

Exploration and Geology of the Earth's Moon



FINAL DESCENT

Franklin-Ogdensburg
Mineral Society (FOMS)
Saturday, 16 May 26

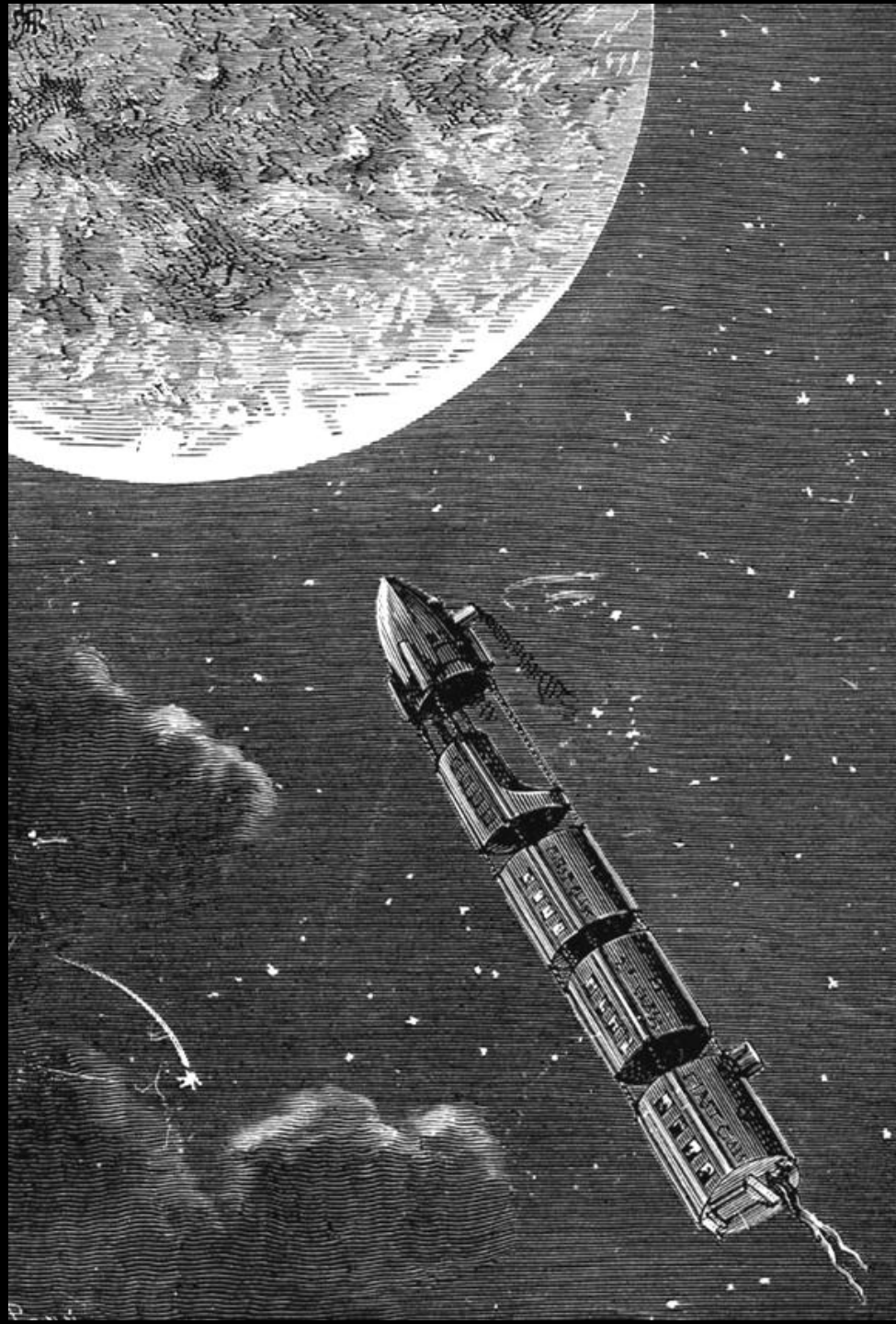
Firefly Blue Ghost – 02 Mar 25

Charles Merguerian

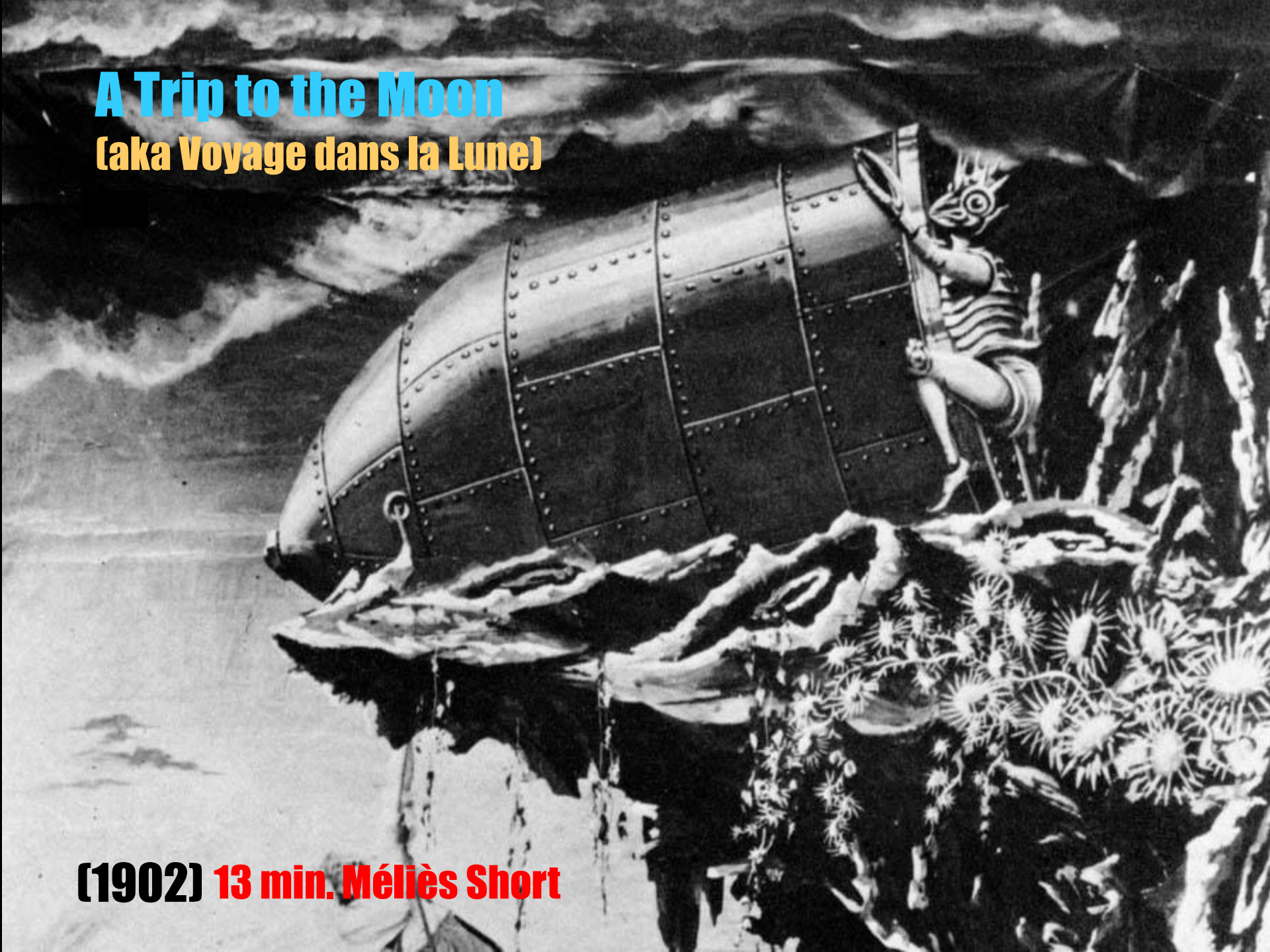
Jules Verne

From the Earth to the Moon (1865)

- **Coal powered rocket to the Earth's Moon**
- **Foresaw military impetus for rocket program**
- **Predicted area near Cape Canaveral for U.S. launch site**

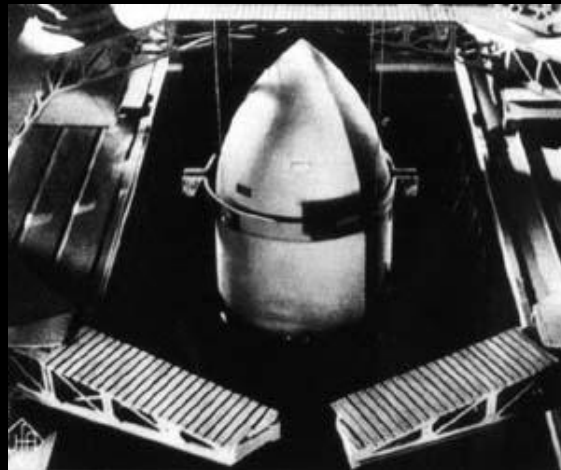
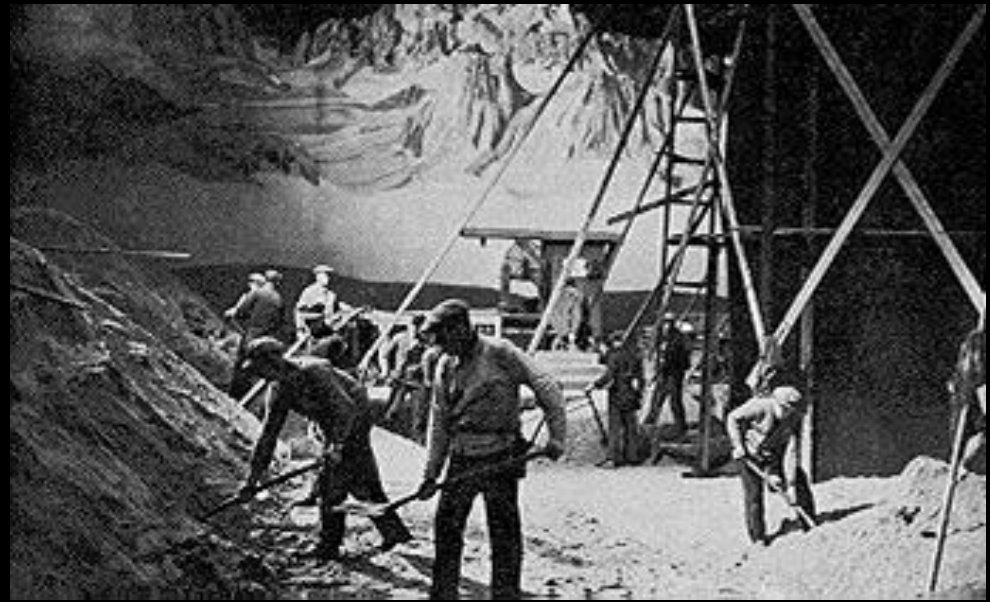


A Trip to the Moon (aka Voyage dans la Lune)



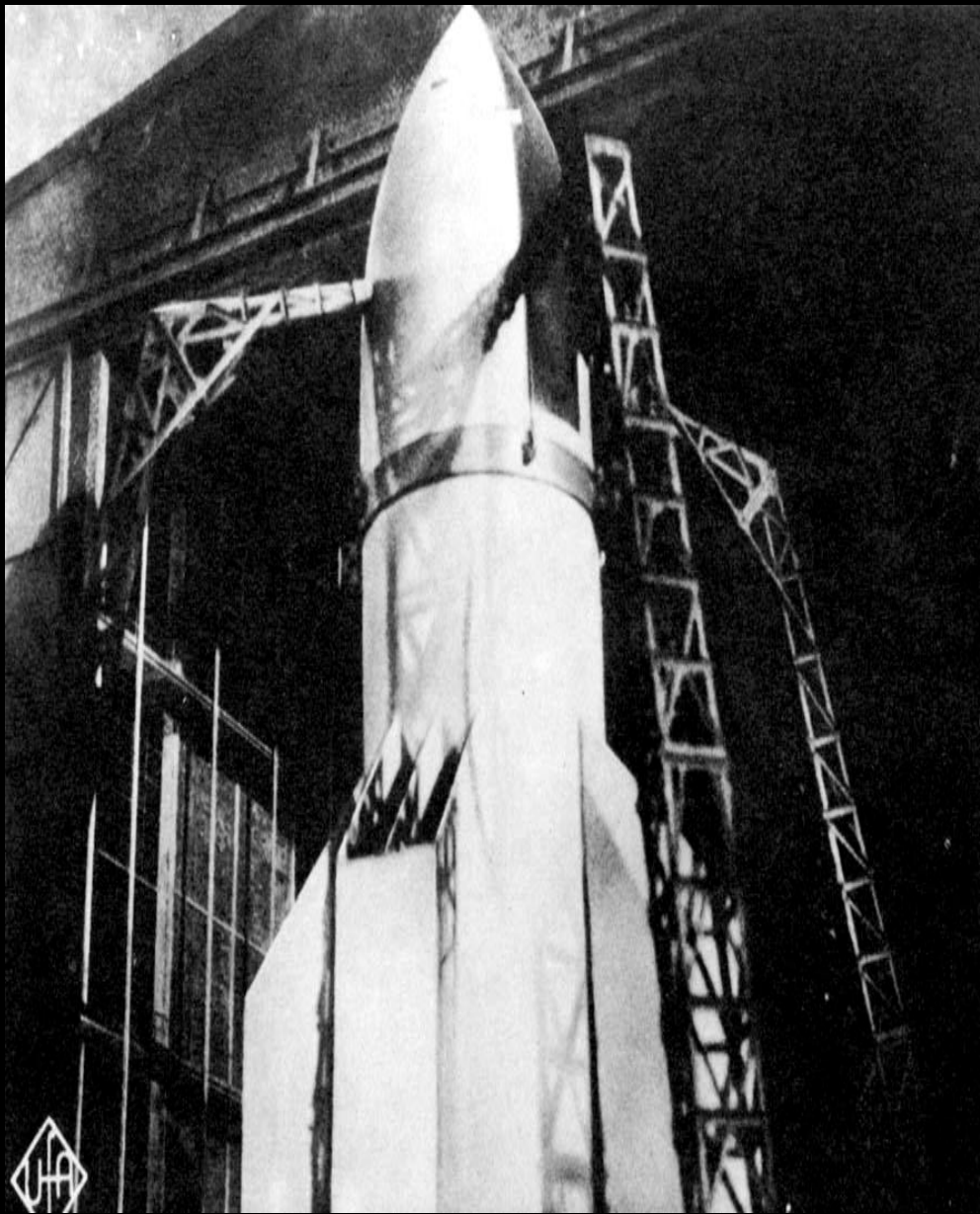
(1902) 13 min. Méliès Short

Woman in the Moon
(aka Frau im Mond;
By Rocket to the Moon)



