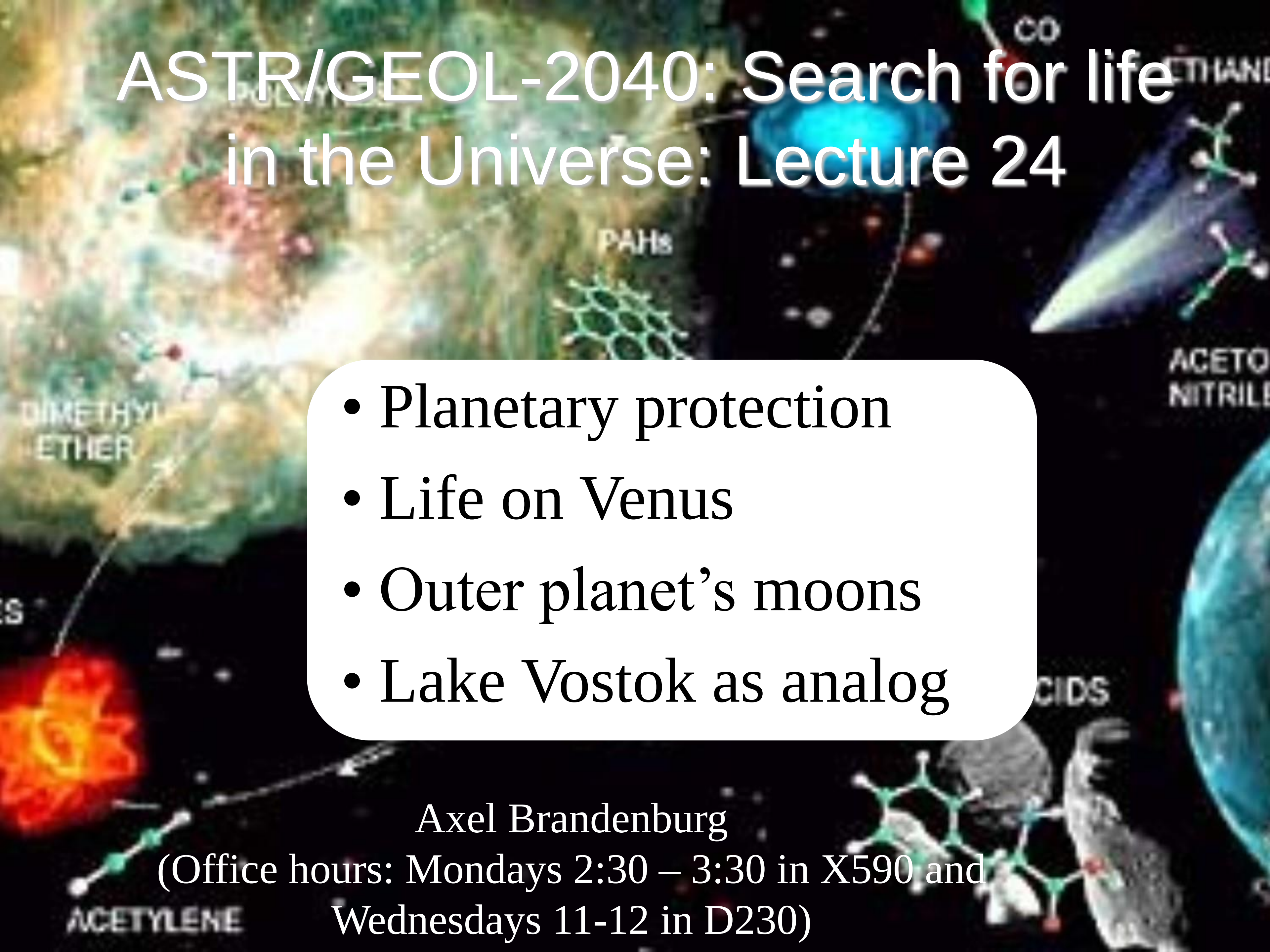
ASTR/GEOL-2040: Search for life in the Universe: Lecture 24



- Planetary protection
- Life on Venus
- Outer planet’s moons
- Lake Vostok as analog

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590 and Wednesdays 11-12 in D230)

Planetary protection

- Forward protection
- Backward protection

Levin & Straat (2016)

