Underglacial lake Vostok in Antarctida

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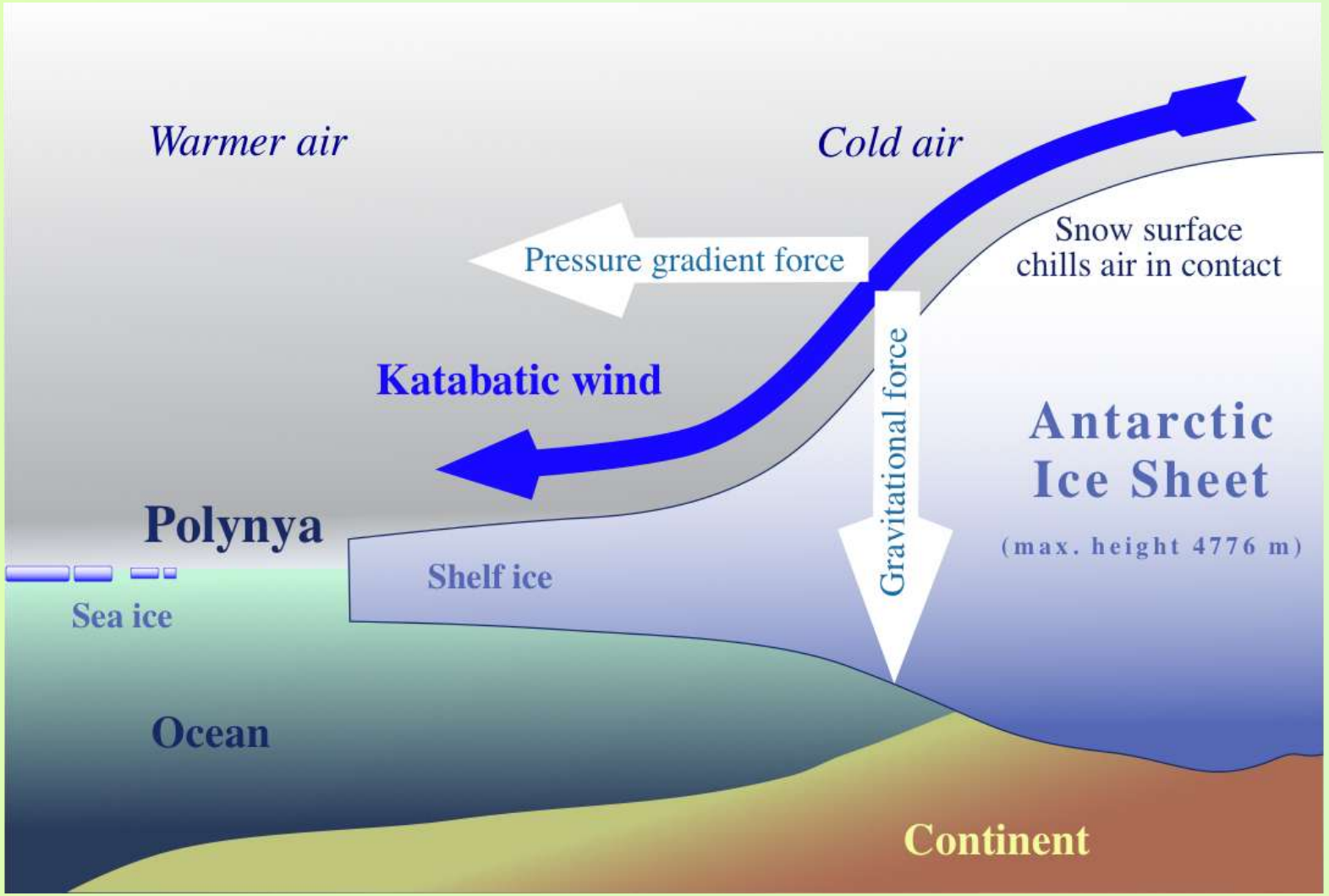
Antarctic geography

- **In 1959 International agreement about Antarctica was concluded. It tells that Antarctica can be used only for scientific research,**
- **All nuclear explosions and storage nuclear waste is forbidden.**
- **Mean height of Antarctic surface ia a biggest one.**
- **Besides of pole of cold the points of lowest relative atmospheric humidity, strongest and long wind, most intensive sun radiation are situated there**
- **USA: south pole (Amundsen-Scott**
- **Russia: the pole of relative inaccessibility and geomagnetic pole (Vostok)**

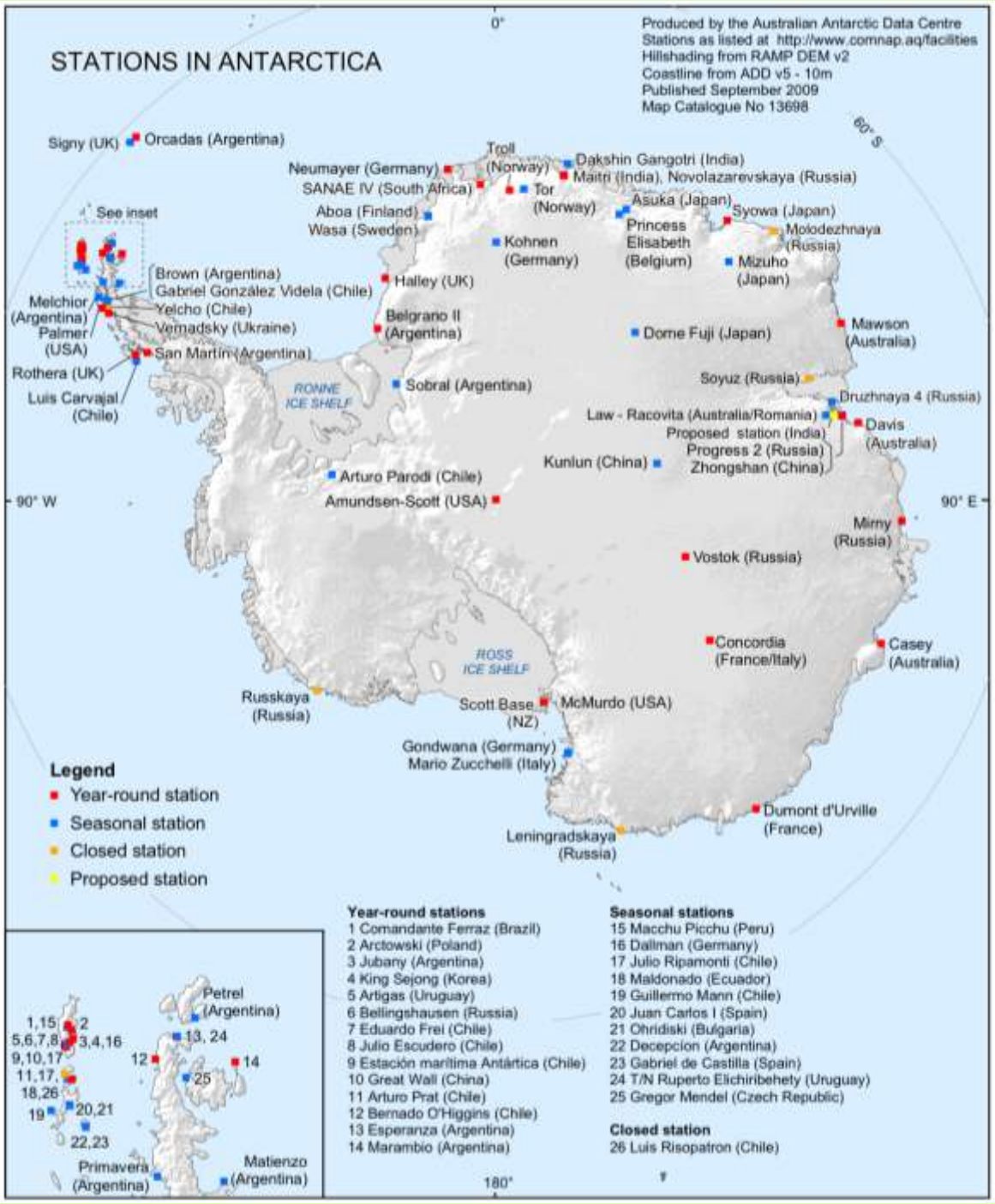
Climate

Since April to November

Wind is blowing as hurricane

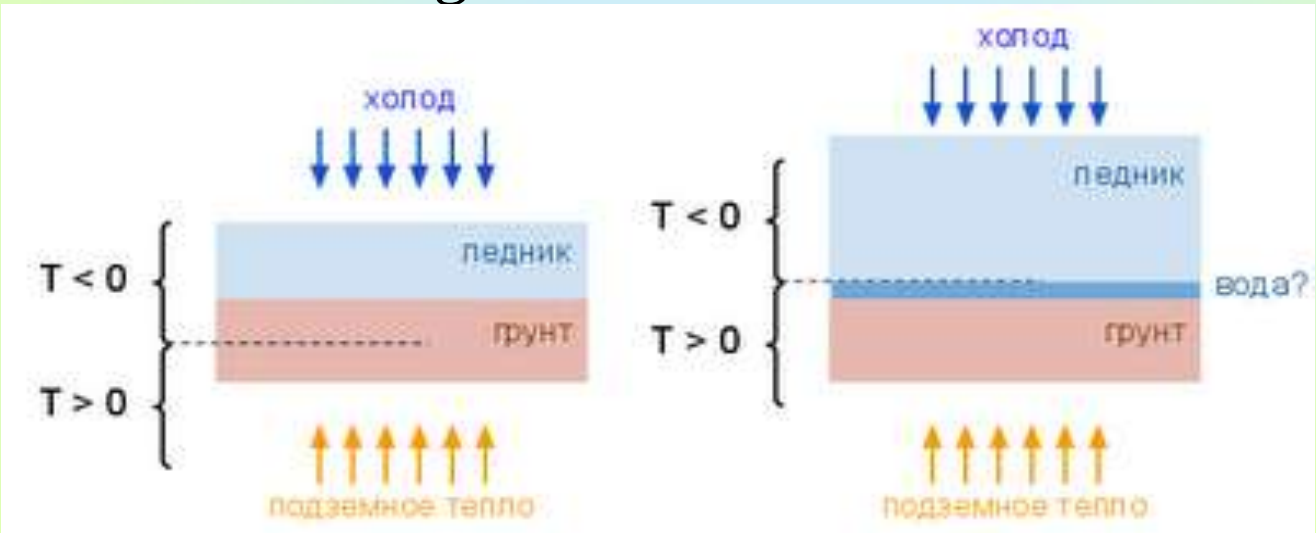


http://commons.wikimedia.org/wiki/File:Katabatic-wind_hg.png#/media/File:Katabatic-wind_hg.png


