Soviet Lunokhod 1 and 2 missions and things around

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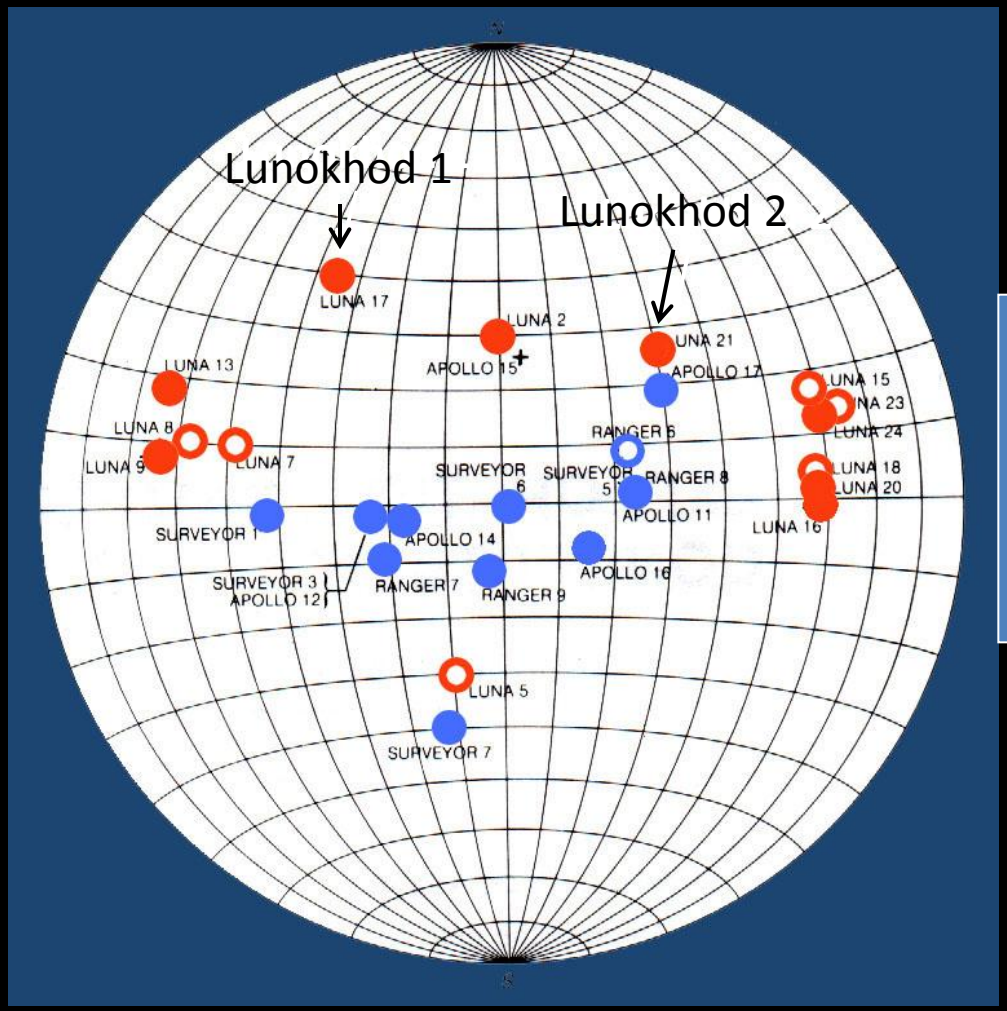
MicroRover
Space Horizons Workshop
Brown University, School of Engineering
February 16, 2012