In summary, in the absence of a nonbiological agent that satisfies all Viking findings, and in view of environmental evidence that Mars may well be able to support extant life, it seems prudent that the scientific community maintain biology as a viable explanation of the LR experimental results. It seems inevitable that astronauts will eventually explore Mars. In the interest of their health and safety, biology should be held in the forefront of possible explanations for the LR results. Plans for any Mars sample return mission

Forward contamination

- Viking probes
- Dry – Heat (oxidation)
  - 135C for 8 hours
  - Hydrogen peroxide plasma
  - Gamma radiation
- Max 300,000 microbes per Martian Lander
- Human sneezing: 10^6 microbes!

Planetary protection

- Why important?
  - Don’t want to detect terrestrial life
- What to consider?
- And what is meant?

Ethical issues

- Terrestrial life outcompete Martian
- Do we have the right to do this?

Or

- Unleash dangerous Martian microbes
- Unprepared
- Outcompete Terrestrial life
  - Unlikely: highly adapted
  - Species jumping very rare
  - Example HIV chimpanzee (SIV) → human
- Natural contamination (reach Earth already)
- Cautious: high stakes involed

To survive crash …

- Columbia disaster….
- Astrobiology experiment survived

Should we send humans?

- 3 – 4 months travel time
  - Food, air, water, radiation
- Humans more capable
  - Complicates issue of finding life
  - Check your mouth
- Human travel not driven by science
- Terraforming
  - Greenhouse gases from CFCs

chlorofluorocarbons

Proposals [edit]

Mission	Launch	Notes	Country or Space Agency
NASA 2022 orbiter	2022	Telecomm orbiter[28]	NASA, USA
	2024	Crewed mission to Mars[citation needed]	SpaceX, USA
Mars One	2026[29]	Orbiter, lander, rover, Human Colony	Mars One, USA
	2030[30]	Sample return phase of the Chinese Mars exploration program	CNSA, PRC
	2036[27]	Crewed phase of the Chinese Mars exploration program	CNSA, PRC
	2040–45	Crewed phase of the Russian Mars exploration program[31]	Роскосмос (Roscosmos), Russian Federation
Mars to Stay		Settlement[citation needed]	United States

Missions to the moons of Mars [edit]

Venus

- Very hot now (462C=863F)
  - Day & night (picture ok?)
- Not so in the past (?)
  - Evolved first on ground
  - Now suspended microbes in venusian atmosphere?

Venusian atmosphere

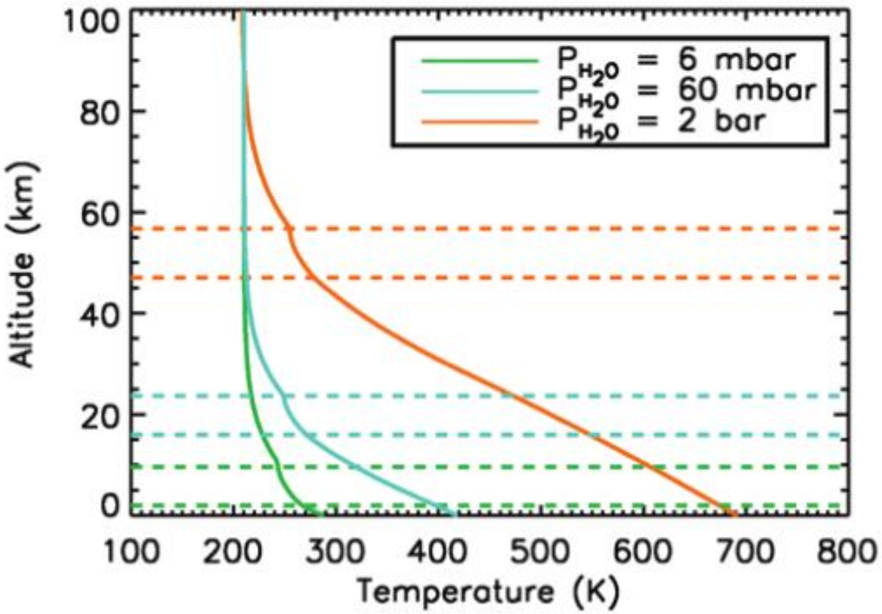


Plate 1. Radiative-convective equilibrium temperature profiles, as described in the text, along with the locations and extent of clouds for atmospheres with 6 mbar, 60 mbar, and 2 bar of H_2O.