STATIONS IN ANTARCTICA
Produced by the Australian Antarctic Data Centre
Stations as listed at http://www.comnap.aq/facilities
Hillshading from RAMP DEM v2
Coastline from ADD v5 - 10m
Published September 2009
Map Catalogue No 13698
0°
90° W
90° E
180°
60° S
Signy (UK)
Orcadas (Argentina)
See inset
Neumayer (Germany)
SANAE IV (South Africa)
Troll (Norway)
Dakshin Gangotri (India)
Maitri (India), Novolazarevskaya (Russia)
Tor (Norway)
Aboa (Finland)
Wasa (Sweden)
Asuka (Japan)
Syowa (Japan)
Princess Elisabeth (Belgium)
Molodezhnaya (Russia)
Kohnen (Germany)
Mizuho (Japan)
Brown (Argentina)
Gabriel González Videla (Chile)
Yelcho (Chile)
Vernadsky (Ukraine)
Melchior (Argentina)
Palmer (USA)
San Martín (Argentina)
Rothera (UK)
Luis Carvajal (Chile)
Halley (UK)
Belgrano II (Argentina)
Dome Fuji (Japan)
Mawson (Australia)
RONNE ICE SHELF
Sobral (Argentina)
Soyuz (Russia)
Druzhnaya 4 (Russia)
Law - Racovita (Australia/Romania)
Proposed station (India)
Progress 2 (Russia)
Zhongshan (China)
Davis (Australia)
Kunlun (China)
Arturo Parodi (Chile)
Amundsen-Scott (USA)
Mirny (Russia)
Vostok (Russia)
Concordia (France/Italy)
Casey (Australia)
ROSS ICE SHELF
Russkaya (Russia)
Scott Base (NZ)
McMurdo (USA)
Gondwana (Germany)
Mario Zucchelli (Italy)
Dumont d'Urville (France)
Leningradskaya (Russia)
Legend
Year-round station
Seasonal station
Closed station
Proposed station
Petrel (Argentina)
1,15
2
5,6,7,8
3,4,16
9,10,17
11,17
18,26
19
20,21
22,23
12
13, 24
14
25
Primavera (Argentina)
Matienzo (Argentina)
Year-round stations
1 Comandante Ferraz (Brazil)
2 Arctowski (Poland)
3 Jubany (Argentina)
4 King Sejong (Korea)
5 Artigas (Uruguay)
6 Bellingshausen (Russia)
7 Eduardo Frei (Chile)
8 Julio Escudero (Chile)
9 Estación marítima Antártica (Chile)
10 Great Wall (China)
11 Arturo Prat (Chile)
12 Bernado O'Higgins (Chile)
13 Esperanza (Argentina)
14 Marambio (Argentina)
Seasonal stations
15 Macchu Picchu (Peru)
16 Dallman (Germany)
17 Julio Ripamonti (Chile)
18 Maldonado (Ecuador)
19 Guillermo Mann (Chile)
20 Juan Carlos I (Spain)
21 Ohridiski (Bulgaria)
22 Decepcion (Argentina)
23 Gabriel de Castilla (Spain)
24 T/N Ruperto Elichiribehety (Uruguay)
25 Gregor Mendel (Czech Republic)
Closed station
26 Luis Risopatron (Chile)

Underglacial lakes milestons

- 1955 N.N. Zubov Introduce the critical value of glacial thickness that is determined the flux of geothermal heat and temperature gradient is determined thermal conductivity.
- 1955 Gordon K Robin Introduce the flux of cold directed to bottom of glacier with moving of ice as mass
- 1961 I.A. Zotikov have shown that in case of thick glacier the heat practically does not go up. It is spent for melting of ice in the bad of glacier.



Map of possible places for underglacial lakes (1963)

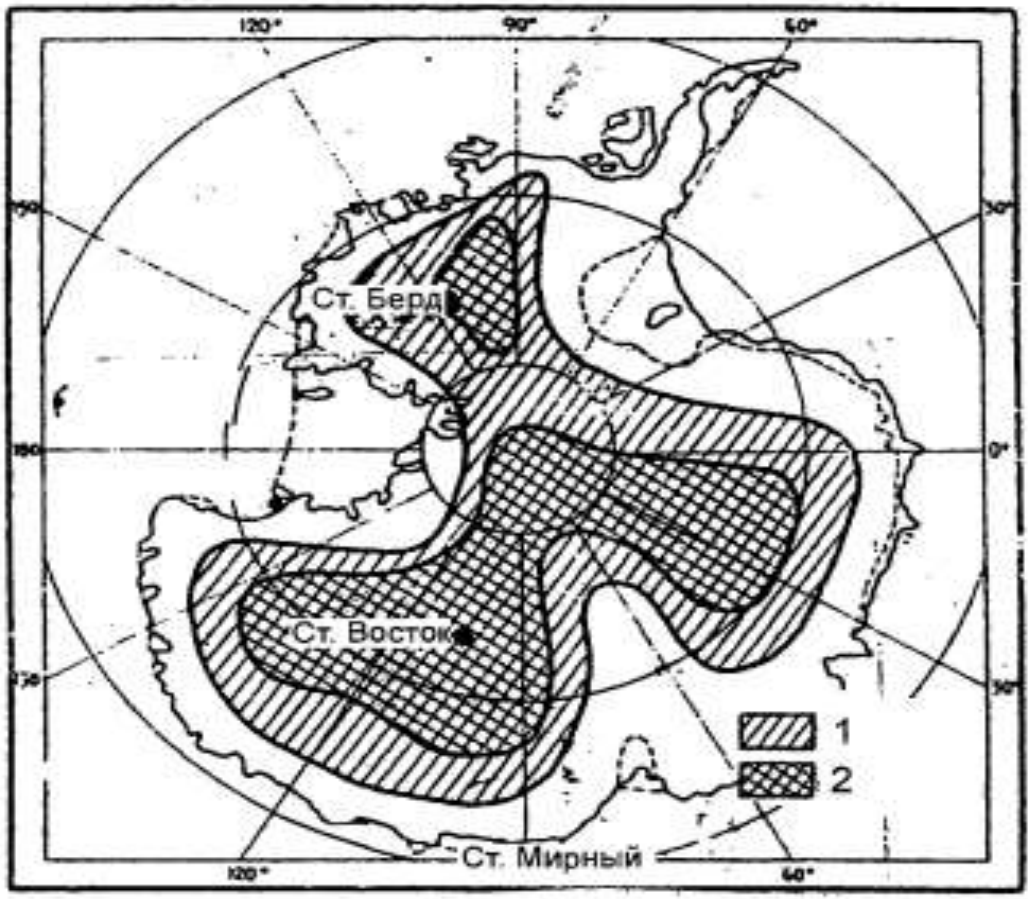
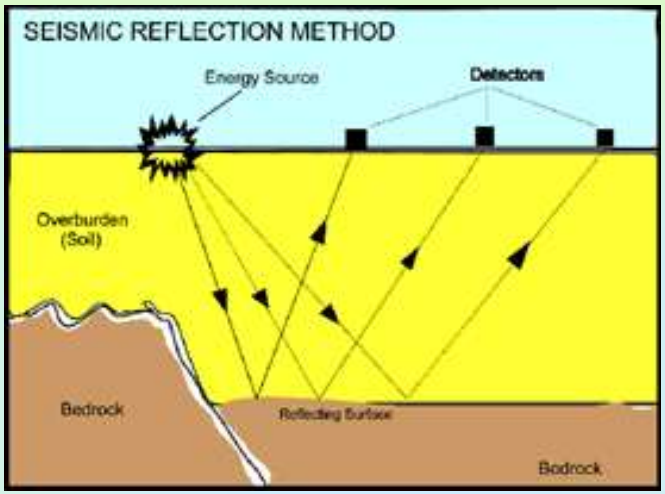
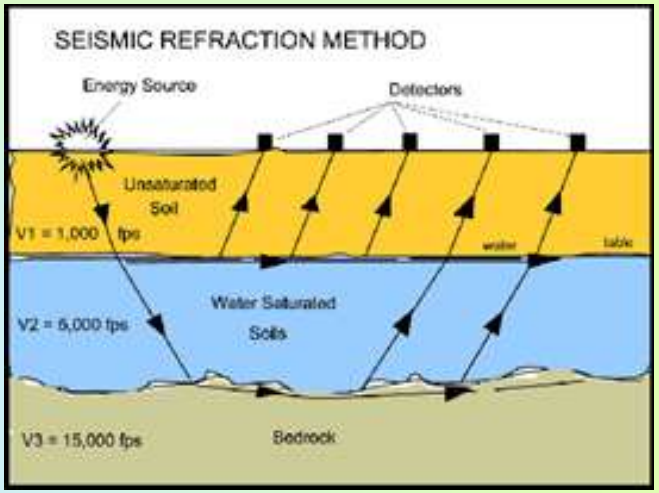


Рис. 2.9. Карта Антарктиды (Зотиков, 1963), на которой показаны зоны постоянного донного таяния льда в центральной части антарктического ледникового покрова. 1 – поток тепла к дну ледника снизу в 2 раза превышает средний геотермический поток (104 мвт/м^2). 2 – область таяния, рассчитанная в предположении, что снизу поступает только средний для земной поверхности геотермический поток тепла 52 мвт/м^2.

