LIFE BEYOND EARTH

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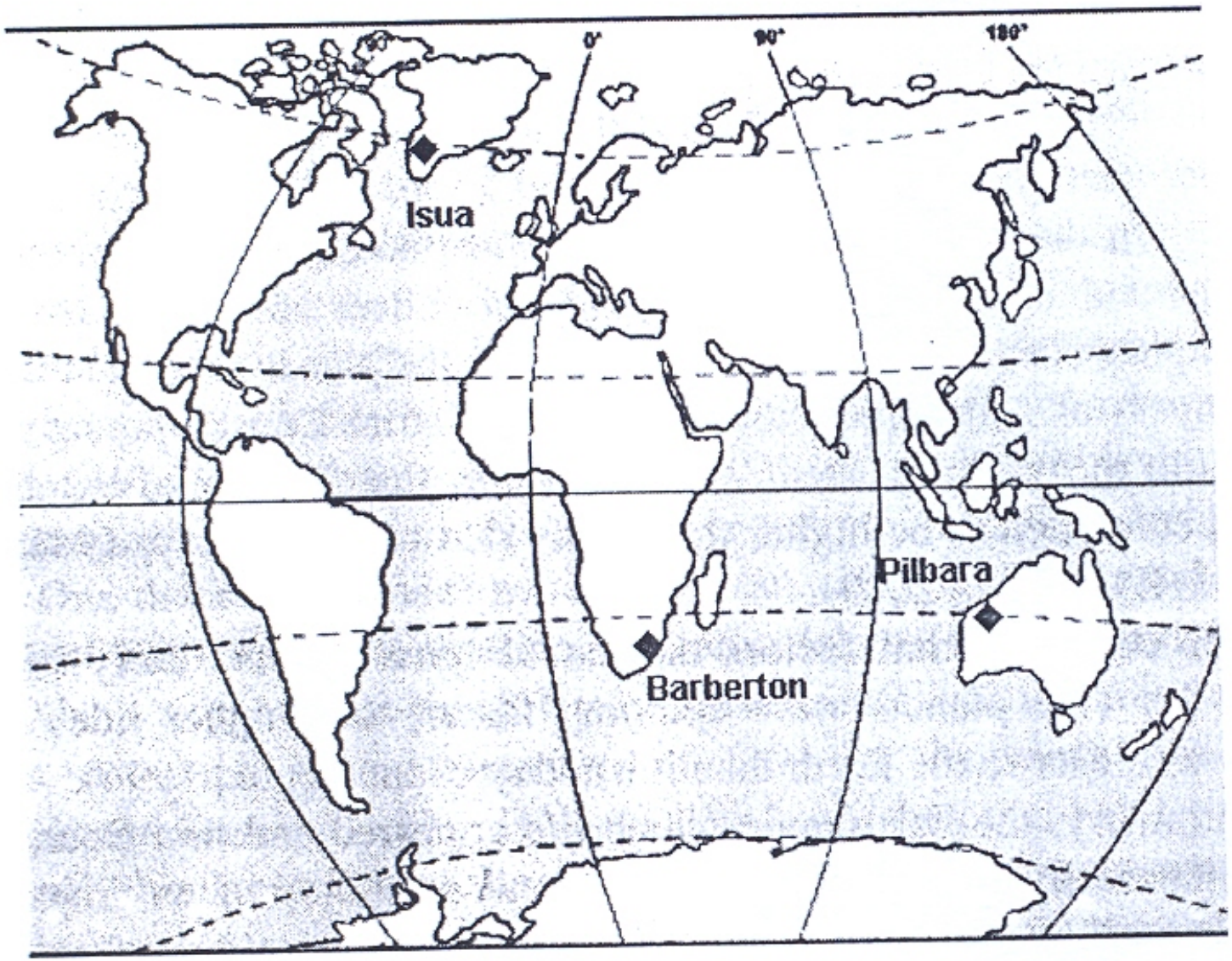
- WHAT IS THE ORIGIN OF THE UNIVERSE?
- WHAT IS IT MADE OF?
- WHAT IS ITS ULTIMATE DESTINY
- HOW DID LIFE, IN GENERAL, AND HUMANS, IN PARTICULAR, ORIGINATE?
- ARE WE ALONE IN THE COSMOS?

STRATEGIES IN THE SEARCH FOR EXTRATERRESTRIAL LIFE

- THE SEARCH OF THE CELLULAR MAKEUP OF EXOTIC ORGANISMS ON EARTH (HOW LIFE BEGAN ON EARTH?)
- THE SEARCH FOR ORGANIC MATTER AND LIVING MICROORGANISMS BEYOND THE EARTH
- SEARCH FOR EXTRATERRESTRIAL INTELIGENCE

HOW OLD IS LIFE ON EARTH?
Early archaean terrains Isua (>3.7 Gy), Pilbara and Barberton (≥3.5-3.2)



HOW OLD IS LIFE ON EARTH?

- 4.56~4 Gy Hadean Eon
- 4~3.2 Gy Early Archaean Eon
- 4-3.85 Gy a peak in bombardment (Ryder, 2002)
- Earliest indications 3.8 Gy rocks – Grenland
- Well preserved microfossils 3.5-3.3 Gy – South Africa and Australia (colonies and biofilms of prokaryote-like organisms)
- ~3-2.8 Gy Mid Archaean oxygen photosynthesis started

THE EVOLUTION OF INTELLIGENCE

- THE FORMATION OF EARTH 1 JANUARY
- PROKARYOTES 27 FEBRUARY
- (lack of membrane bound nucleus)
- EUKARYOTES 28 OCTOBER
- (well defined nucleus)
- CHORDATES 17 NOVEMBER
- VERTEBRATES 21 NOVEMBER
- MAMMALS 12 DECEMBER
- PRIMATES 26 DECEMBER
- ANTHROPOIDS 30 DECEMBER at 1:00 AM
- HOMINIDS 30 DECEMBER at 10:00 AM
- HUMANS 30 DECEMBER at 11:56:30 PM

1982 – 51st IAU Commission - BIOASTRONOMY

- To search for planets around other stars
- To study the evolution of planets and their possibilities for life
- To detect extraterrestrial radio signals
- To detect organic molecules in the Universe
- To detect primitive biological activity
- To search for signs of advanced civilisations

SIGNATURES OF LIFE

- BIOSIGNATURES
- GEOSIGNATURES
- GEOINDICATORS

BIOSIGNATURES

- Found only on Earth:
- – Organic macromolecules larger than 1000 amu
- – Coral reefs
- –Biogenic substances (chlorophyll)
- – Emitted heat inconsistent with abiotic origin
- – Energetic emission (radio waves)
- - Fossil evidence (ALH48001)
- - Presence of metabolic by-products and end-products

GEOSIGNATURES

- -Atmospheric gas composition (O2, CH4, O3) resulting from biogenic processes
- -Rate and type of erosion consistent with biological processes
- Structural complexity like roads, canals, insect colonies, cities, Dyson sphere

GEOINDICATORS

- - An atmosphere or ice shield
- - Internal differentiation (radioactive core, a mantel, a crust)
- - Complex polymeric chemistry
- - A source of energy (energy flows or thermal gradients - on Earth light from the Sun or oxidation of inorganic compounds provide energy for the biosphere)
- - Liquid medium as a solvent

ASTROBIOLOGY PLAUSIBILITY CATEGORIES (Irwin & Schulze-Makuch 2001

I - Liquid water, available energy,organic compounds (Earth)

II – Evidence for the past or present existence of liquid water, availability of energy, organic compounds (Mars, Europa)

III – Extreme conditions, evidence of energy source and complex chemistry, possibly suitable for unknown on Earth life forms (Titan, Triton, Enceladus, Venus)

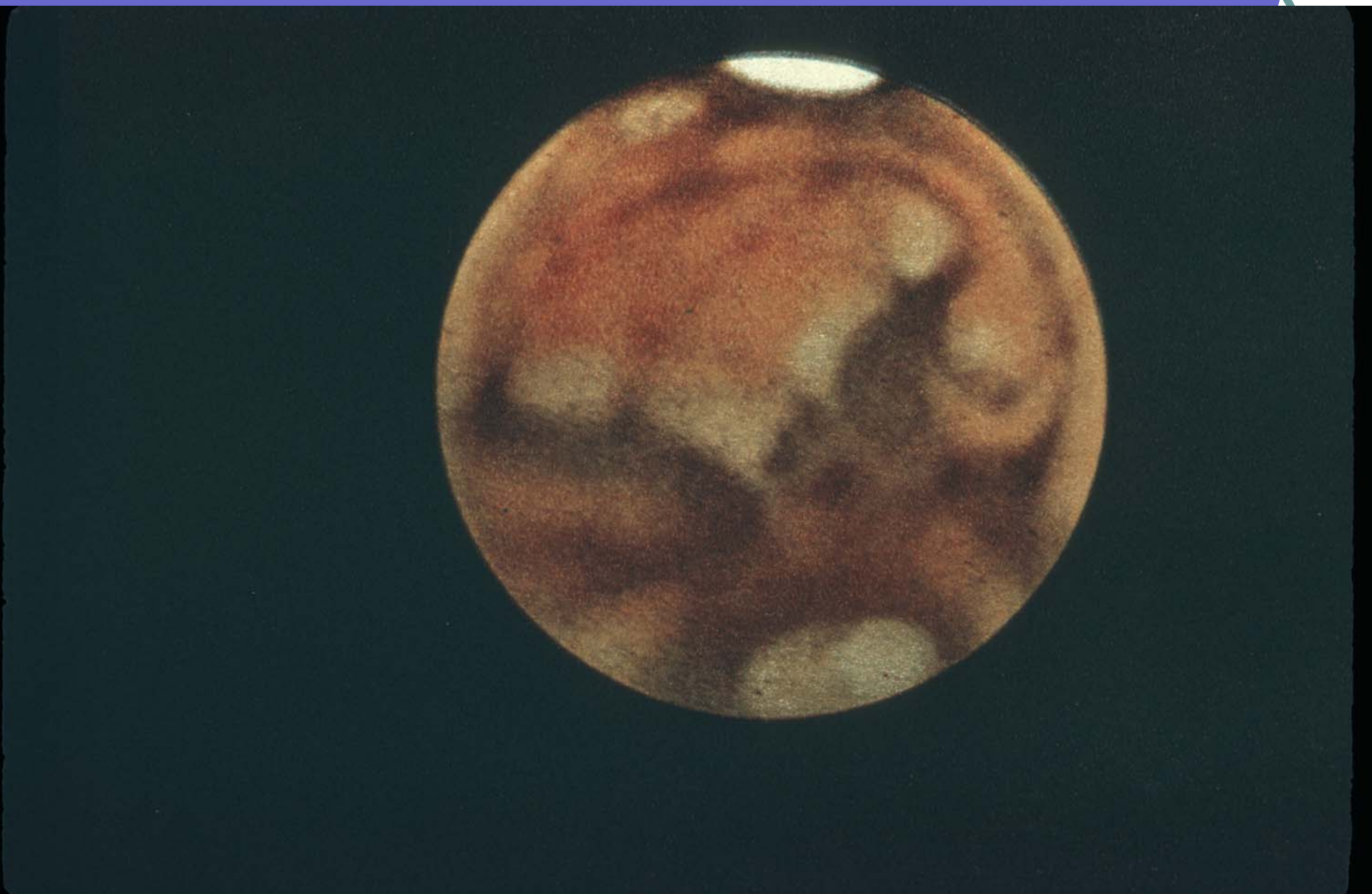
ASTROBIOLOGY PLAUSIBILITY CATEGORIES (Irwin & Schulze-Makuch 2001