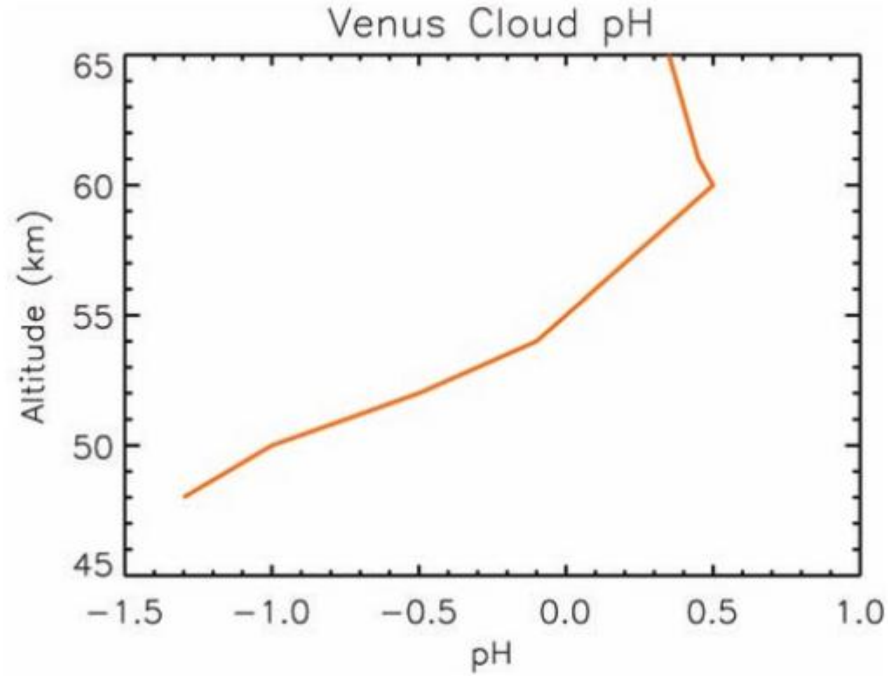


Plate 2. The pH of Venus' clouds as a function of altitude. The relatively water-rich aerosols in the upper cloud have a small range of positive pH, from 0.3 to 0.5. In the lower cloud, with its larger and more water-poor particles, pH can be as low as -1.3. Aerosol H_2SO_4 concentrations were calculated using the cloud model of Bullock and Grinspoon (2001), constrained by PV data. Correction for high activities is from Nordstrum et al. (2000).

Pressure 90 bar on the ground

Life in 50 km height?

Venus express (2006)

- Mariner 2 (1962) fly-by
- Mariner 5 (1967) fly-by
- Venera 5,6 (1969)
- Venera 8 (1972) lander
- Landers/orbiters since 1980s
- Used in many gravity assists

Astrobiology and Venus Exploration

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For hundreds of years prior to the space age, Venus was considered among the most likely homes for extraterrestrial life. Since planetary exploration began, Venus has not been considered a promising target for Astrobiological exploration. However, Venus should be central to such an exploration program for several reasons. At present Venus is the only other Earth-sized terrestrial planet that we know of, and certainly the only one we will have the opportunity to explore in the foreseeable future. Understanding the divergence of Earth and Venus is central to understanding the limits of habitability in the inner regions of habitable zones around solar-type stars. Thus Venus presents us with a unique opportunity for putting the bulk properties, evolution and ongoing geochemical processes of Earth in a wider context.

Sulfur life

Elemental sulfur might also be microbially produced by a photosynthetic reaction in which hydrogen sulfide is oxidized to elemental sulfur and carbon dioxide is reduced to organic carbon (equation 1)

$$2H_2S + CO_2 + light \rightarrow \text{“}CH_2O\text{”} + H_2O + 2\,S \qquad (1)$$