Lunokhod 1 and 2 rovers and scientific instruments on them

Space race to the Moon

Cold war time flights to the Moon

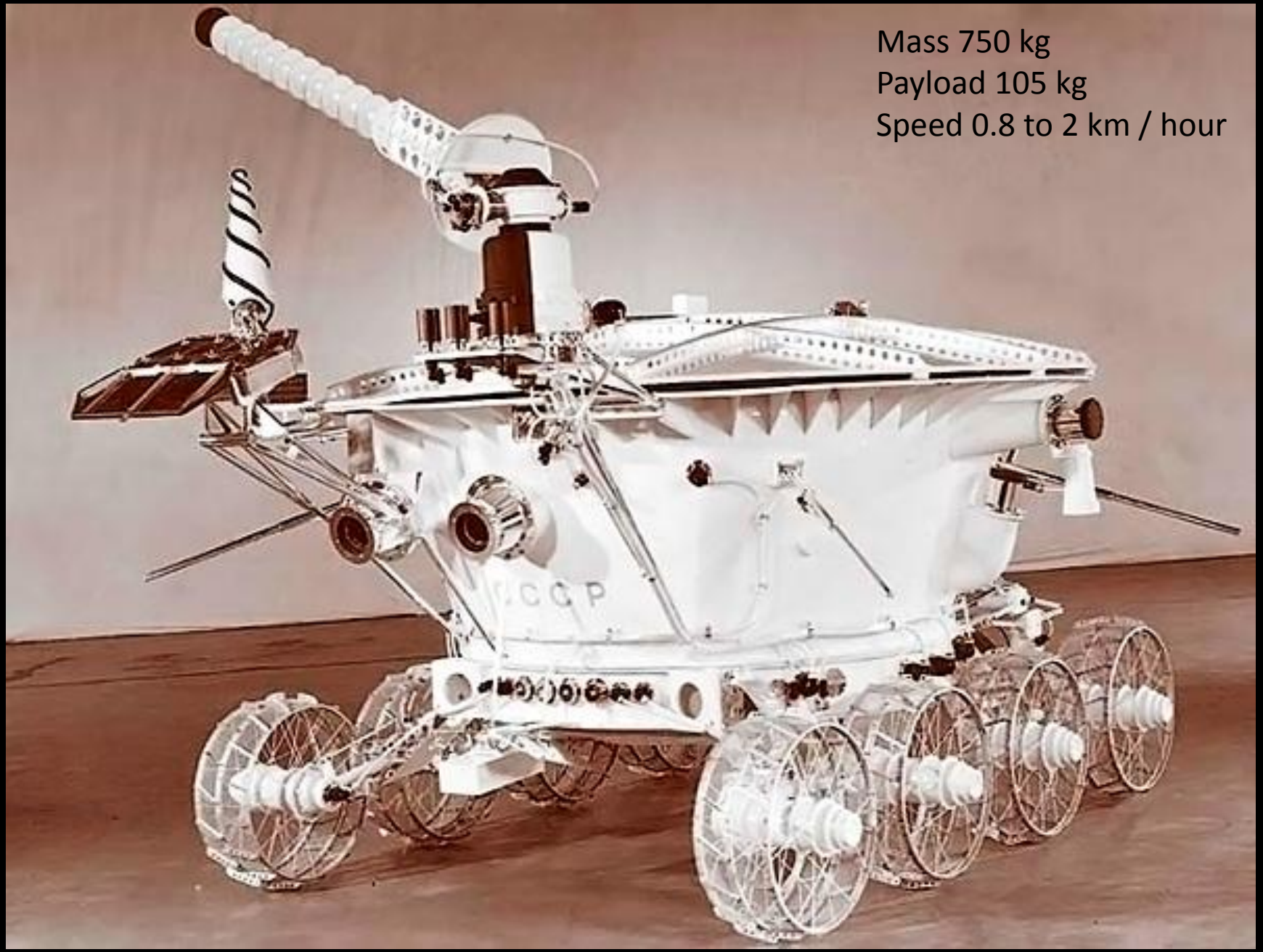
USSR
Attempts 48
Successful 21



USA
Attempts 31
Successful 22

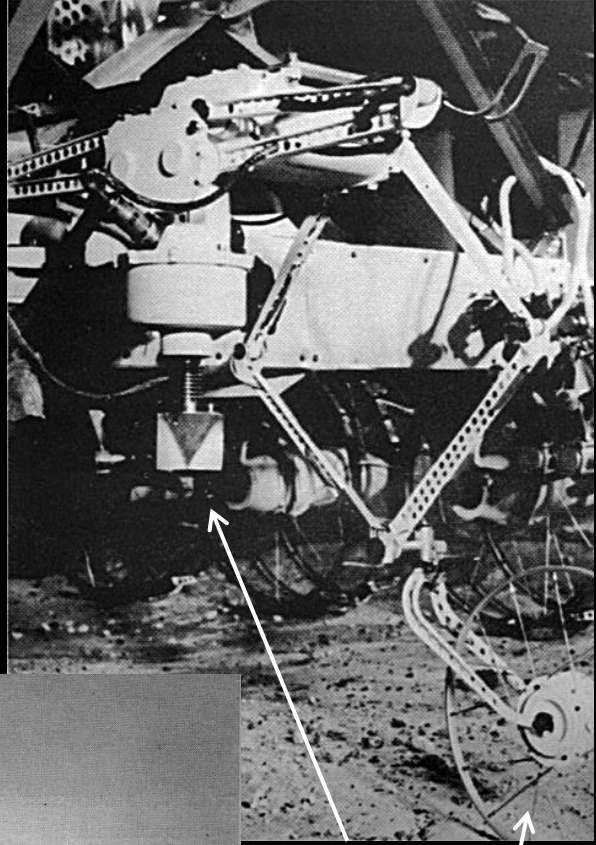
From Huntress, Moroz, Shevalev, 2003

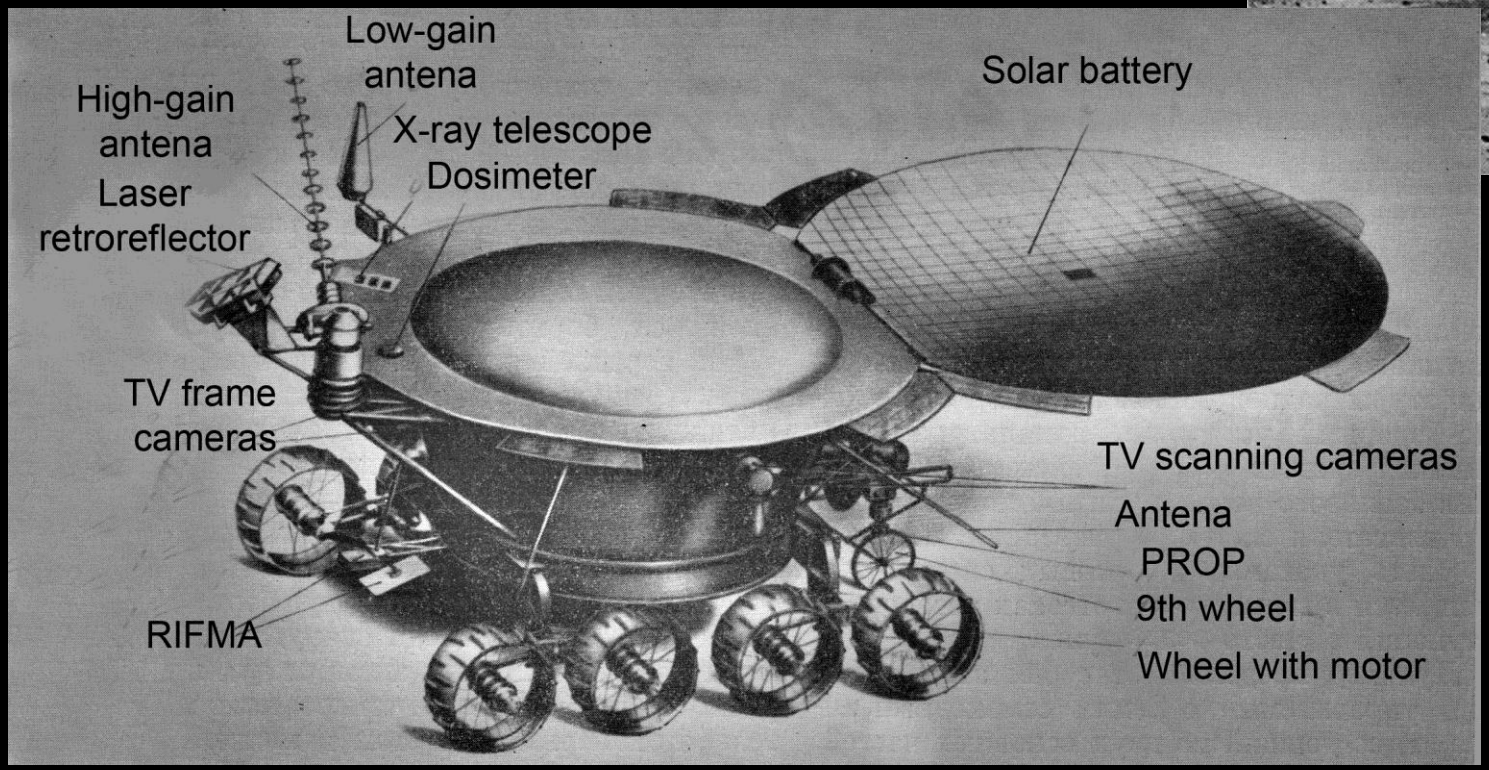
Lunokhod 1



Lunokhod 1 payload

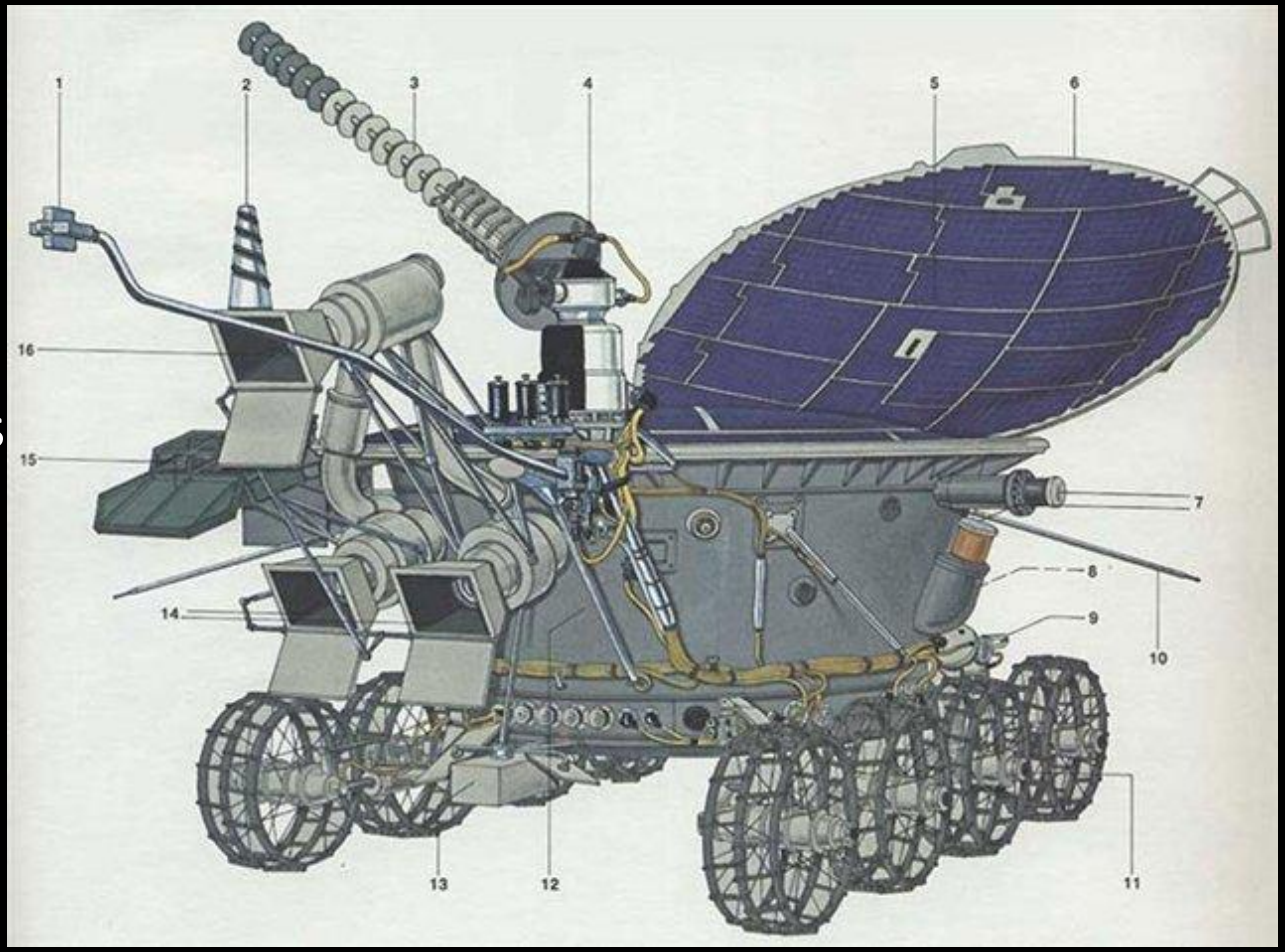
- Frame & Panoramic TV cameras
- RIFMA X-ray Fluorescence Spectrometer
- X-ray Telescope
- PROP Soil Mechanics Sensor
- Radiation Detector
- Laser Retroreflector