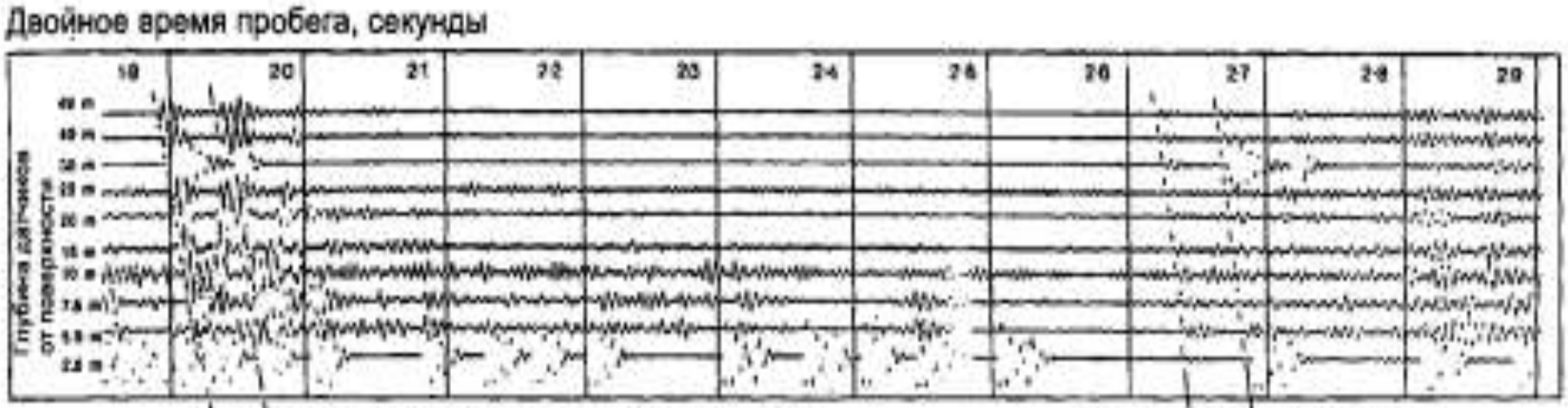
Seismic prospecting

A.P. Kapitsa
1964





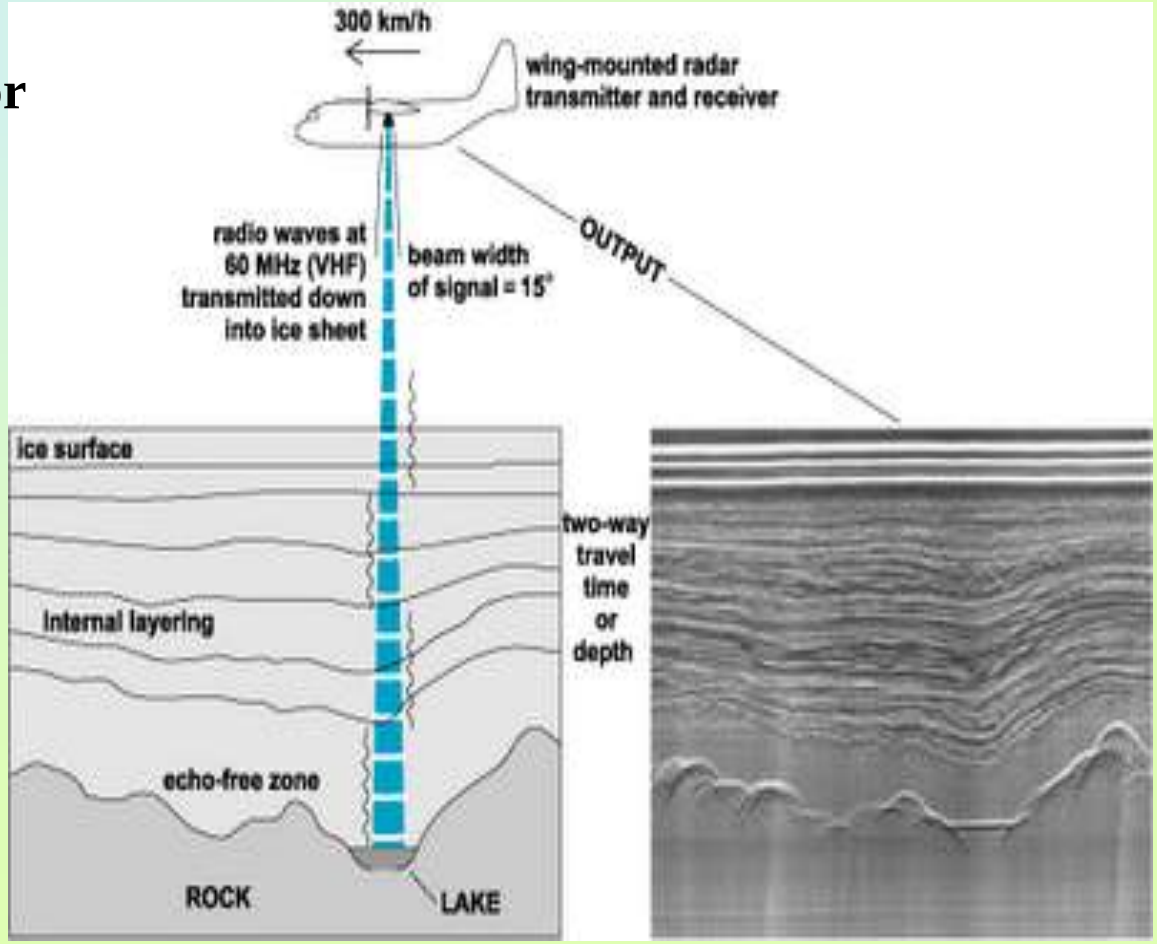
Single-reflection seismogram



Radiosonde observation

Radio waves penetrate through ice very well and are reflected of border between substances with different properties.
Since 60-th they were used for measuring the profile of underglacial surface.

Huge radio transparency was the problem for pilots as standard equipment gave wrong data



Lake Vostok

The discovery of **Lake Vostok** was reported at the **23rd session of SCAR in Rome** in **1994**

Data were published in ***Nature*** (**Kapitsa et al., 1996**)

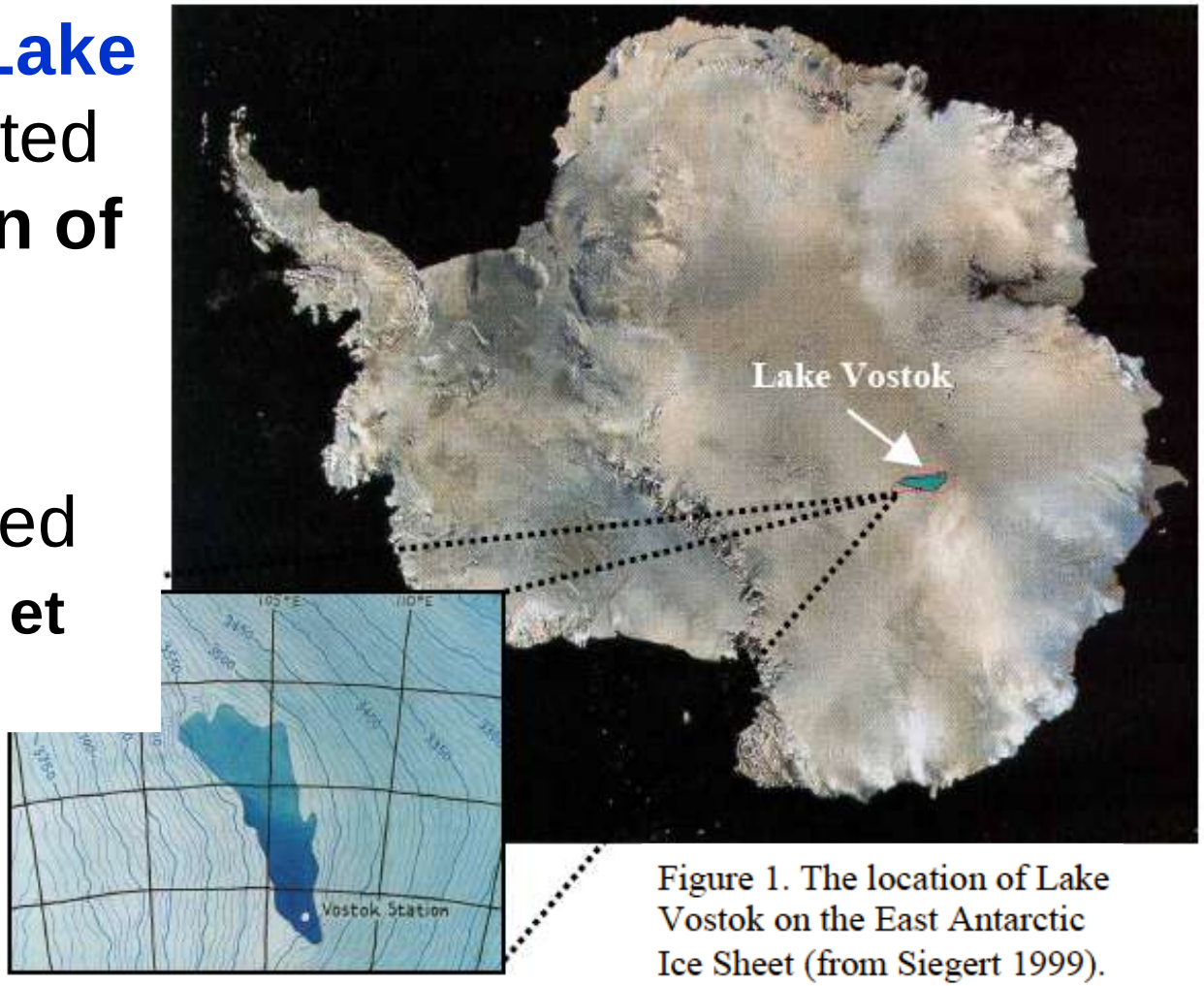
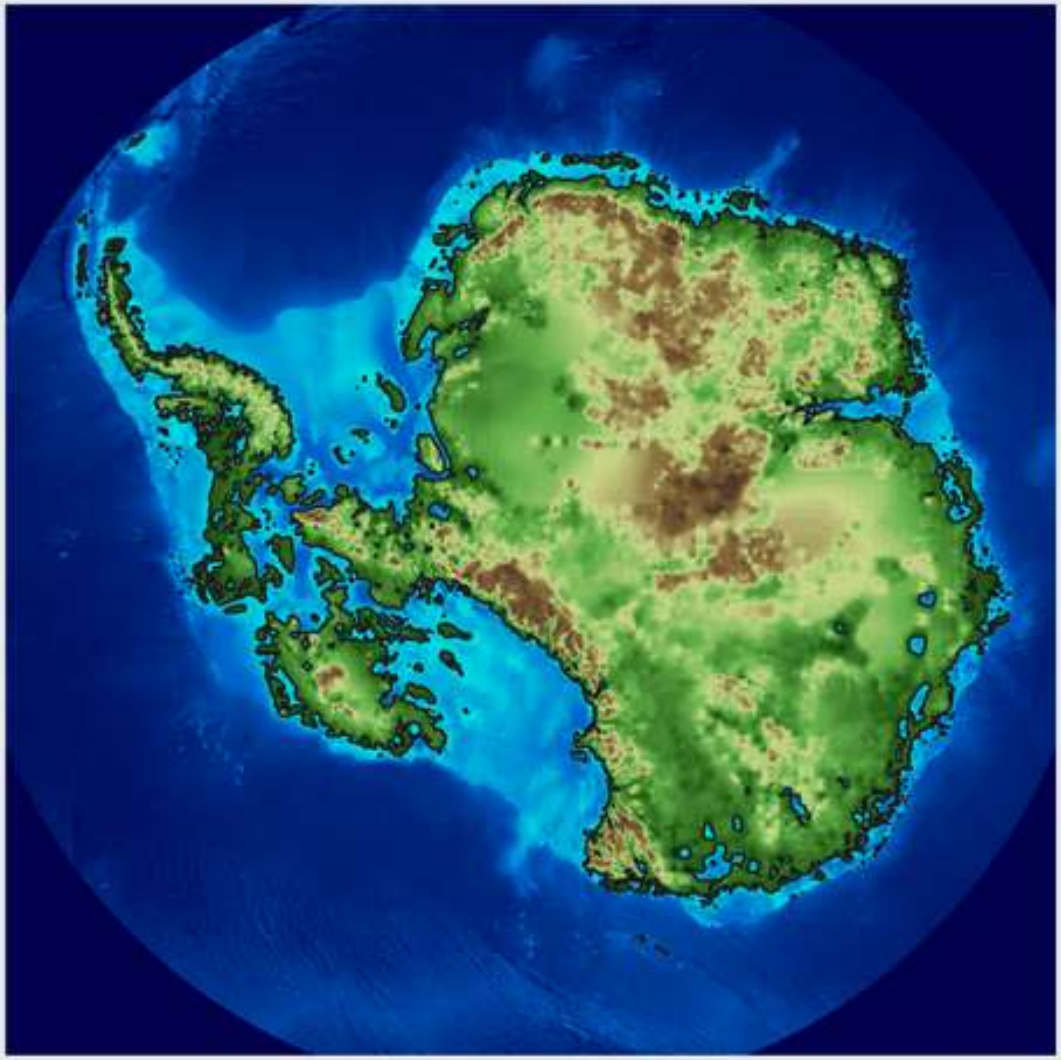
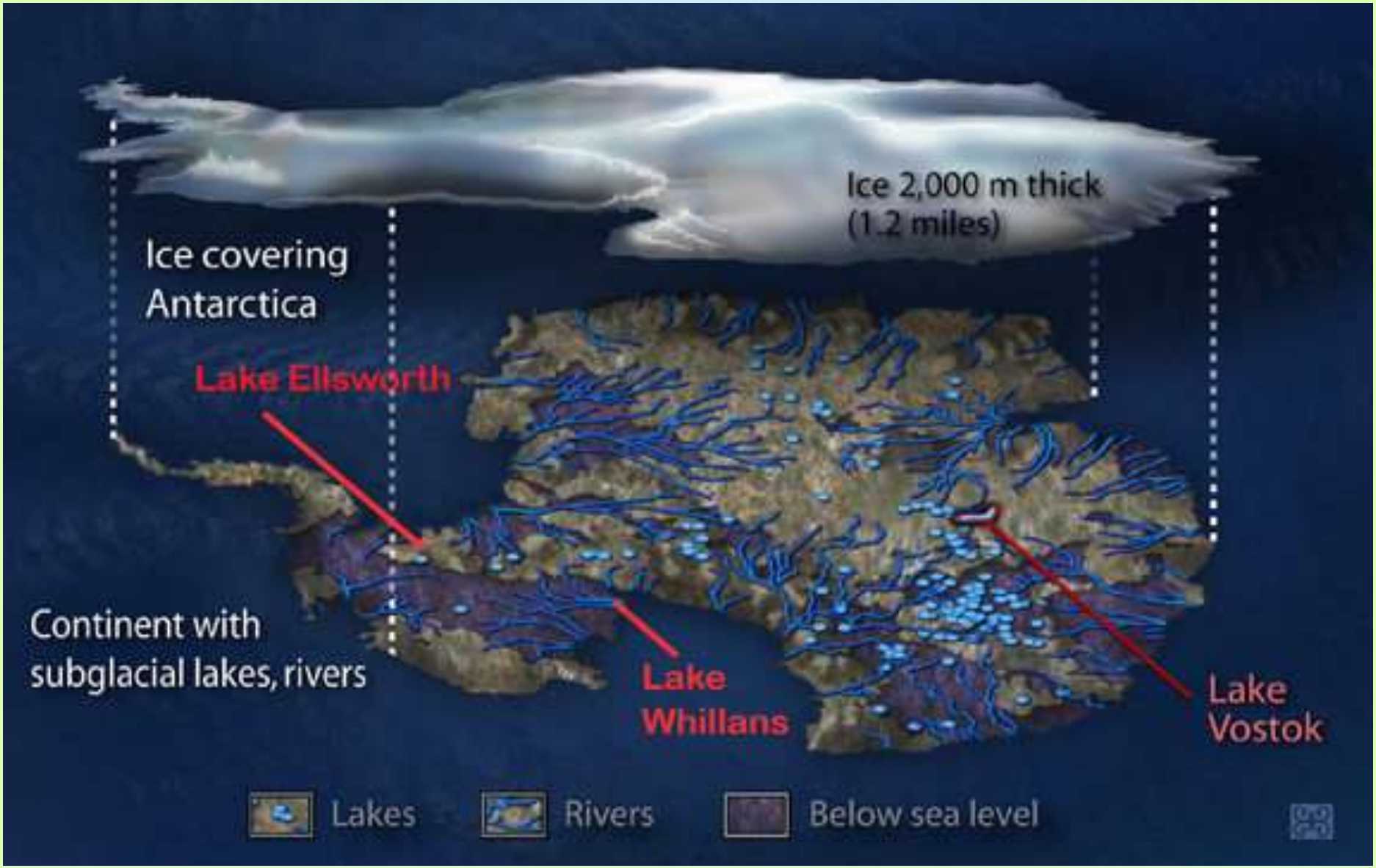


