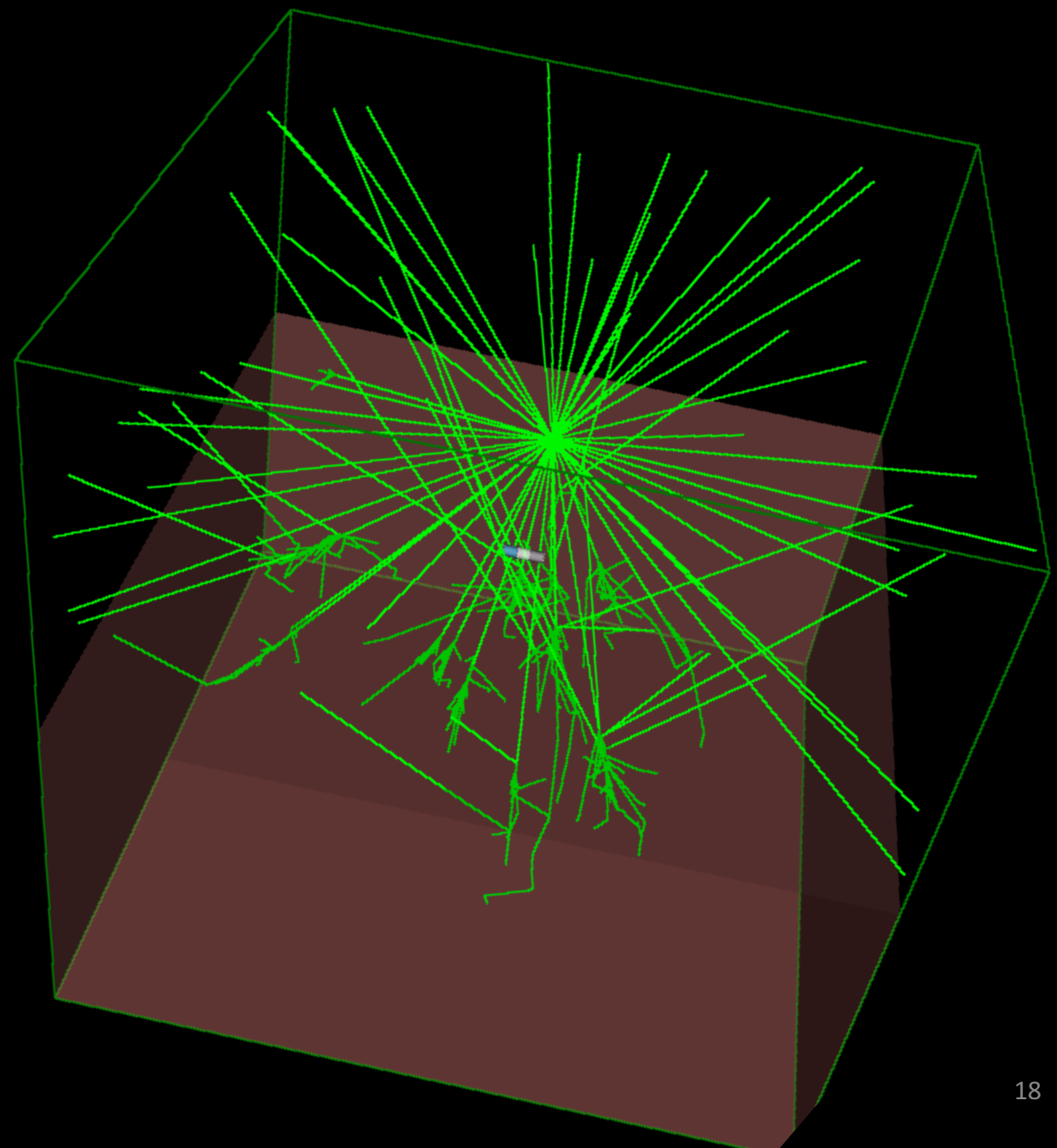


Geant4 Simulations

Yellowknife Bay Regolith

Background Composition (density = 1.8 g/cm3)
SiO2: 46.3%
FeO: 11.2%
Al2O3: 10.1%
MgO: 8.6%
CaO: 6.34%
SO3: 6.00%
Fe2O3: 5.4%
Na2O: 3.00%
TiO2: 0.87%
P2O5: 0.82%
K2O: 0.44%
Cr2O3: 0.35%
MnO: 0.32%