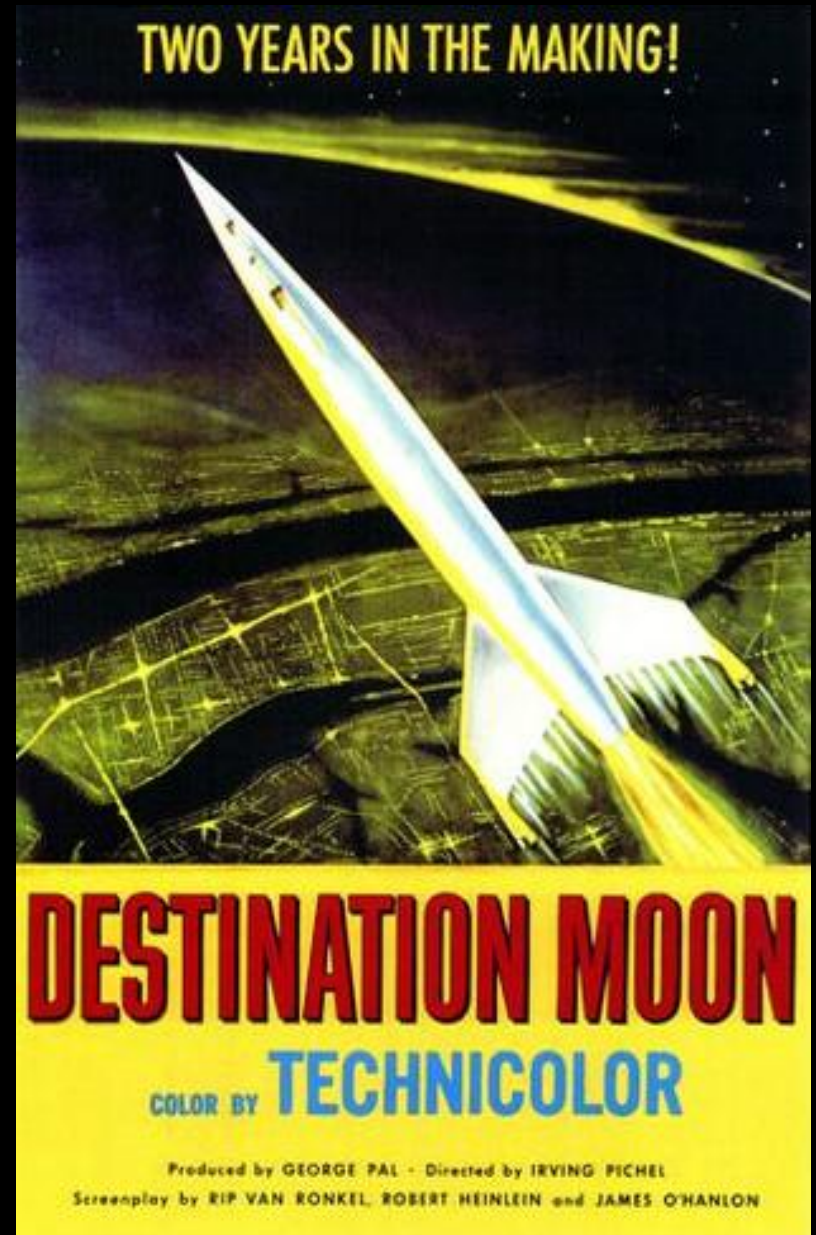
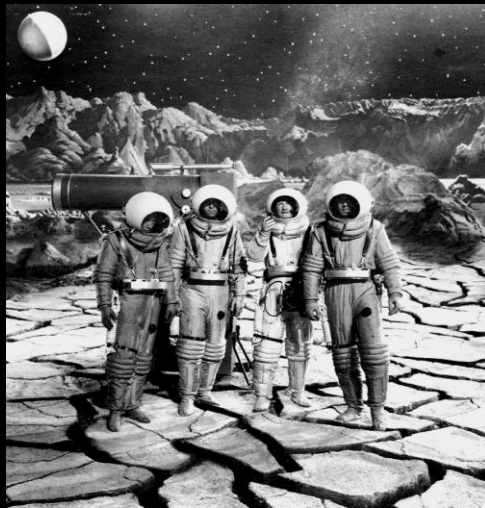
(1929)

95 min.



(1929) - Rocket Built by Hermann Oberth for Film Opening

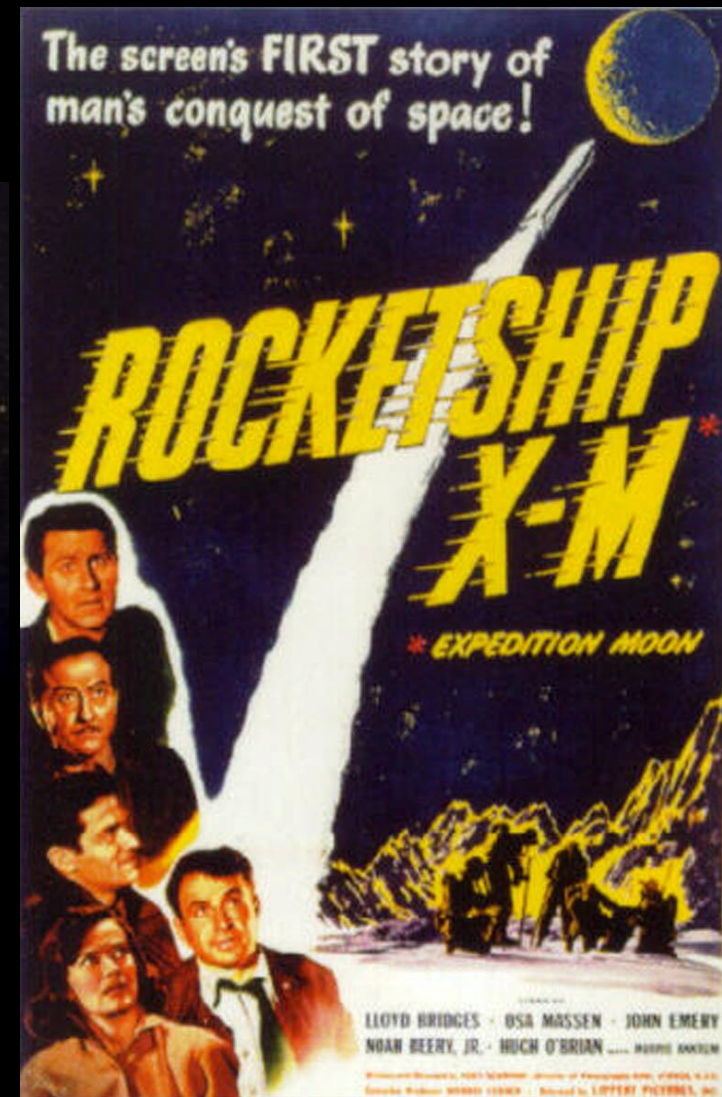
Destination Moon



(1950)

92 min.

Rocketship X-M

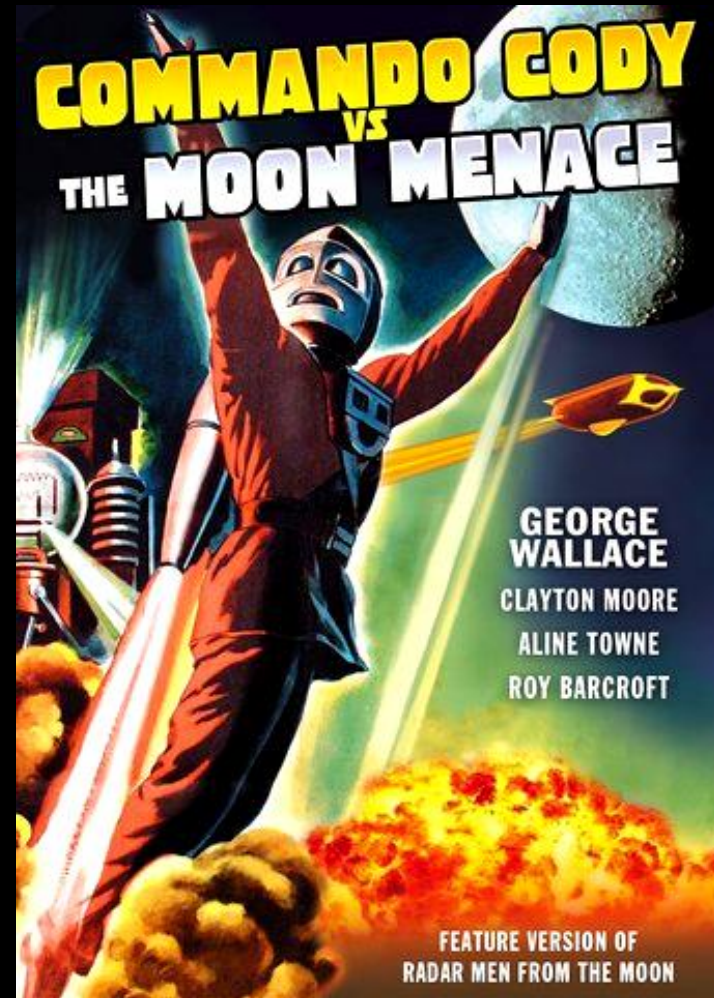


(1950)

77 min.

Radar Men from the Moon

(aka Planet Men from Mars; Retik, the Moon Menace)



(1952)



2 hr. 47 min. 12-chapter Republic Pictures serial

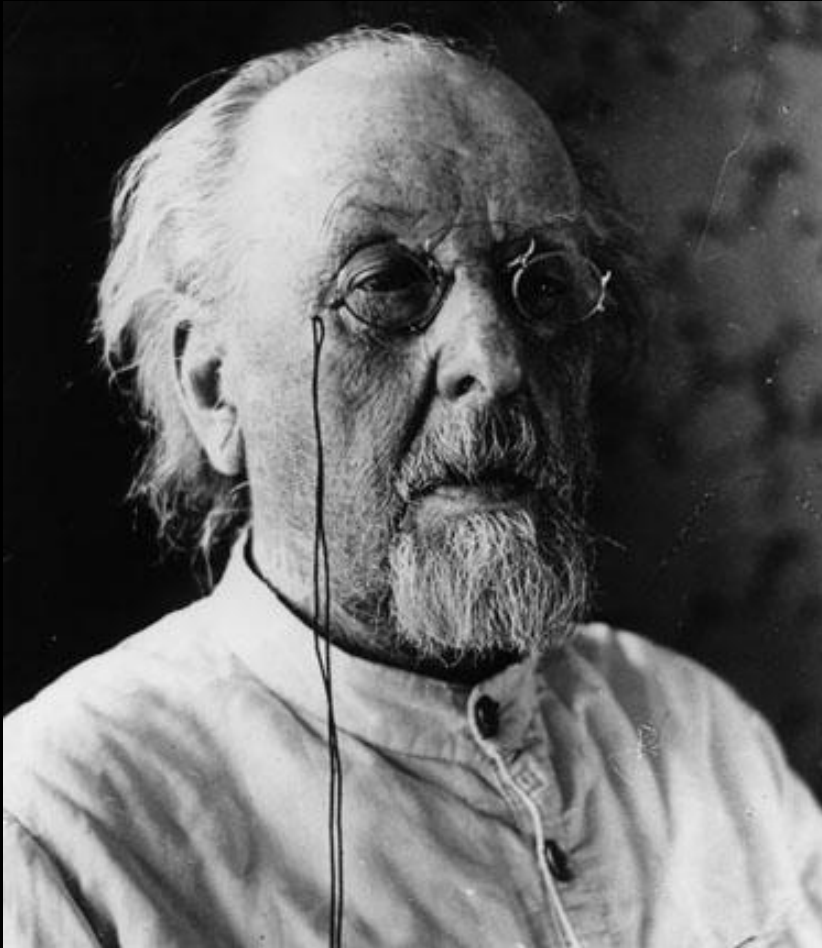
Cat-Women of the Moon (aka Rocket to the Moon)



(1953)

64 min.