Figure 1. The location of Lake Vostok on the East Antarctic Ice Sheet (from Siegert 1999).

Deglaciated Antarctic Topography



Underglacial Antarctica



Vostok station (+3488m)

(78°S, 106°E) (since 1957)

1260 km from the coast

Absolute minimum -89.2°C
Average ann. Temp. -55.1°C

Lake Vostok (-3663m)

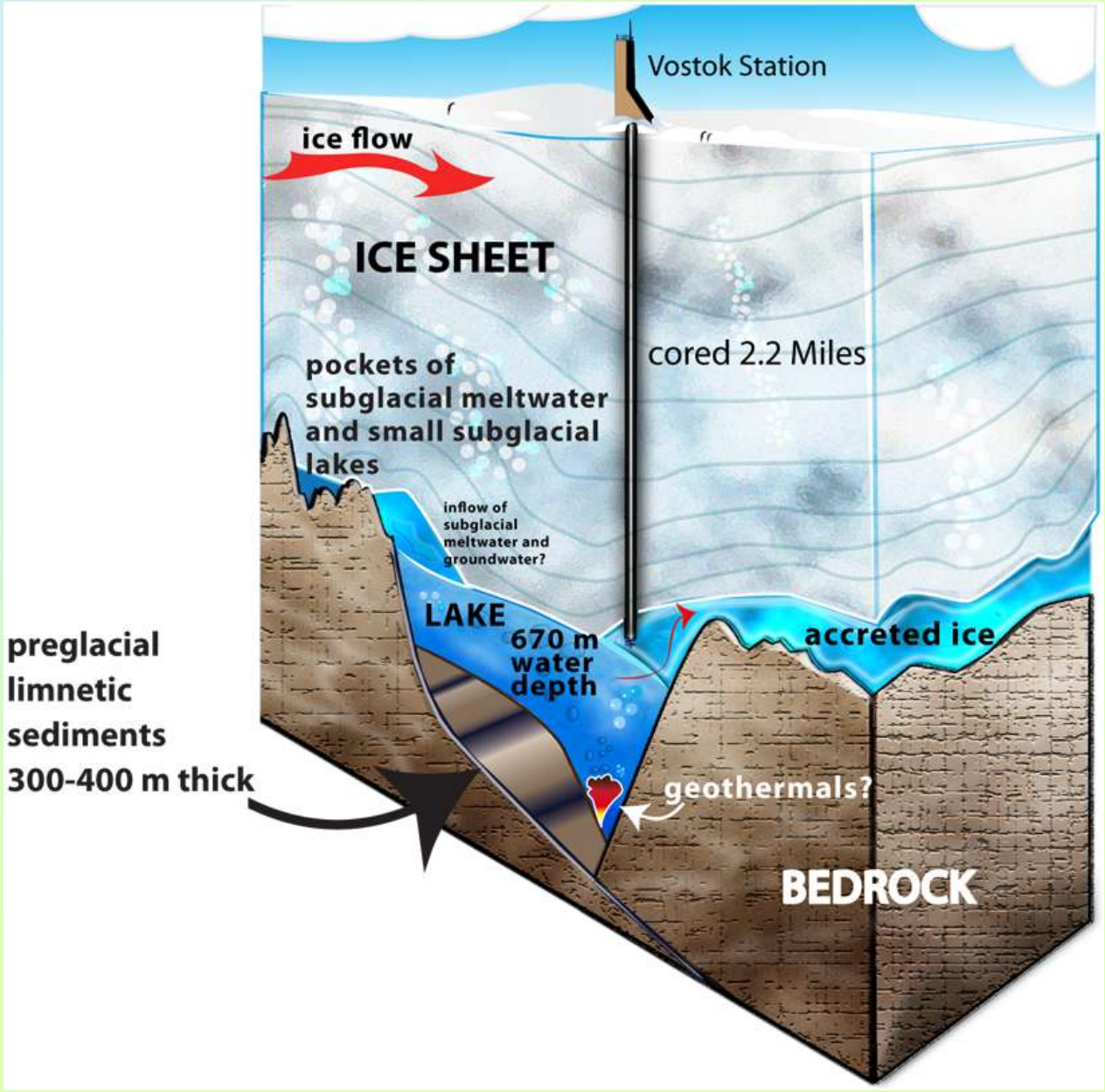
RADARSAT, CSA


ВОСТОК
ВОСТОК

Vostok lake

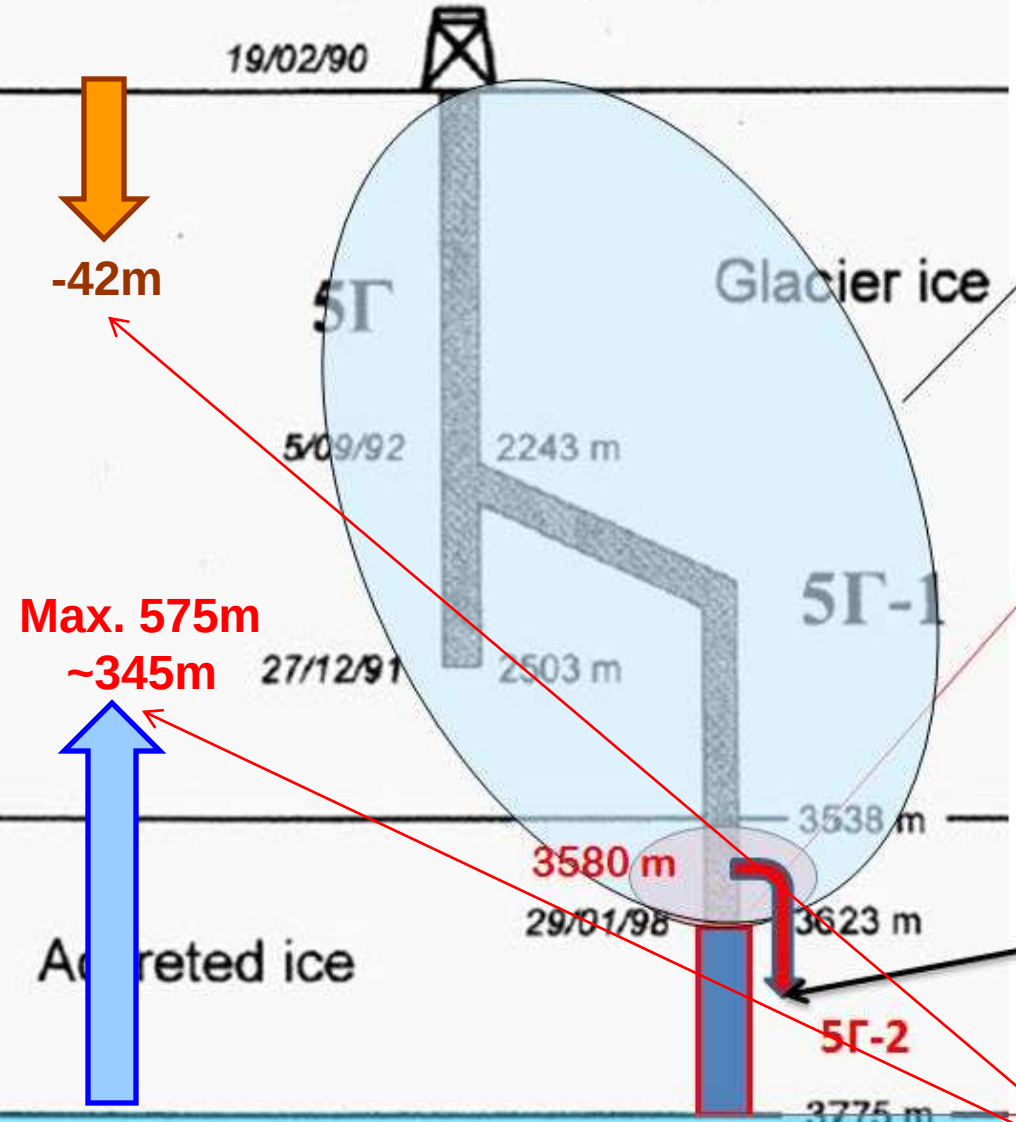

THE ANTARCTIC
The South Pole
Surface area
15,500 km²
The world's 15th largest lake.
It is the size of Chechnya
or a bit larger than Montenegro
The coastline is
1,010 km long
Water volume
6343 km³
Seventh largest
in the world
Maximum depth
More than
1,200 m
The world's
third deepest
(after Baikal
and Tanganyika)
Maximum length
250 km
Maximum width
50 km