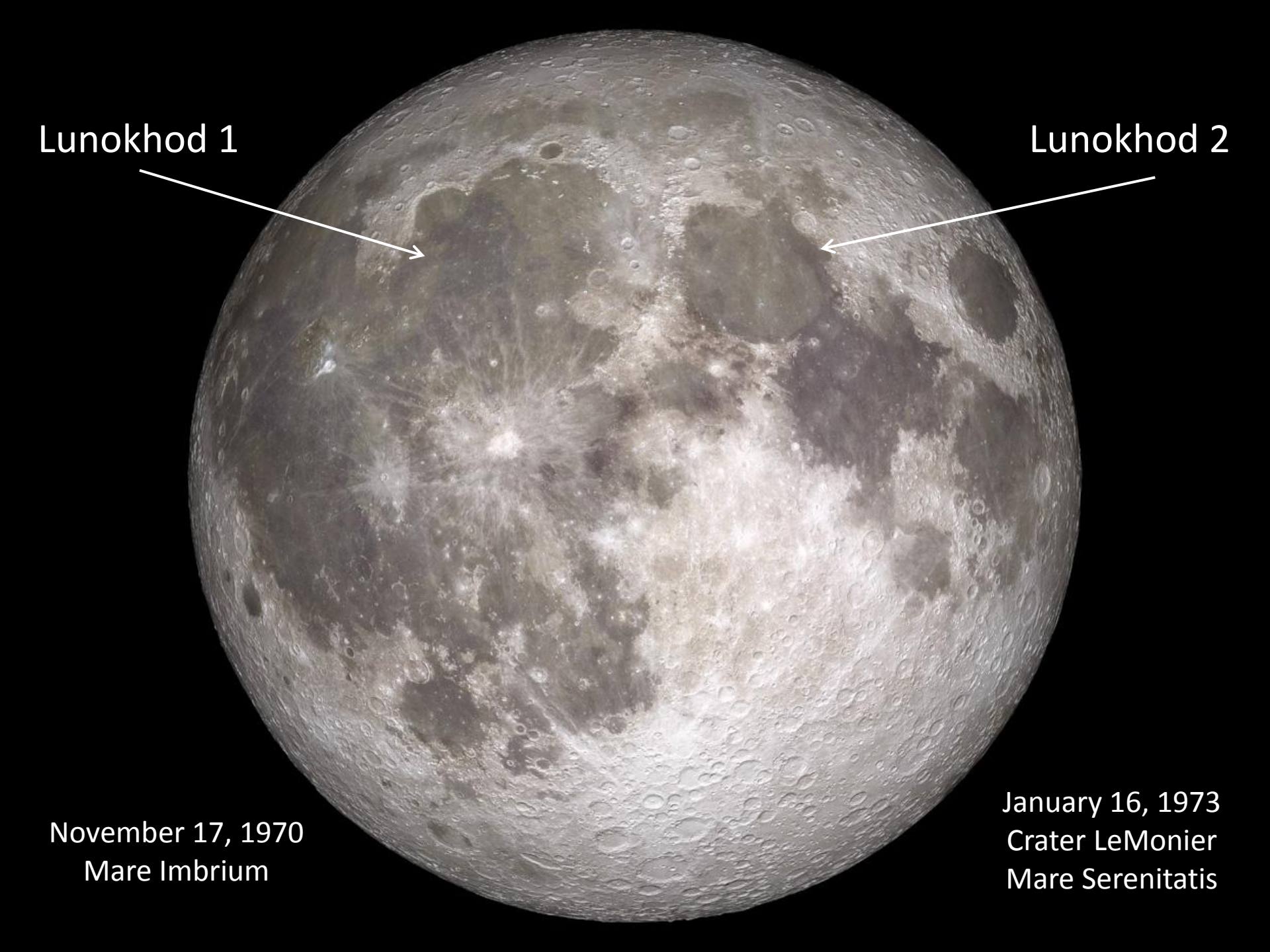


Lunokhod 2 and its payload

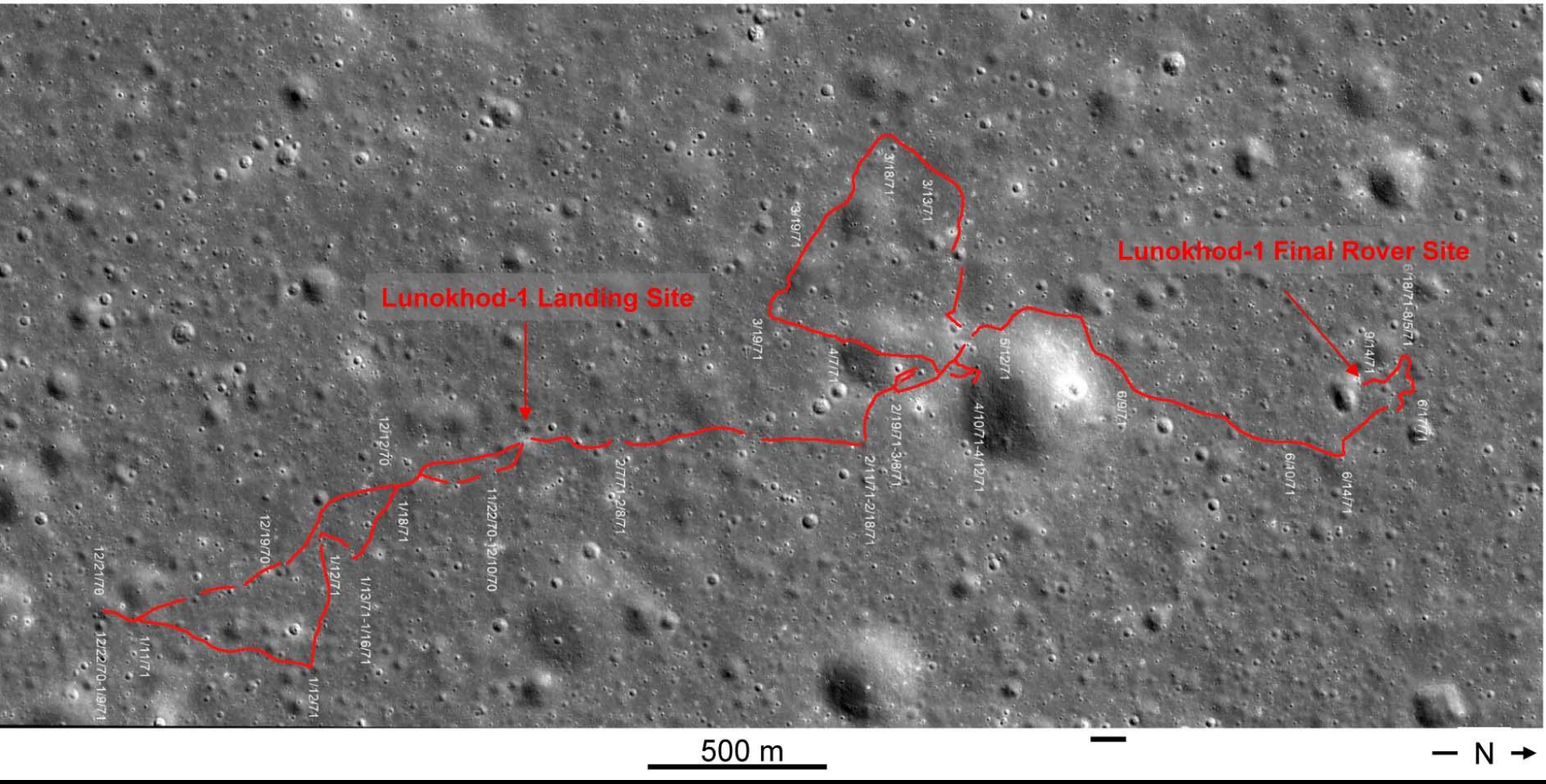
- Frame & Panoramic TV cameras
- RIFMA X-ray Fluorescence Spectrometer
- X-ray Telescope
- PROP Soil Mechanics Sensor
- Radiation Detector
- Laser Retroreflector
- UV/Visible Astrophotometer
- Magnetometer
- Photodetector

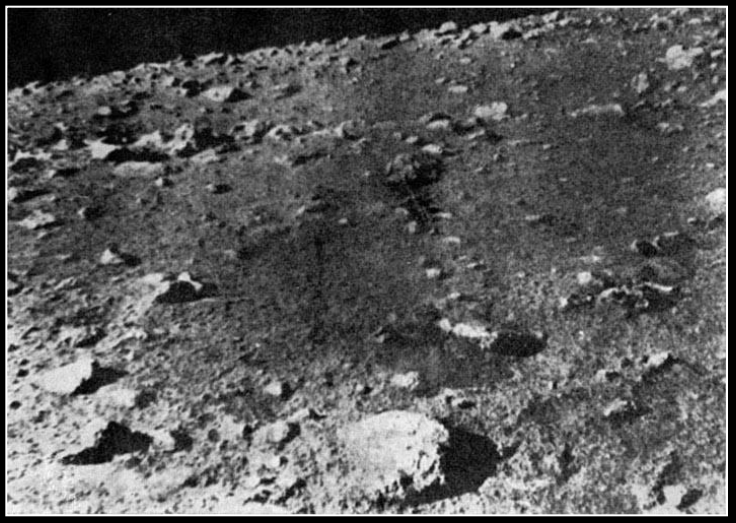


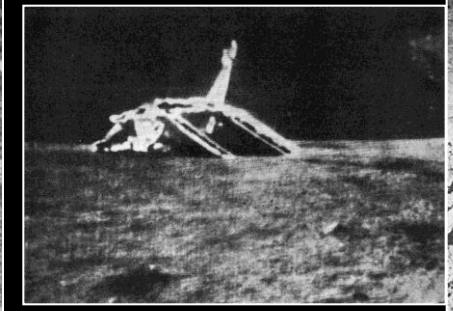
Lunokhod 1 and 2 missions


Lunokhod 1
Lunokhod 2
November 17, 1970
Mare Imbrium
January 16, 1973
Crater LeMonier
Mare Serenitatis

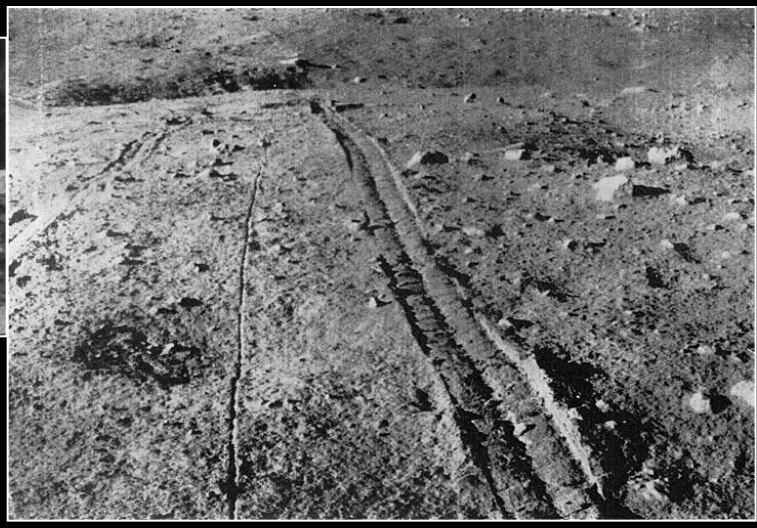
Lunokhod-1 landing site
Lunokhod-1 rover traverse mapped by J. Plescia
on LROC NAC-L/R image M150749234/M150756018

