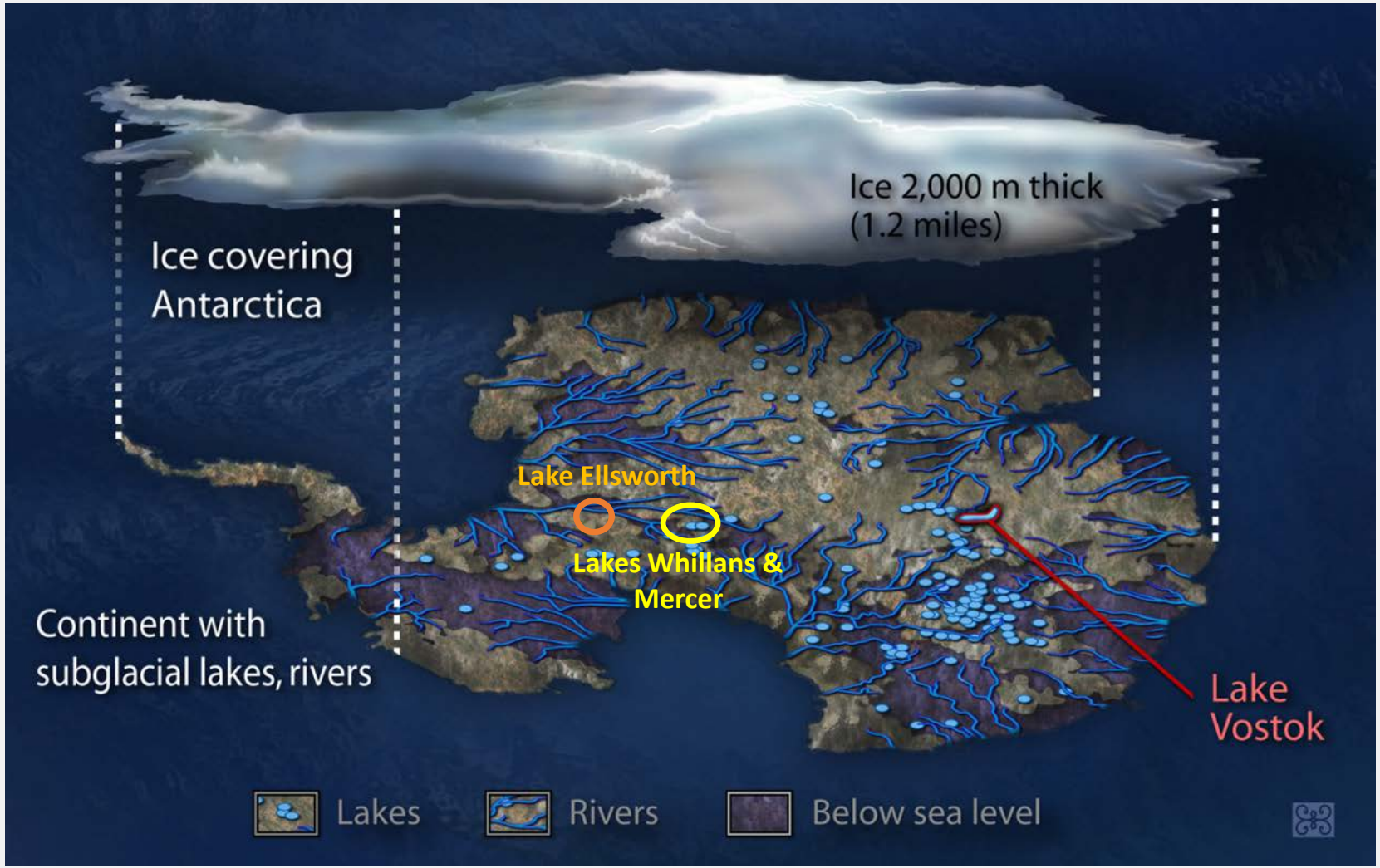
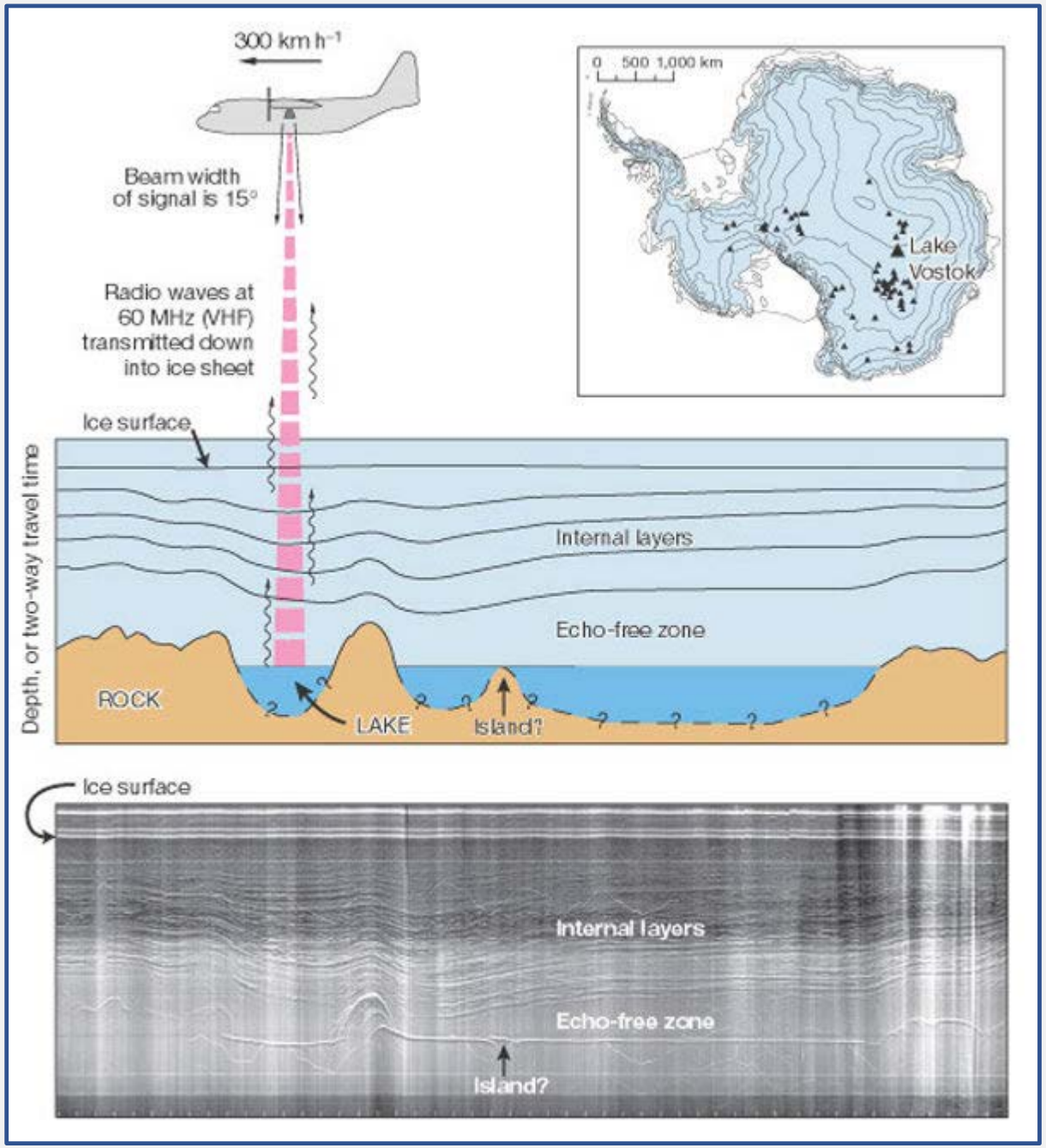
Antarctic Subglacial Lakes:
What if we could look beneath the Antarctic ice sheet?