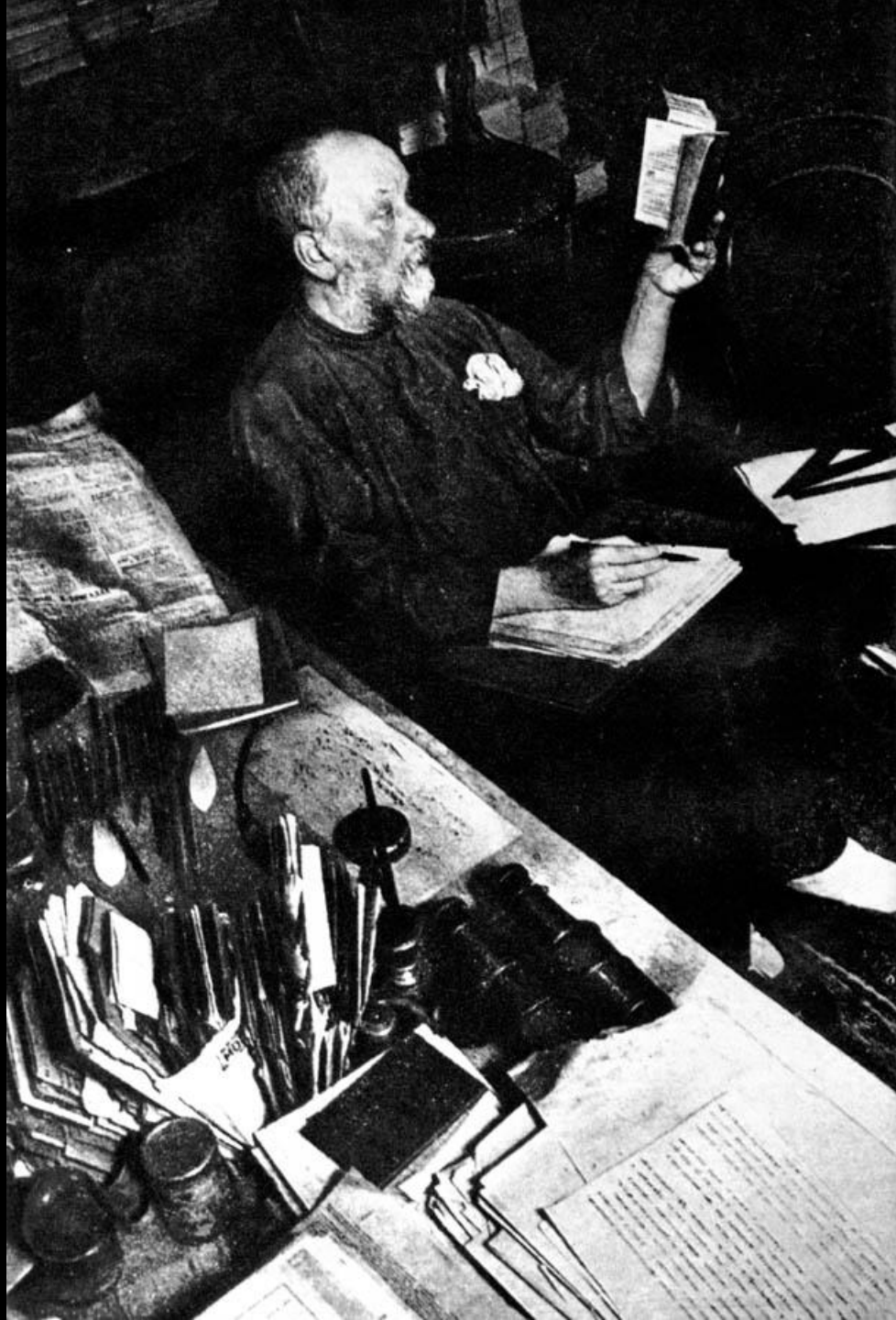
Rocket Scientists



Tsiolkovsky



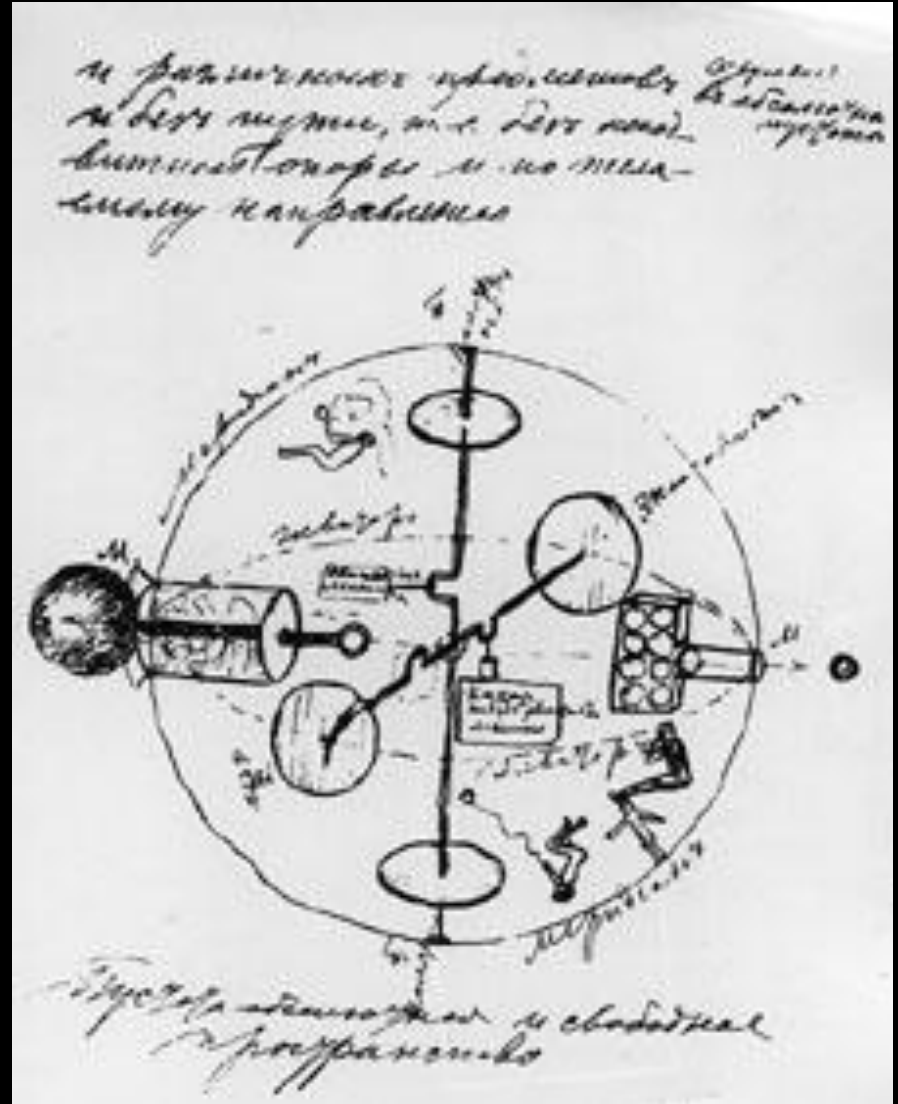
Goddard



**Konstantin
Eduardovitch
Tsiolkovsky
(1857-1935)**

**Russian School
Teacher**

Free Space (1883)



Tsiolkovsky

28 Mar 1883 - Reaction principle in “Free Space”

1895 – Publishes “Dreams of the Earth and Sky”

25 Aug 1898 – Reaction thrust motor

1903 – Publishes “Exploration of Space with Rocket Devices”. Liquid oxygen and liquid hydrogen design and all basic equations for rocketry

Envisioned multi-stage rockets for space travel

Weightlessness

ее можно раздвинуть при жам-
цах фокусировки вдали от центра:
там он длиннее, чем температура буду-
щего.

54. Поверхность обрывается от вращения,
далеко от оси так, что при ска-
чке вдали ее поверхность и за-
тенность на ней разнятся. На те-
же шара погва не удерживает раз-
ный жам не будет и сила солнца
будет пропадать даром вблизи
при длинных конусах, наклон
поверхности и погва будут не ви-
лик, она останется на месте и раз-
ния будут освещены конусом му-
жом до самой оси. Сохранен
и чужеродной температуры и целю-
завания солнечной лучей

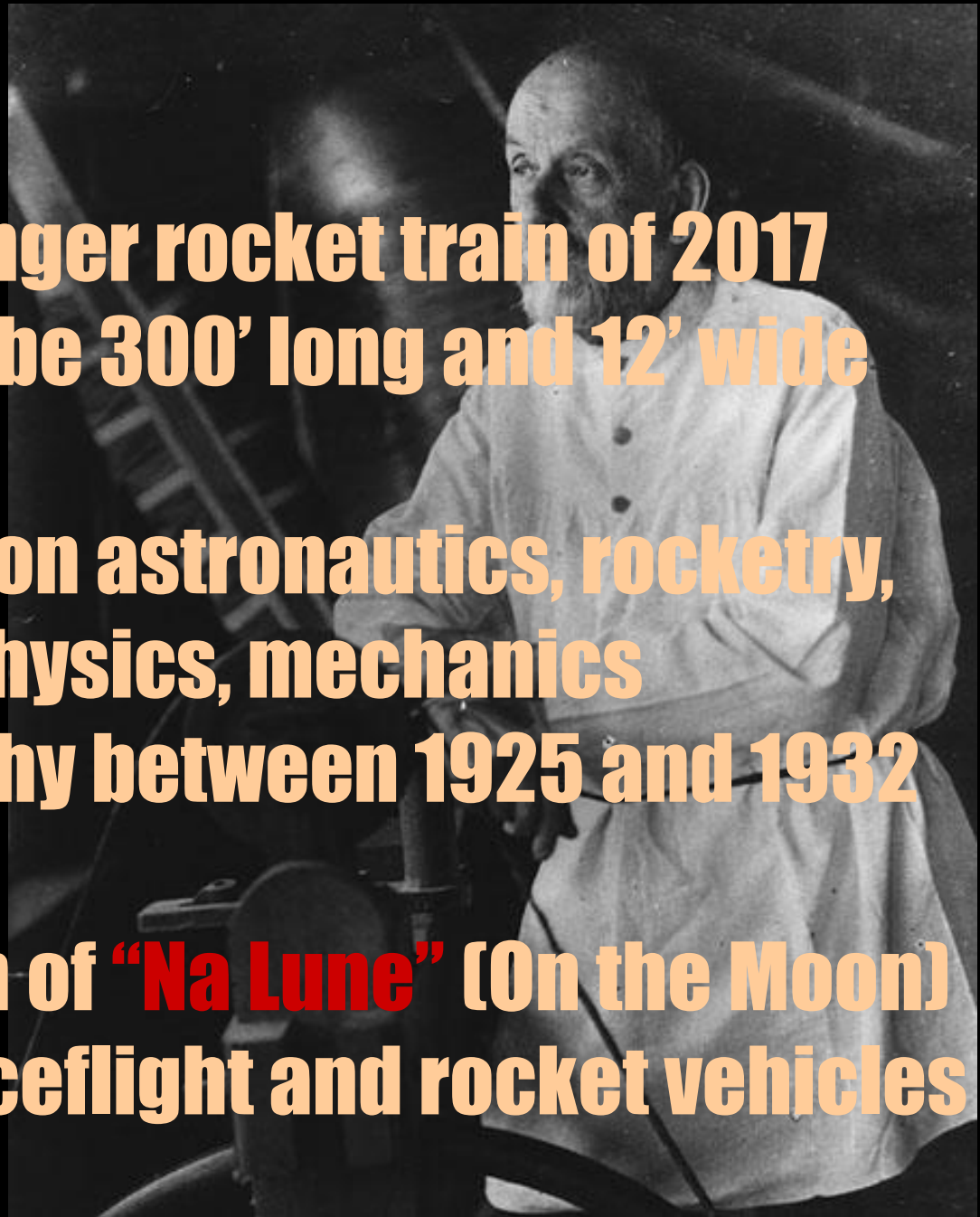


Tsiolkovsky

**Envisioned passenger rocket train of 2017
The rocket would be 300' long and 12' wide**

**Wrote 60 articles on astronautics, rocketry,
astronomy, physics, mechanics
and philosophy between 1925 and 1932**

**1935 – Publication of “Na Lune” (On the Moon)
refers to spaceflight and rocket vehicles**



Robert H. Goddard (1882-1945)

**Father of
American Rocketry**

**Independent
Experimentalist**



Goddard

Independently developed liquid fuel rockets

1909 – Discovers that liquid hydrogen and liquid oxygen served as efficient propulsion

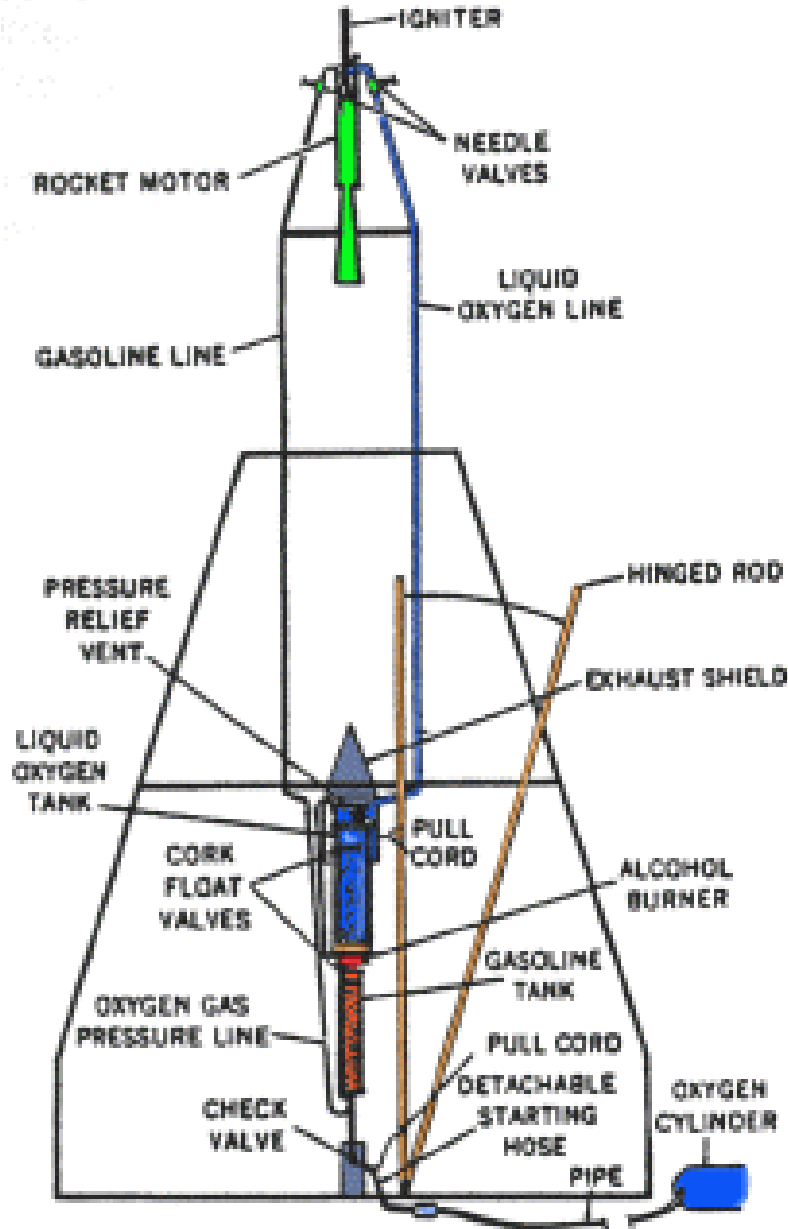
1912 – Mathematic proof of the feasibility of using rockets for high altitude or lunar flight

1914 – Receives U.S. patent for multi-stage rocket and proves rocket would work in a vacuum

On the morning of 16 March 1926 barely a year after Wernher von Braun's rocket wagon fiasco, Goddard launched a liquid-powered rocket he had designed and built from a snow-covered field at his Aunt Effie Goddard's farm in Auburn, Massachusetts

The rocket flew only 46 meters -- about the same distance as the Wright Brothers' first manned flight -- it was the first flight of a liquid-fueled rocket in history