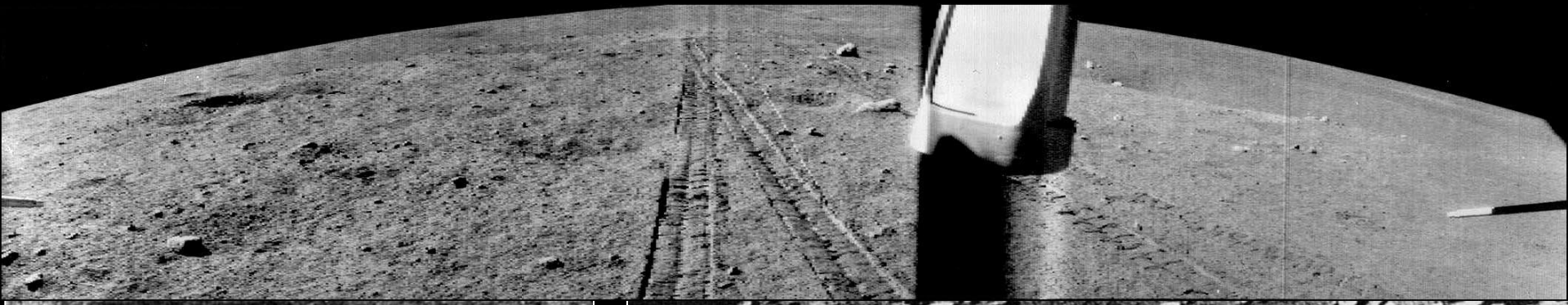






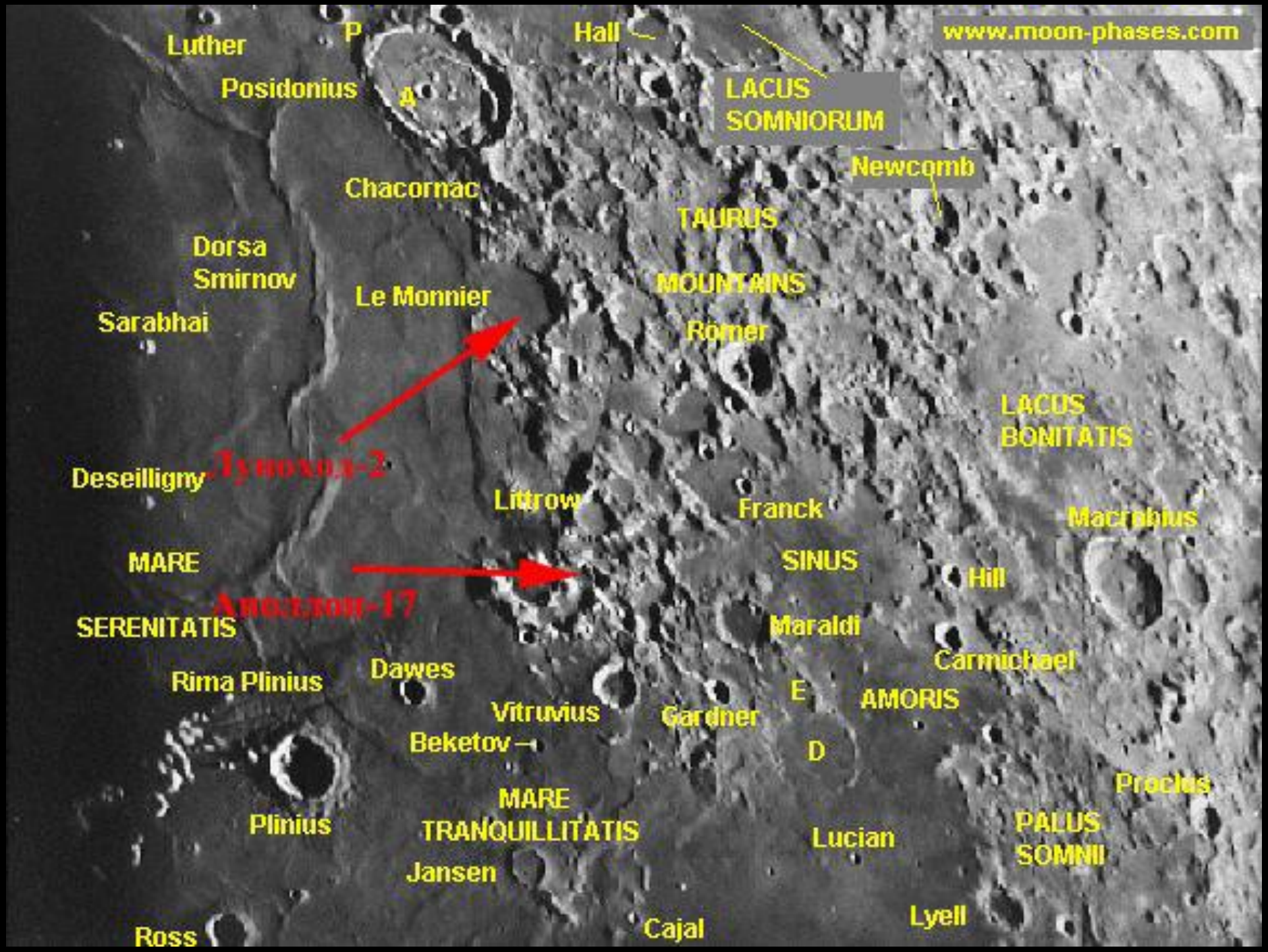
Lunokhod 1
landscapes





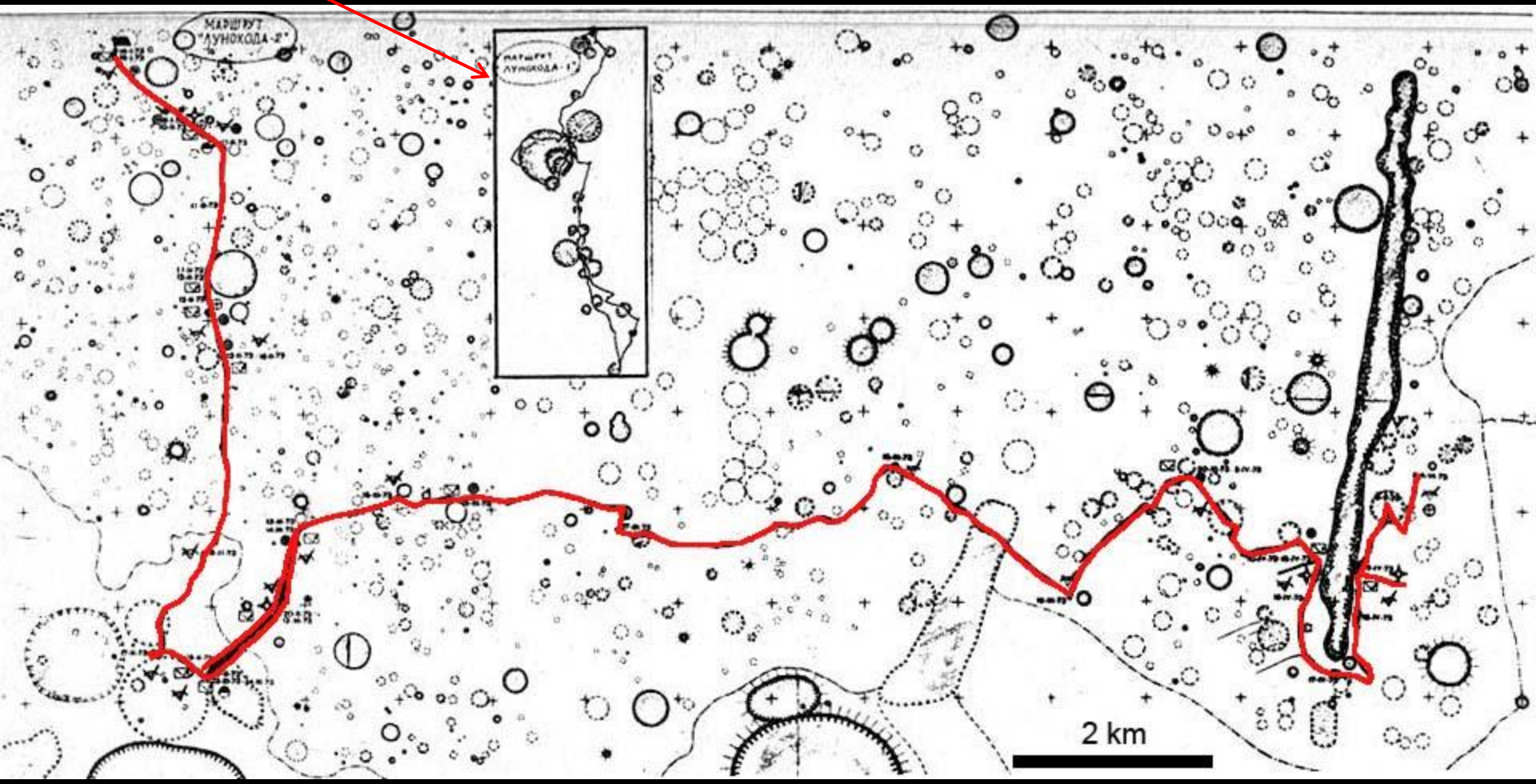
Lunokhod 1

- traveled 10,540 m,
- sent to Earth more than 50,000 pictures of the navigation TV cameras and more than 200 TV panoramas,
- conducted more than 500 lunar soil mechanics tests,
- made numerous measurements of the chemical composition of the soil by X-ray-fluorescence technique,
- it also had the French-made laser retroreflector for high-precision measurements of the distances between the Moon and Earth.