Many terrestrial organisms using this reaction thrive in marine sediments and hot springs (e.g. Vethanayagam, 1991, Bryantseva et al., 2000). The oxidized sulfur could then be polymerized to S_8. Several photosynthetic microbes, which use H_2S as their electron source, deposit sulfur outside the cell including Green Sulfur bacteria, some Purple Sulfur bacteria and some cyanobacterial species (e.g. Pierson et al., 1993; Tortora et al., 2001). Putative Venusian microbes might deposit elemental sulfur on the outside of their cells to convert potentially harmful UV radiation to electromagnetic frequencies that are usable for photosynthesis, or harvest the energy of UV photons through conversion to appropriate electron donors. Alternatively, they may just utilize sulfur

Outer planets

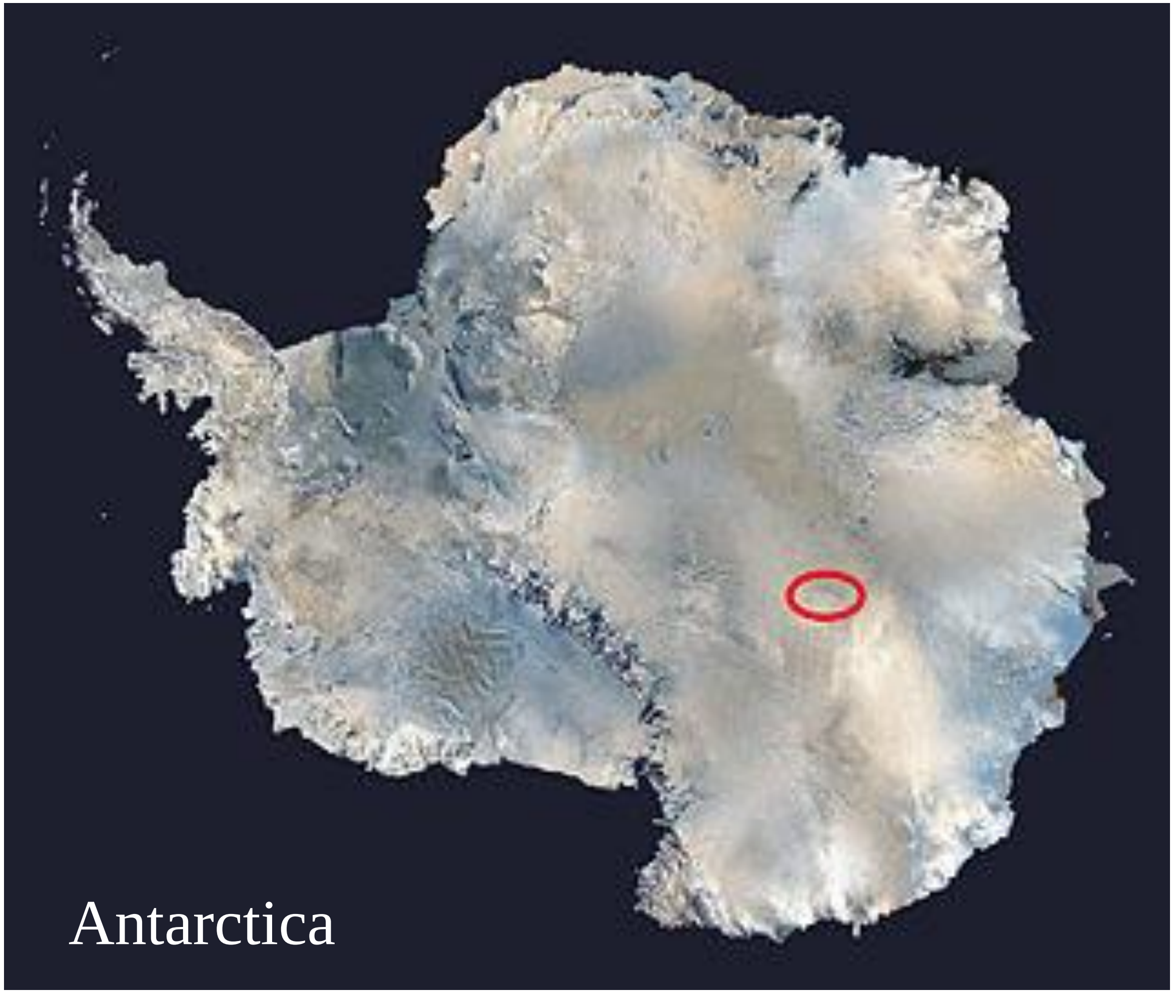
- Giant gas planets
  - Interesting moons
- Moons not rocky, but icy!
  - Water underneath!
- Analog on Earth
  - Lake Vostok

Lake Vostok: analog for Europa where is it??