Goddard 1926 Rocket



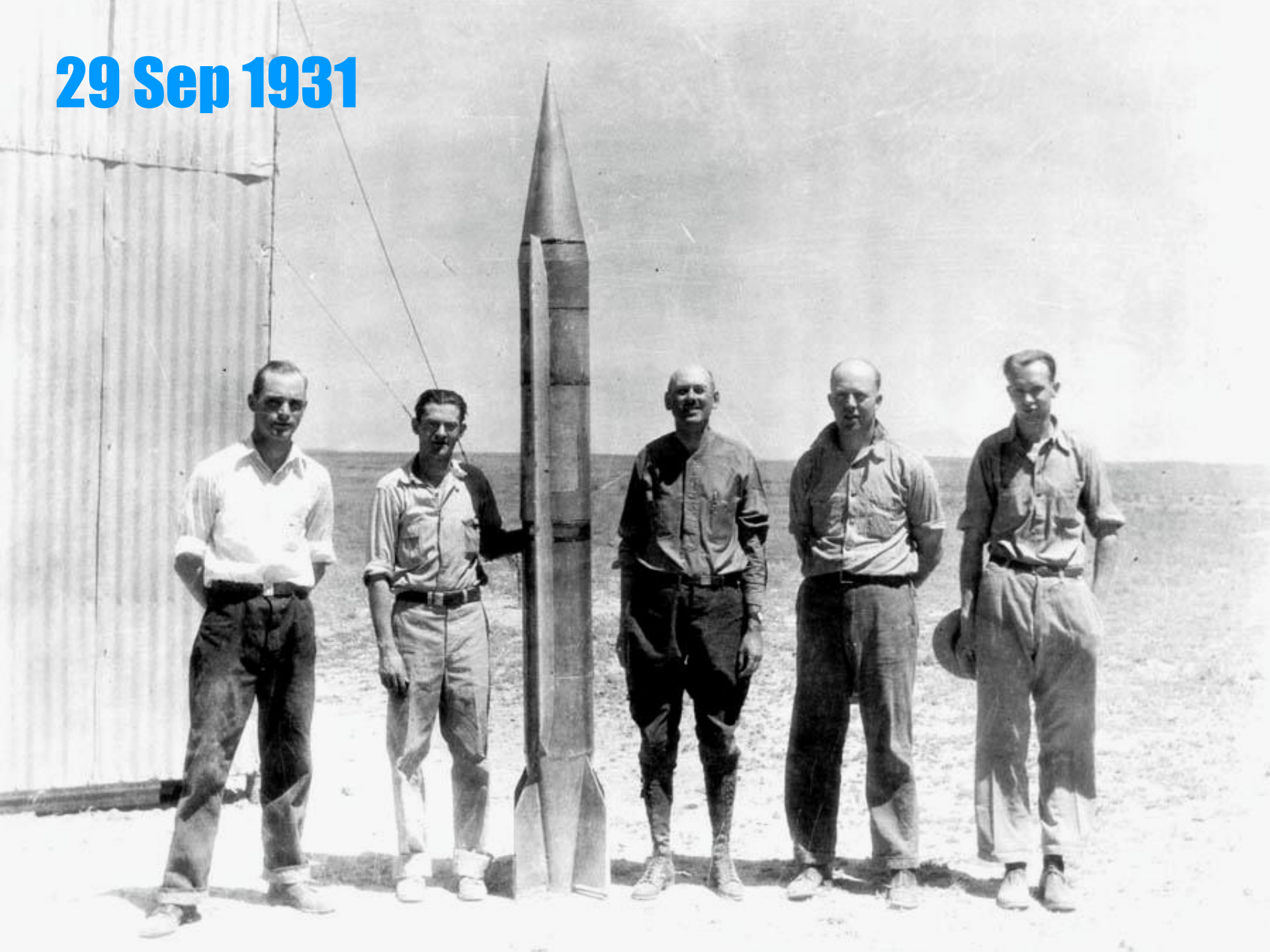
**Aunt Effie Goddard's
farm in Auburn, Massachusetts**



Goddard

- 1919** – Publishes paper on Moon travel but the subject of public ridicule. Prompts 16-year exile from public eye
- 1926** – **First successful liquid fuel rocket launch!!**
- 1929** – First scientific payload on a rocket (Barometer and Camera)
- 1932** – Guidance systems and gyro control
- 1937** – Guided rocket launched with gimballed motor and gyro mechanism

29 Sep 1931



1935



Die Rakete

1927

Monthly Journal
of German Society
for Space Travel

Other Civilian Societies:
United States
Soviet Union
France
Britain



Max Valier

15 Mar 1928

**Member of
German VfR
(Society for
Space Travel)**

**Wrote: *The Advance
into Space* (1924)**

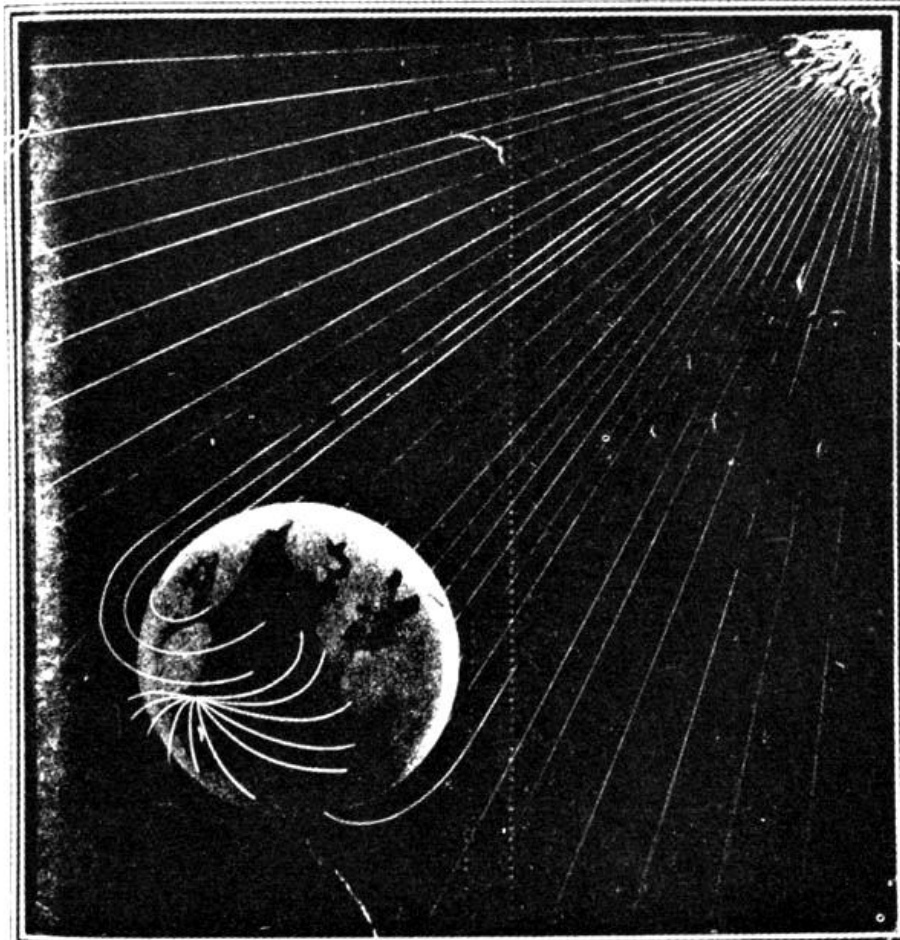
**Rocket Car (Opel)
Used Liquid
Propellant**



МЕЖПЛАНЕТНЫЕ СООБЩЕНИЯ

Н. А. РЫНИН

ЛУЧИСТАЯ ЭНЕРГИЯ



1 0 3 1

**Soviet Union
Rynin's
Interplanetary
Communications
Vol. 3**

**Nine-Volume
Encyclopedia
(1928-1932)**

**Hermann
Julius Oberth
(1894-1989)**

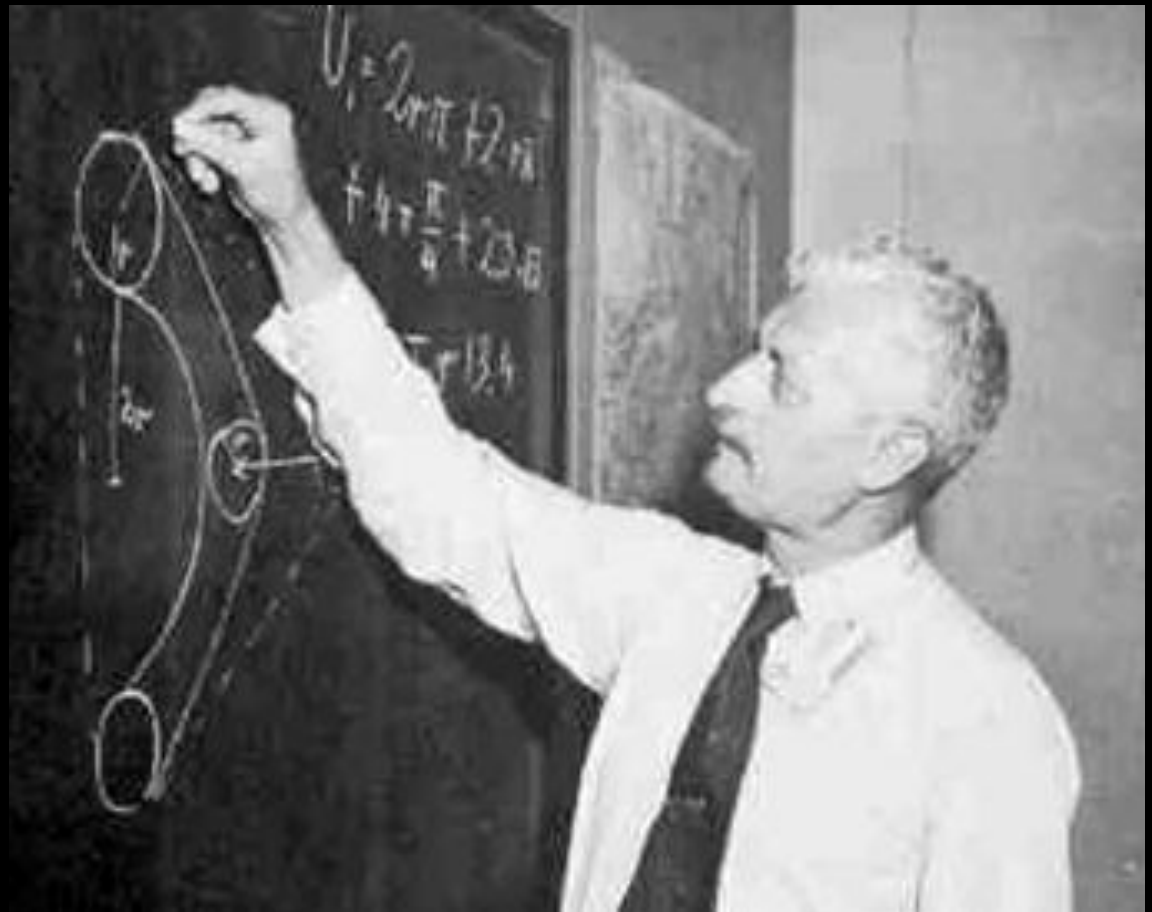
**Born in
Hermannstadt,
Transylvania,
Romania**

**Read Jules Verne
at Age 11 – Fascinated
with Space Travel**

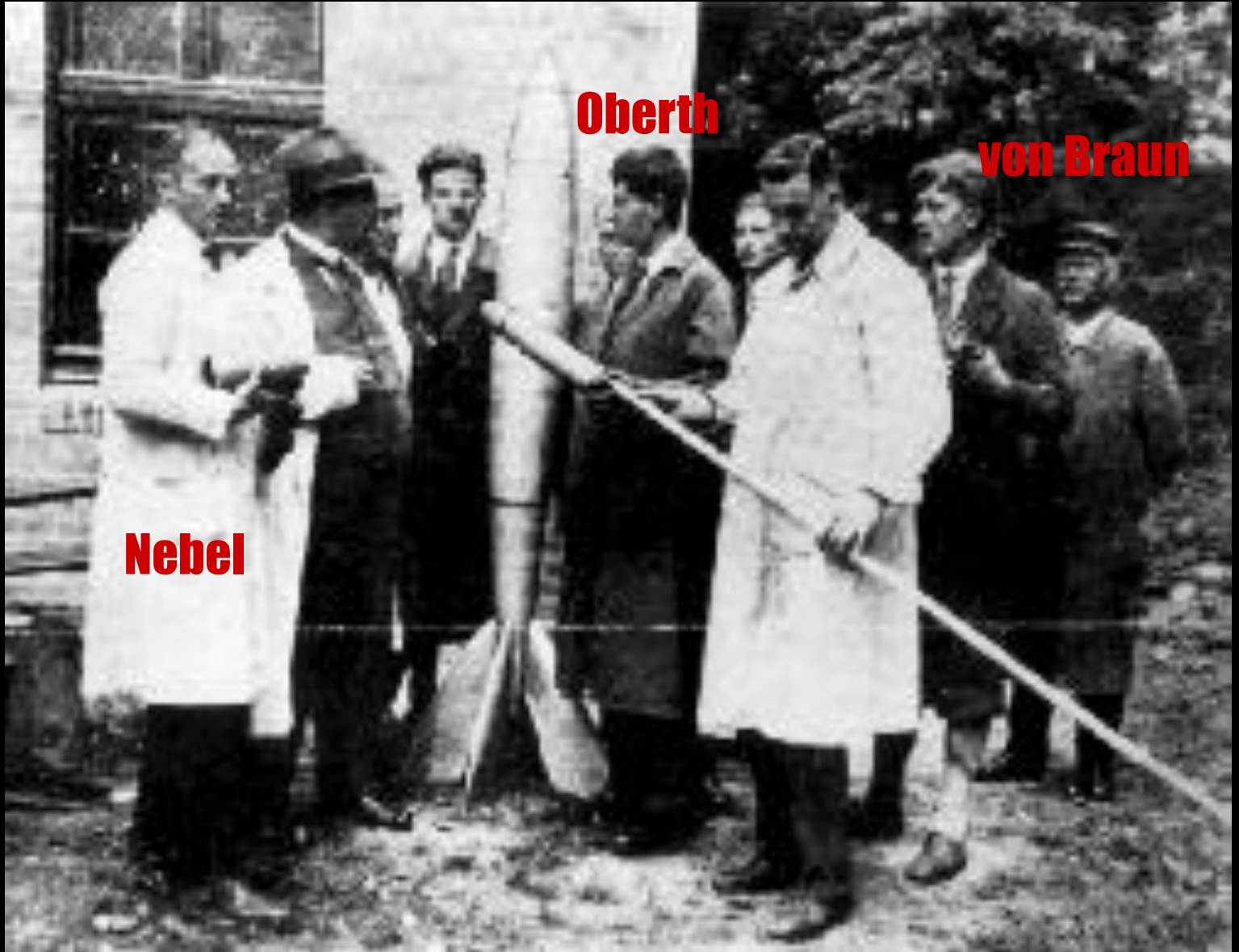


Publishes **Die Rakete zu den Planetenraumen**
(The Rocket into Planetary Space, 92 p.) in **1923**
A longer version in **1929** (429 p.) gained acclaim