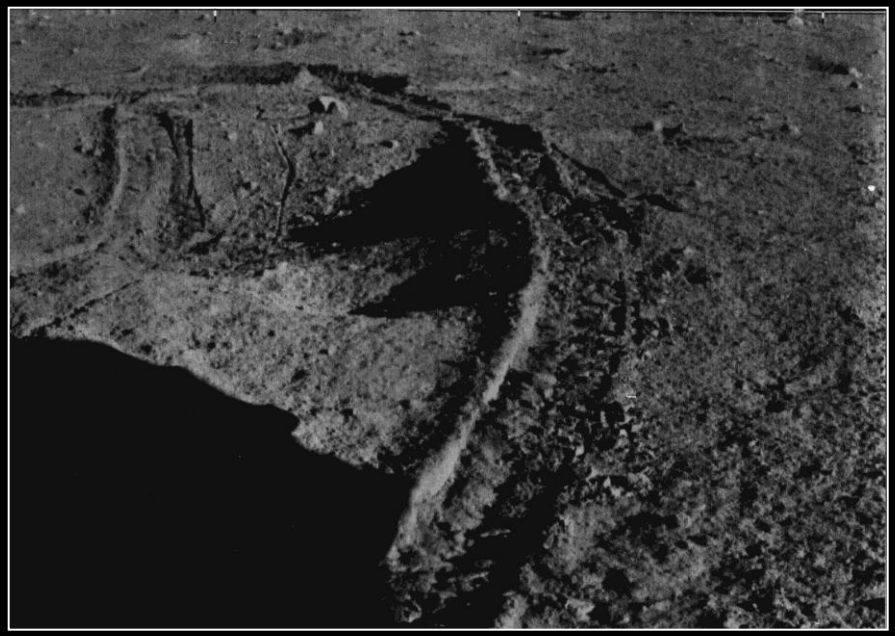

www.moon-phases.com
Luther
P
Hall
Posidonius
A
LACUS
SOMNIORUM
Newcomb
Chacornac
TAURUS
Dorsa
Smirnov
MOUNTAINS
Le Monnier
Sarabhai
Römer
LACUS
BONITATIS
Deseilligny
Луноход-2
Littrow
Franck
Macrobius
MARE
SINUS
Hill
Аполлон-17
SERENITATIS
Maraldi
Carmichael
Rima Plinius
Dawes
E
AMORIS
Vitruvius
Gardner
Beketov
D
Proclus
MARE
TRANQUILLITATIS
Plinius
PALUS
SOMNII
Lucian
Jansen
Lyell
Cajal
Ross

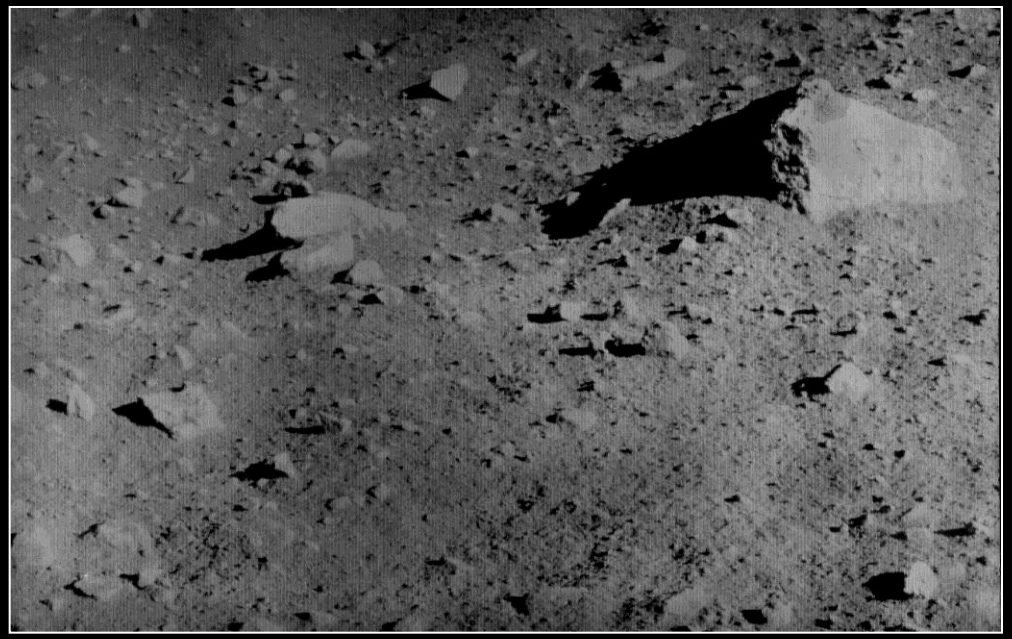
Lunokhod -2 traverse

Lunokhod -1 traverse



Lunokhod 2 landscapes





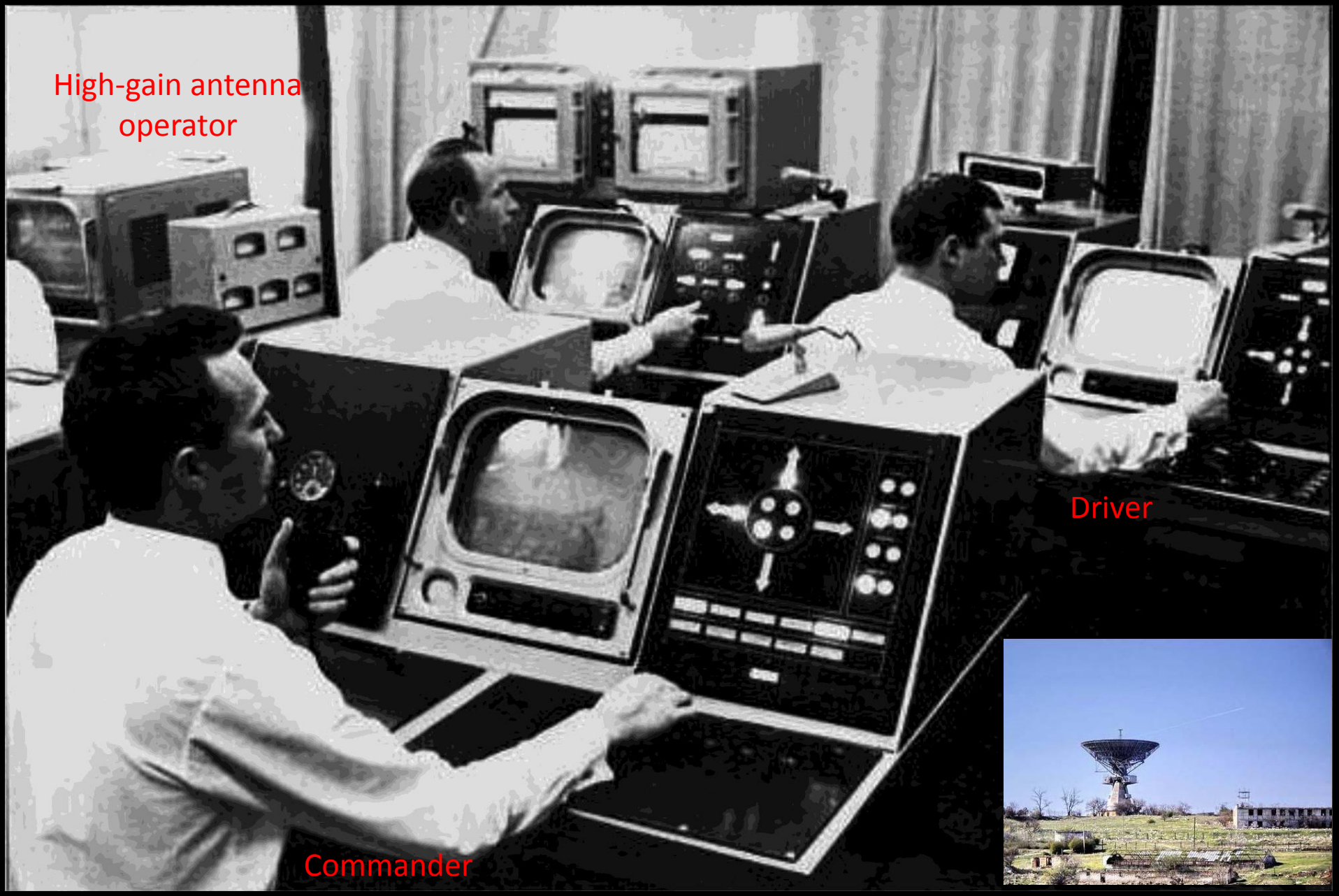
Lunokhod 2

- traveled 37,450 m, partly along the mare-like surface, partly intruding into hilly terrain of highland type and studying the edges of a 15 km long tectonic trough
- sent to Earth more than 80,000 pictures of the navigation TV cameras and 86 TV panoramas,
- conducted more than 150 lunar soil mechanics tests,
- conducted numerous chemical analyses,
- made numerous magnetometric measiurements,
- using a photometric standard in the field of view of the panoramic TV cameras measured albedo of various landforms,
- using special up-looking photometer studied brightness of the night sky of the Moon as indicator of levitated dust.