A. Siberia
B. Earst Russia
C. Greenland
D. Antarctica

Lake Vostok

- 1890s: Kropotkin pressure from 3km ice: liquid
- 1967 Zotikov theoretical work
- 1959-64 Kapitsa expeditions → subglacial lake
- Low -89C=-128F



A large deep freshwater lake beneath the ice of central East Antarctica

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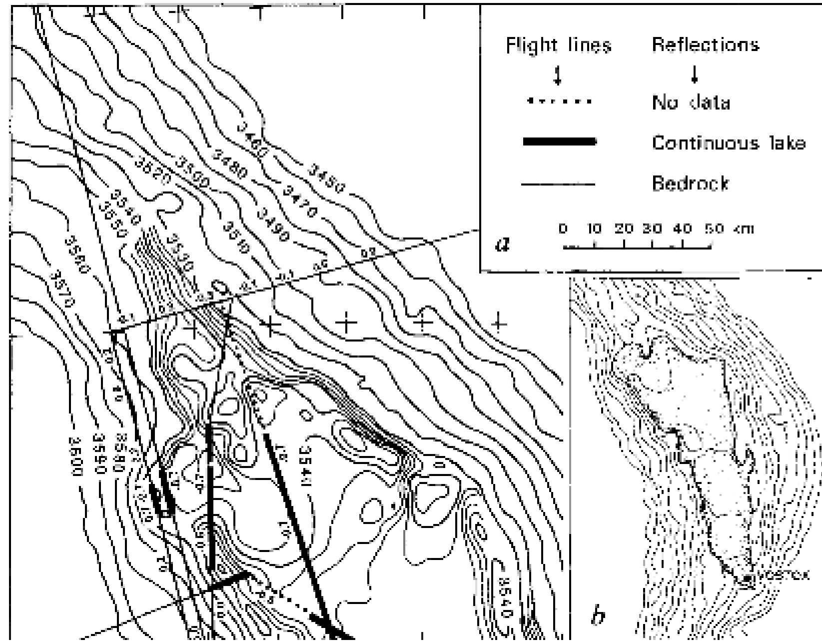
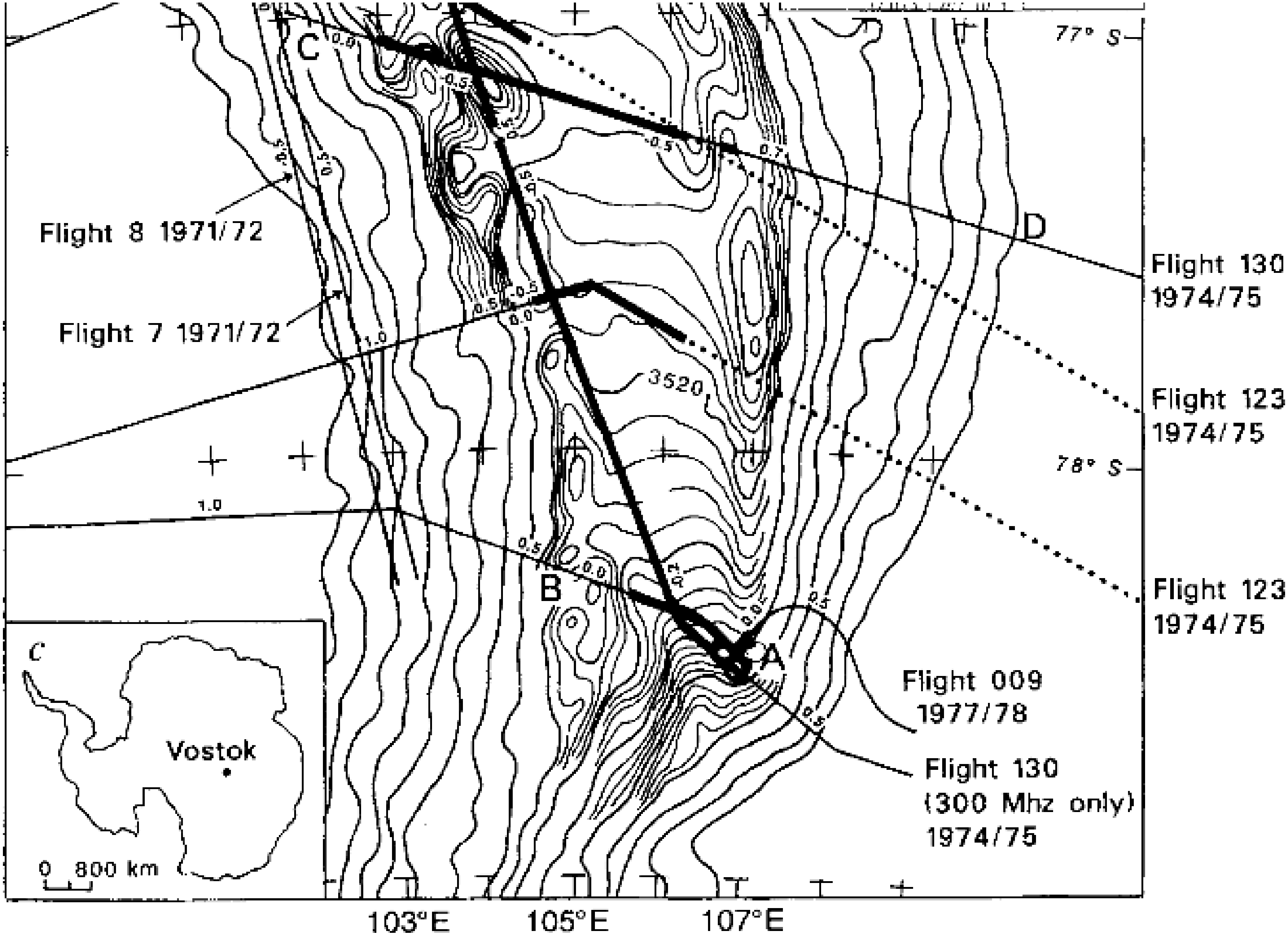
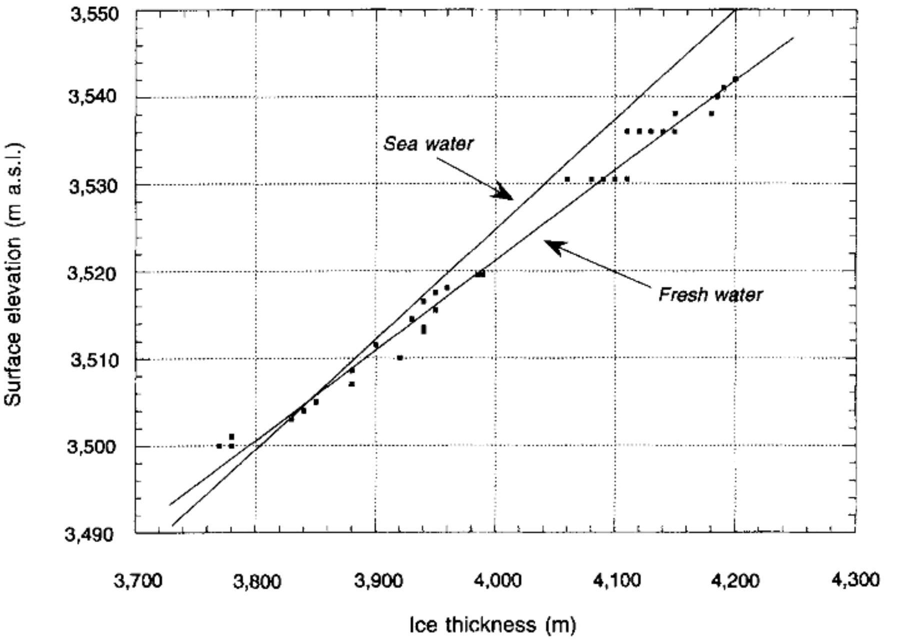


seismic data[3], to show that the lake is deep (mean depth of 125 m or more) and fresh, and that it has an area that exceeds previous estimates by about 50%—dimensions comparable with those of Lake Ontario. We estimate that the residence time of the water in the lake is of the order of tens of thousands of years, and that the mean age of water in the lake, since deposition as surface ice, is about one million years. Regional ice-dynamics can be explained in terms of steady-state ice flow along and over the lake.