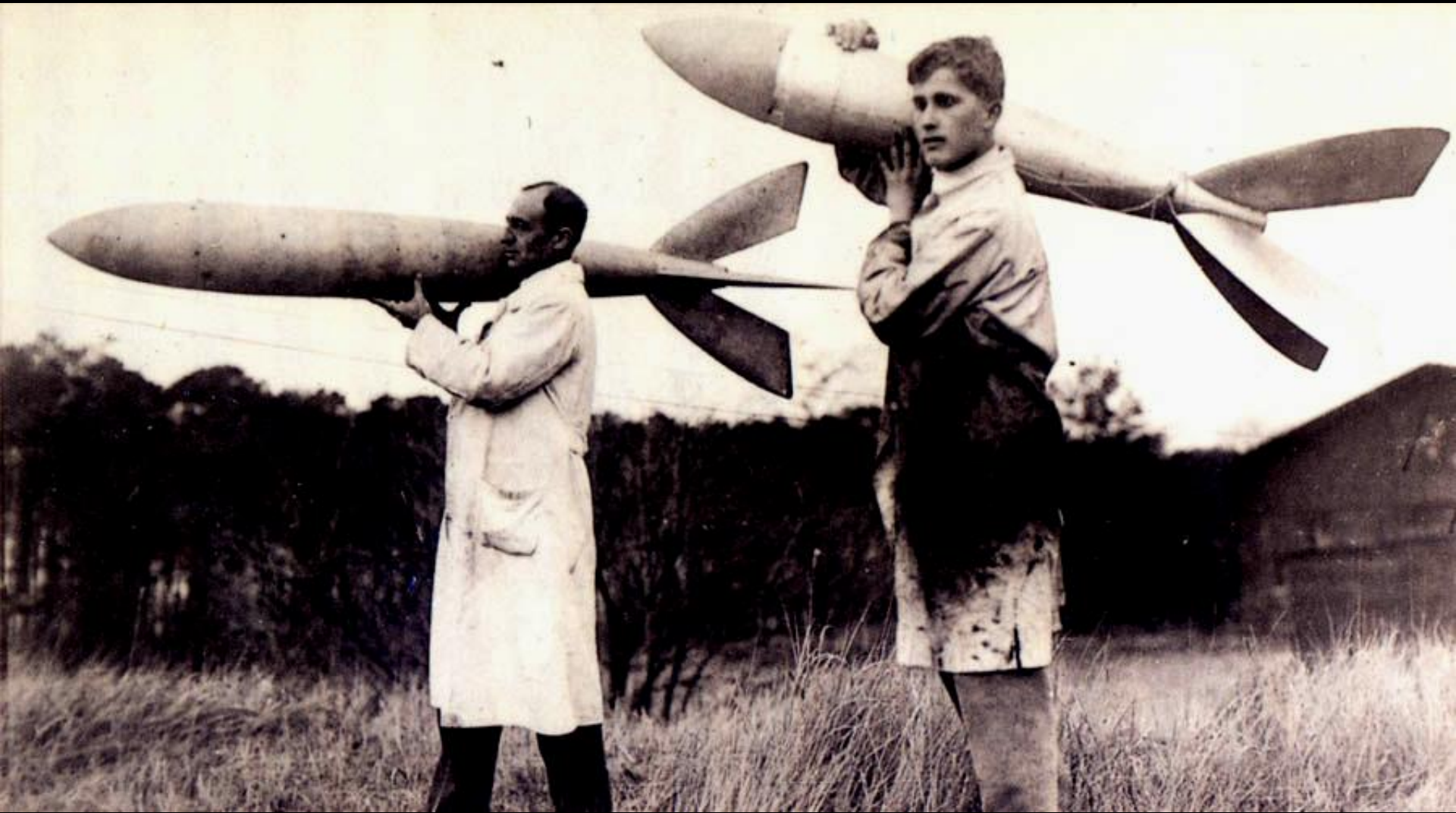
Worked with
**Dr. Wernher
von Braun** first
in the 30s, then
at Peenemunde
during WWII, and
in the U.S. in the
1950s and 1960s



Oberth Rocket



Rudolf Nebel and Wernher von Braun (age ~19)



Oberth's **Repulsor** Rockets at Raketenflugplatz (~1932)

By **1932** the German Army was beginning to show an interest in the German Rocket Society's efforts, and in July of that year a **Mirak rocket** was launched as a demonstration for the head of the newly created German Army rocket research group, Headed by **Captain Walter Dornberger**.

The Mirak rocket didn't impress Dornberger but **von Braun** did. Three months after the Mirak flight, von Braun was engaged to work on liquid propelled rockets for the Army. Most of the German Rocket Society followed von Braun into national service and the society officially disbanded.

**German Rocket
Scientists Worked
for Nazi War Effort
To Develop Weapon
Systems Not Barred
by WWI Treaties**

**At One Point, von Braun
was Arrested and Jailed
by Goebbels - Who Felt That
von Braun More Interested
in Rocket Science than
Weapons Development**



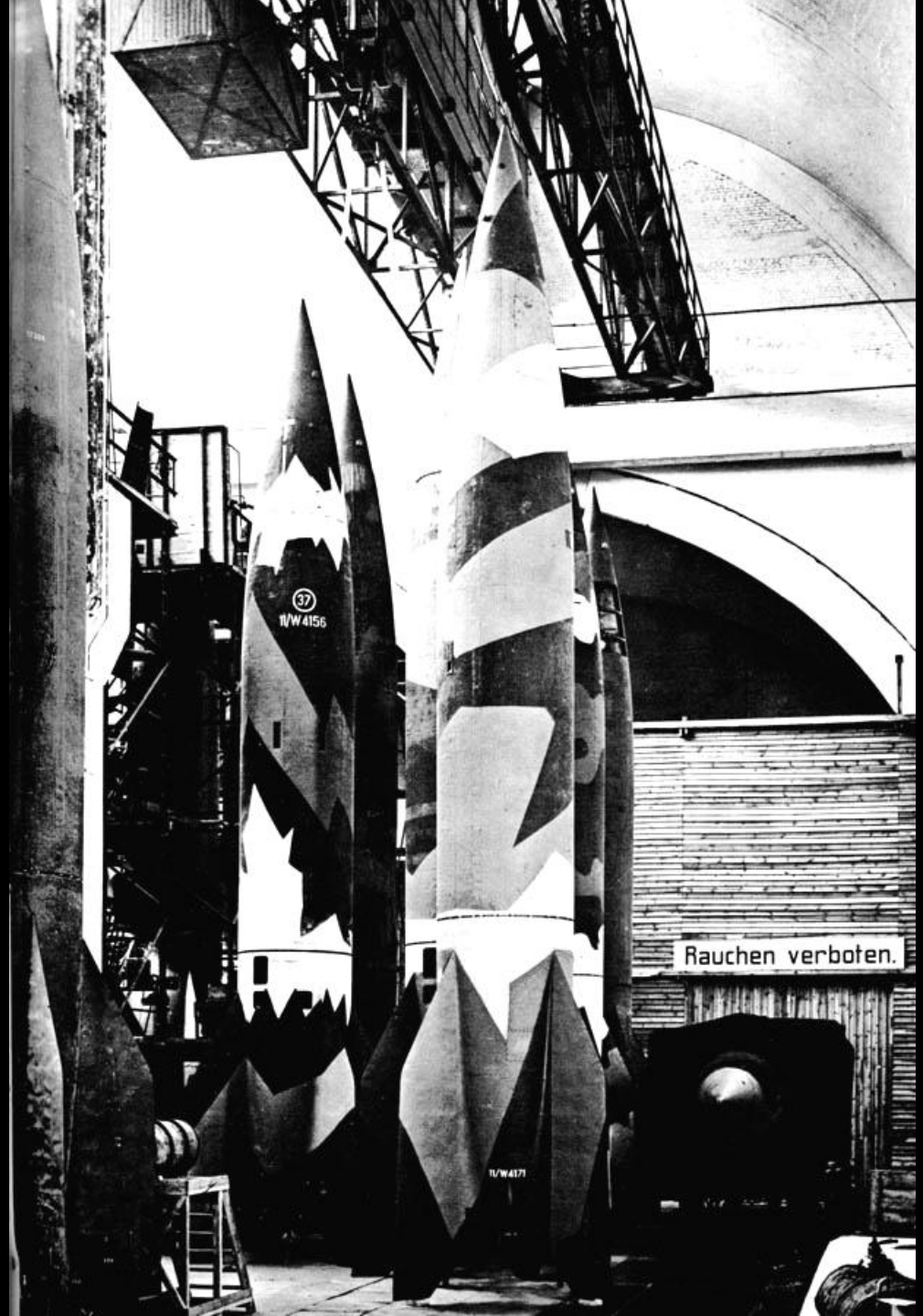


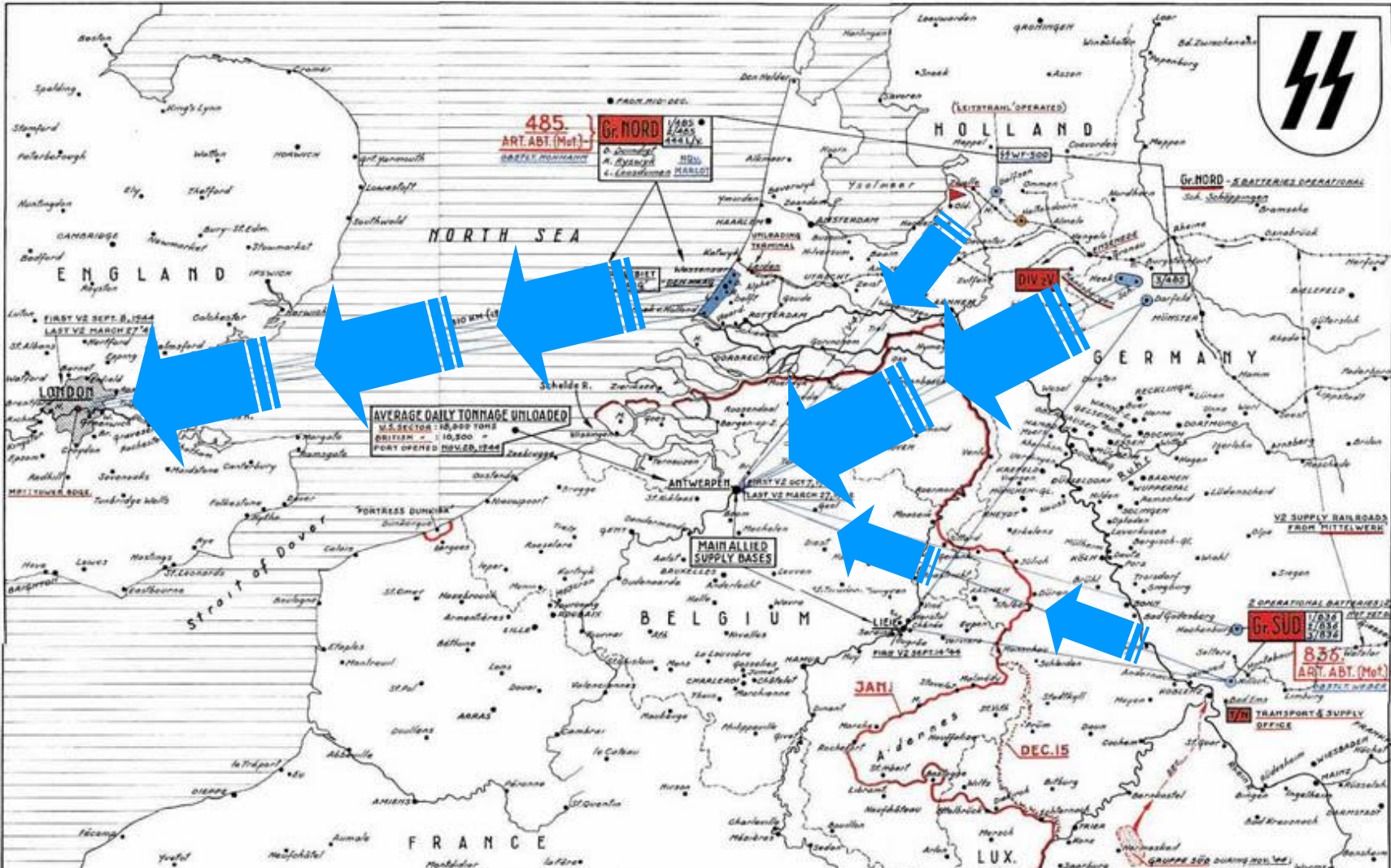
Peenemünde Rocket Facility on Baltic Coast Established 1936

- A – Launch Area**
- B – Engineering**
- C – Production Plant**
- D - Test Stands**
- E – Military Camp**
- F – Residential Area**

**Nordhausen
and Mittelwerks
Rocket Depots
after August 1943
British Bombing
of Peenemunde**

**Extensive Use of
POWs by Germany**





THE V2-ROCKET DEPLOYMENT WINTER 1944-45 DIVISION zV.

(GENLT. J. WAFFEN-SS KAMMLER)

SITUATION AS OF JAN. I, 1945

(DAY 118 OF THE GERMAN ROCKET OFFENSIVE)

NOTE: LOCATIONS OF BATTERIES AND BATTERIES ARE SHOWN FOR JANUARY I, 1945.
MOVEMENTS OF BATTERIES ARE SHOWN FOR DECEMBER AND DECEMBER 1944 ONLY.

CITIES TARGETED BY V2 - SEPT. 6 TO DEC. 31, 1944 (German and German sources)

LONDON	447	ROCKETS	MOOS	3	ROCKETS
ANTWERPEN	924	"	BIEST	2	"
LIEGE	27	"	TOURNAI	7	"
PARIS	19	"	MASBET	13	"
MORWICH	43	"	MAASTRICHT	19	"
IPSWICH	1	"			
ST. QUENTIN	1	"			
CAMBRAI	4	"			
ARRAS	6	"			
LILLE	25	"			
TOURNAING	19	"			
TOTAL:		1,562	ROCKETS LAUNCHED		
			UP TO DECEMBER 31		

VE SUPPLY RAILROADS

FRONTLINE DEC. 15, 1944

FRONTLINE ON JAN. I, 1945

OPERATIONAL LAUNCHING AREAS 1.1.45

OPERATIONAL UNTIL DEC. 30, 1944

FRONTLINE

GRUPPE 508 DURING NOV. 1944 MOVES EAST OF ARRAS A. LATE NOV. - EARLY DEC.