The analysis of TV images led to better understanding of the geologic and geophysical processes on the Moon:

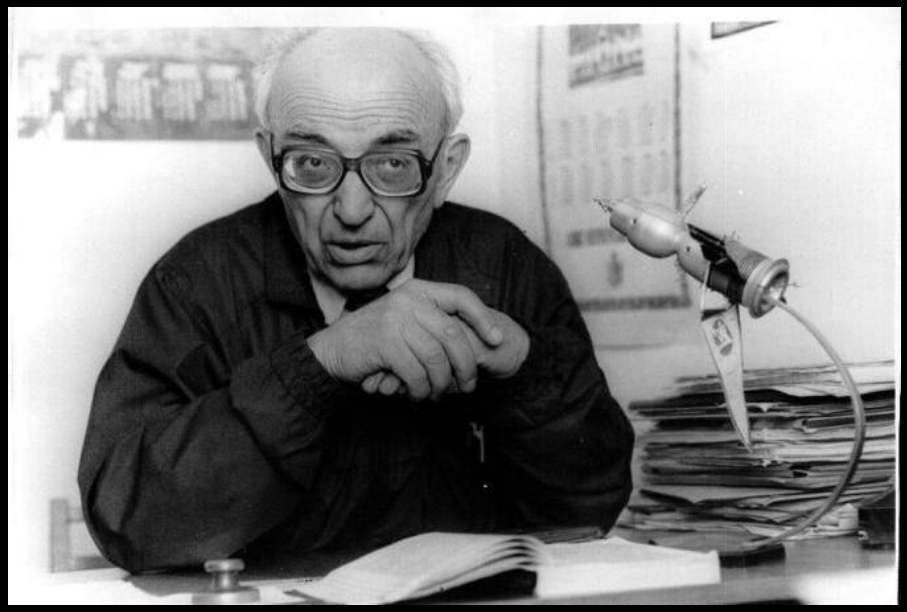
- It was found that the surface gardening by meteorite impacts was accompanied by a variety of down-slope mass-wasting phenomena.
- Joint consideration of local geology, measurements of the soil mechanics, chemical composition and soil albedo led to conclusions on lateral and vertical mixing of lunar mare and highland materials.
- Magnetic measurements along the route and on the observation stations led to discovery of small spots of residual magnetization probably formed by the impacts.
- Analysis of time variations of the interplanetary magnetic field also registered by the magnetometer led to estimates of the large-scale (100's km) structure of the Moon interior.

Lunokhod 1 and 2 control center

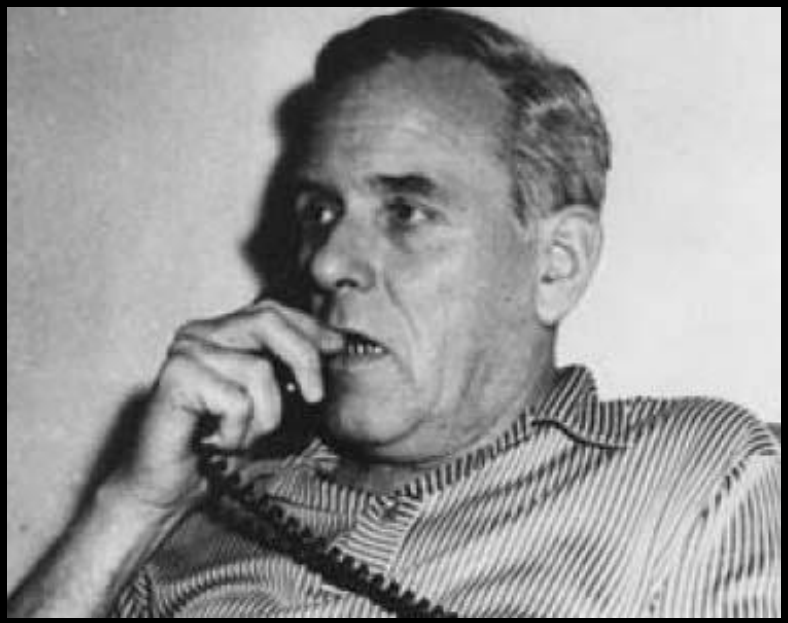

High-gain antenna operator
Driver
Commander

Lunokhod crew and their chiefs

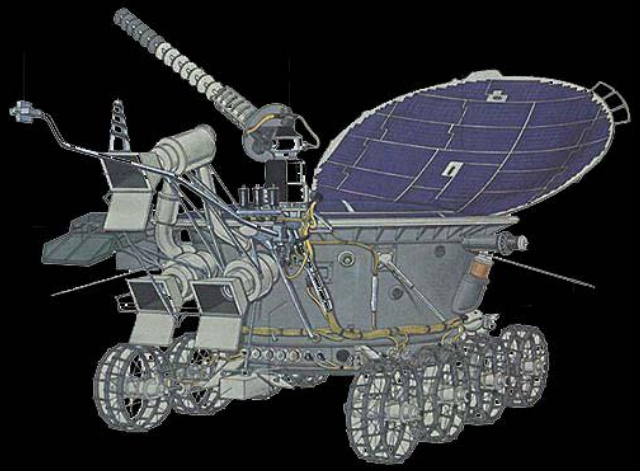
Five days after landing of Lunokhod 1



Alexander Kemurdzhian,
Chief Designer of Lunokhods



Georgii Babakin,
Chief Designer of Lavochkin Association

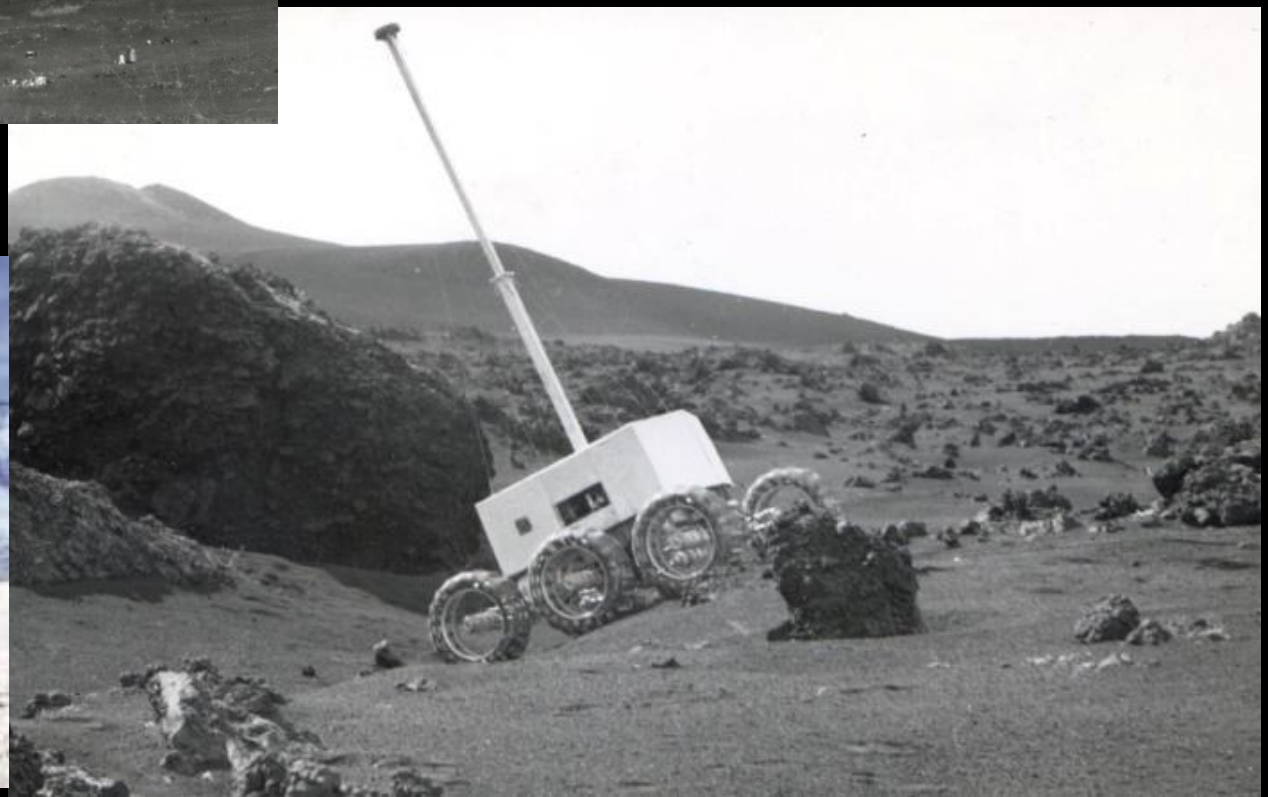


Alexander Kemurdzhian, Ivan Kozhedub, WW2 Hero,
Oleg Ivanovsky , Deputy Chief Designer of Lavochkin Assoiciation