IV – Persistance of life very different from on Earth imaginable in isolated habitats or reasonable inference of past conditions suitable for the origin of life prior to the development of conditions so harsh as to make its perseverance now unlikely but imaginable in isolated habitats (Mercury, Jupiter)

ASTROBIOLOGY PLAUSIBILITY CATEGORIES (Irwin & Schulze-Makuch 2001

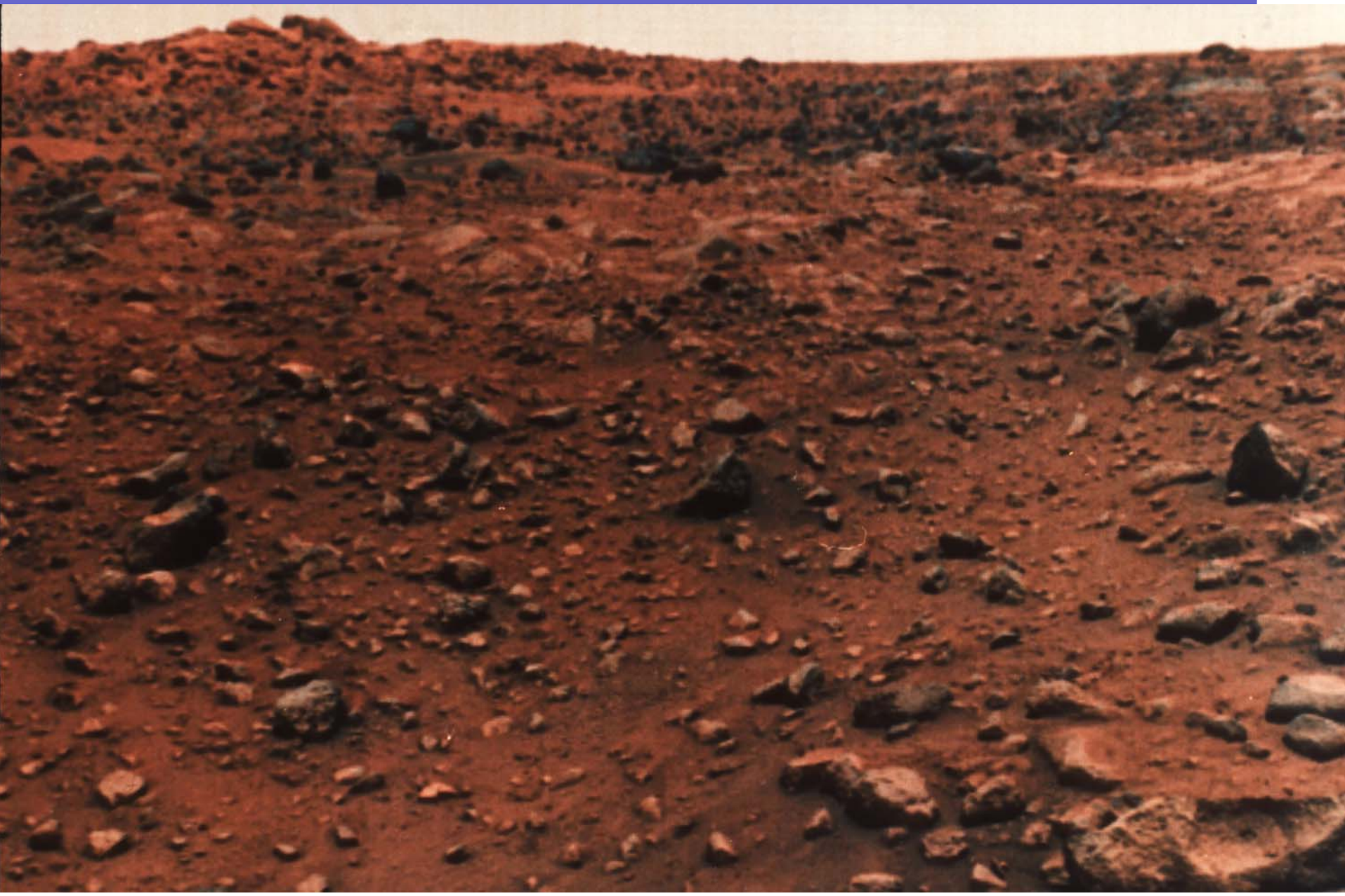
V – The origin or persistence of life cannot be a realistic possibility (Sun, Moon)

MARS



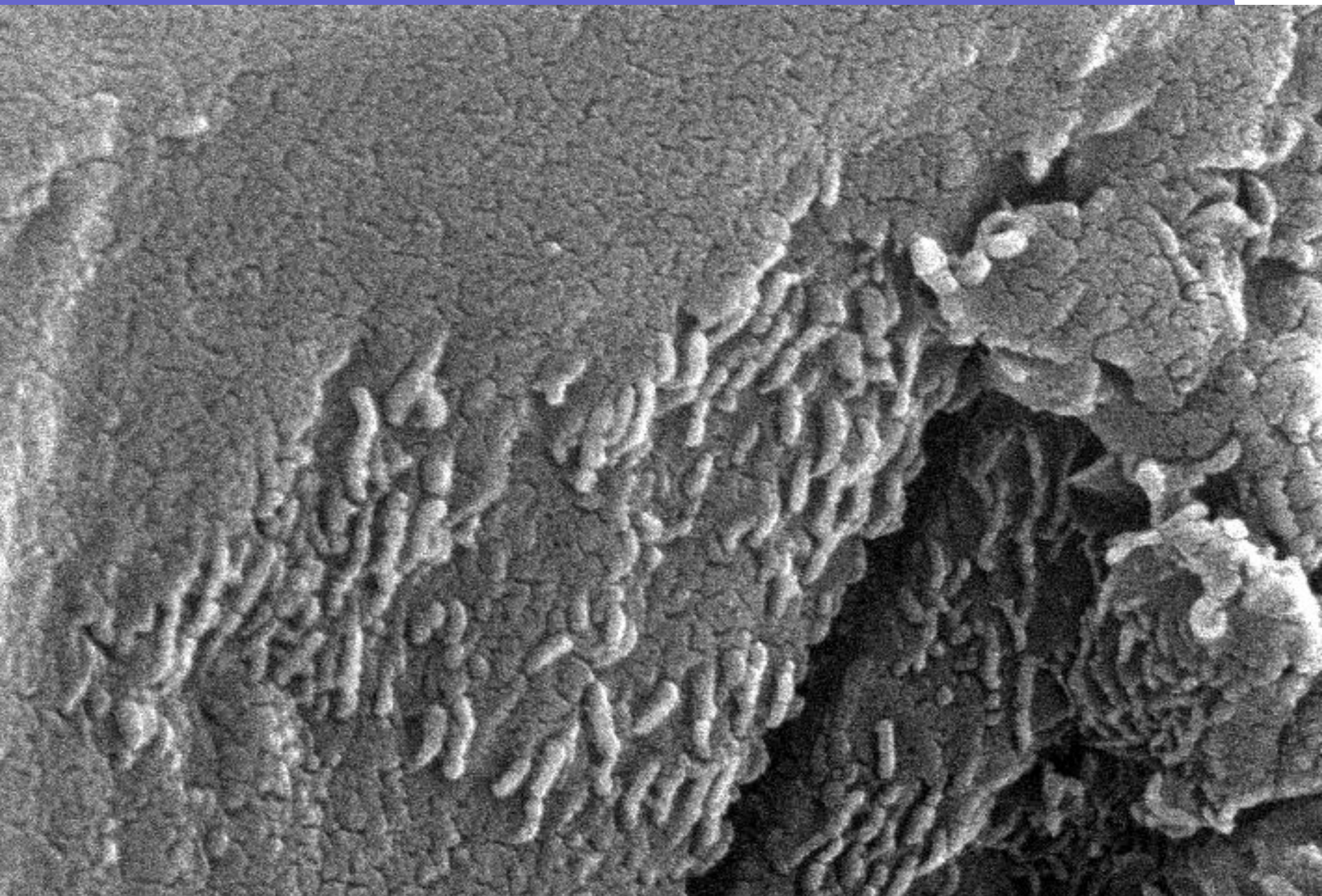
- 1877 Giovanni Schiaparelli – canals
- H. G. Wells – The war of the worlds

Mars surface




ALH84001,0
Ni
1cm


ALH84001,0
1cm
E



PANSPERMIA

- **Anaxagora** – proposed “panspermia” hypothesis – All life originated from the combination of tiny seeds spread throughout the cosmos
- 1871 – **Lord Kelvin** in Edinburg – plant seeds
- 1908 - **Svante Arhenius** - bacteria by light pressure
- 1970s – **Fred Hoyle** & **Chandra Wickramasinghe** – the thermal infrared spectrum emitted by interstellar grains resemble that of dried bacteria – the interiors of cometary nuclei