Gr. NORD - BATTERIES OPERATIONAL

Gr. SUD

835 ART. ABT. (Mot)

TRANSPORT & SUPPLY OFFICE

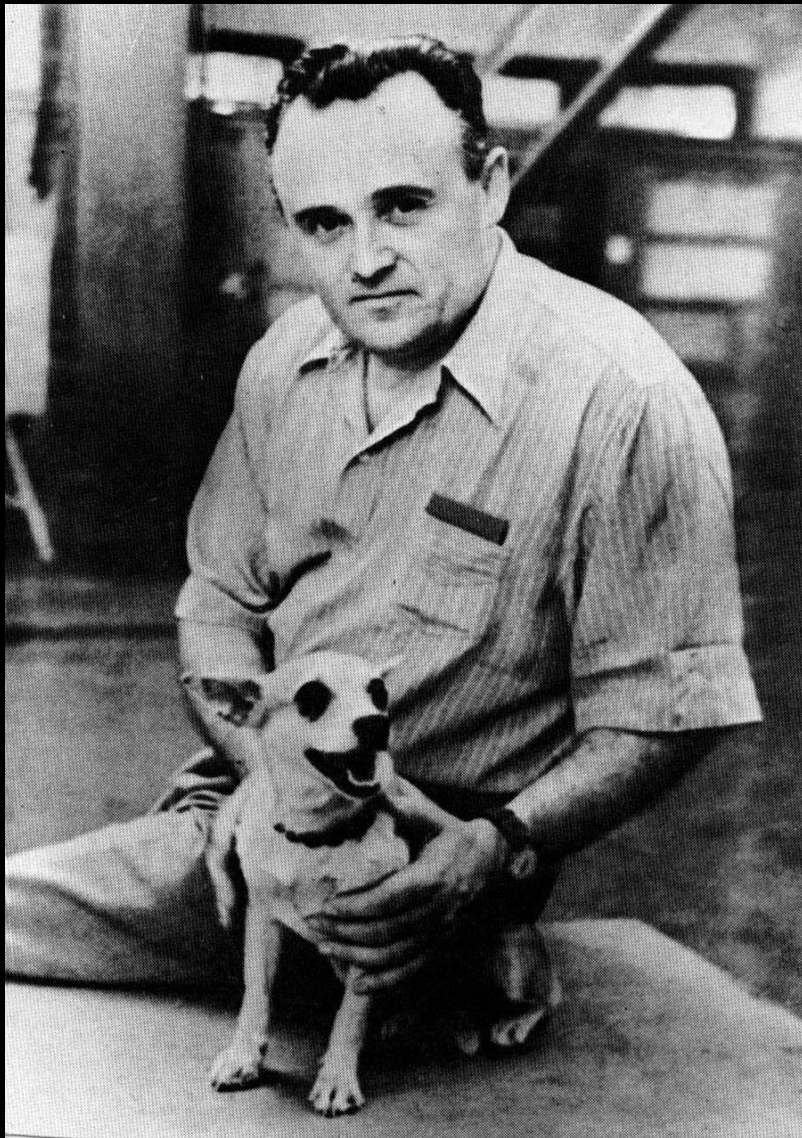
DIV zV

NO. OF GENLT. KAMMLER (HAASBRAGEN) SEPT. - NOV. 44 1,000

DIV zV TRAINING DEPOT AND ADVANCED BASE/SECURITY TRAP

Kamp Bledt

Sergei Pavlovich Korolev (1907-1966)



**Grand Designer
For Soviet Rocket
Program**

**1954 – Soviet Planning for IGY Prompted
A Scientific Paper on Satellites by Korlev**

**1955 – Soviet Academy of Sciences,
inspired by Korolev's paper, meet to create
“Commission for Interplanetary Travel”**

**1955 – On 29 August Korolev Submits Plans
for a Satellite to the Soviet Leadership**



**V-2 Rocket
Captured by
Americans
at Peenemunde**

**Launched from
White Sands, NM
1946**

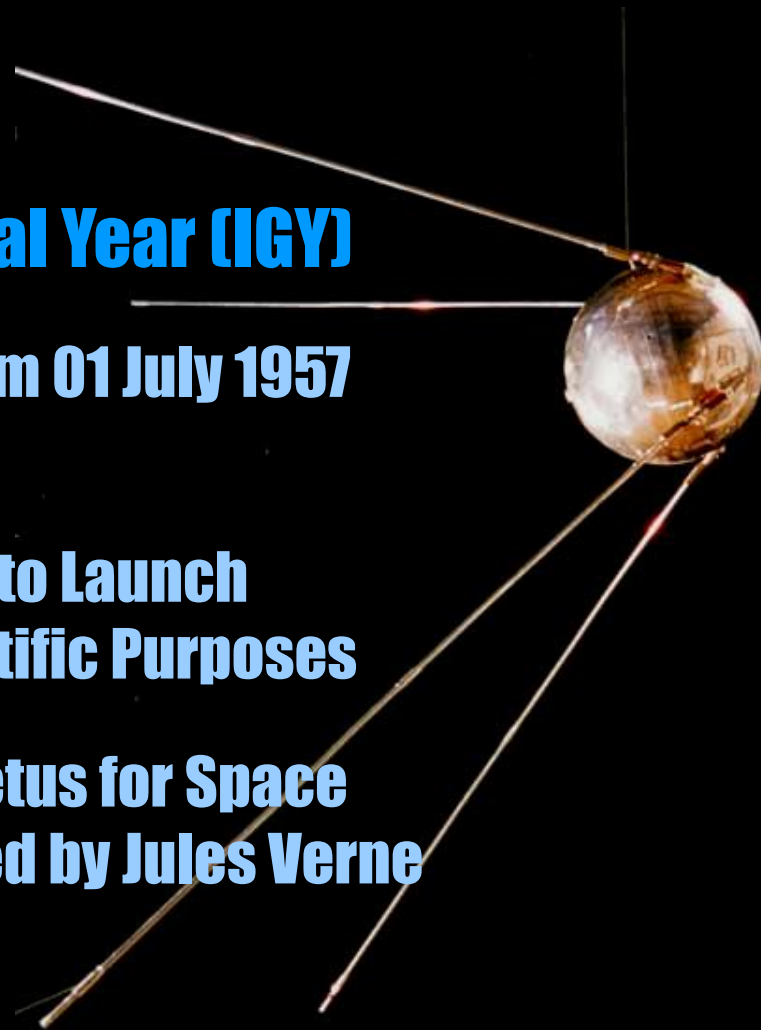
The IGY Satellite Race

International Geophysical Year (IGY)

Actually a year and a half from 01 July 1957
to 31 December 1958

Global Agreement and Effort to Launch
Satellites for Peaceful Scientific Purposes

Yet, Underlying Military Impetus for Space
Programs, as originally stated by Jules Verne
in 1865



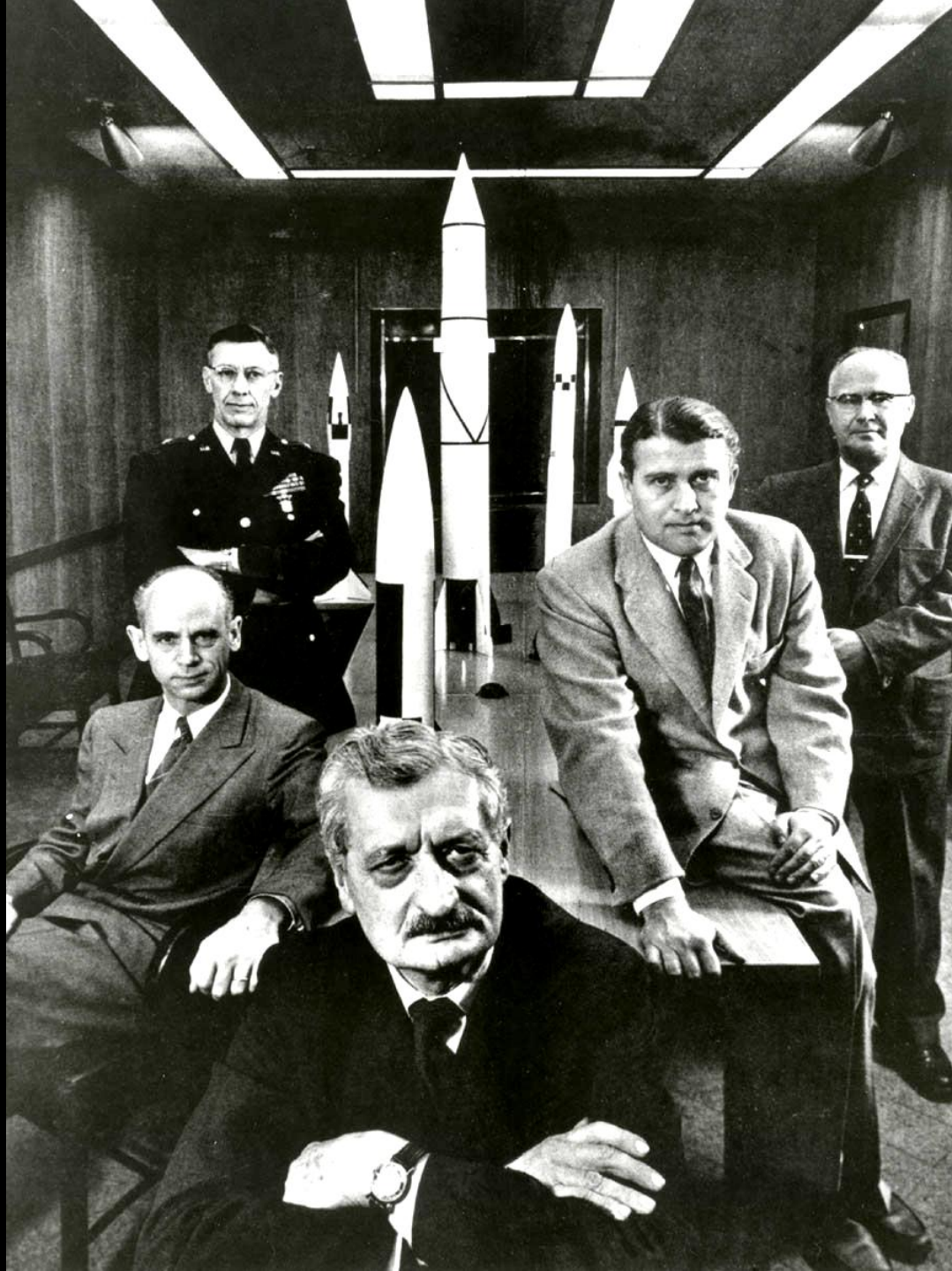
1958

HEADQUARTERS
U. S. ARMY ORDNANCE
MISSILE COMMAND

HEADQUARTERS
ARMY BALLISTIC MISSILE AGENCY



Huntsville, AL



**Rees
von Braun
Stuhlinger
Torkoy
Oberth**

**ABMA
1957**

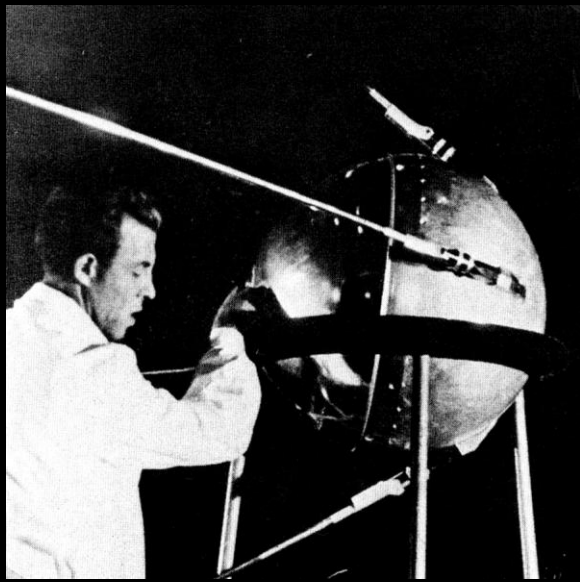


Who's In Charge Here?

By 1955, the U.S. Navy was charged with developing their **Vanguard Program** to launch first U.S. satellite

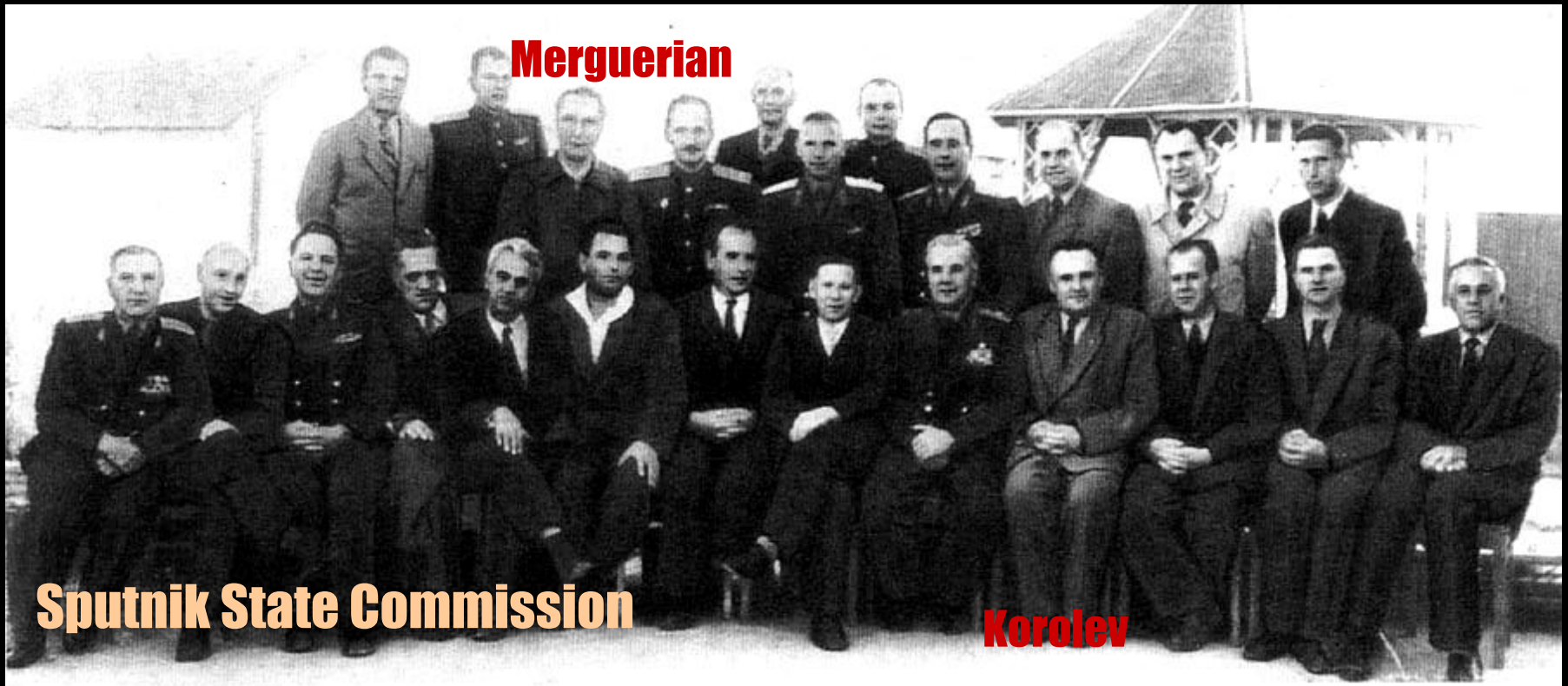
NACA became NASA in 1958





Sputnik 1 “Fellow Traveler”
Launched 04 Oct 1957
First Artificial Satellite
185#, Diameter 23”