Variable Composition:
H2O
Cl

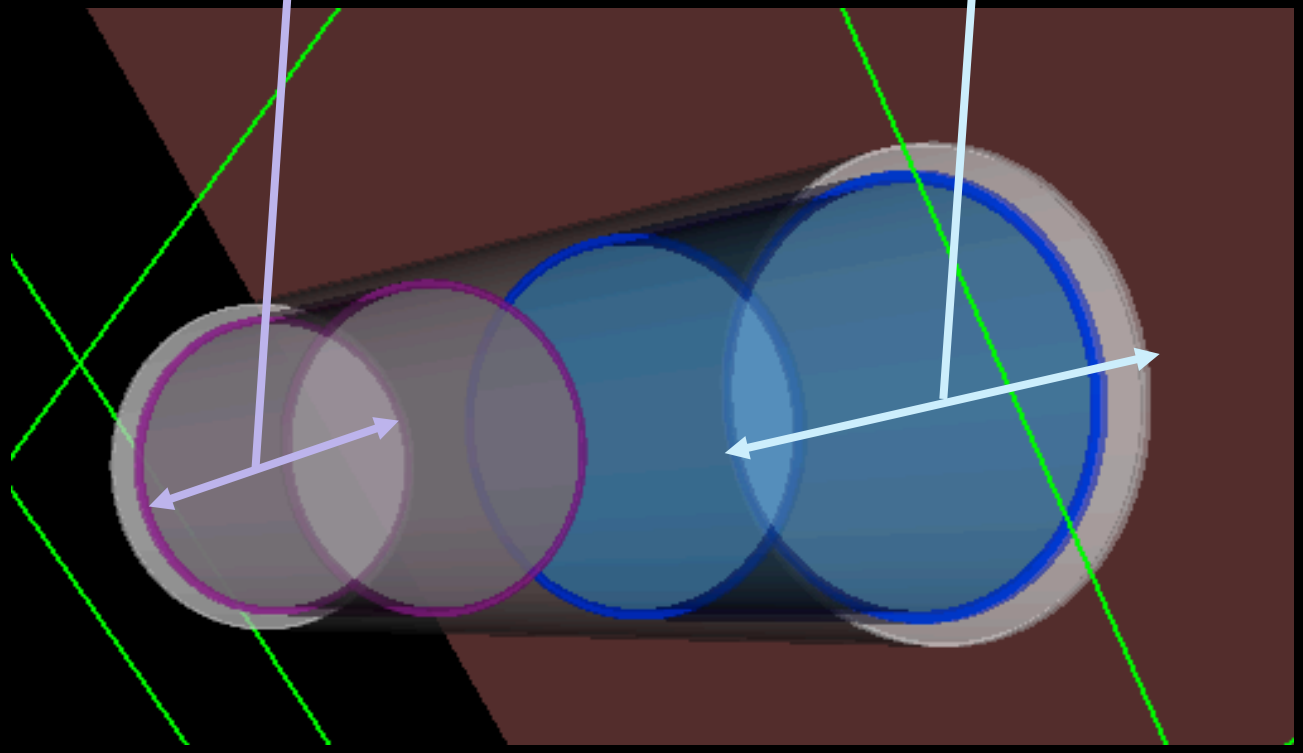


Geant4 Simulations

The He3 Detector Design

CTN & CETN
2.64 cm radius

Outer
Aluminum Case
2.9 cm radius



Outer
Aluminum Case
20 cm

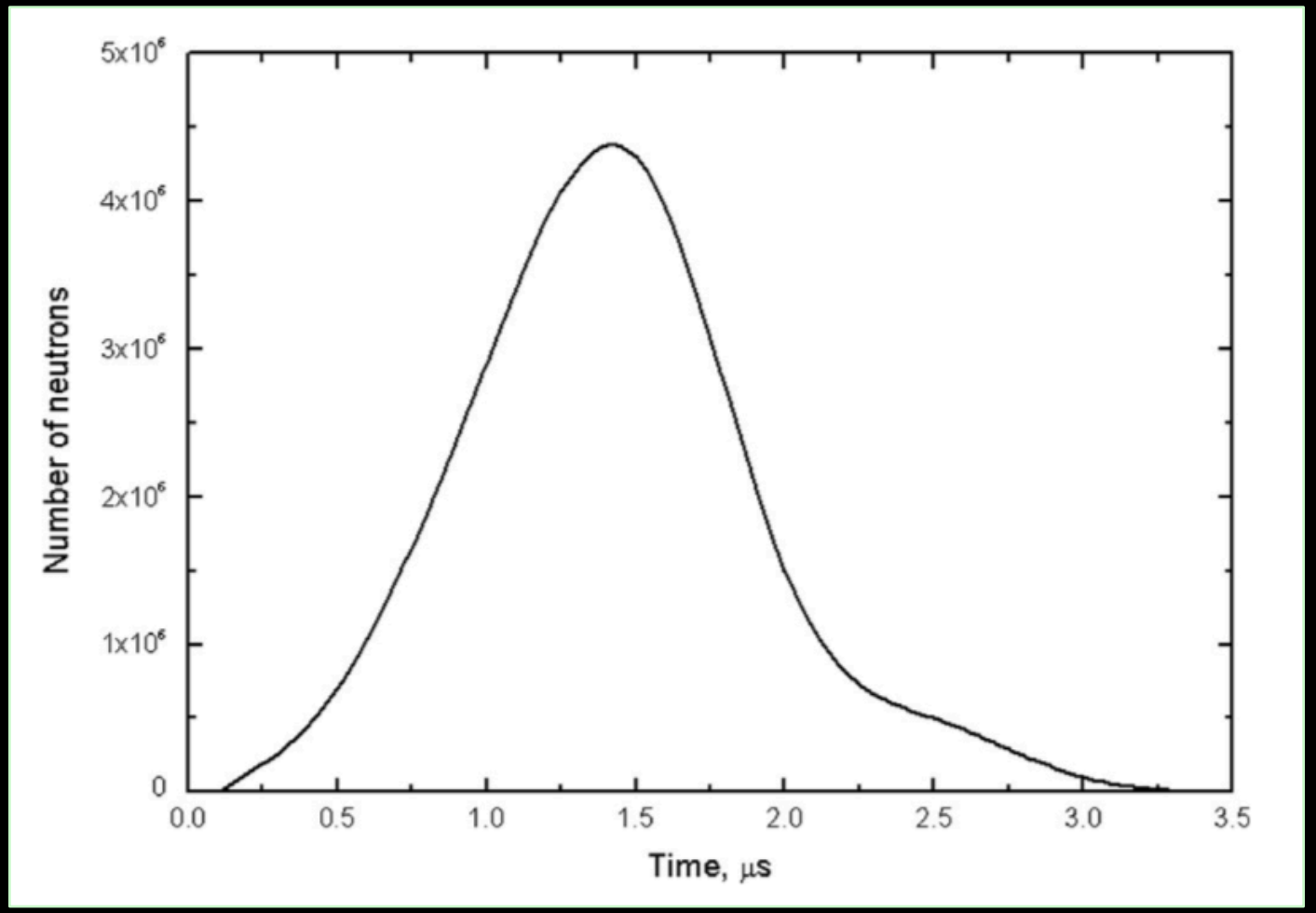
CETN
6.4 cm

CTN
6.4 cm

Geant4 Simulations

Primary Generator