Vostok lake


Vostok Station
ice flow
ICE SHEET
cored 2.2 Miles
pockets of subglacial meltwater and small subglacial lakes
inflow of subglacial meltwater and groundwater?
LAKE
670 m water depth
accreted ice
preglacial limnetic sediments 300-400 m thick
geothermals?
BEDROCK


ВОСТОК

5G-1[2] Vostok borehole



Russian-French-US collaborative program of Deep Drilling and Ice Core Study at Vostok station

Each party obtained 1/3 part of core

... stopped for almost 8 years

3650 m – 2005/06

3659 m – 2006/07

3667 m – 2007/08

3599 m – 2008/09

3650 m – 2009/10

~80m

3720 m - Jan 21, 2011

3750 m – ice-water boundary

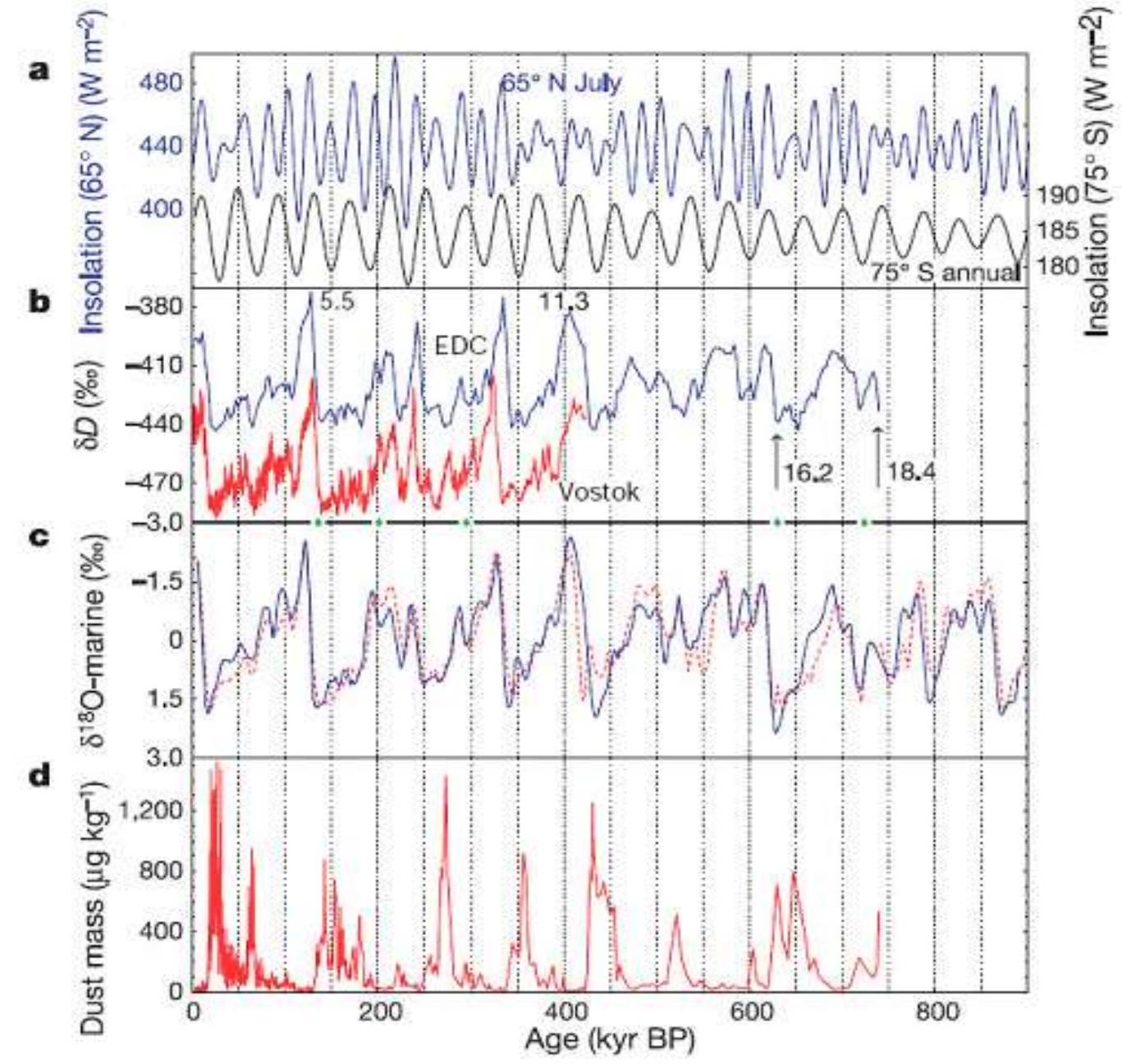
3769.3 m – Fev 05, 2012

Enter!

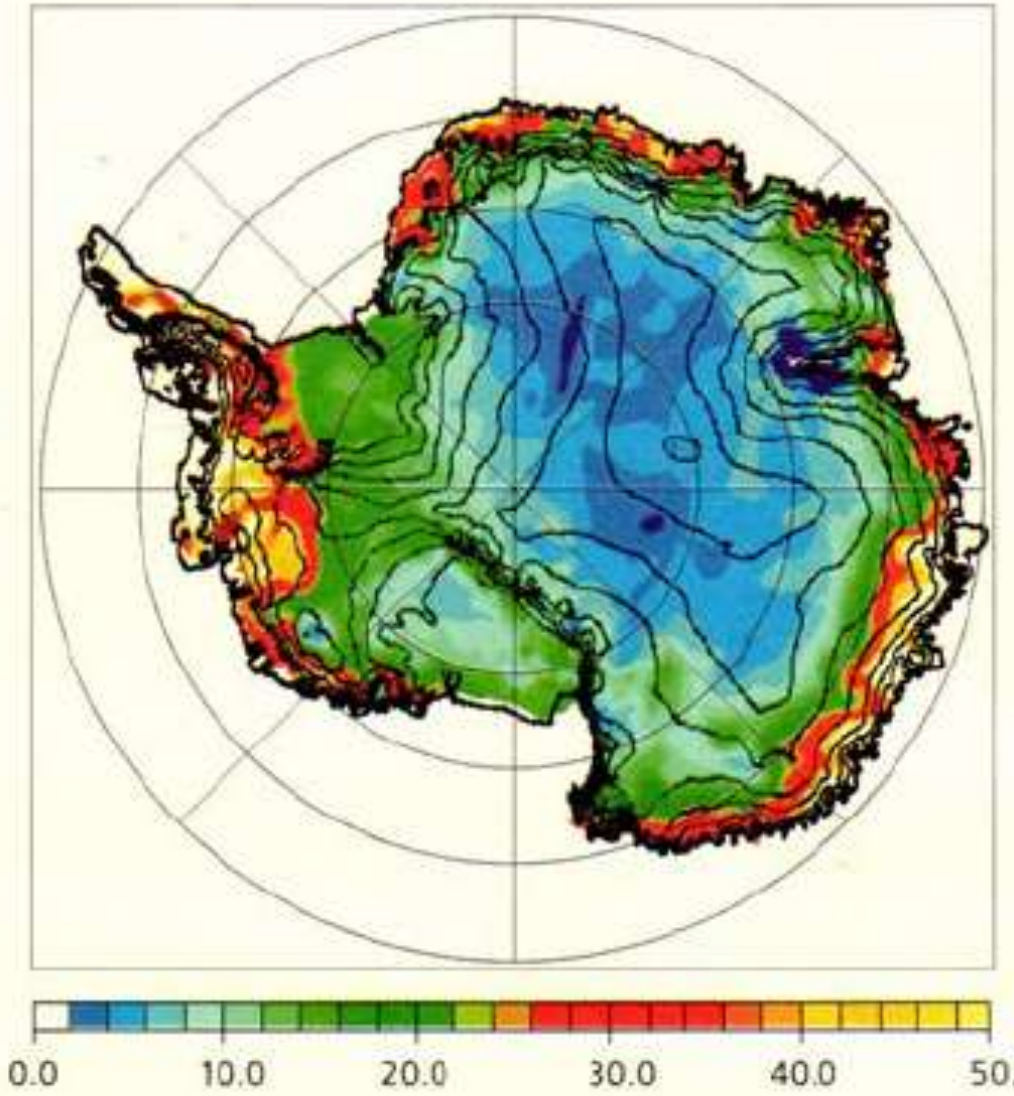
Bulat13 nov-20


05.02.12.
ст.Восток скв.5Г2
гл 3769,3 м Озеро

Dynamic of Antarctic climate during 800 thousand years



EPICA community members *Eight glacial cycles from an Antarctic ice core* *(Nature)*