Merguerian

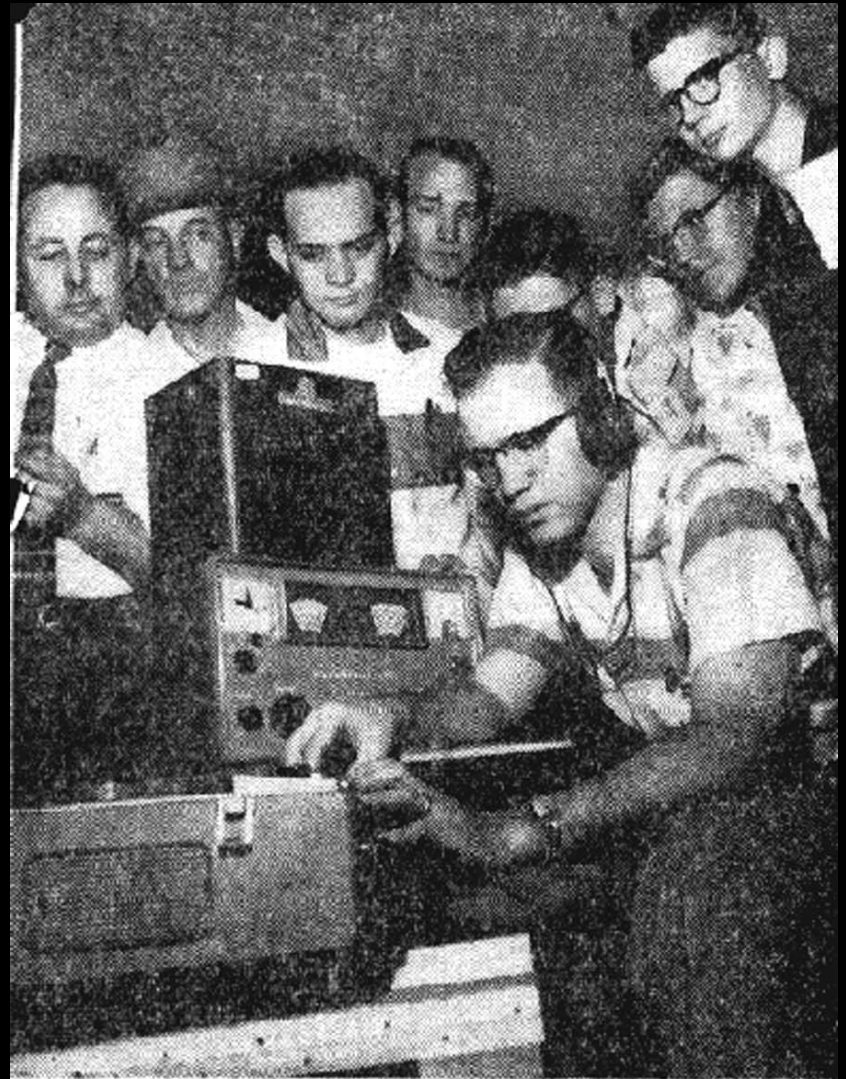


Sputnik State Commission

Korolev



Clever Marketing Ploy as Sputnik Signals on Ham Radio Frequency



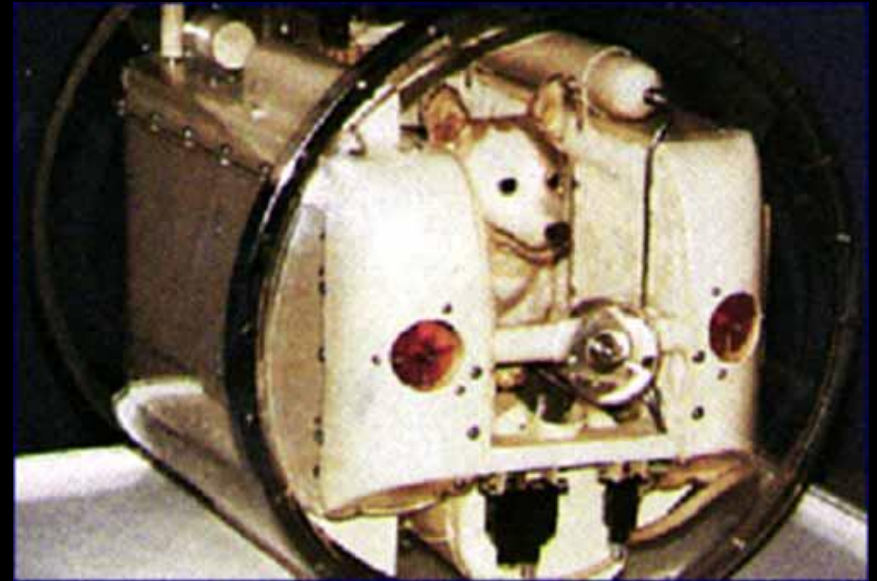
—Dallas News Staff Photo.

SIGNALS FROM THE SATELLITE

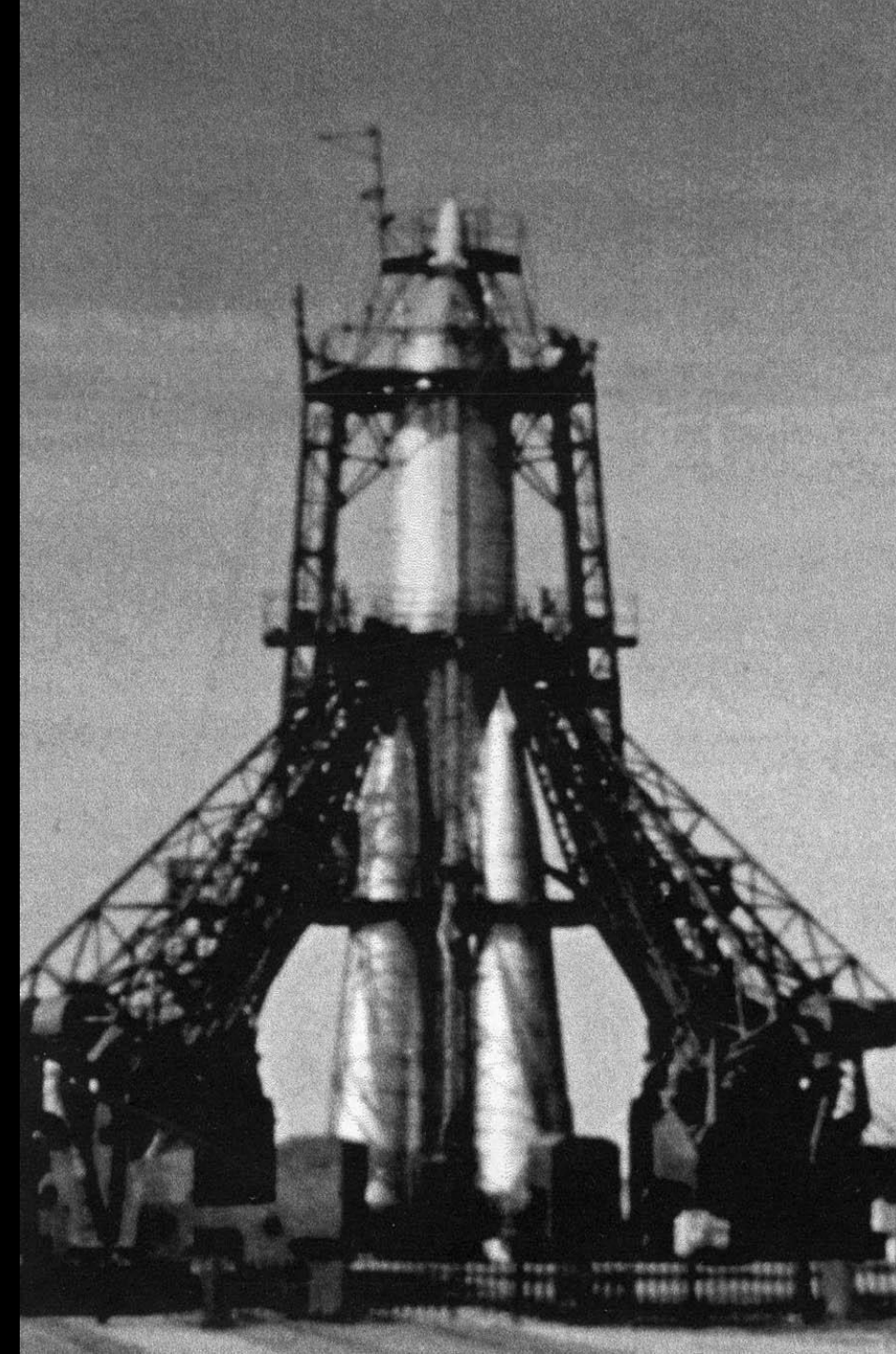
Ham operator Roy Welch of Dallas, seated, plays a tape-recorded signal from the Russian space satellite for fellow hams at the State Fair of Texas. Welch recorded the signals on a receiver at his home.

Sputnik 2 Laika

03 Nov 1957



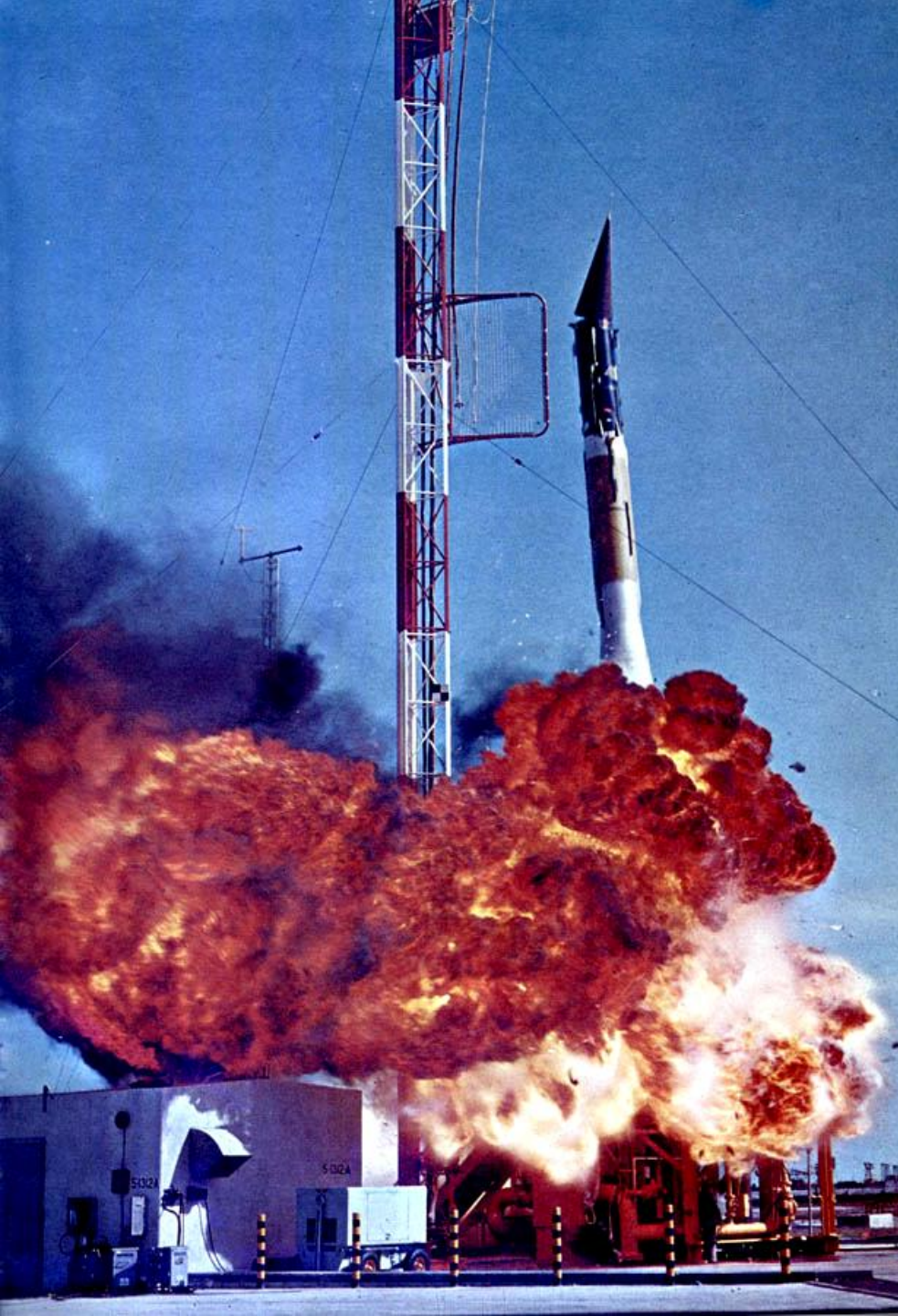
**Massive Satellite that
Weighed 1,120 Pounds
Proved Soviets Capable of
Launching Huge Payloads**



By 1957, the Soviets had big ICBMs - the United States had yet to test the far smaller Atlas.

The Soviets had the glory of launching the Space Age - a vast gain in prestige for the Communists and morale blow to the West.

If the Soviet ICBM was reliable and effective and put into mass production, and if the Americans failed to catch up or take vital counteractions, the Soviets might gain a first-strike capability within a few years.



Vanguard I Explosion

06 Dec 1957

**Hopes of American
Space Program
Tumble along with
Cracked Nose Cone of
Navy Vanguard Missile**





31 Jan 1958

**Successful Launch
of Explorer I on a
U.S. Army Jupiter C
(V-2 Design)**

**In Less Than 2 Months
Retooled Launch
Facility at Cape for
an off-the-shelf
Redstone – Launch
Vehicle 29 (UE)**

Jupiter-C Puts Up Moon

Wail Of Sirens Brings In Era On Space Here

Thousands Gather On The Square For Noley Success Demonstration

By H. L. THORNTON
Of The Times Staff

The wail of sirens, sounding horns and the throbbing of powerful motors added to the rocket's lift and thrust as it roared at space at Huntsville last night.