Priscu et al. 2009


300 km h⁻¹
Beam width of signal is 15°
Radio waves at 60 MHz (VHF) transmitted down into ice sheet
0 500 1,000 km
Lake Vostok
Ice surface
Depth, or two-way travel time
Internal layers
Echo-free zone
ROCK
LAKE
Island?
Ice surface
Internal layers
Echo-free zone
Island?

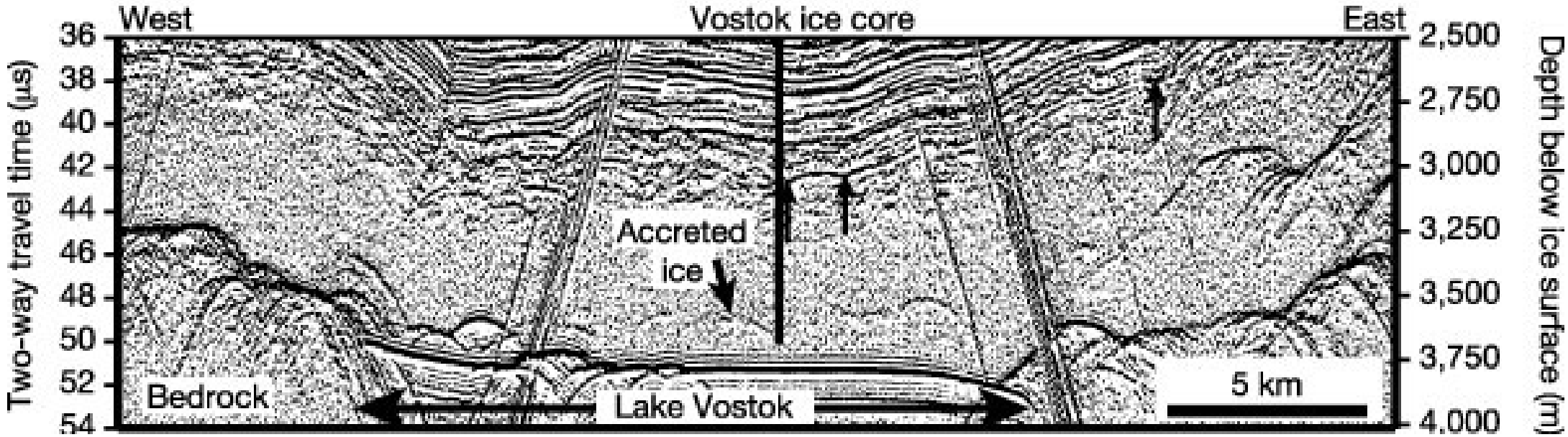
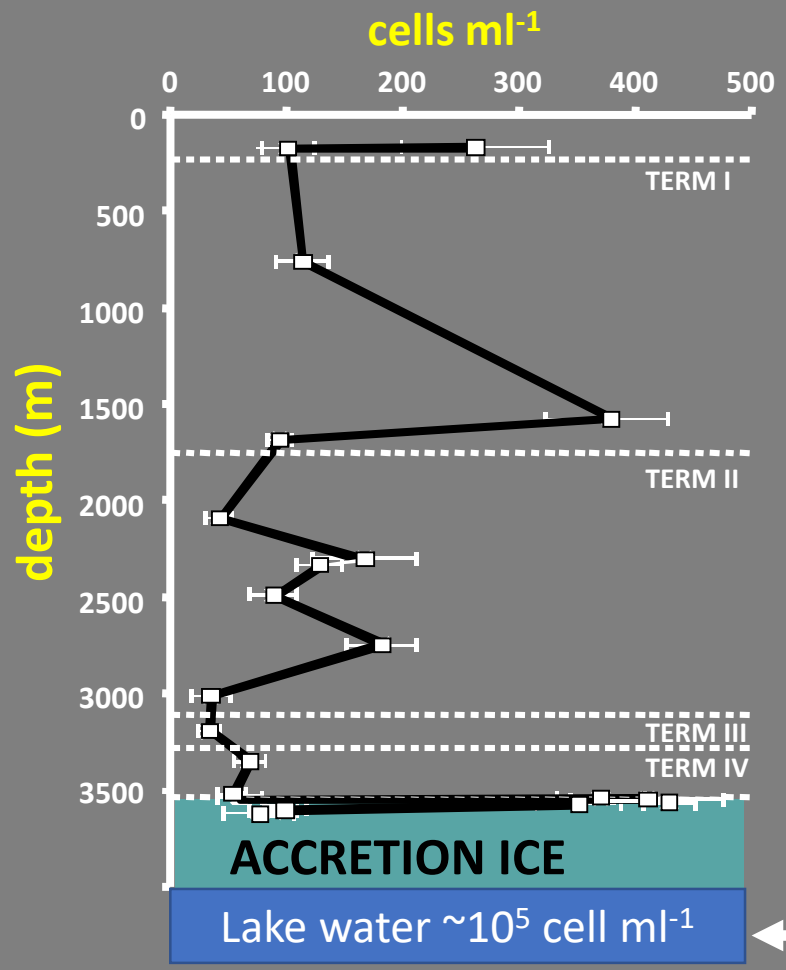