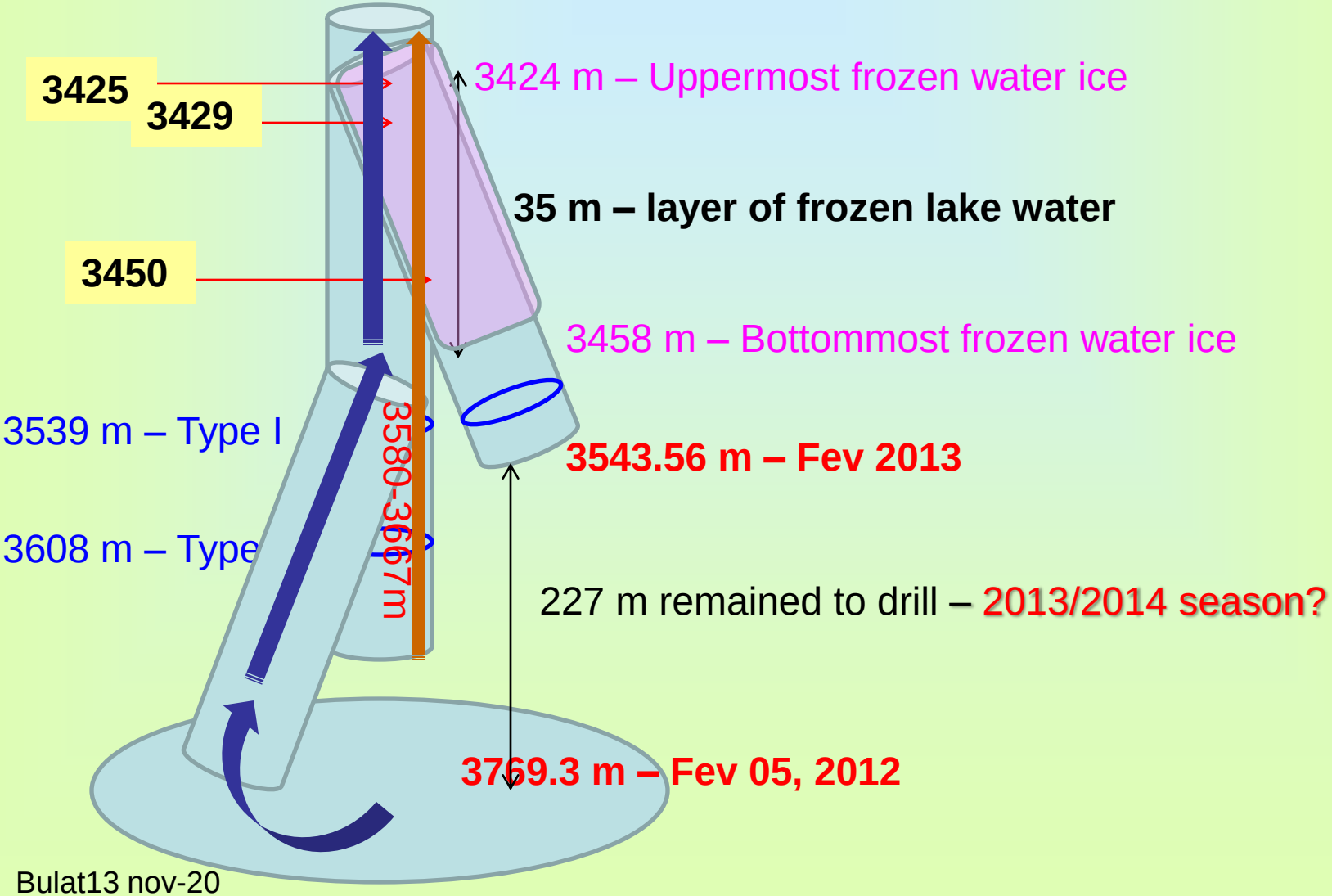


Удельная аккумуляция (г/см²) ледникового покрова Антарктиды. Ее низкие значения (темно-голубые пятна) — один из основных критериев выбора точки глубокого бурения для проекта «Полтора миллиона лет».

Project
1.5 billion years
Choice of place

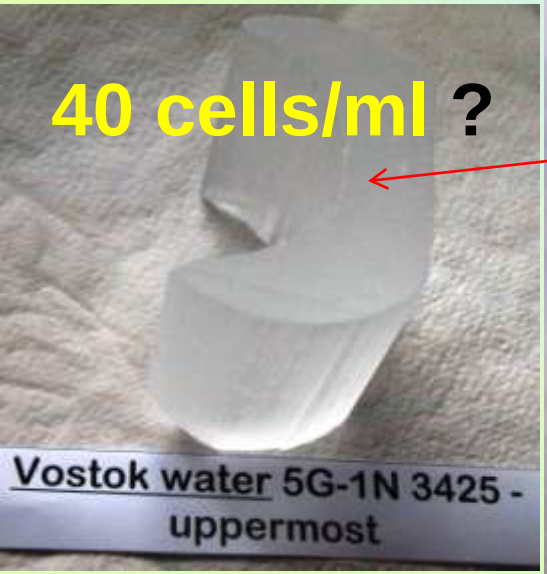
atmospheric precipitates have to be minimal

5G-2[3] Vostok borehole



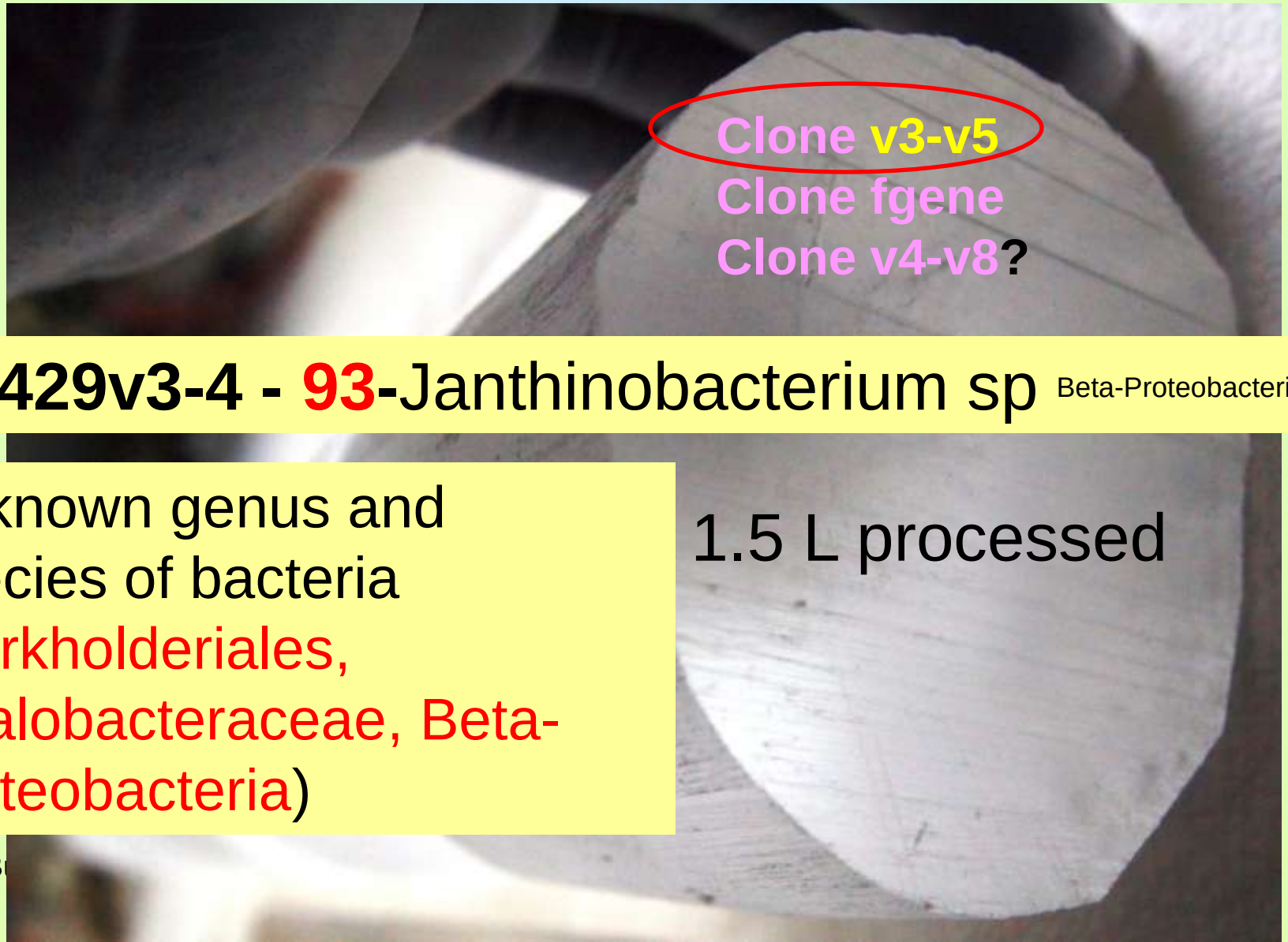
Bulat13 nov-20

5G-1N-3425 Vostok water ice



Bulat13 nov-20

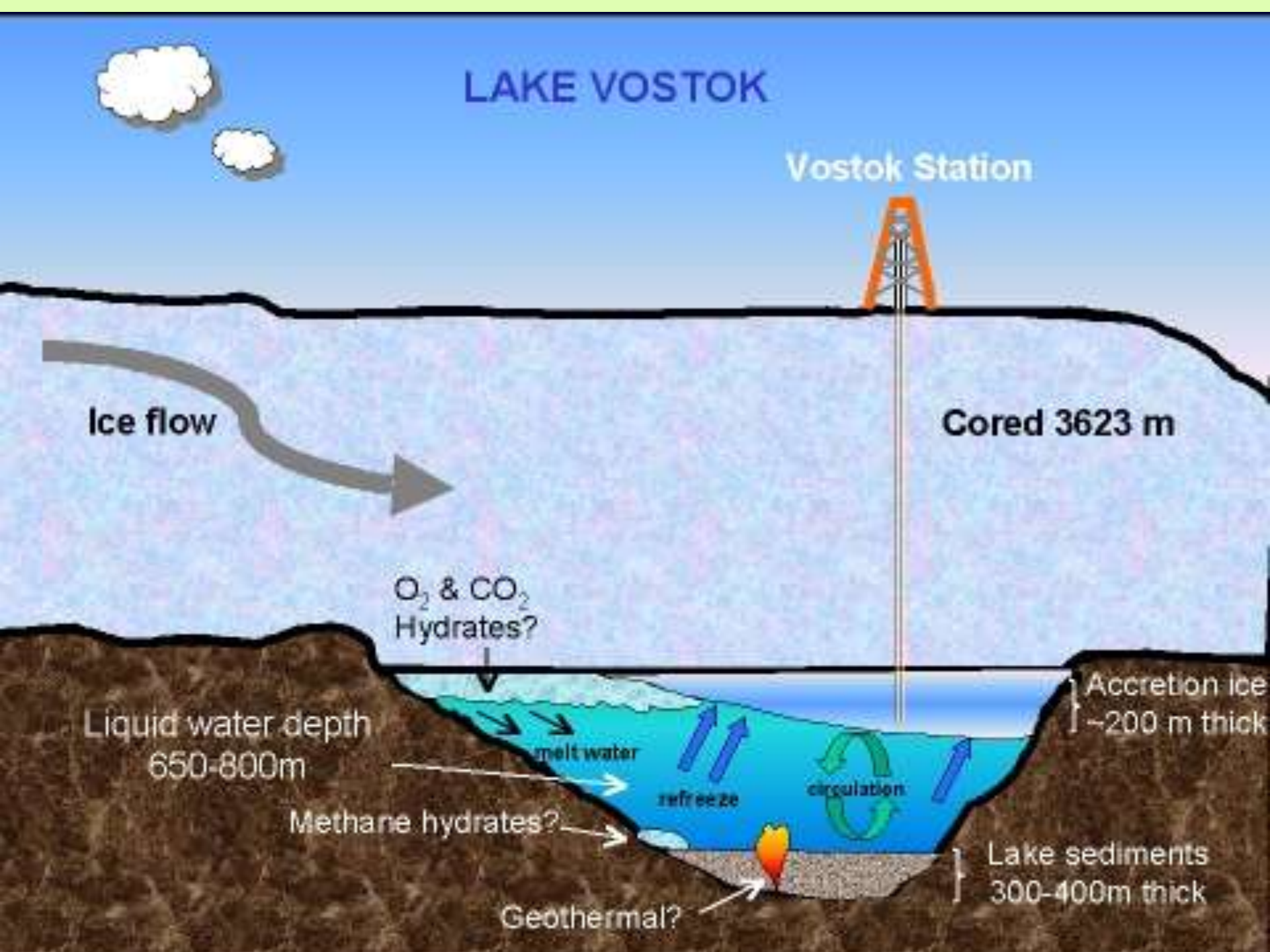
5G-1N-3429 16S rRNA gene



3429v3-4 - 93-Janthinobacterium sp Beta-Proteobacteria

Unknown genus and species of bacteria (Burkholderiales, Oxalobacteraceae, Beta-Proteobacteria)

1.5 L processed


LAKE VOSTOK
Vostok Station
Ice flow
Cored 3623 m
O_2 & CO_2
Hydrates?
Liquid water depth
650-800m
melt water
refreeze
circulation
Accretion ice
~200 m thick
Methane hydrates?
Lake sediments
300-400m thick
Geothermal?