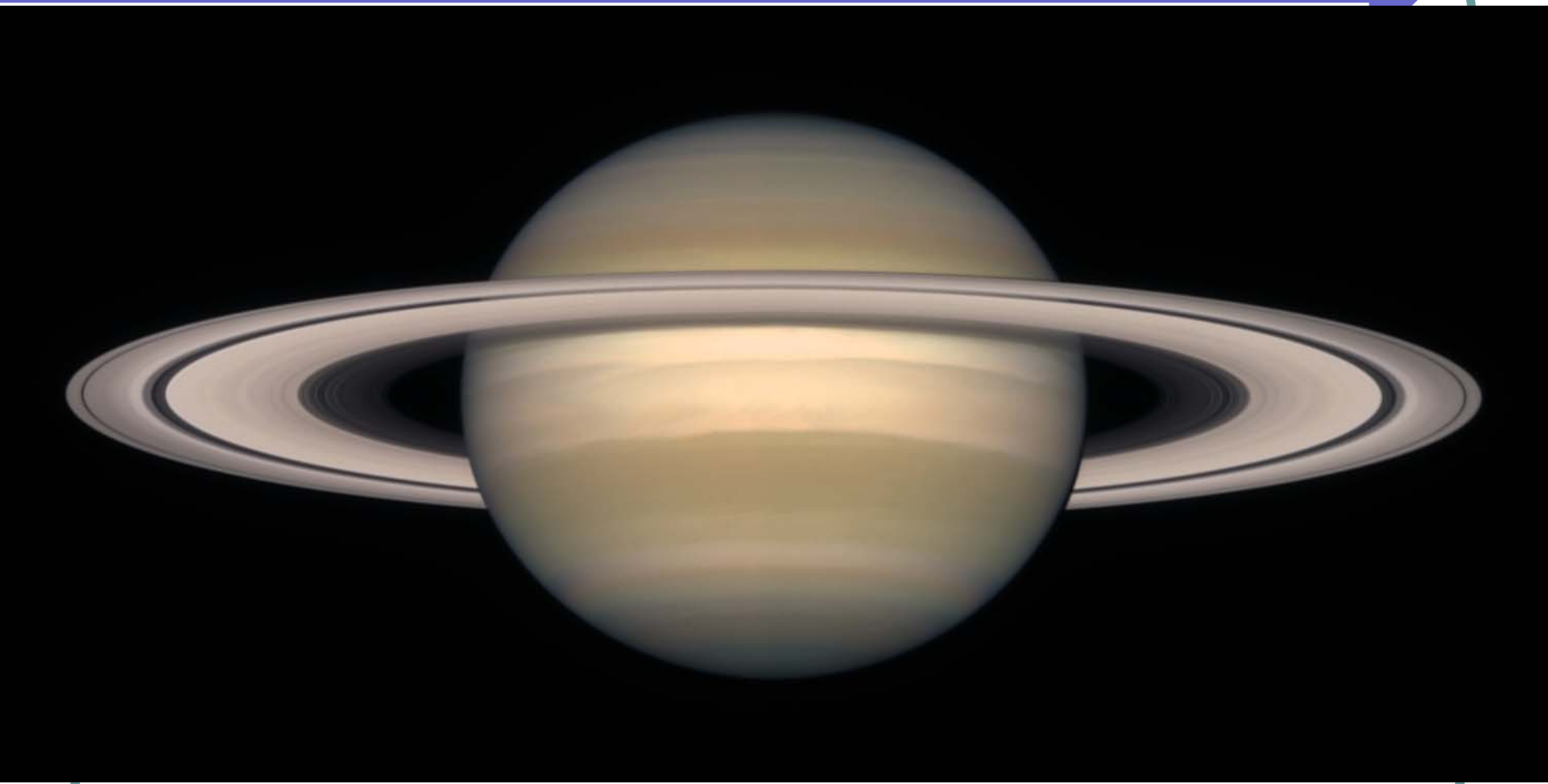
- **Deinococcus radiophilus** – recover from X-ray blasts millions of times the intensity would kill most living things
- **Bacilus subtilis** – nearly six years in space (1984 Long Duration Exposure Facility – NASA) – another experiment simulated 250 years of space exposure

Rocks from Mars

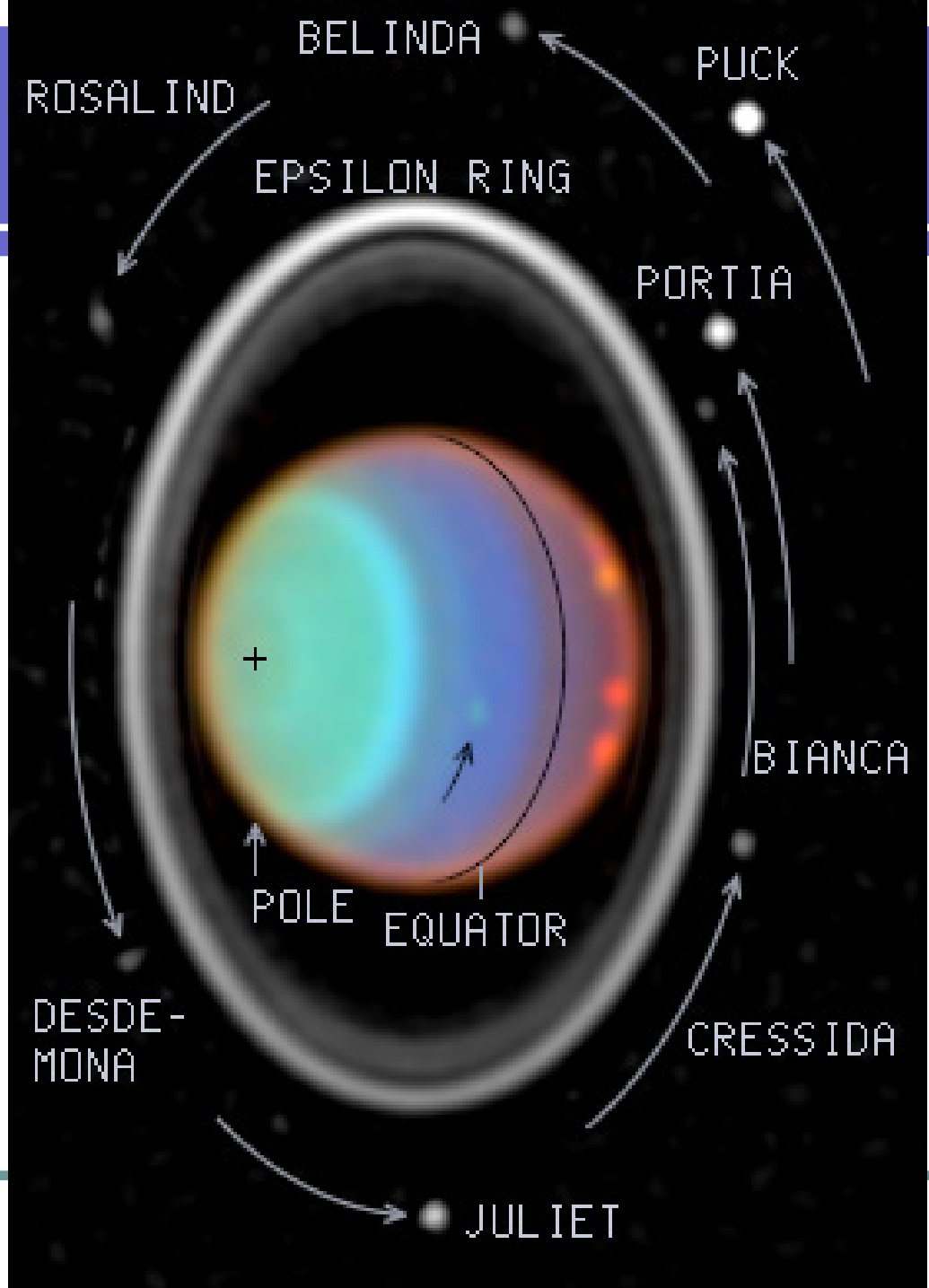
- Gladman et al. – Every few million years Mars undergoes an impact powerful enough to eject rocks that could reach Earth.