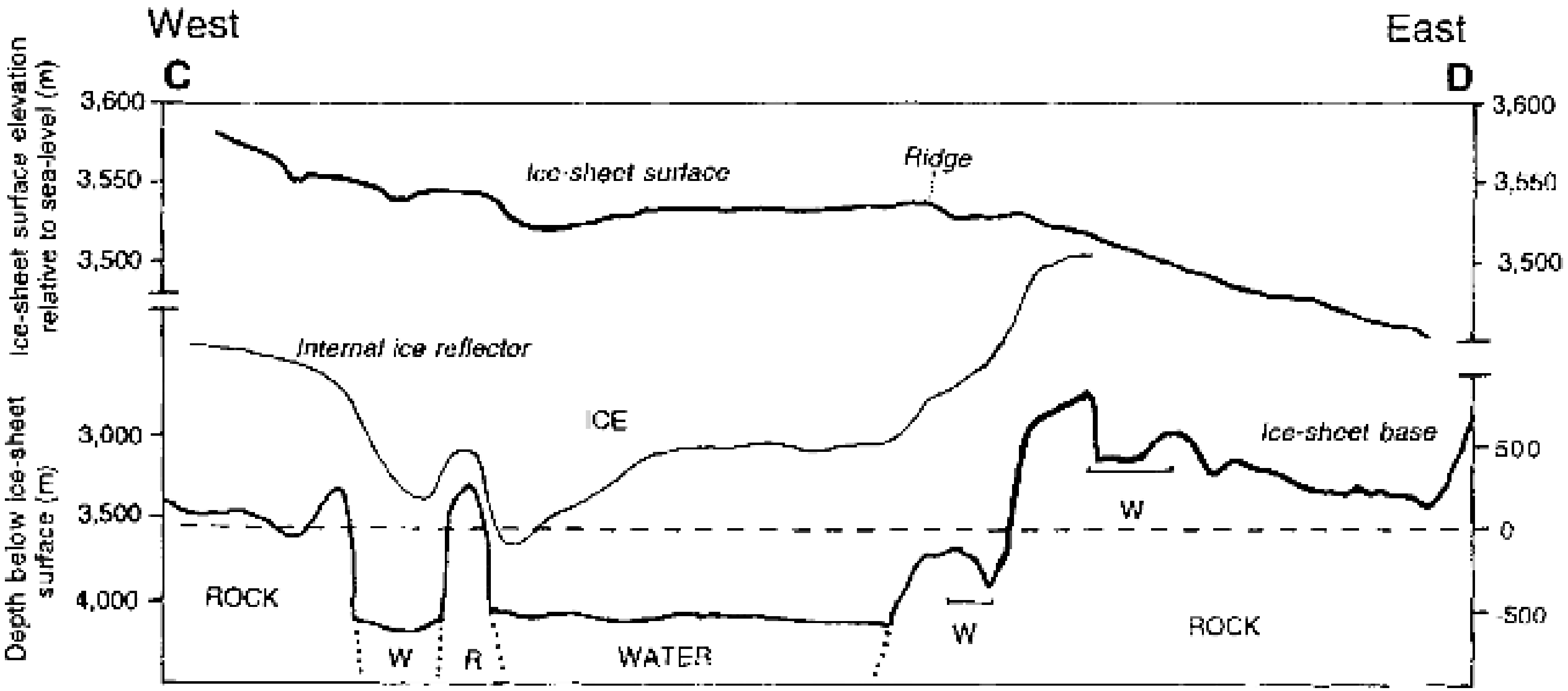


77° S
78° S
C
D
B
A
Flight 8 1971/72
Flight 7 1971/72
Flight 130
1974/75
Flight 123
1974/75
Flight 123
1974/75
Flight 009
1977/78
Flight 130
(300 Mhz only)
1974/75
3520
1.0
1.0
0.5
0.0
-0.5
Vostok
0 800 km
103°E
105°E
107°E