Figure 2: Airborne ice-penetrating radar data through the Vostok core site transverse to the ice flow. The internal layers are the rugged, roughly horizontal features in the upper half of the image. The lake is the strong flat reflector between 50 and 51 s two-way travel time (3,745 m below the ice surface at the Vostok core site). The ice sheet sags as it enters the lake on the western grounding line, and compresses as it flows out to the east. The bounding topography is the rough feature on the western and eastern side of the image. The accreted ice layer is noted at 49 s—3,570 m below the surface. The accreted ice layer is observed to the east of the lake between the base of the internal reflectors and the subglacial topography. Three of the features in the internal layers traced to generate the flowlines are indicated with arrows. Vostok station appears as a major surface diffractor, roughly centered over the core site.

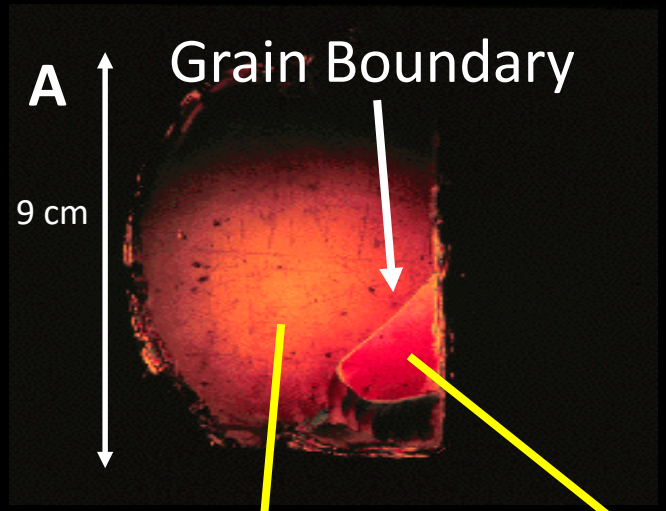
From R. Bell

Bacterial Counts in the Vostok ice core



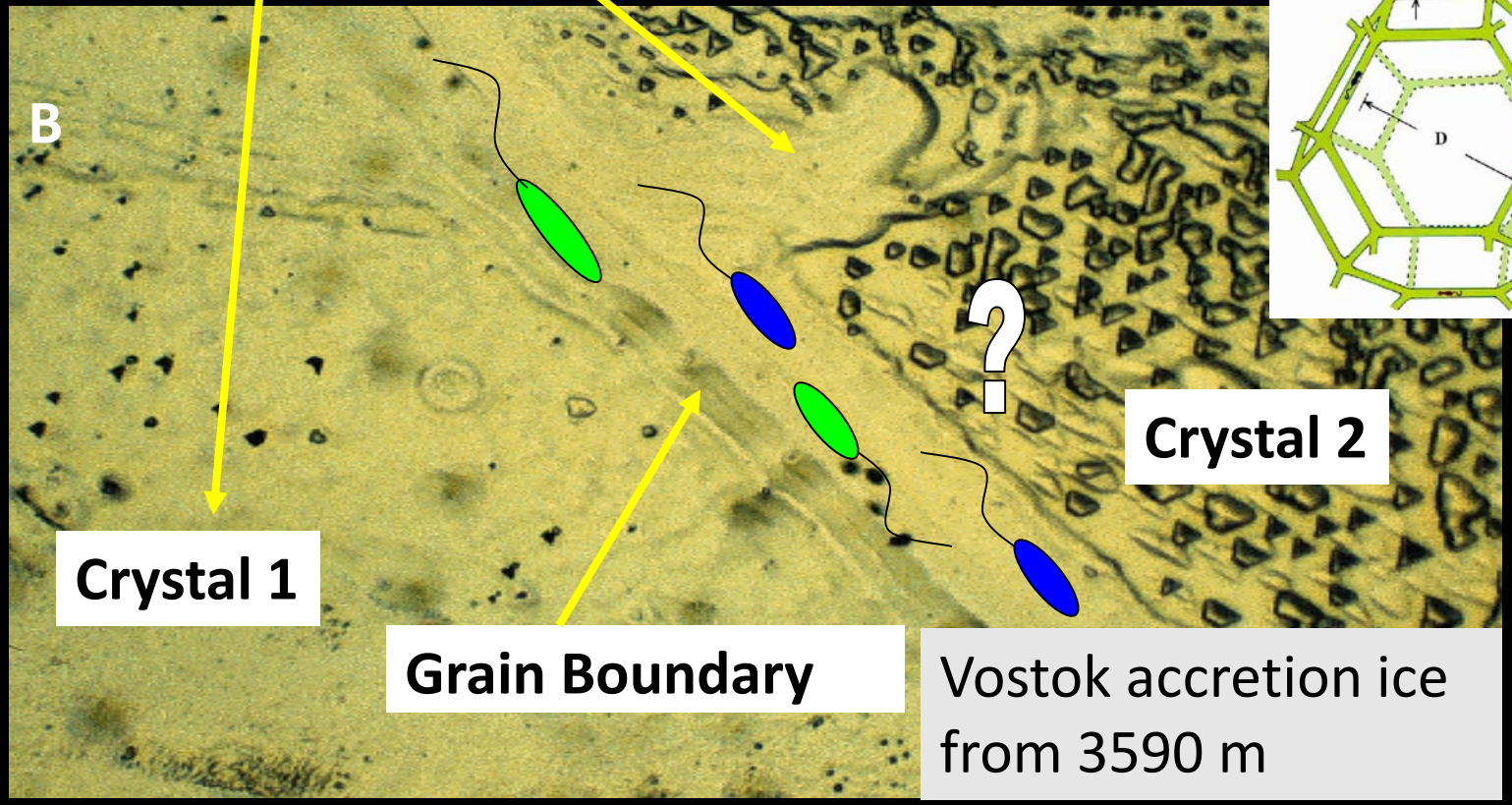
Christner et al. 2006
Priscu et al. 2008