JUPITER

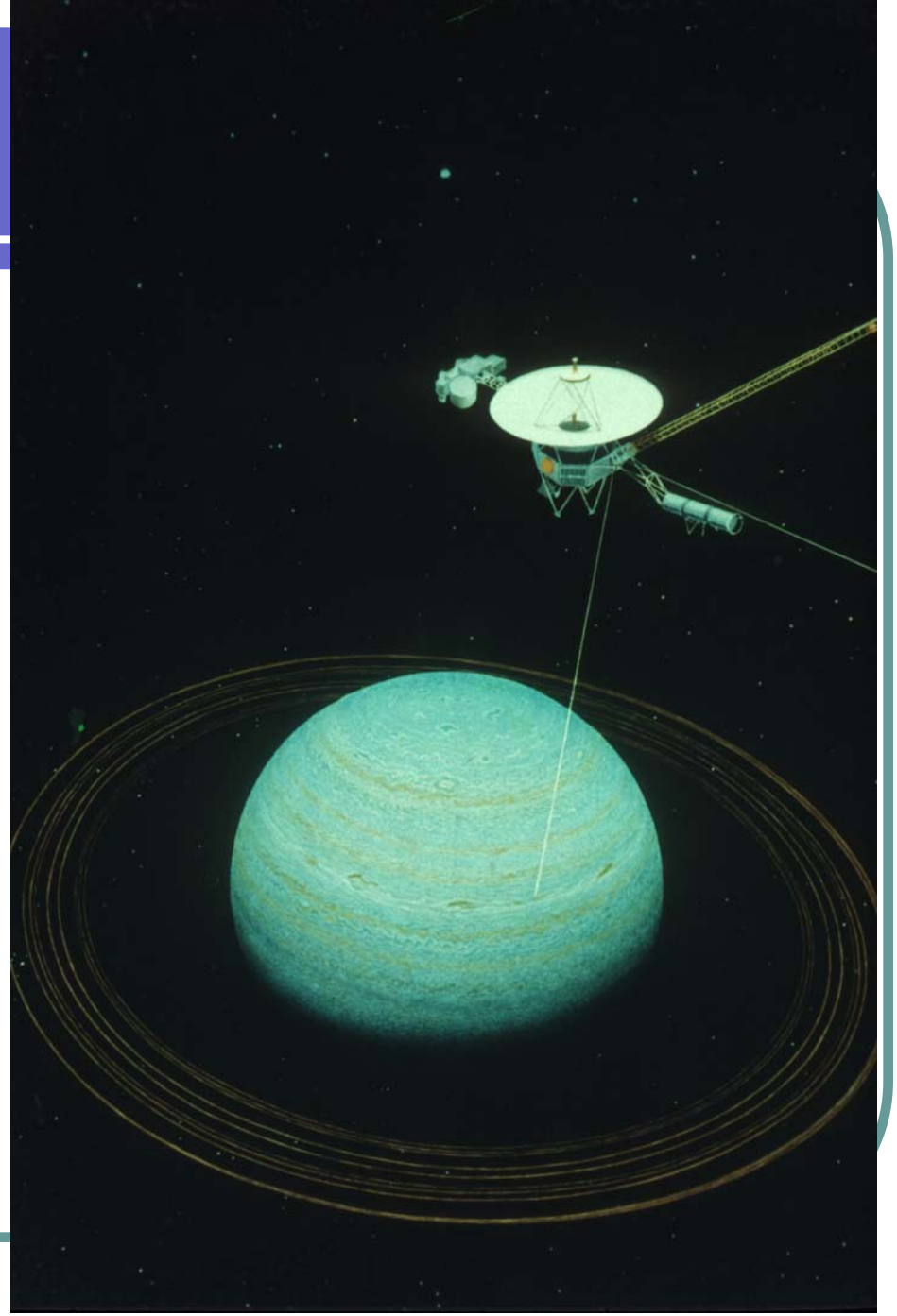
SATURN



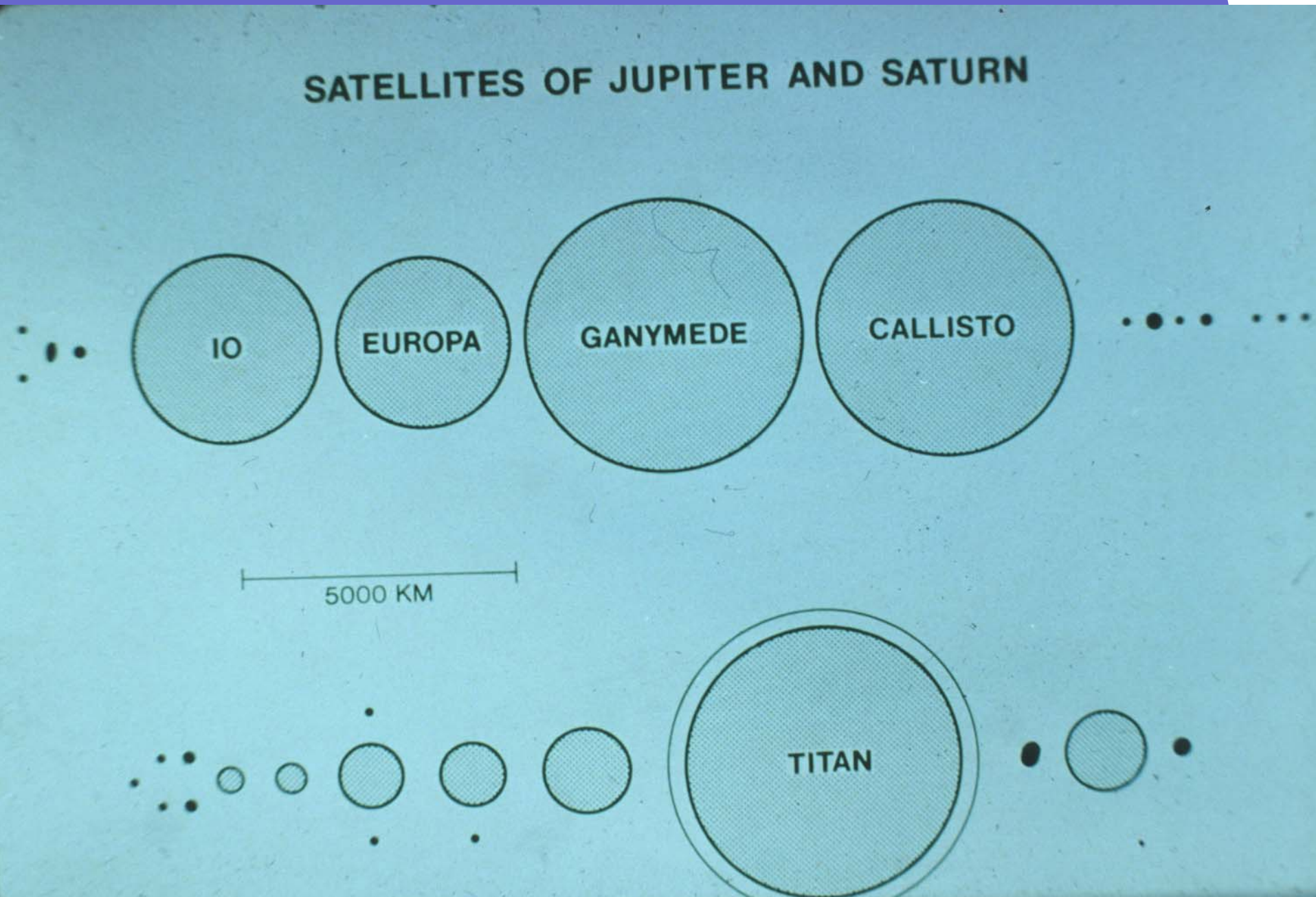
URANUS

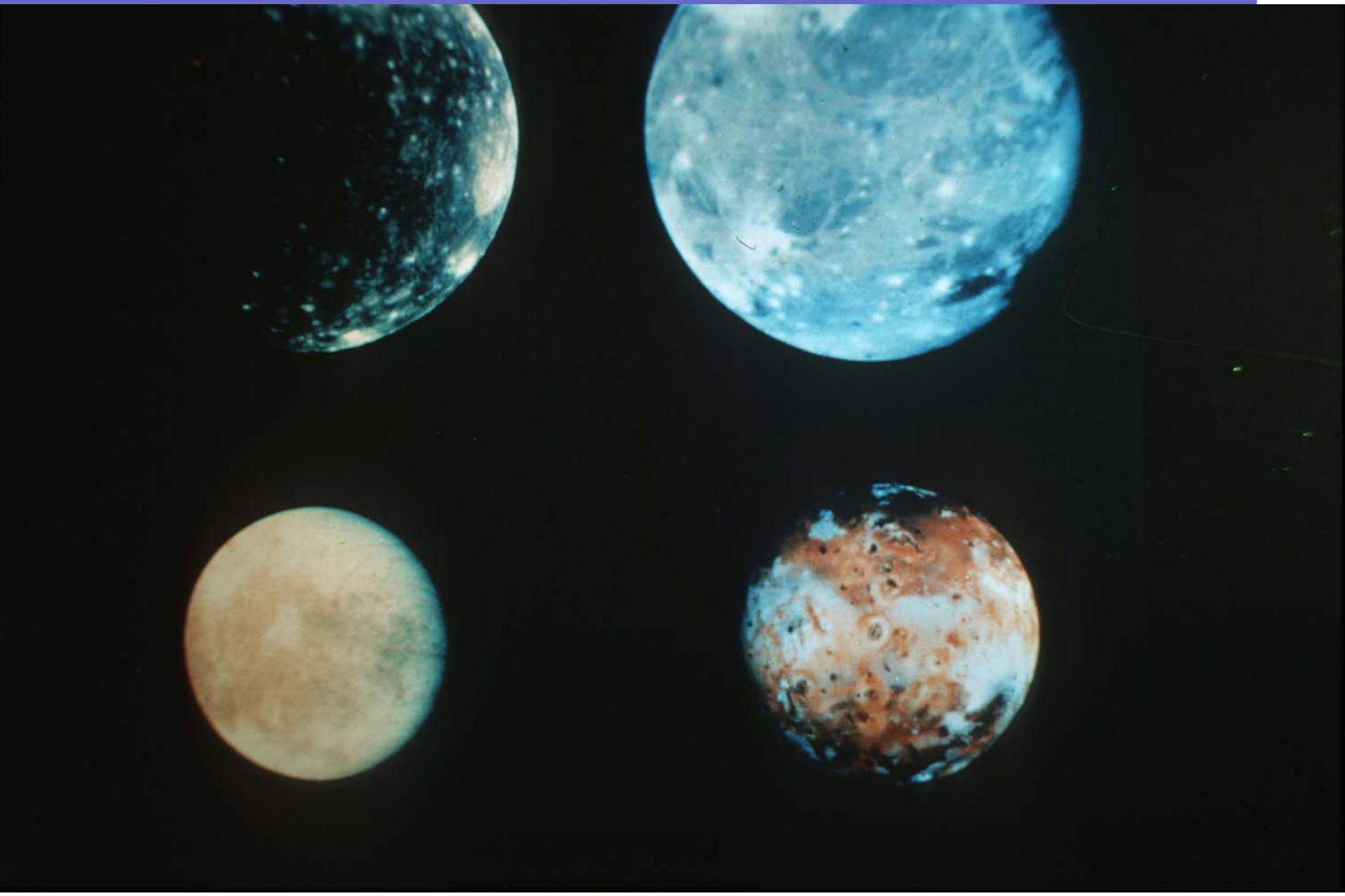

BELINDA
PUCK
ROSALIND
EPSILON RING
PORTIA
BIANCA
POLE
EQUATOR
DESDE-
MONA
CRESSIDA
JULIET

NEPTUNE

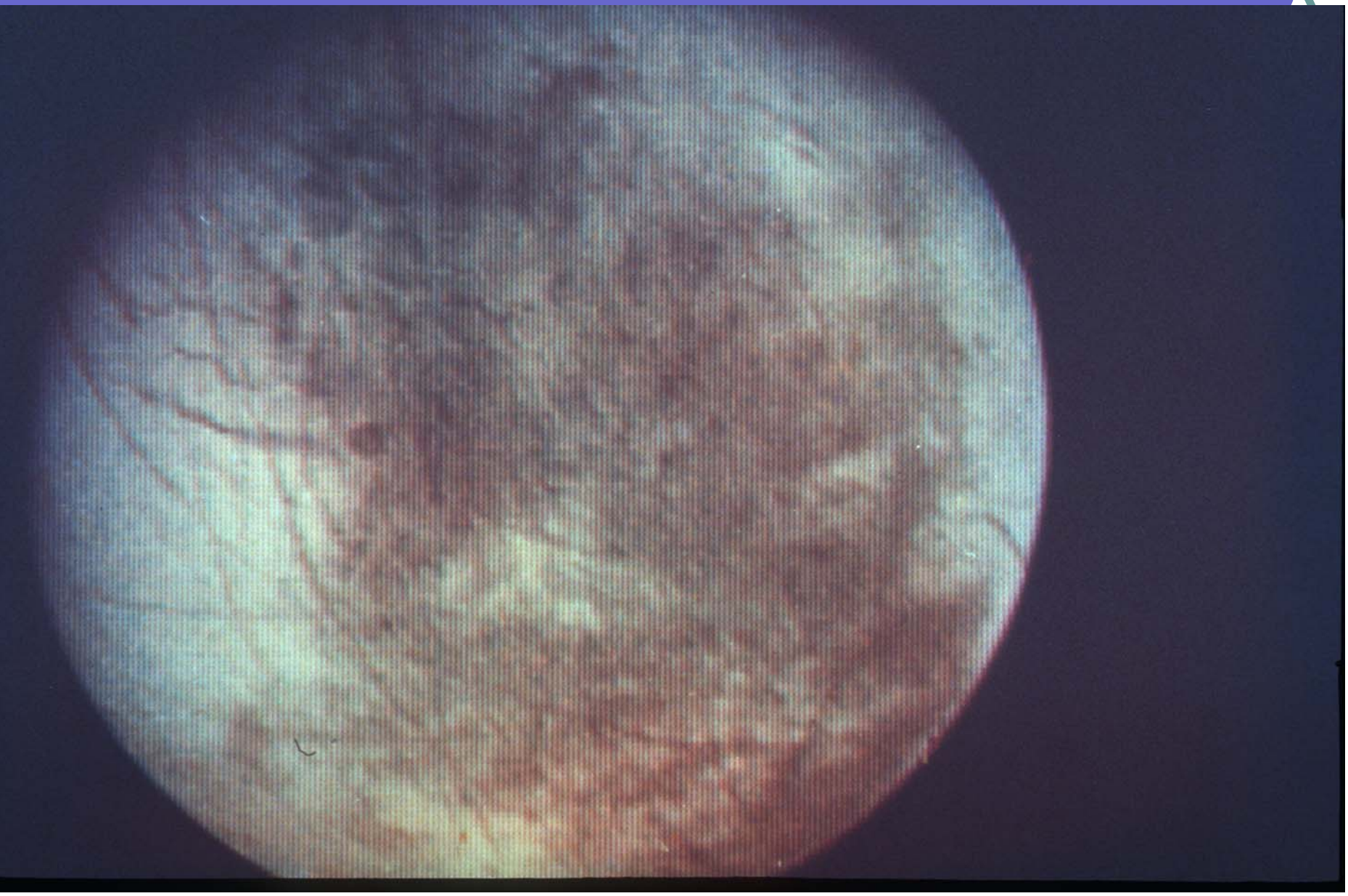