Oleg Ivanovsky: WW2, work at NPO Energia, escorted Gagarin, work at Lavochkin NPO

Lunokhod tests and crew trainings

Tests in Kamchatka



Crew training in Shkol’naya

Rover’s varieties
done by VNIITRANSMASH

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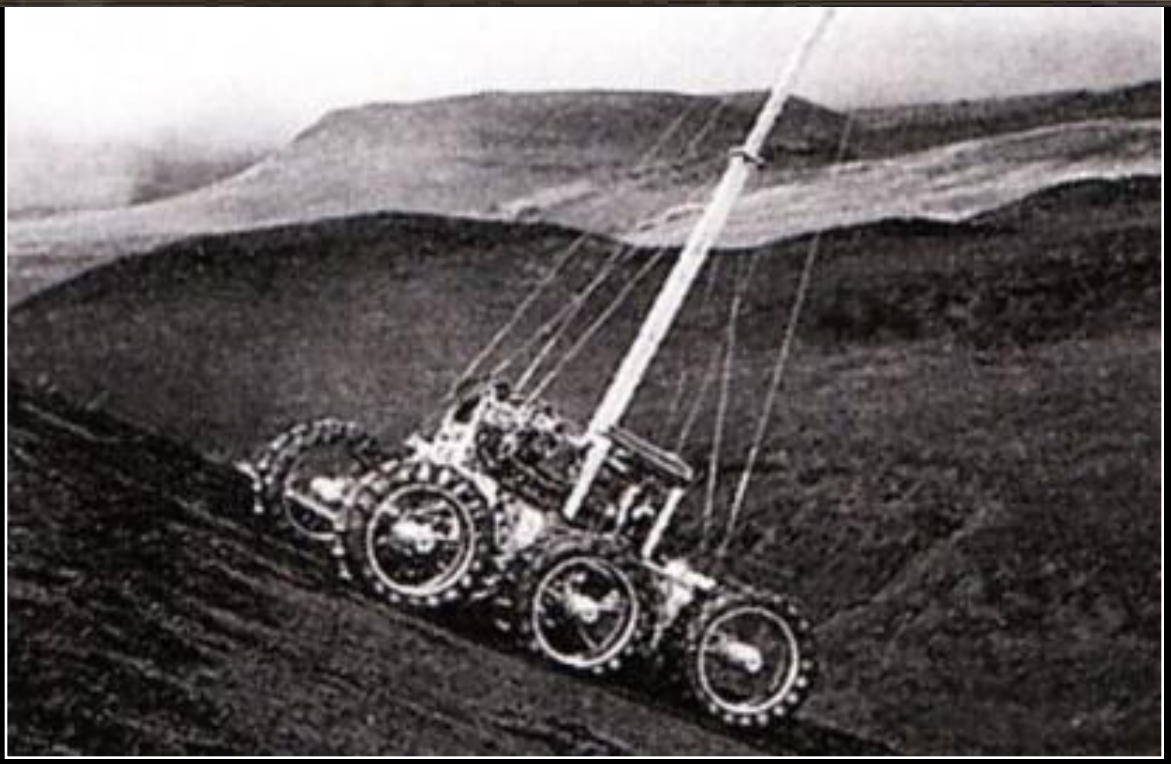

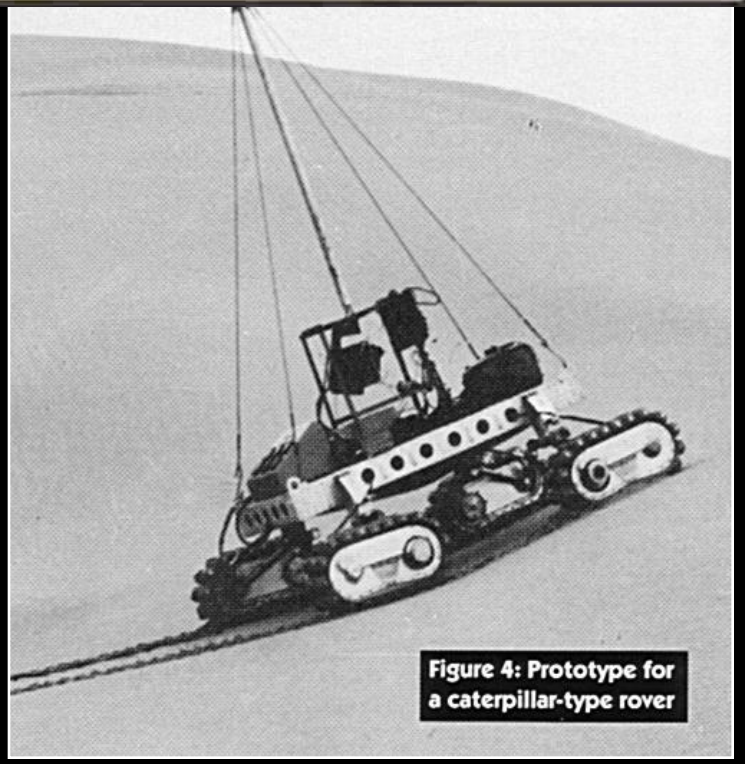

Figure 4: Prototype for a caterpillar-type rover

Six-wheel version

Caterpillar-type version

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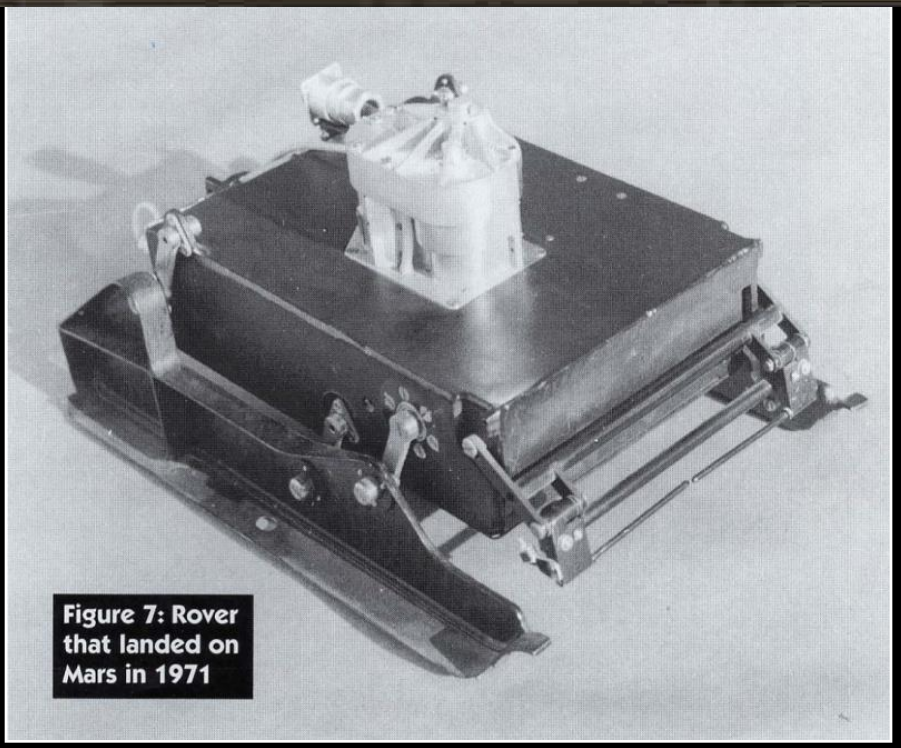