Obtained using segregation coefficients from a permanently ice-covered lake in the McMurdo Dry Valleys



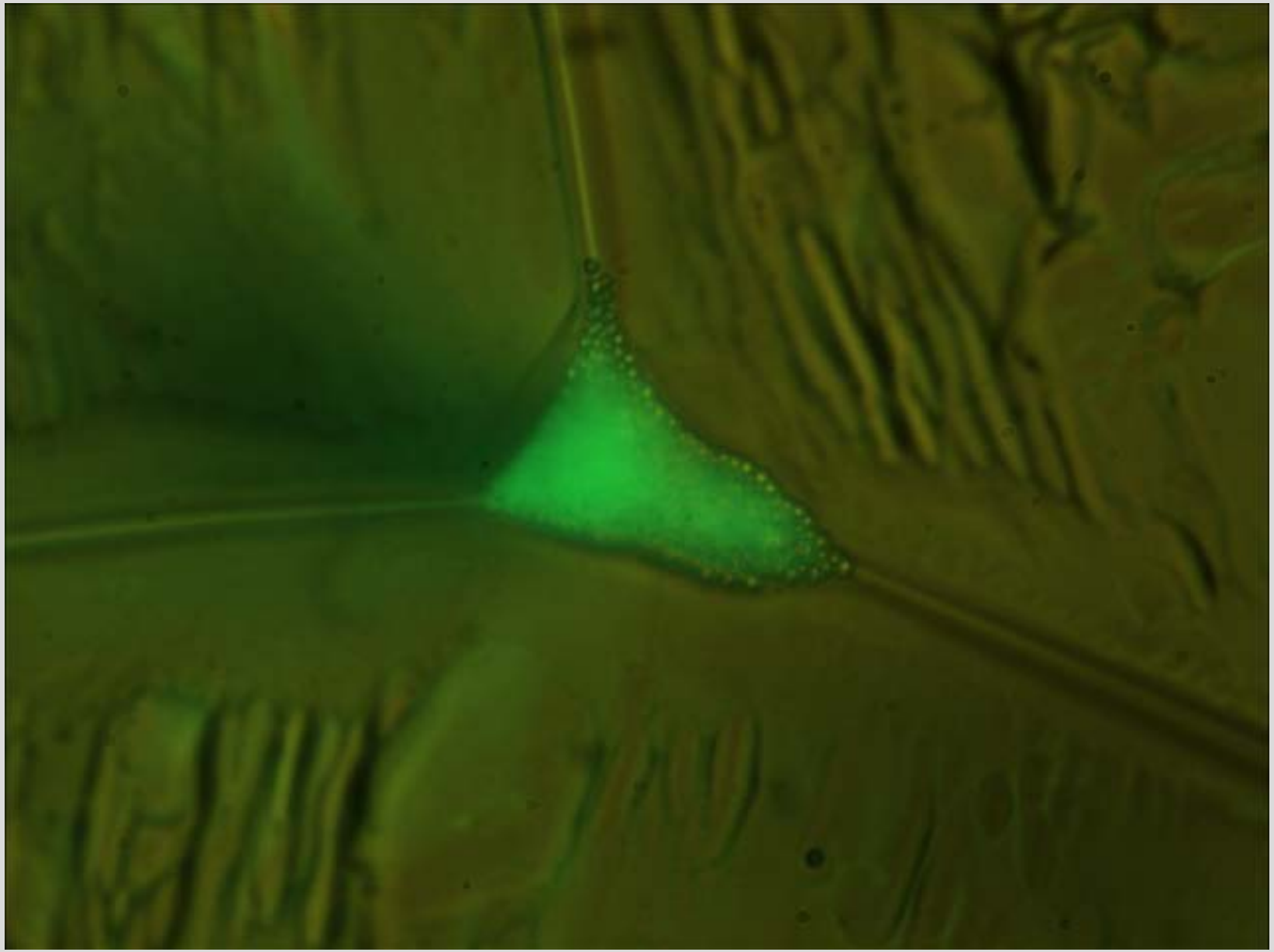
IS THERE METABOLISM IN SOLID ICE?