SATELLITES OF JUPITER AND SATURN

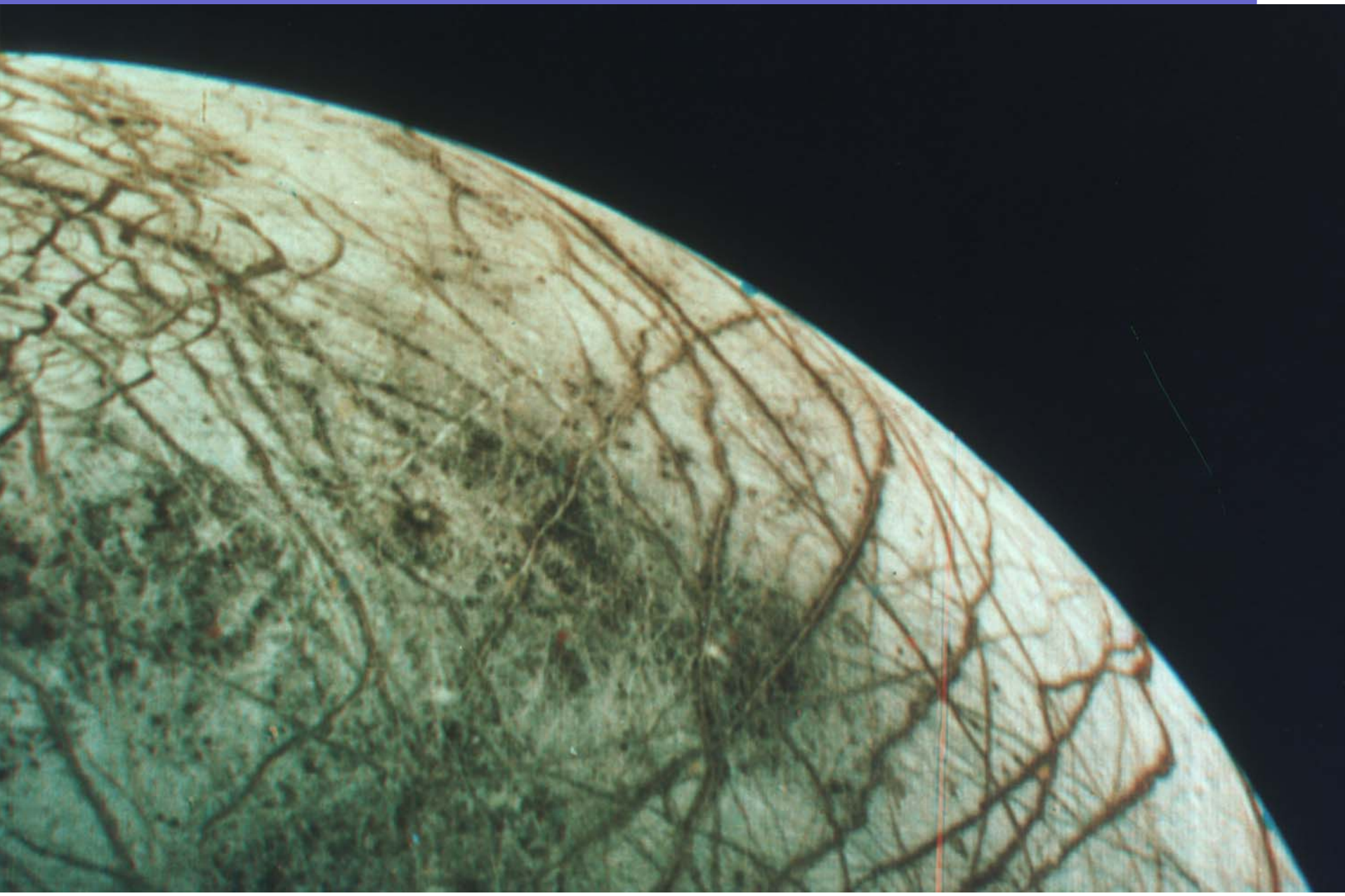


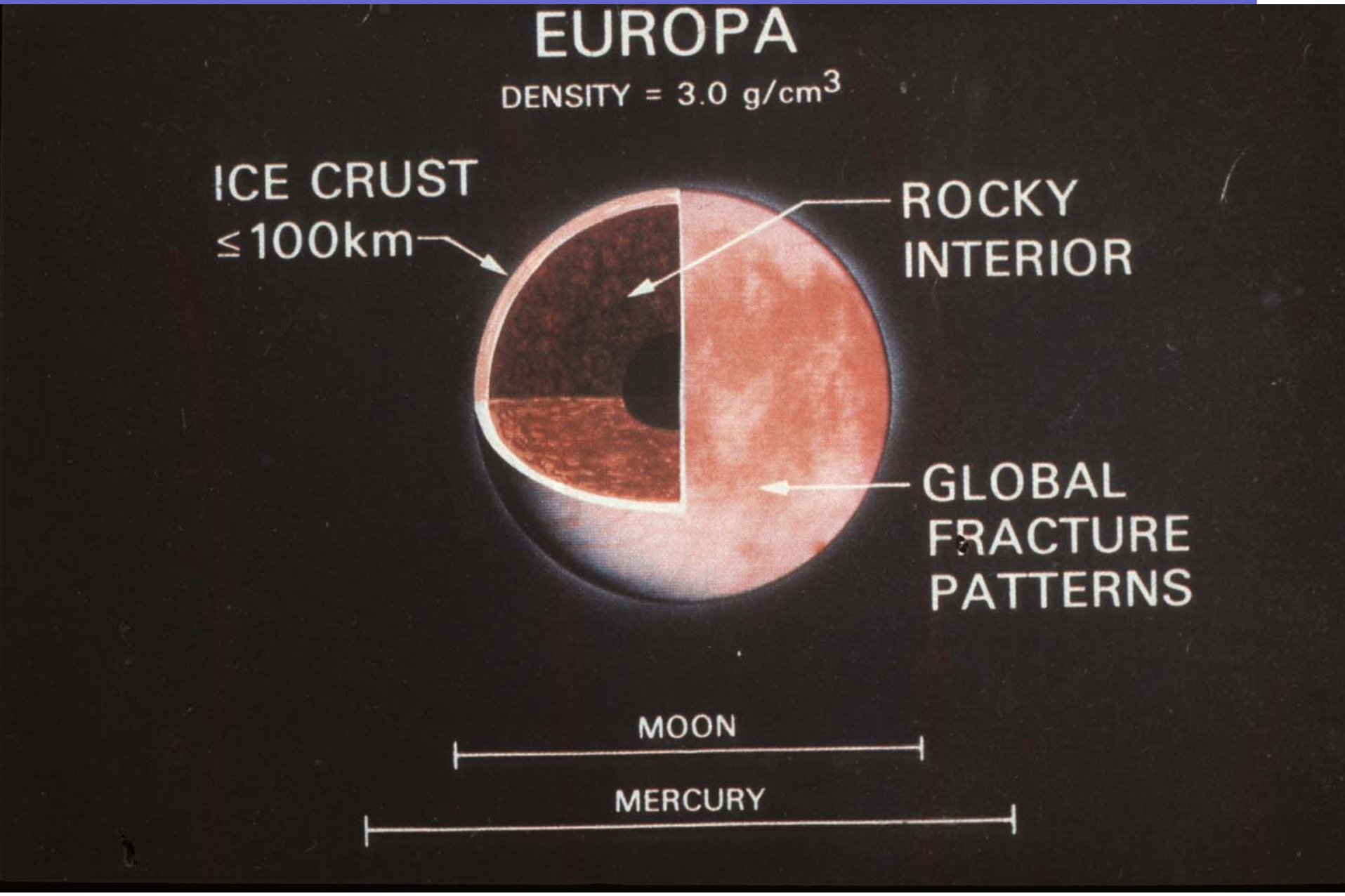


EUROPA



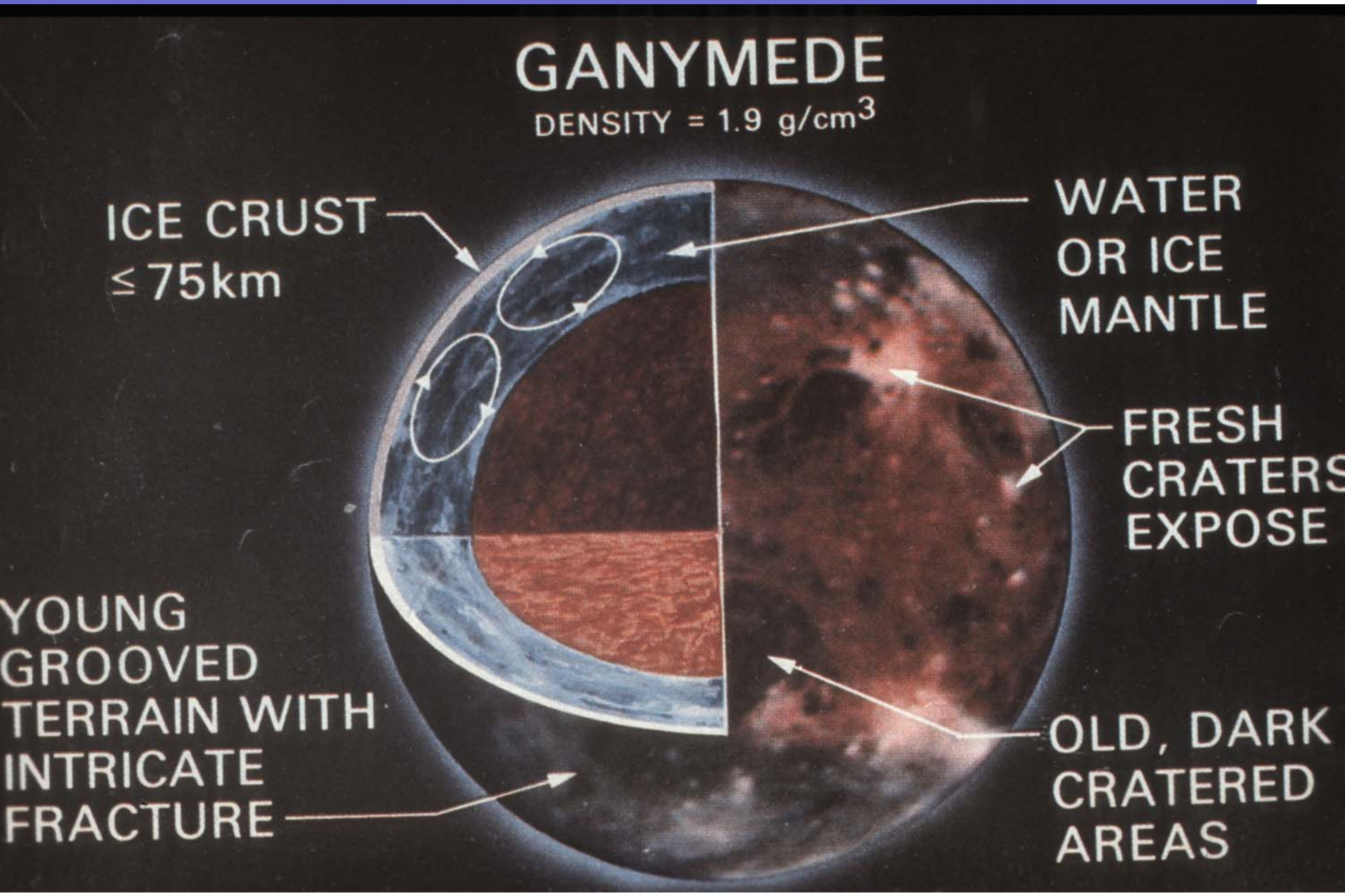
EUROPA



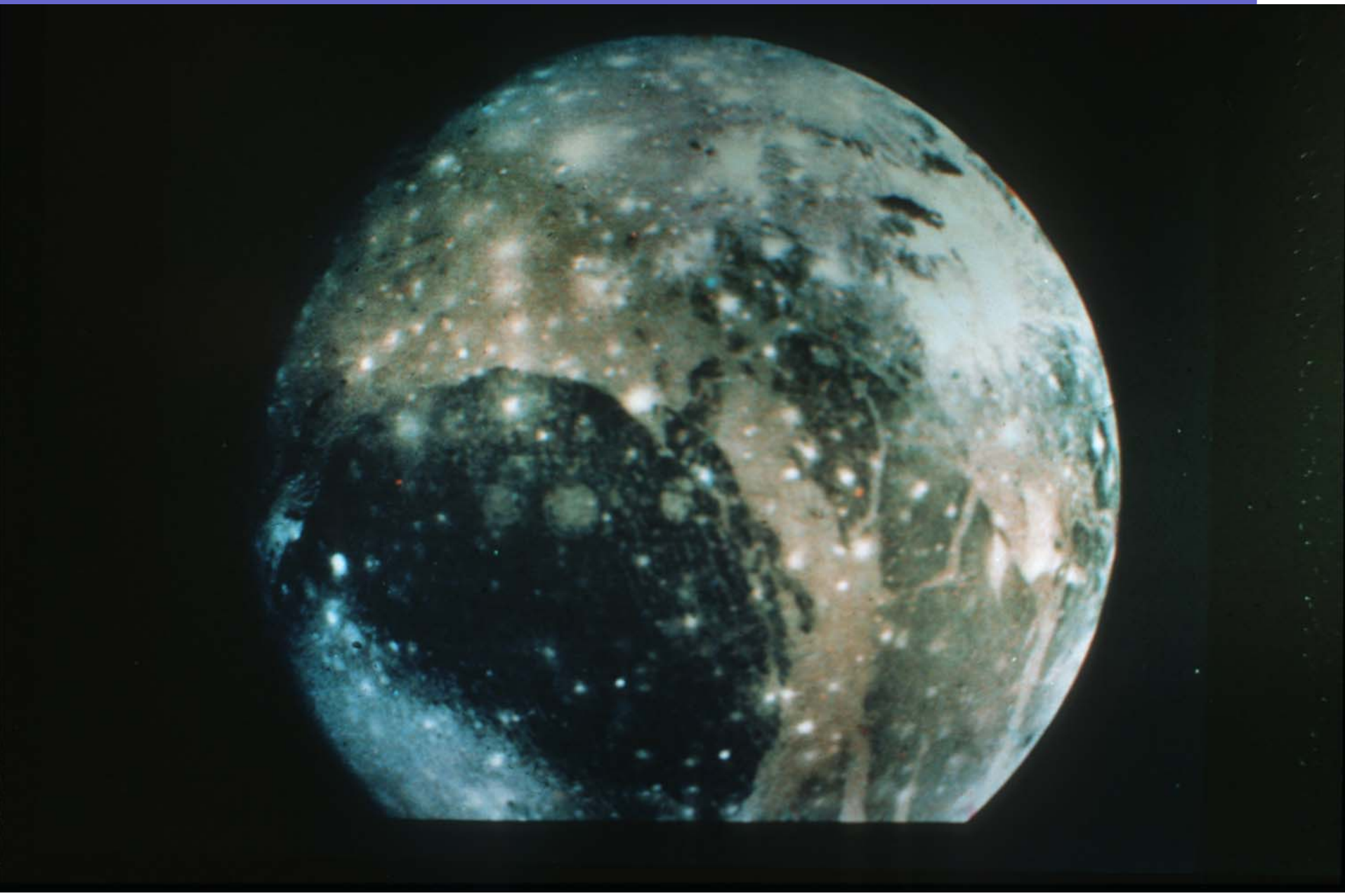

EUROPA
DENSITY = 3.0 g/cm3
ICE CRUST
≤100km
ROCKY
INTERIOR
GLOBAL
FRACTURE
PATTERNS