RADARSAT, CSA

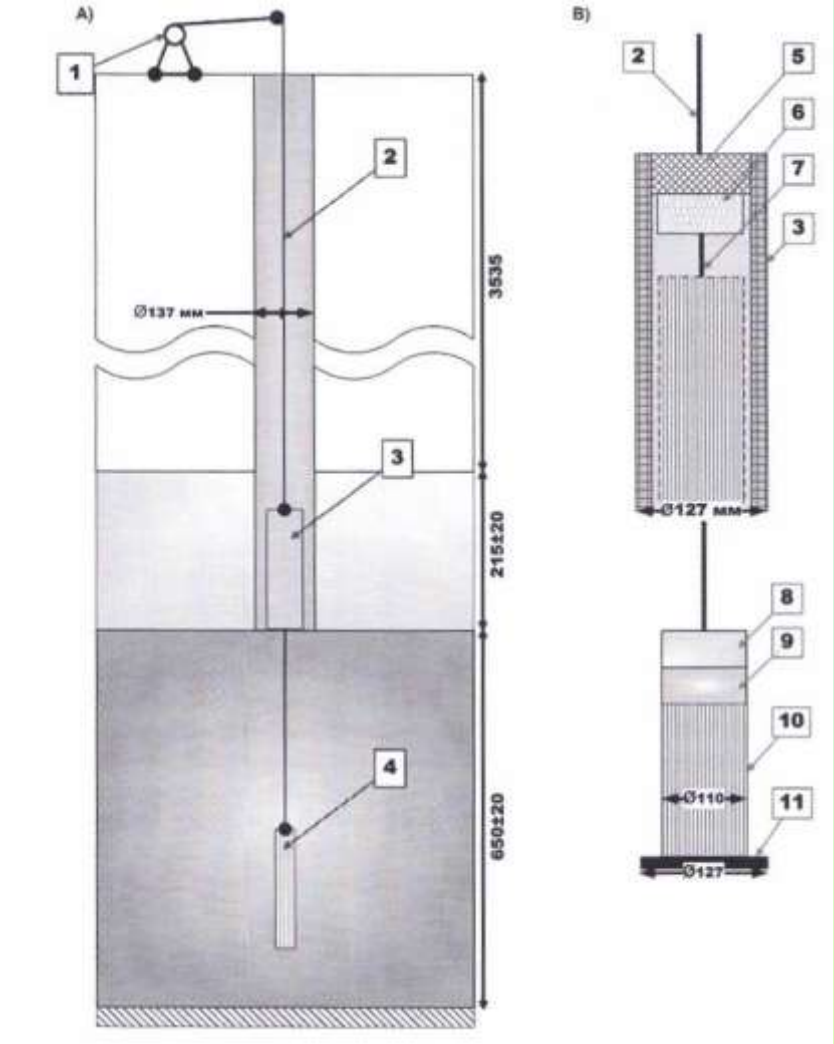
Lake Vostok known since 1994

Published in ***Nature*** (**Kapitsa et al., 1996**)

Friendly environment?

FREE (LIQUID) WATER!

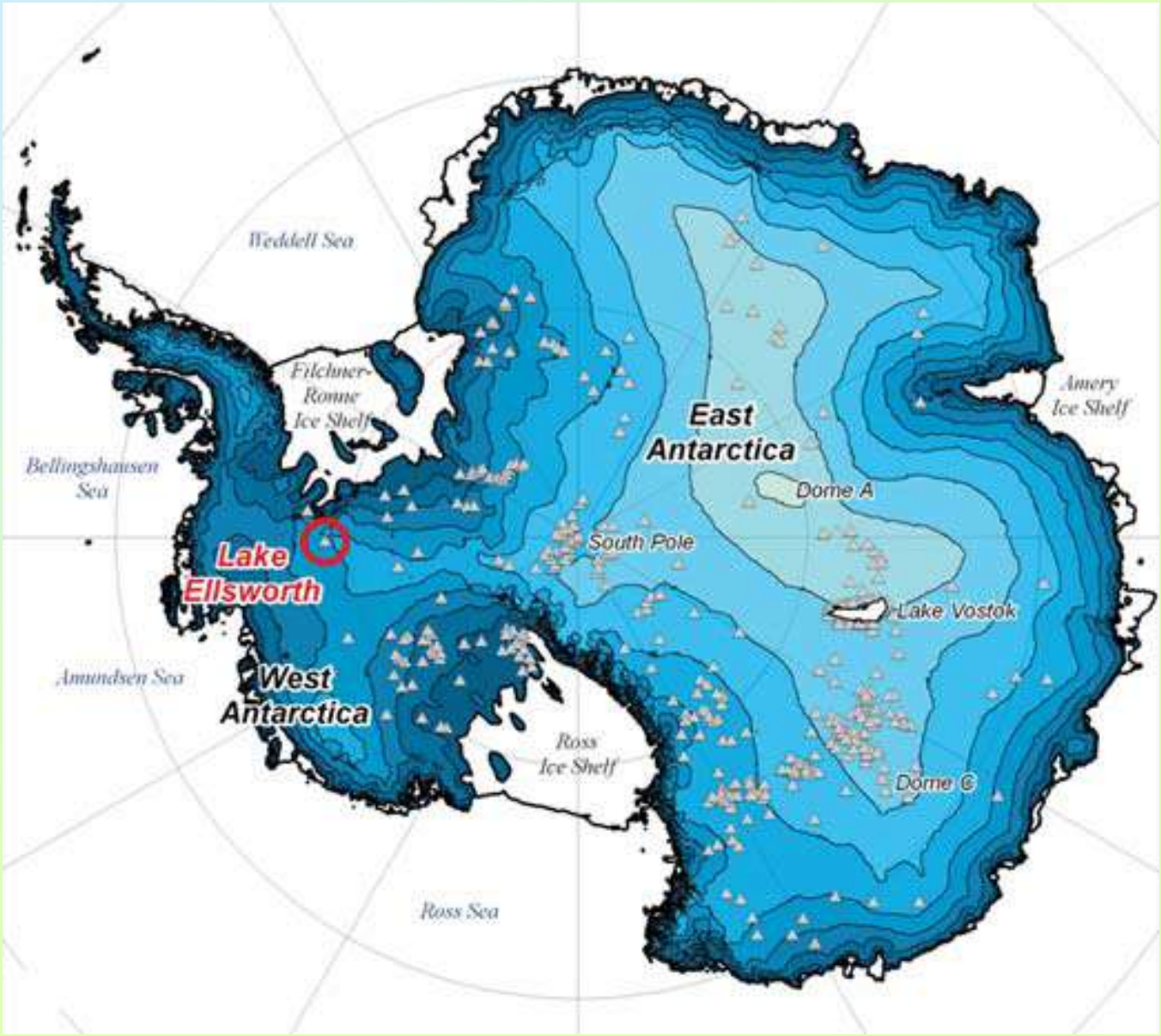
- Deeply ice buried (in dark) – **4 km**
- High pressure – **337-377** bar
- Permanently BUT not very cold – **-2.65**°C
- Likely **oxygen supersaturated** - **800 mg/L** (upper bound **700-1300** mg/L)



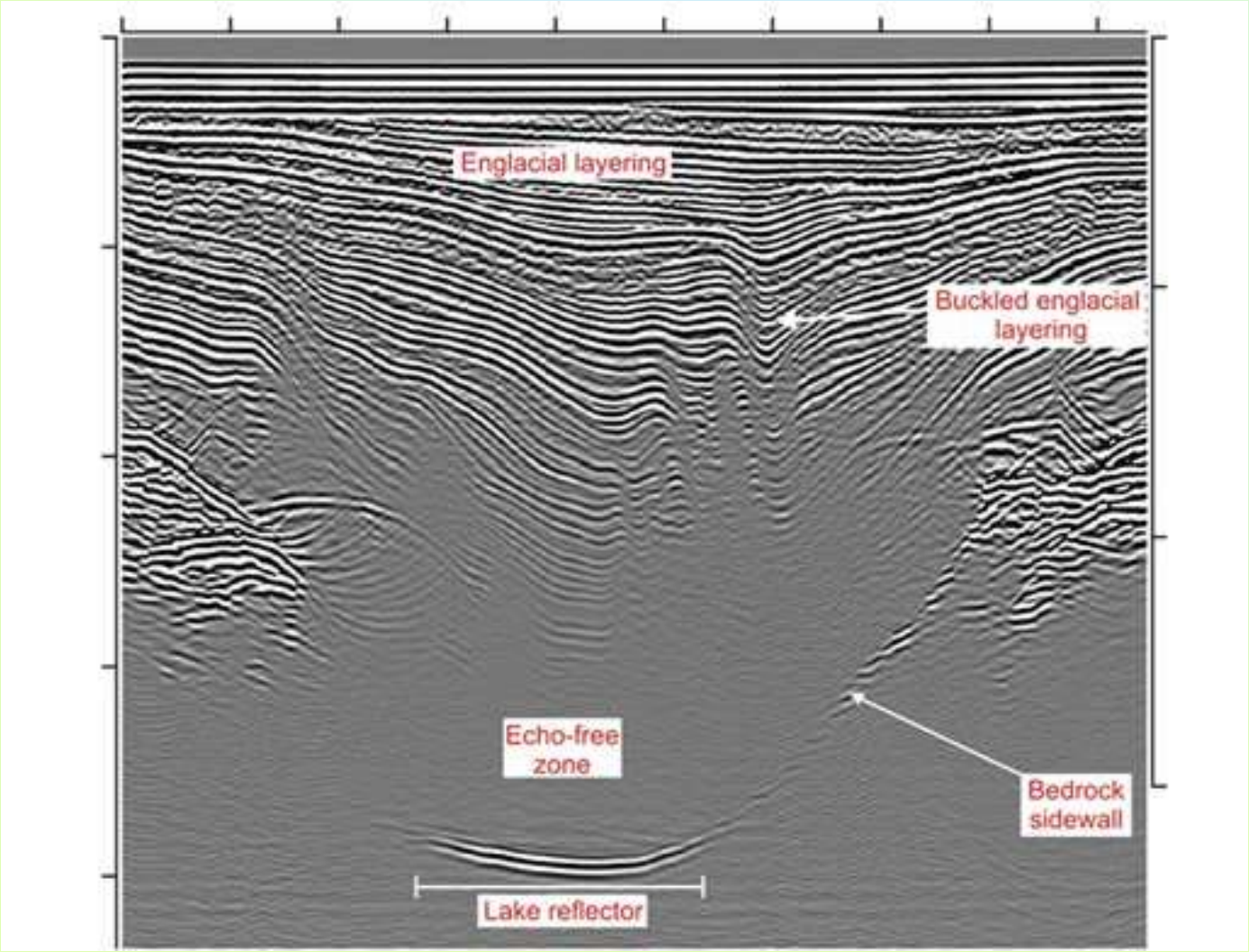
Module for Vostok lake research

Plate 3. (a) Diagram of technology used for exploring the water column of Vostok Subglacial Lake within borehole 5G-2, (b) with principal schemes of transportation and measurement-exploration modules. Numbers indicate the following: 1, drill winch; 2, load-carrying electrical cable; 3, transportation module; 4, exploration module with respective sensors or water sampler; 5, power supply engine; 6, winch; 7, steel cable; 8, 12-V battery set; 9, microprocessor; 10, exploration unit; 11, hermetically sealing lid. The borehole is shown filled with drilling fluid (yellow-green shading).