The boundaries between crystal grains in deep ice may provide a viable liquid habitat for microbes. “A” polarized light image; “B” microscopic image.

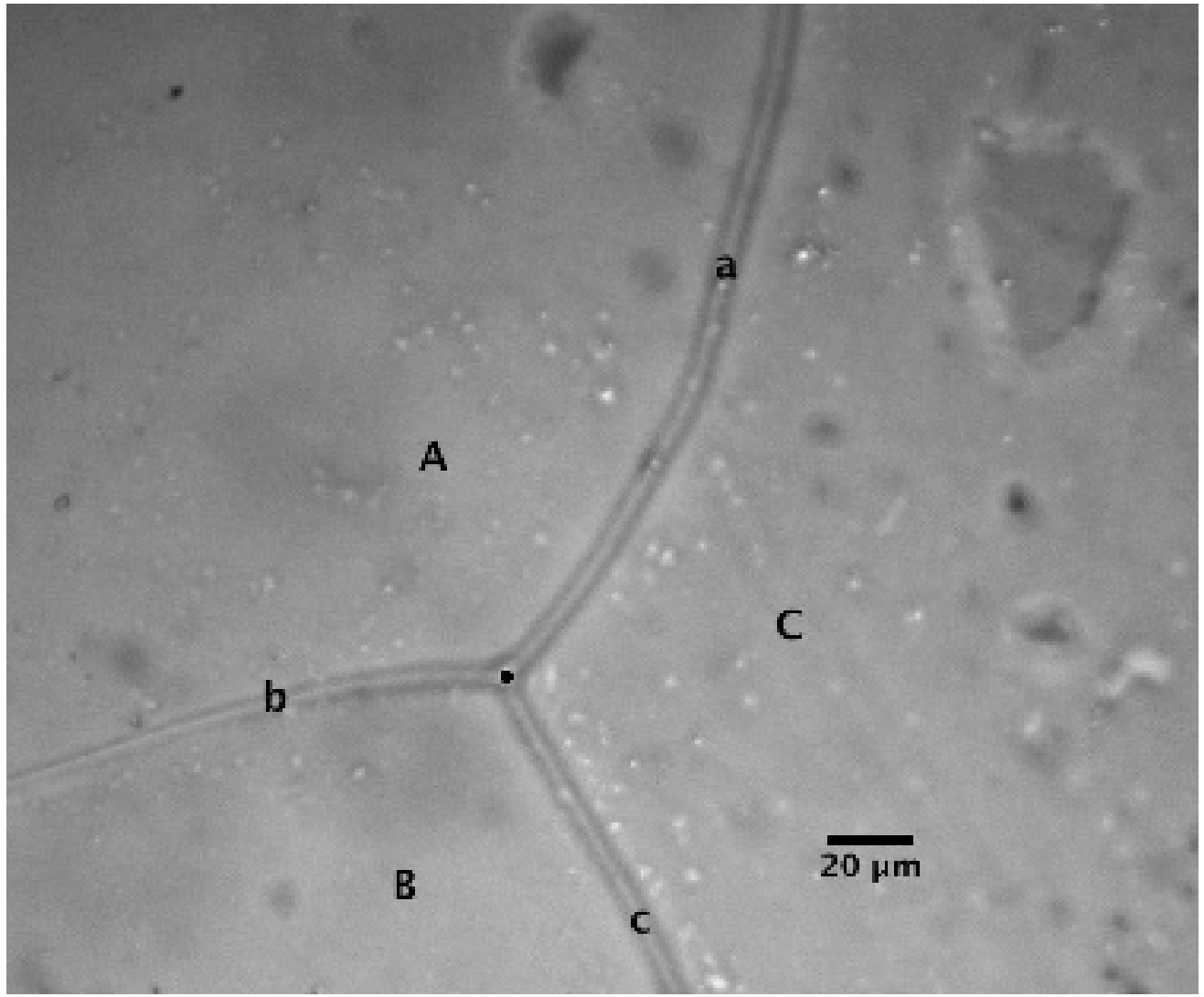


Vostok accretion ice from 3590 m