MOON
MERCURY

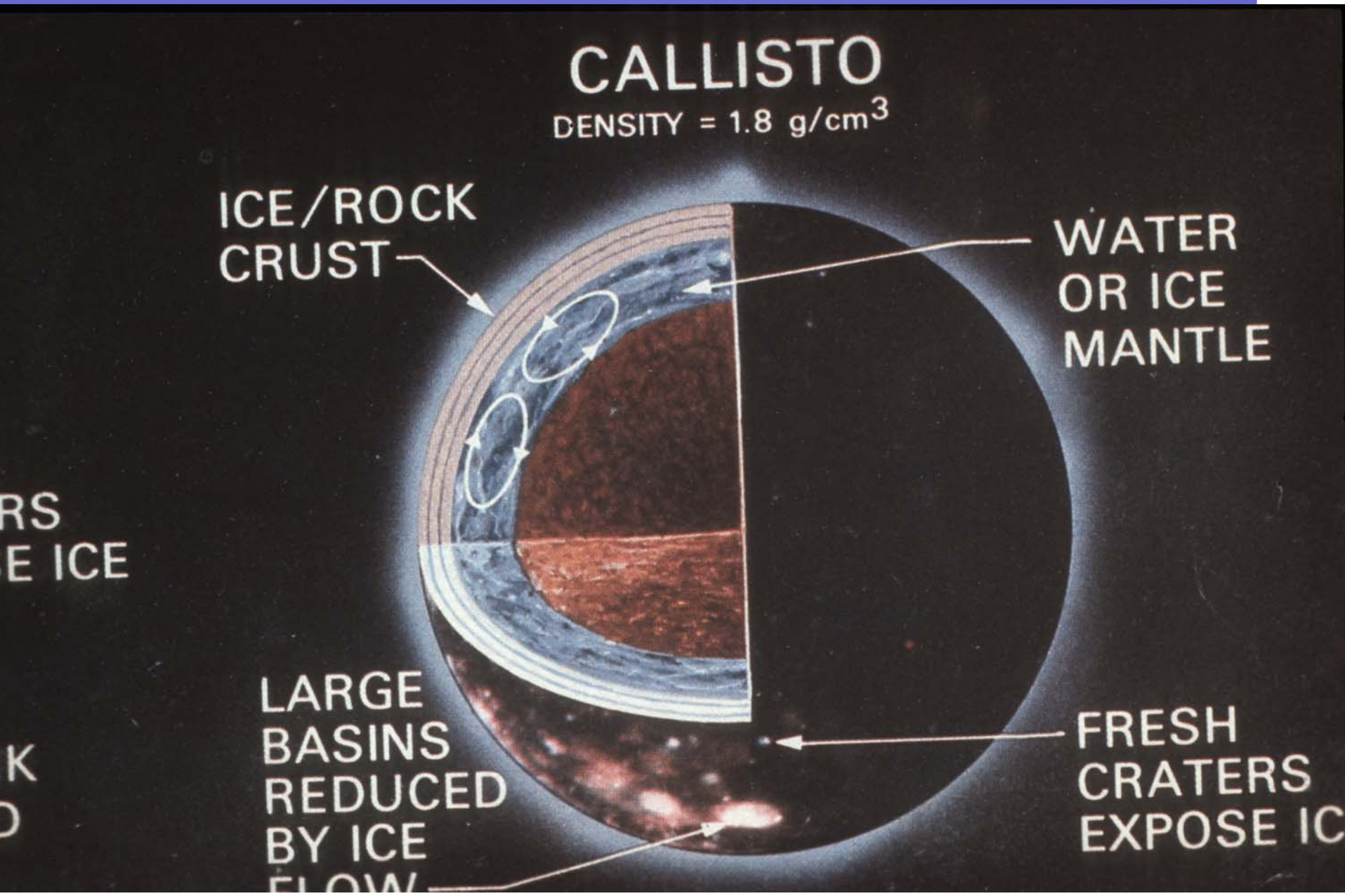
LAKE VOSTOK - ANTARCTIC

- 1996 discovered by radar – Russian station
- Isolated from the rest of the world 500 000 - 1 million years
- Surface 14000 km2
- Maximum depth 670 m
- Ice above 3600 m
- Found single celled organisms, fungi, algues