The location of 386 Antarctic subglacial lakes (from Wright and Siegert, in press). Lake Ellsworth is circled.



DELORES radio-echo sounding data across Lake Ellsworth (Line D7.5). A prominent lake-like reflector is observed between 2600 and 5400 m along the profile at depths of ~3100 to ~3220 m. Buckled englacial layers generated by ice flow over a zone of pronounced subglacial topography southeast of Lake Ellsworth (see Figure 5) are annotated. Ice flow is approximately into the page. See figure 5 for location.



Lake Ellsworth

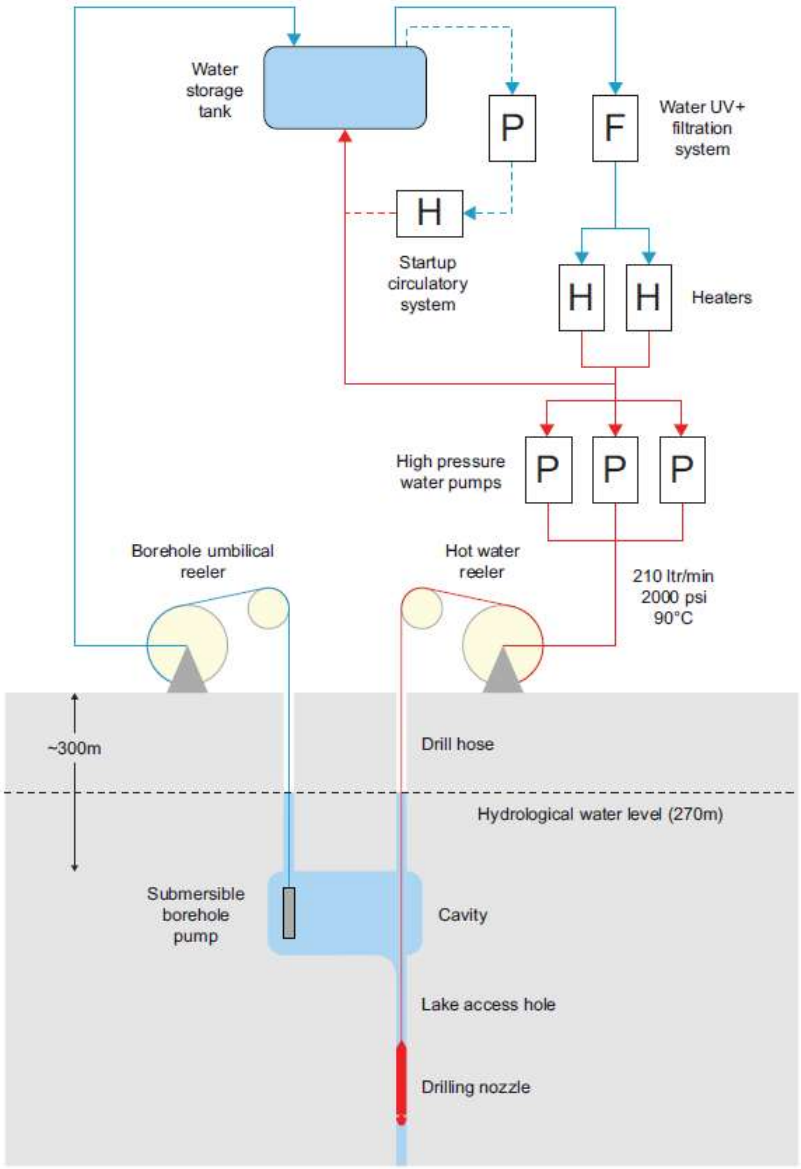
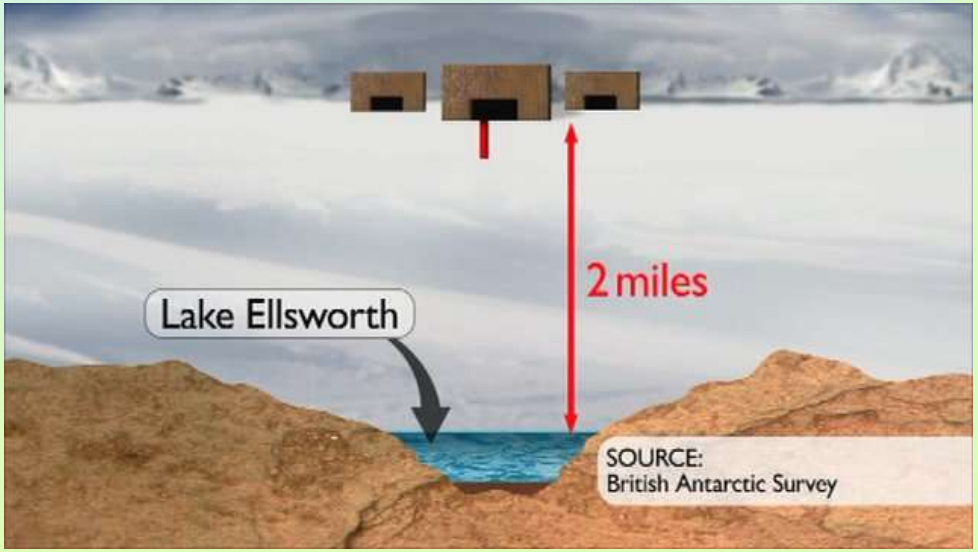


Figure 11. *Schematic diagram of the hot water drill system. H = heaters; P = pumps; F = filters.*



Hose for drilling

There will be 1 x 30 kVA unit to run the domestic camp and
3 x 100 kVA units which will have a combined output capable of running the drilling operation.

Total AVTUR = 51,250 l (250 drums)
Total PETROL = 1,025 l (5 drums)

2 seasons!

Figure 20. *shows an image of the proposed flexible bulk fuel container on a skid base.*

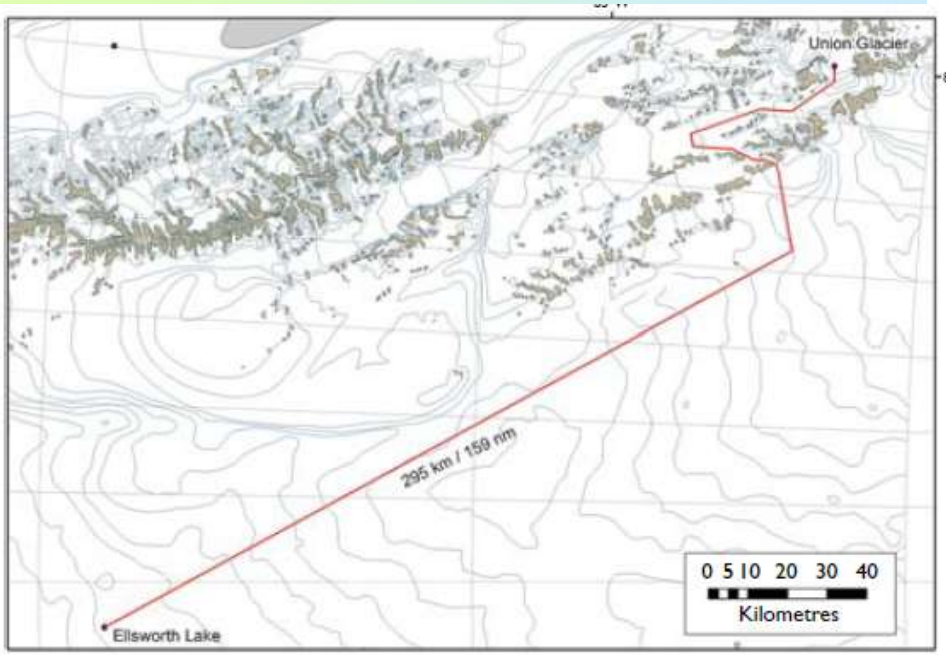


Figure 21. *The transport route for equipment and fuel from the ALE base camp at Union Glacier to the proposed drill site.*

Figure 22. *The tractor and sledge used to transport equipment and fuel to the drill site.*

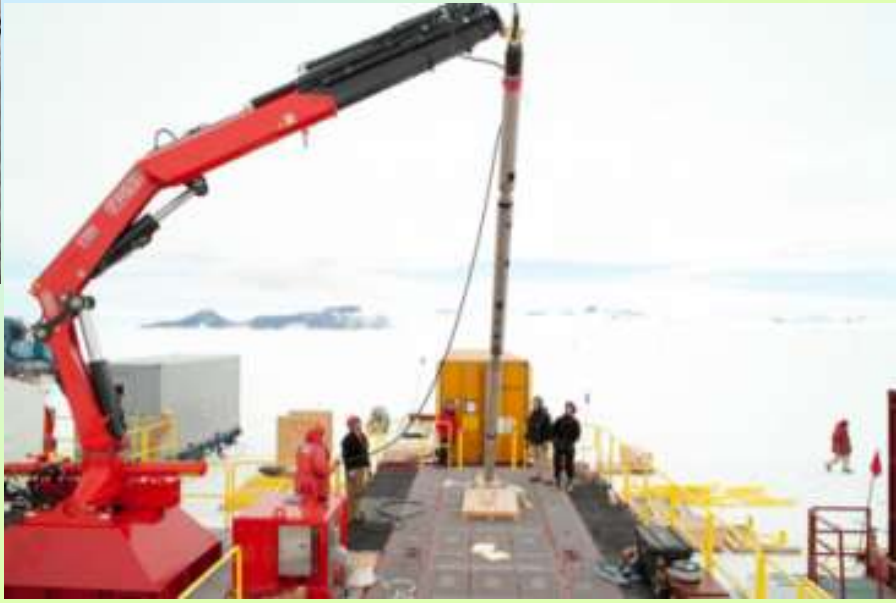
Lake Whillans

- Одновременно с отечественными буровыми работами на станции Восток, американские коллеги проводили свои операции в подлёдном водном потоке Виланс по проекту «Виссард». Данный поледниковый водный объект по своему происхождению, характеристикам и методам исследований значительно отличается от подледникового озера Восток. Водоём расположен на юго-западной границе шельфового ледника Росса и представляет собой один из элементов обширной подледниковой гидрологической системы, направленной в море Росса. Один раз в 10 лет вода в этом водоёме полностью обновляется. Его объём составляет всего 0,5 км3, в то время как объём озера Восток 6100 км3. Толщина ледника над водоёмом составляет 801 метр, а на станции Восток 3769,3 м.
- Lake Ellsworth (750 years) and Lake Vostok (10,000 years).

READY TO BORE Daren Blythe and Dar Gibson shoveled snow into a melter feeding the hot water drill to be used to penetrate half a mile of ice above Lake Whillans. Exploring extreme environments offers lessons for efforts in space.

Lake Whillans

Lake Whillans




АЭРОФЛОТ
АЭРОФЛОТ

*Thank you for attention