1 micron fluorescent beads in an ice vein



Micro-Raman analysis of ice vein µ-environments: Analysis of glacial samples from Greenland and Antarctica



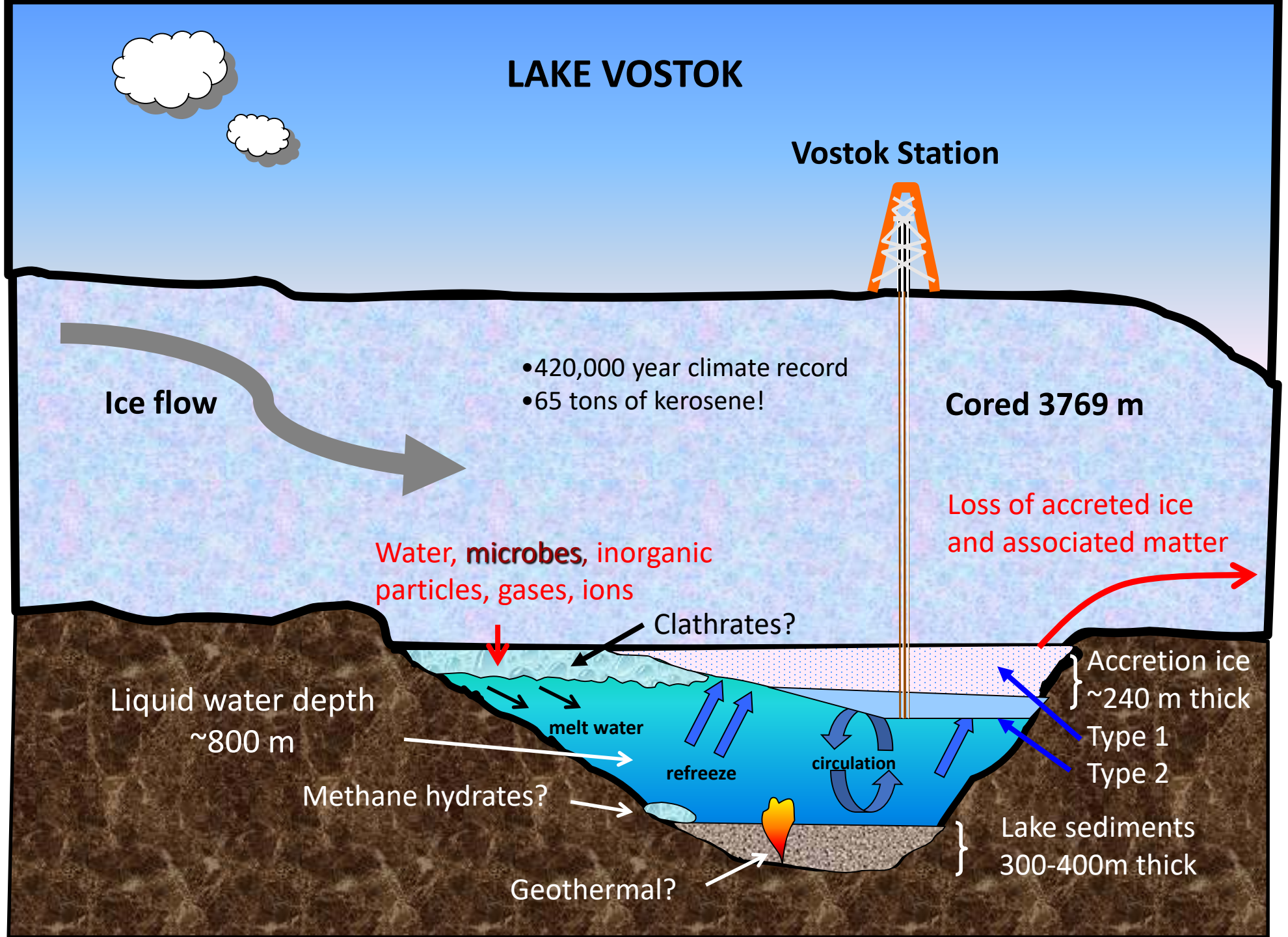
GISP 2 core at a depth of 146.39 to 146.46 m