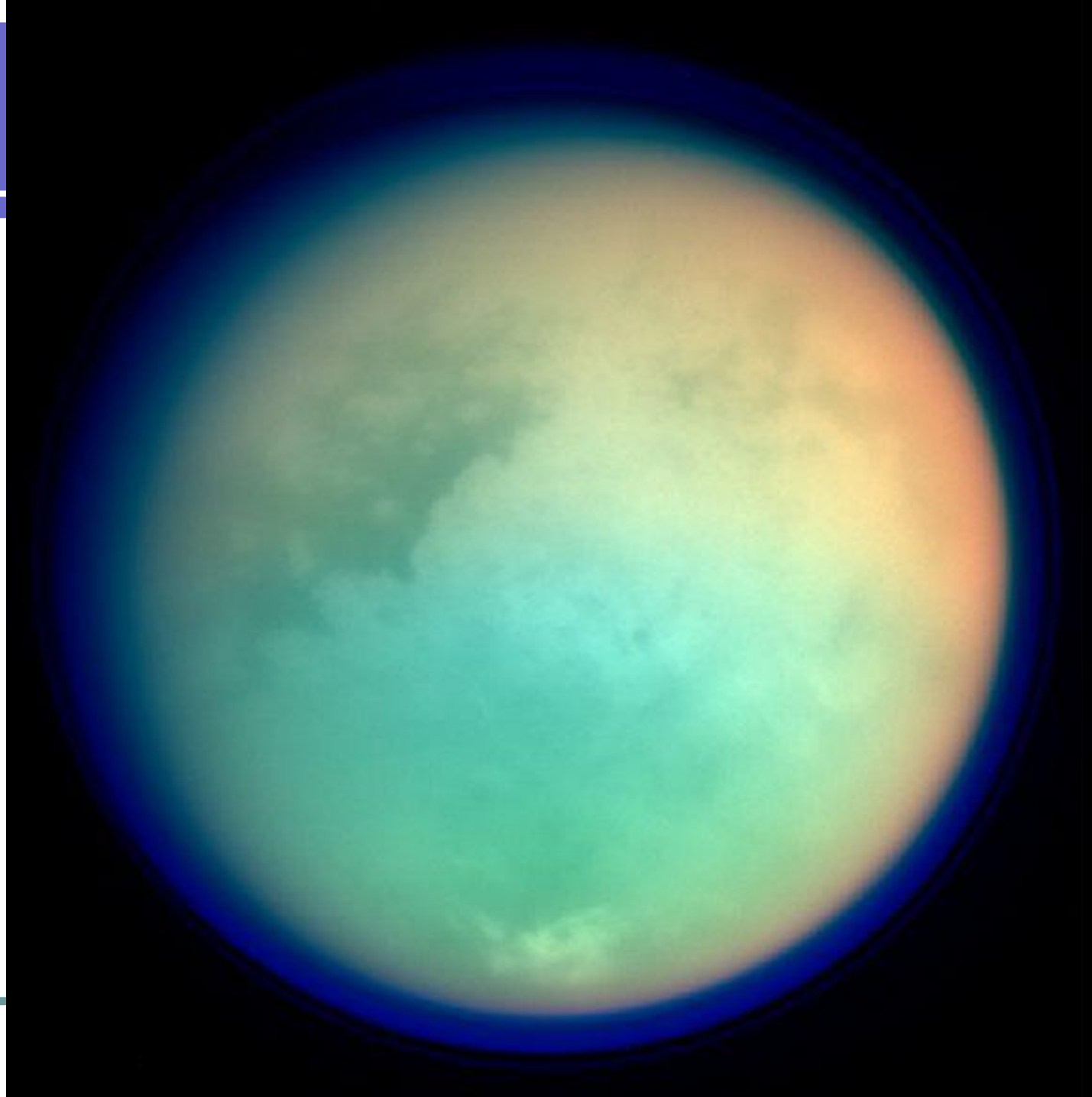

GANYMEDE
DENSITY = 1.9 g/cm3
ICE CRUST
≤75km
WATER
OR ICE
MANTLE
FRESH
CRATERS
EXPOSE
YOUNG
GROOVED
TERRAIN WITH
INTRICATE
FRACTURE
OLD, DARK
CRATERED
AREAS