Figure 7: Rover that landed on Mars in 1971

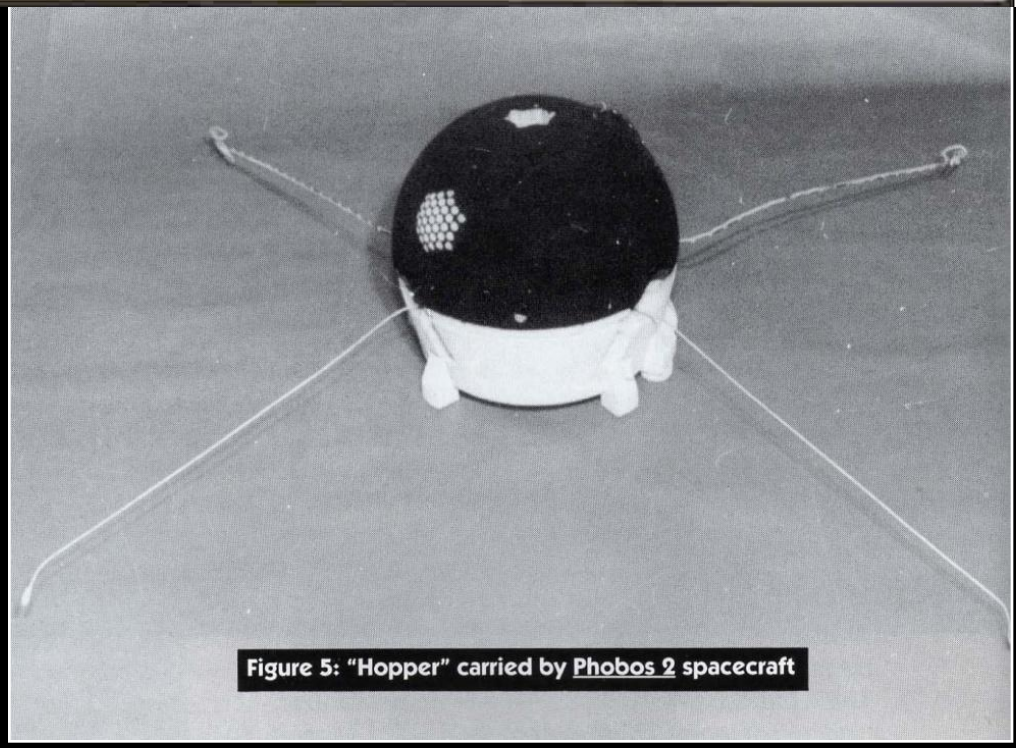

Figure 5: "Hopper" carried by Phobos 2 spacecraft

Rover for Mars 71

Hopper for Phobos 2

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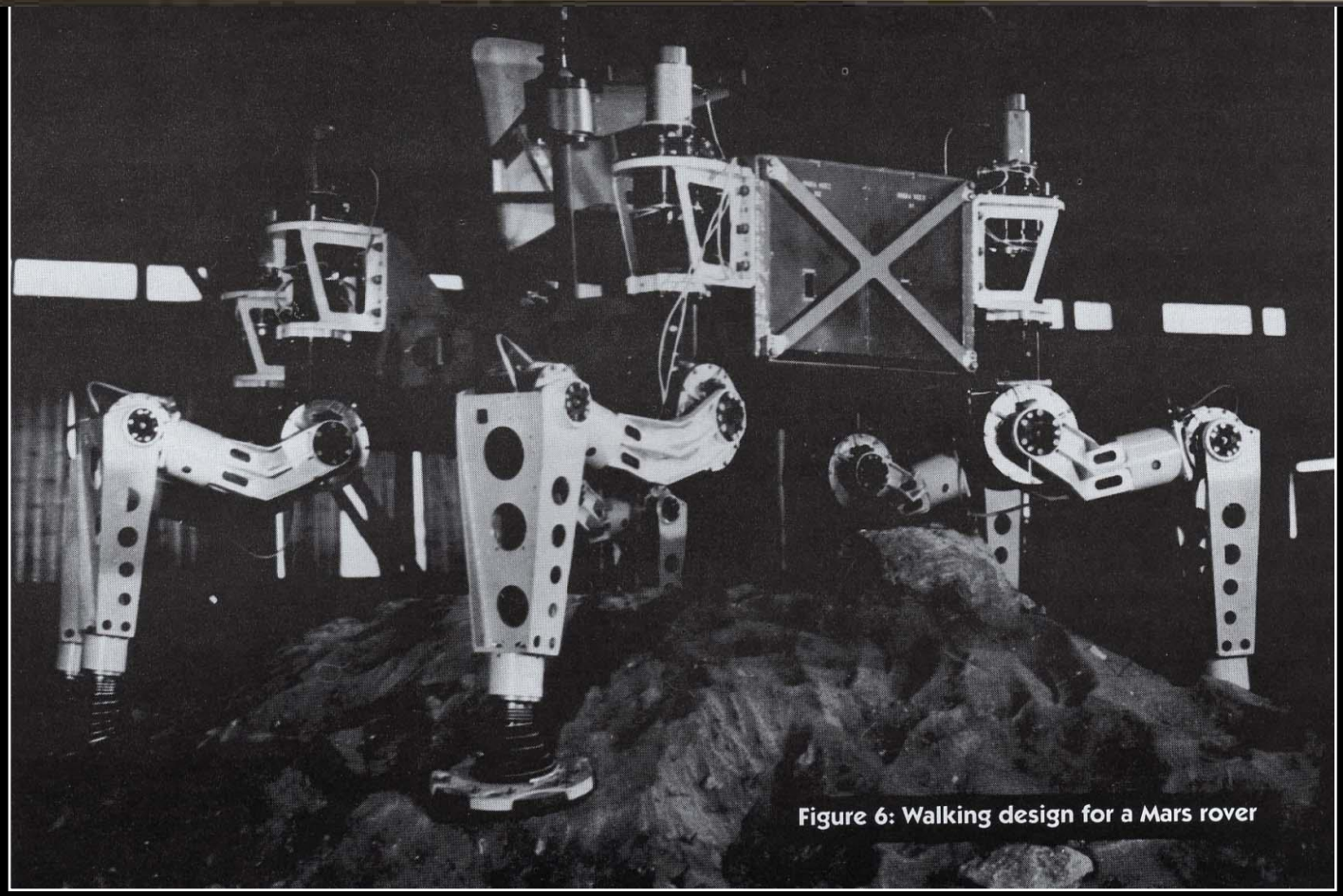

Figure 6: Walking design for a Mars rover

Walking rover

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Figure 8: Mock-up of a wheel-walking rover

Mockup of wheel-walking rover

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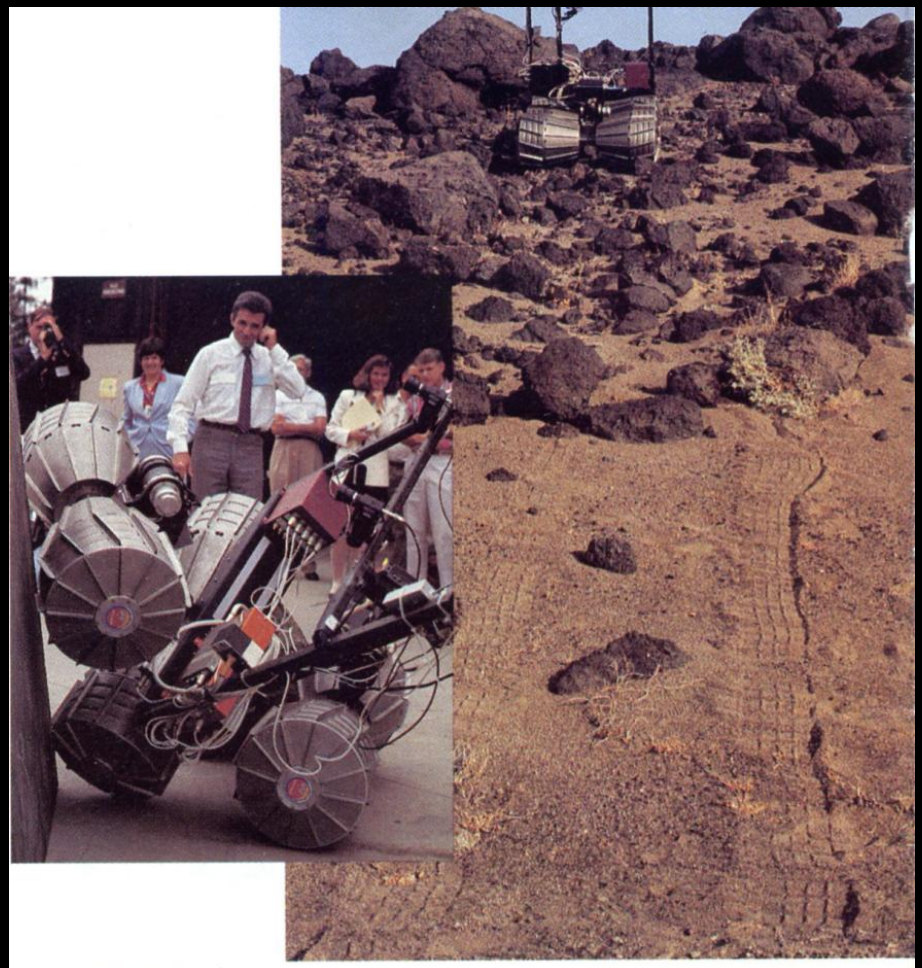
Figure 9: Wheel-walker that can change body to accommodate relief

Wheel-walking rover with changing body

Clean-up in Chernobyl

Tests of Russian Mars rover in Mohave



ABOVE: At the beginning of the test program, at Dumont Dunes, the tracks of the rover seemed strange and alien, almost as if they were the marks of a robot from another world. By the end of the program, they were as familiar as our own footprints, and the tracks wending their way up Mars Hill were symbolic of the success of our tests. On this hill in Death Valley, there is also an ancient Native American site that we roped off. Both the test team and the spectators carefully avoided it.

INSET: The Mars Rover misbehaved only once during the entire test program: when NASA Administrator Daniel Goldin came to visit. At the Pasadena setup facility, the rover's handlers attempted to demonstrate

Tests of Russian Mars rover in Mohave

Rovers of the Future:

- High trafficability and long lifetime.
- Reasonable self-dependence.
- Ability to study targets of interest:
  - Contact analyses using robotic arm.
  - Remote analyses with laser and so on.
- Combination of rover(s) with sample return.

Vyacheslav Dovgan', Anton Ivanov,
Emily Stewart Lakdawalla, Juergen Oberst
and Jennifer Vaughn
provided valuable images and other information.

Enormous help was provided by
Mikhail Malenkov, close associate
of Alexander Kemurdzhian.

Prof. Mikhail Malenkov can be achieved
for questions and discussion
by e-mail m.i.malenkov@gmail.com

Thank you for your attention!

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