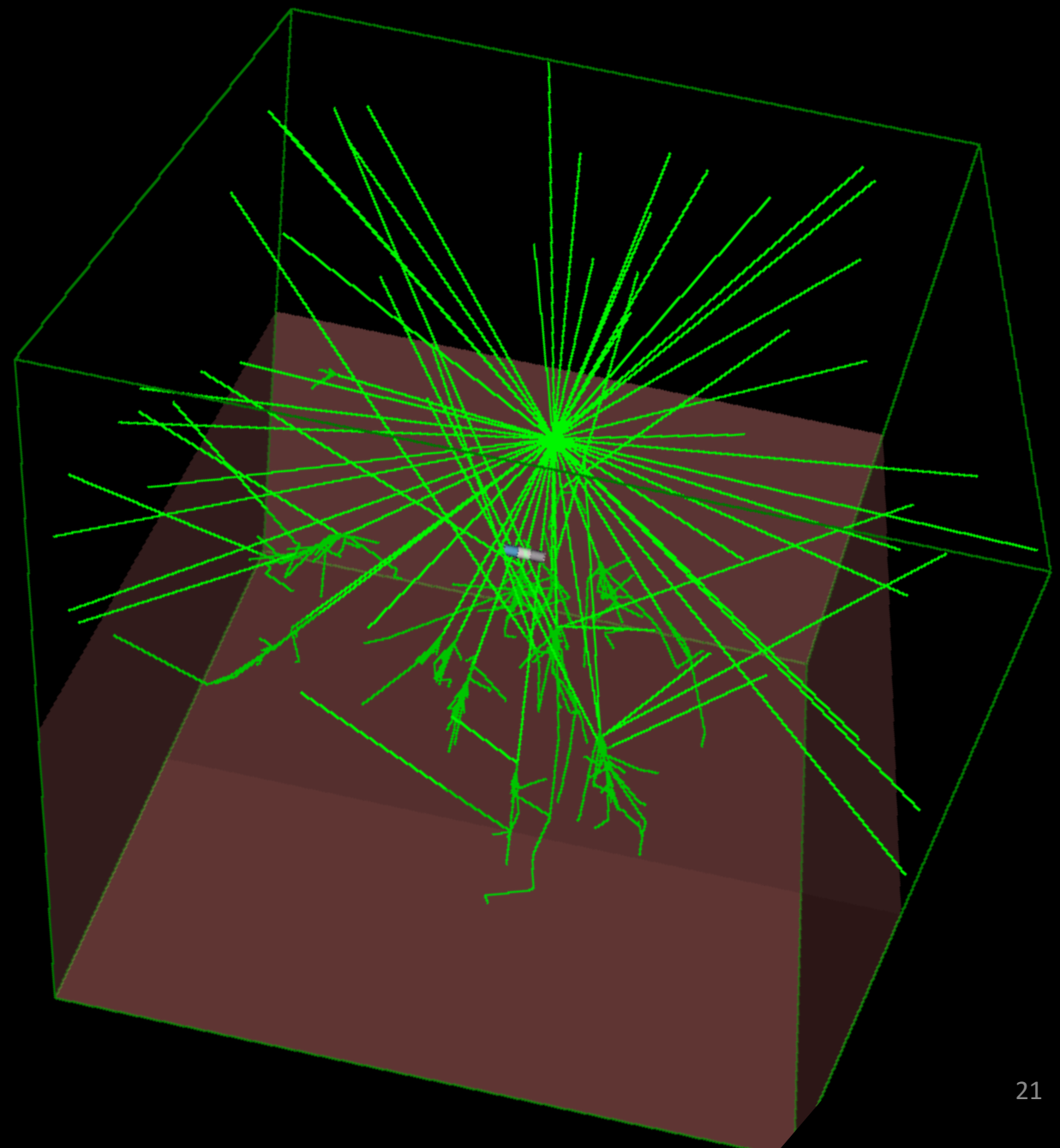
- PNG is 1 m away from the detectors, and 80 cm from the regolith.
- 14 MeV neutrons
- Isotropic
- Pulse description:
  - 50 μs: 7% primary neutrons
  - 100 μs : 29%
  - 150 μs : 43%
  - 200 μs : 15%
  - 250 μs : 5%
  - 300 μs : 1%



(Sanin et al., 2015)

Project Status

- Skeleton Code has been written
- Benchmark Geant4 code with MCNPX simulations
- Verify Litvak et al., 2014 results
- Create die-away curve library
  - WEH at 0.1 wt% intervals
  - AEC at 0.5 wt% intervals
  - Depth of second layer at 1 cm intervals
- Correlate best fit to the geology of Yellowknife Bay



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