We estimate that the vein volume provides 16.7 km^3 and 576 km^3 of habitable space within the Greenland and Antarctic ice sheets, respectively, which could support the metabolism of organisms that are capable of growing in cold, high ionic strength (mM-M) solutions with pH ~3.

Vein pH ~3 coupled with high ionic strength = hard place for cell growth!!

Cells will eventually run out of free energy to metabolize!

Barletta, R.E., J.C. Priscu, H.M. Mader, W.L. Jones and C.W. Roe. 2012. J. Glaciology, 58:1109-1118


LAKE VOSTOK
Vostok Station
Ice flow
•420,000 year climate record
•65 tons of kerosene!
Cored 3769 m
Loss of accreted ice
and associated matter
Water, microbes, inorganic
particles, gases, ions
Clathrates?
Liquid water depth
~800 m
melt water
refreeze
circulation
Accretion ice
~240 m thick
Type 1
Type 2
Methane hydrates?
Lake sediments
300-400m thick
Geothermal?

Effective segregation coefficients (k_{eff}) from a mesocosm experiment on Sukok Lake water (Northern Alaska).

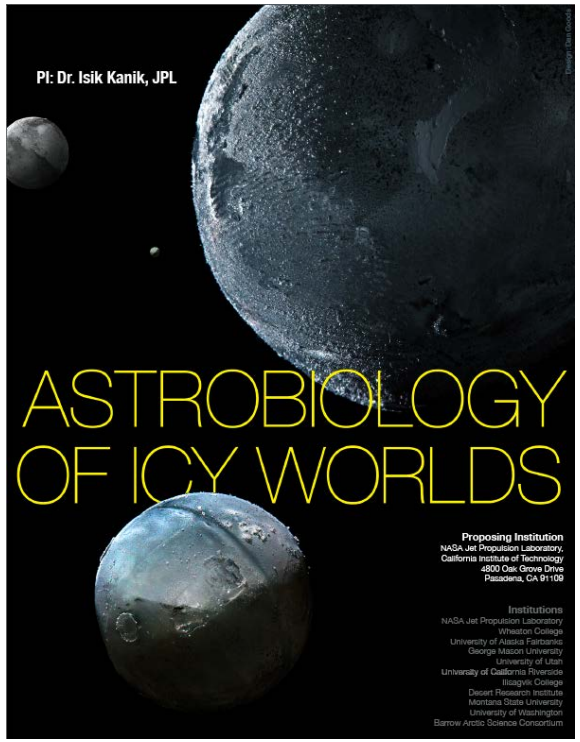
Freeze-Down Experiment: Phase 1

~8cm of insulation around the tub

- Ambient temperature was -10°C with cold ceiling at -50°C

- Conductivity increased from 67.9 µS/cm at 1% of water frozen to 646 µS/cm at 98% of water frozen

- Sedimentation of organic matter as a result of freezing



Problems with biosignatures in accretion ice:

- Segregation upon freezing will produce biological signatures near limits of detection
- Differential segregation of various constituents will lead to ambiguous results
- We have played the “biosignature game” for decades on Mars—and we still know little about life on Mars!

* Liquid water lenses cannot support extant life without energy disequilibrium (ie, constant REDOX gradient)