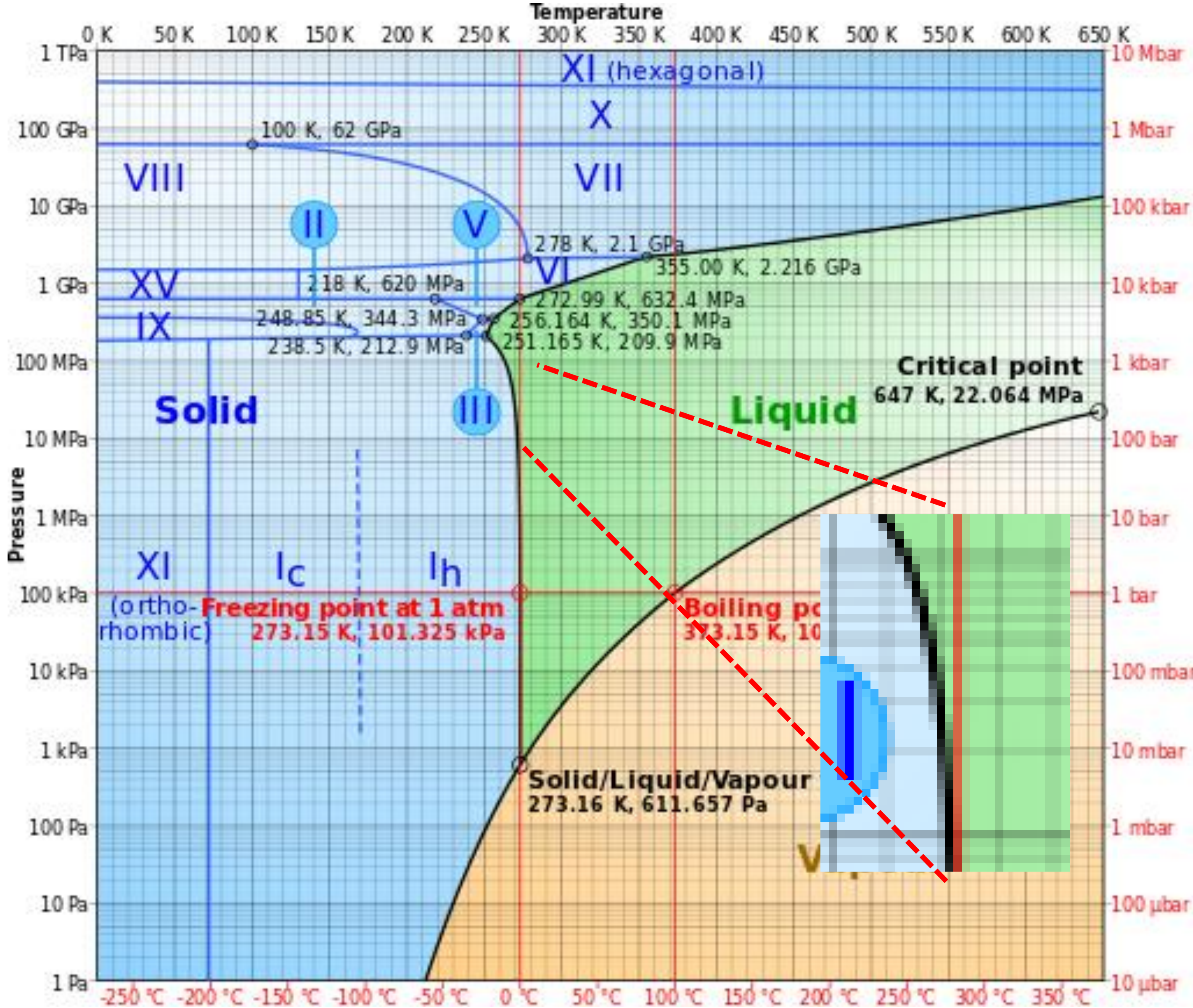
Lake Vostok



- Bedrock topography similar to deglaciated Lake Baikal
-



Pressure: 345 bars



Why liquid water?

A. Because of high pressure
B. Because of insulation by the ice
C. Because of geothermal heat
D. Because of salt content
E. Because of tidal force

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Why liquid water?

- Pressure helps (but very little)
- Insulation from the top is important
- Important: geothermal heat: 50 mW/m^2
  - basal melting 1mm/yr
  - 125 m / (1mm/yr) = 125,000 yr
- Lake is freshwater: no salts
- Tides detected in lake, but unimportant for melting

Monday

- Icy words: our south pole
- Analog of Europa's subsurface ocean
- RGS pp. 127 – 141
- Box 4.8