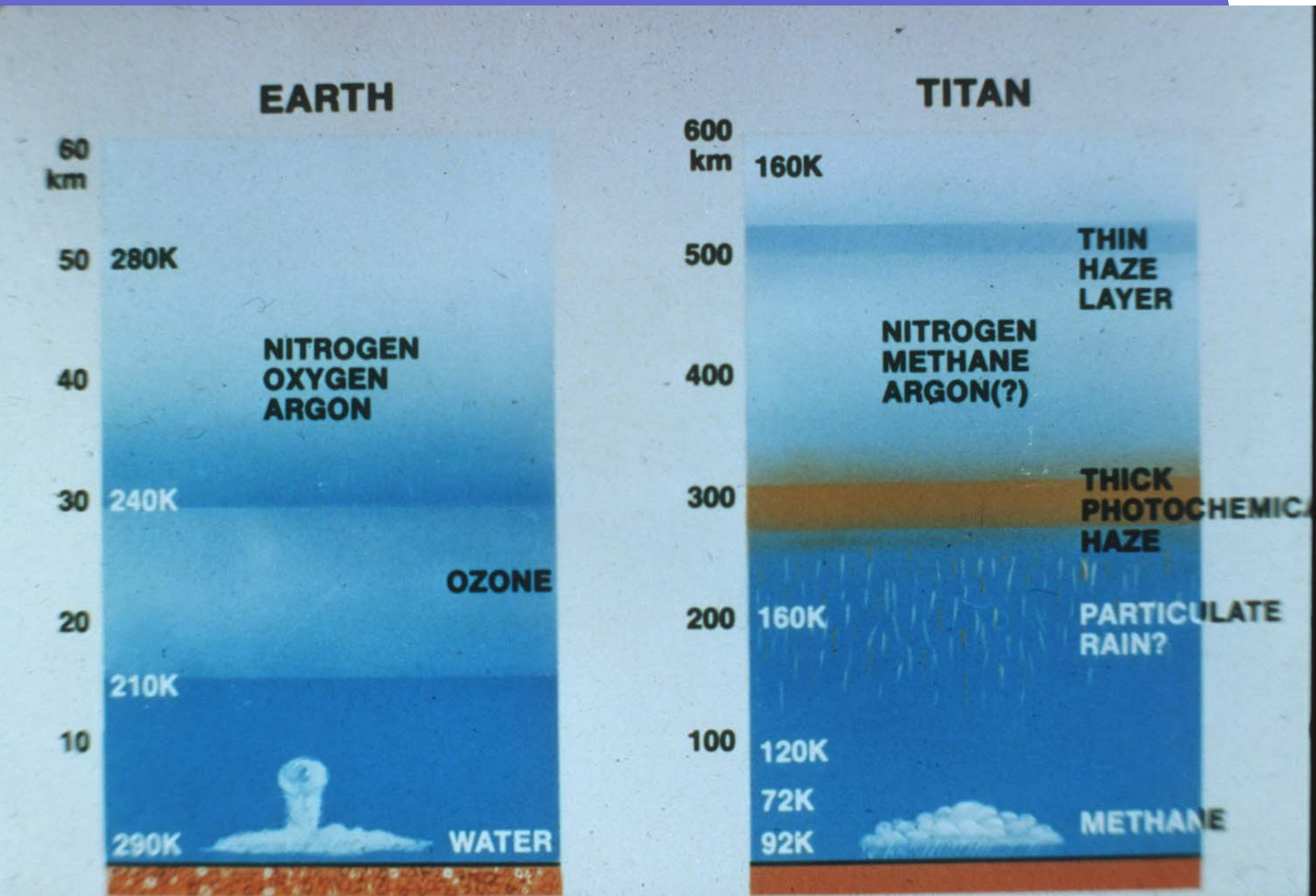
CALISTO

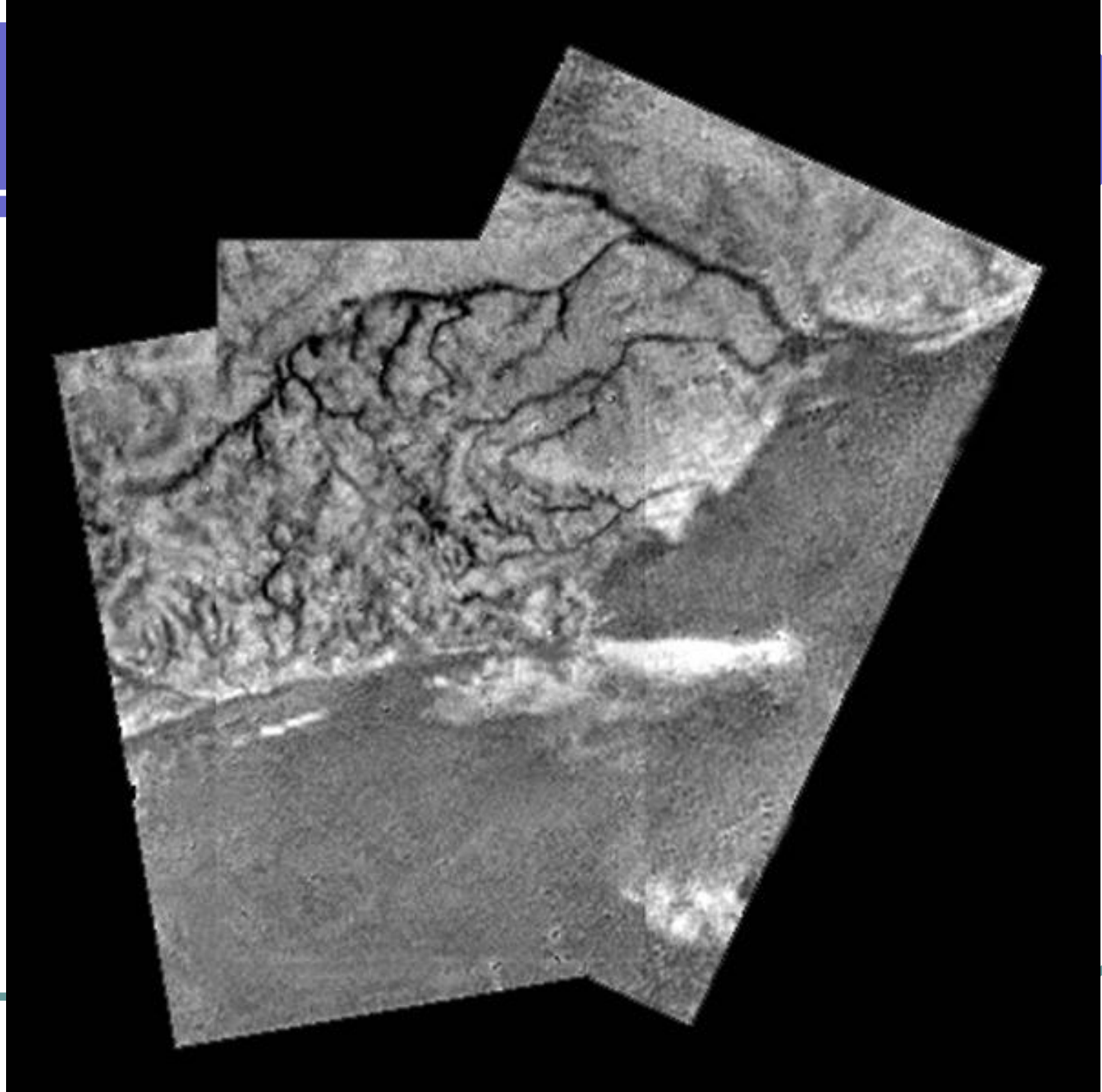


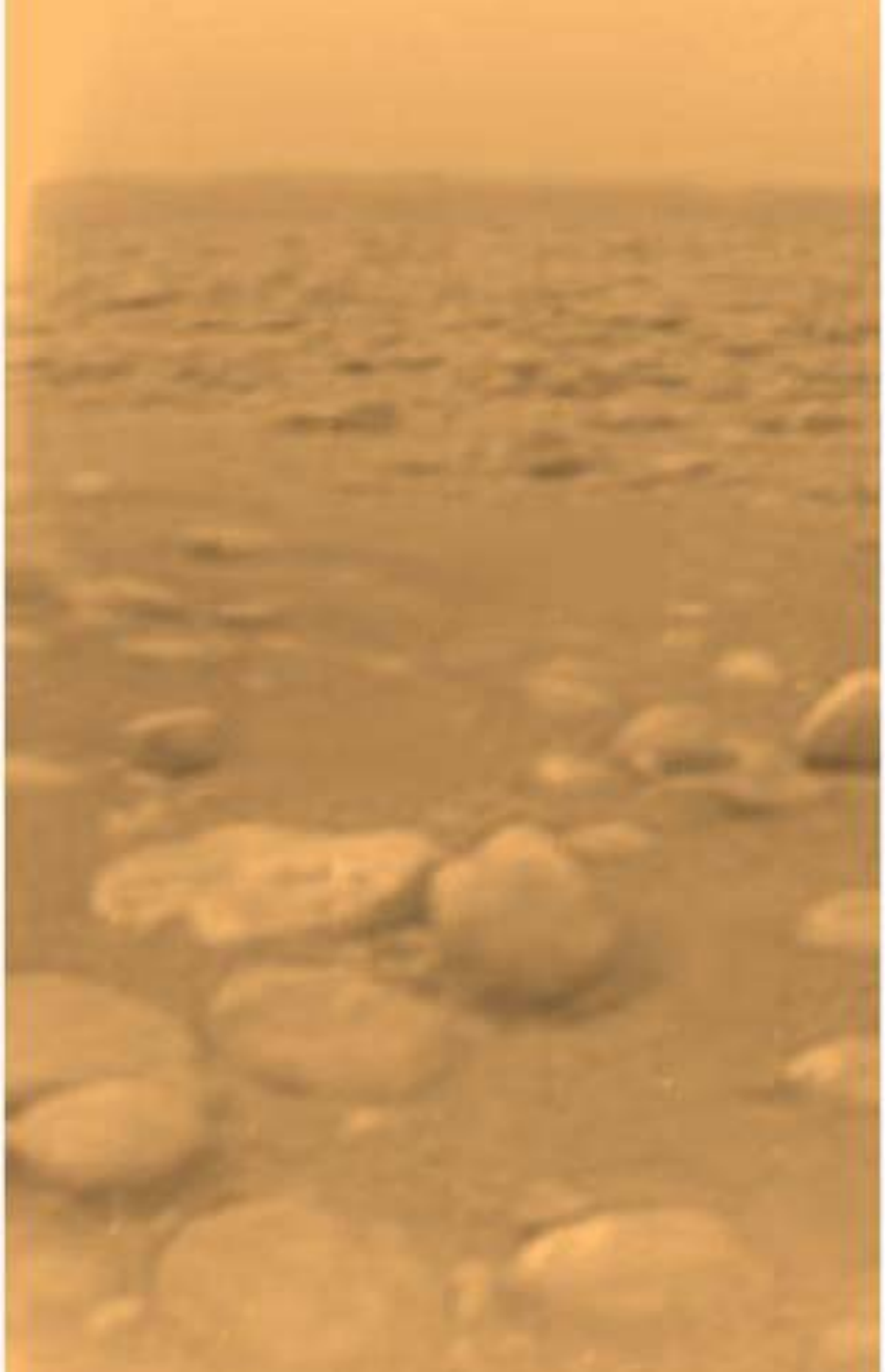

CALLISTO
DENSITY = 1.8 g/cm3
ICE/ROCK
CRUST
WATER
OR ICE
MANTLE
LARGE
BASINS
REDUCED
BY ICE
FLOW
FRESH
CRATERS
EXPOSE IC

TITAN

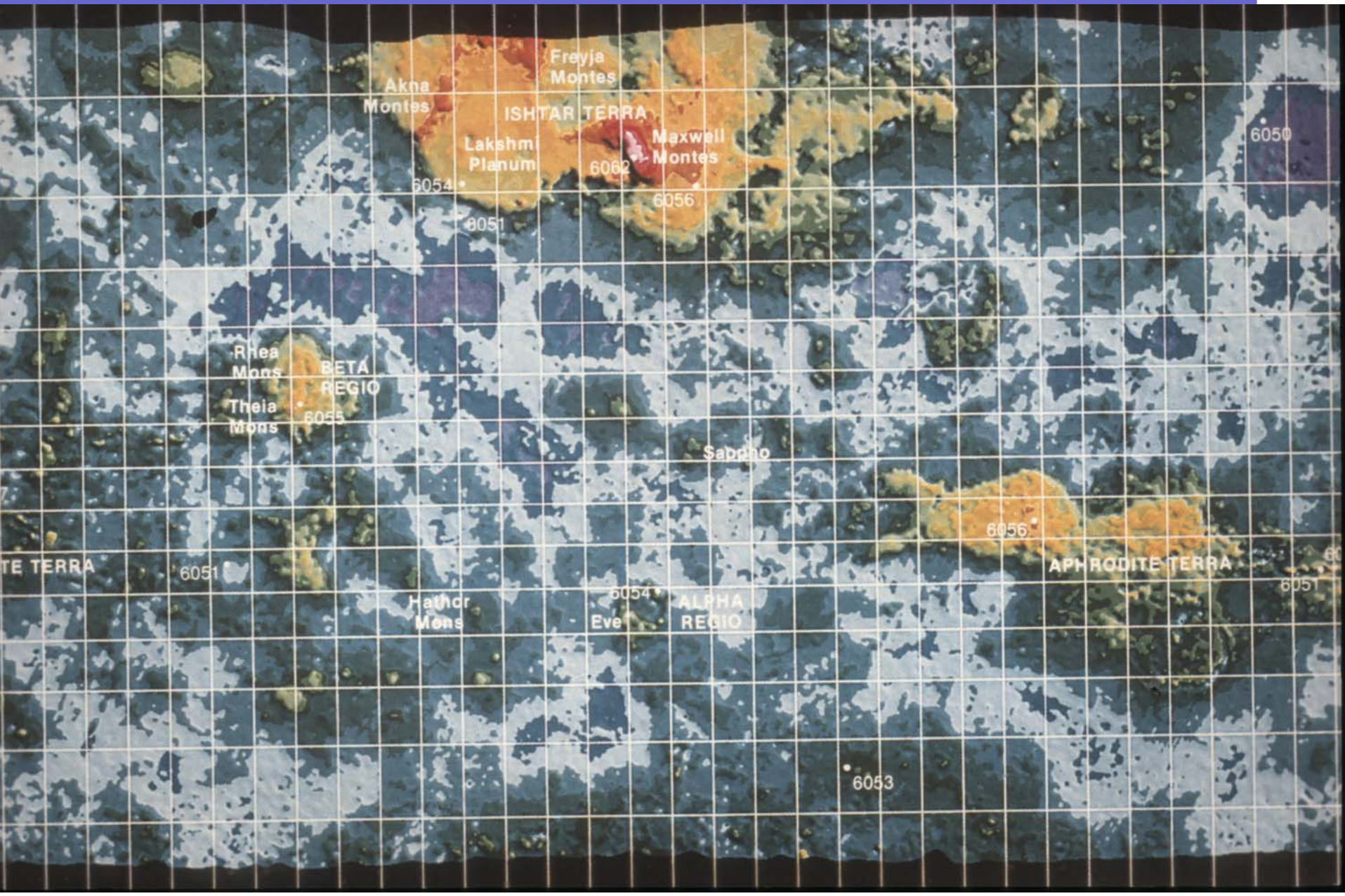



EARTH
60
km
50
280K
NITROGEN
OXYGEN
ARGON
40
30
240K
OZONE
20
210K
10
290K
WATER
TITAN
600
km
160K
500
THIN
HAZE
LAYER
NITROGEN
METHANE
ARGON(?)
400
300
THICK
PHOTOCHEMICA
HAZE
200
160K
PARTICULATE
RAIN?
100
120K
72K
92K
METHANE

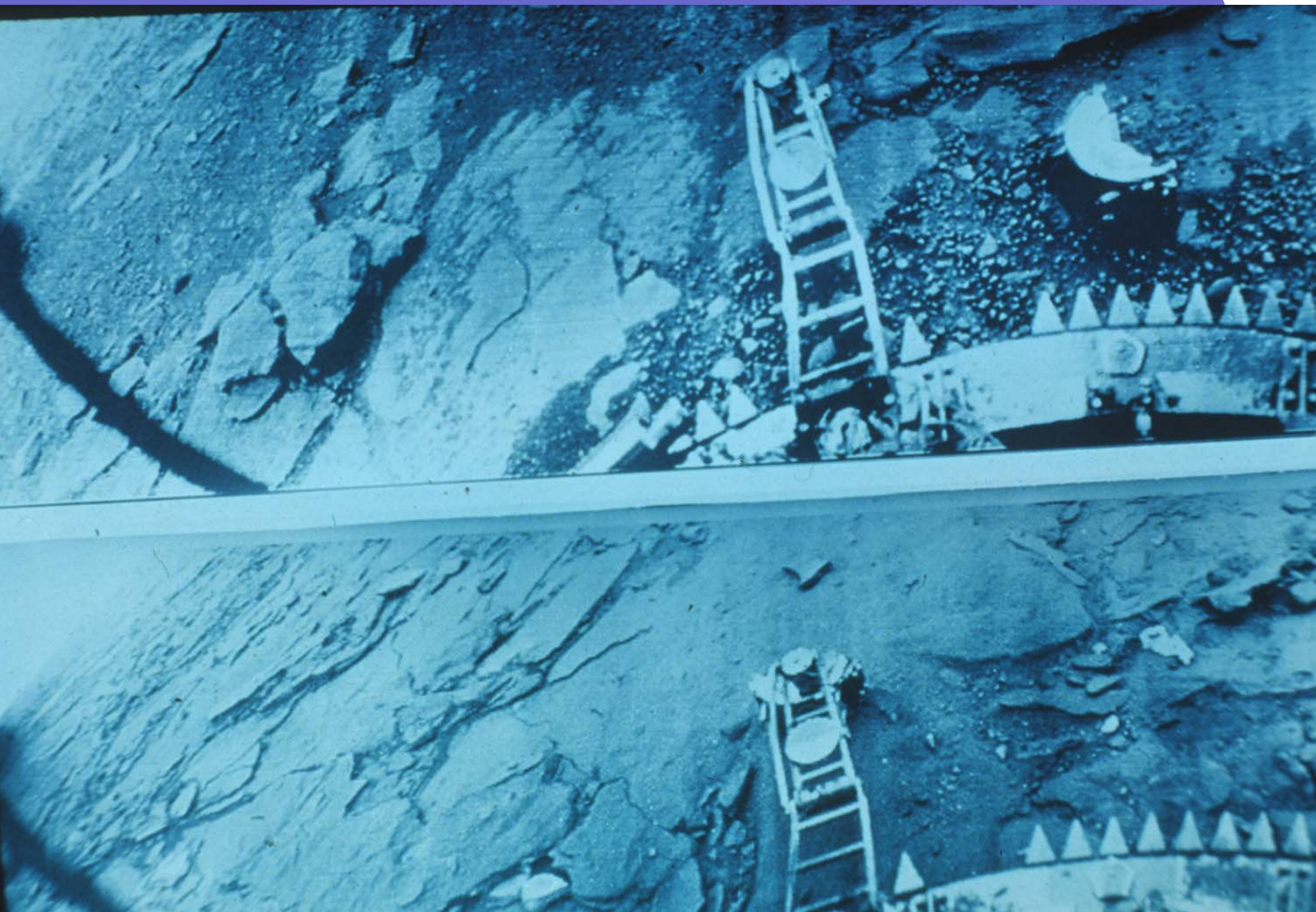




VENUS


Freyja Montes
Akna Montes
ISHTAR TERRA
Lakshmi Planum
Maxwell Montes
6062
6054
6056
6051
6050
Rhea Mons
BETA REGIO
Theia Mons
6055
Sappho
6056
APHRODITE TERRA
6051
TE TERRA
6051
Hathor Mons
6054
Eve
ALPHA REGIO
6053

VENERA 14



Thank you!