Like that, on from other a Jupiter-C rocket built at Huntsville, the nation's first satellite was on its way around the earth's orbit. The launching, where a dozen of scores of thousands of the nation's citizens gathered to witness the event, was a success, but it came with a wail of sirens.

9 Labs Here Aided Project Of Launching

It Took Every One To Successfully Put Up Moon Vehicle

The successful efforts of all laboratory facilities of the Army-Navy Space Agency, the first of the nation's space agencies, were put to the test in the launching of the Jupiter-C rocket last night. The rocket, built at Huntsville, was the first of a series of rockets to be launched from the space center here.

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Eisenhower Officially Announces Huntsville Satellite Circles Globe

Weather Change Sped Launching

AGRESTA, Ga., Feb. 1 (AP)—President Eisenhower announced early today America's first satellite is in orbit around the earth.

The President's dramatic announcement was issued at his vacation headquarters a few minutes before 1 p.m. EST by White House press secretary James C. Hagerty.

The satellite was launched at Cape Canaveral, Fla., at 11:42 p.m. EST last night.

The late moon was expected to orbit in an orbit 1,000 miles high.

Army Reveals Second Moon Is Scheduled

The second of the President's satellites.

The J. William Aron, head of the International Geophysical Year office at National Science Foundation, was quoted as saying that the United States has successfully placed a satellite around the earth in orbit around the earth.

The satellite was launched at Cape Canaveral, Fla., at 11:42 p.m. EST last night.

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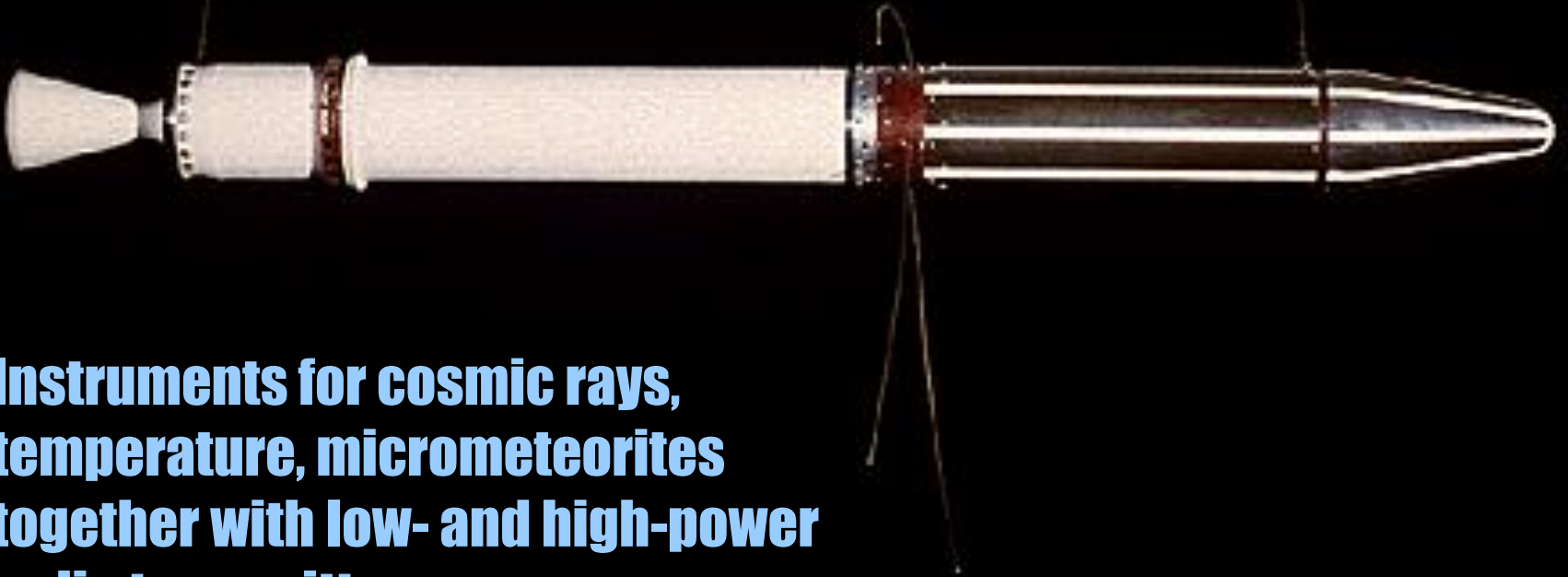
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LAUNCHED BY THORNTON: The Jupiter-C rocket is shown at the moment of launch from Cape Canaveral, Fla., at 11:42 p.m. EST last night.

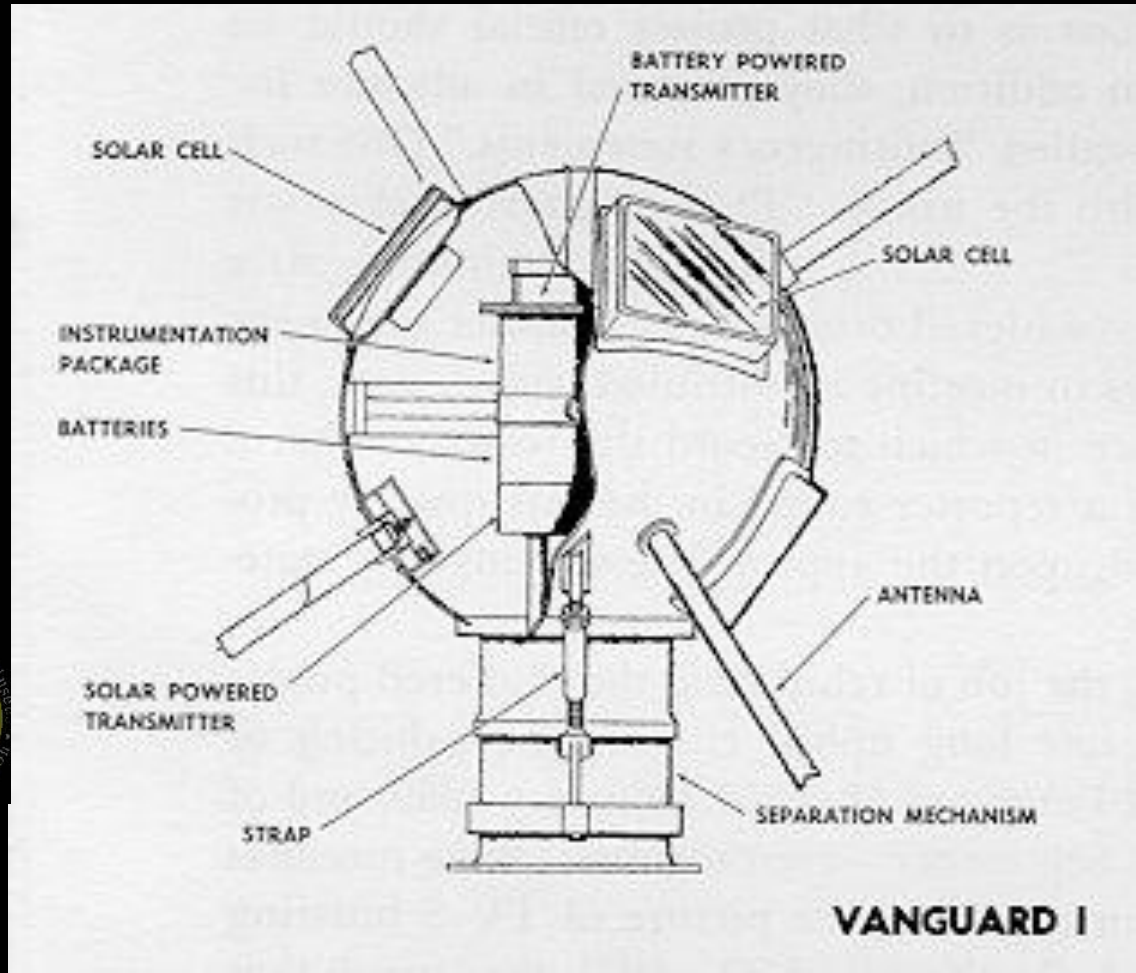
Explorer I Satellite



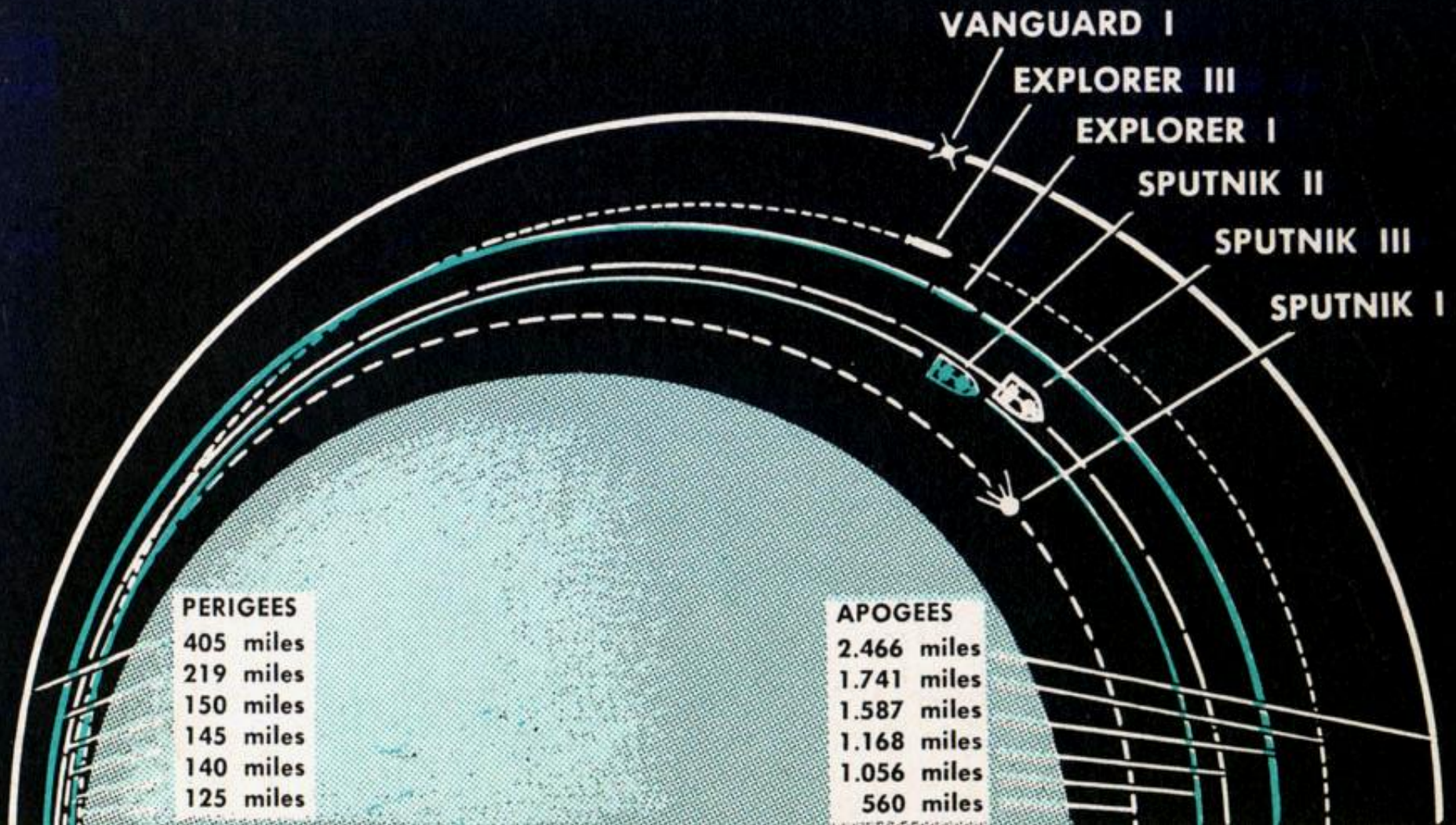
**Instruments for cosmic rays,
temperature, micrometeorites
together with low- and high-power
radio transmitters**



Vanguard I



IGY Satellite Orbits



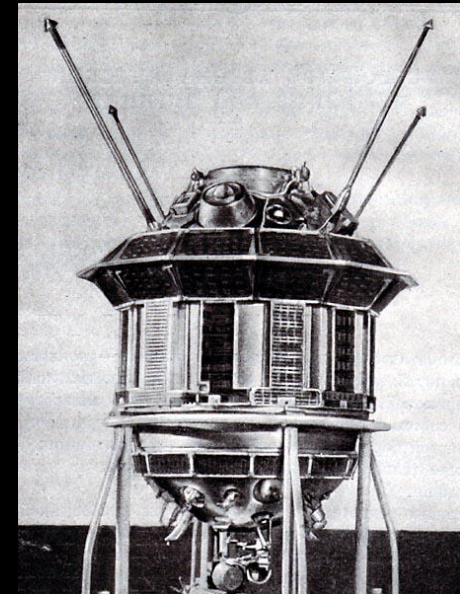
Luna 1



Luna 2



Luna 3



Soviet Luna Program 1959-1969

02 Jan 1959 – Luna 1 (Bypassed Moon 4,600 mi)

12 Sep 1959 – Luna 2 (Lunar Impact)

04 Oct 1959 – Luna 3 (Circum Lunar Orbit –

First Images of Lunar Far Side)

02 Apr 1963 – Luna 4 (Bypassed Moon by 4,300 mi)*

09 May 1965 – Luna 5 (Impacted on Lunar Surface)*

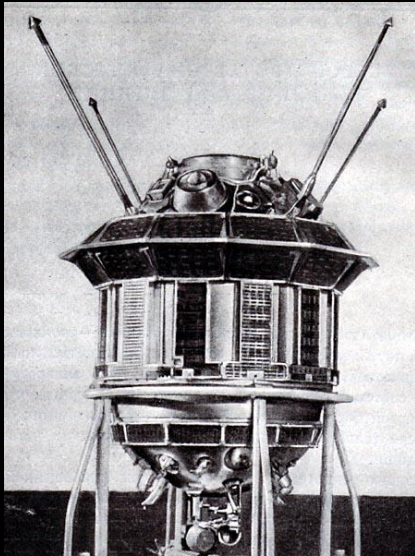
08 Jun 1965 – Luna 6 (Bypassed Moon)*

*** = Unsuccessful**

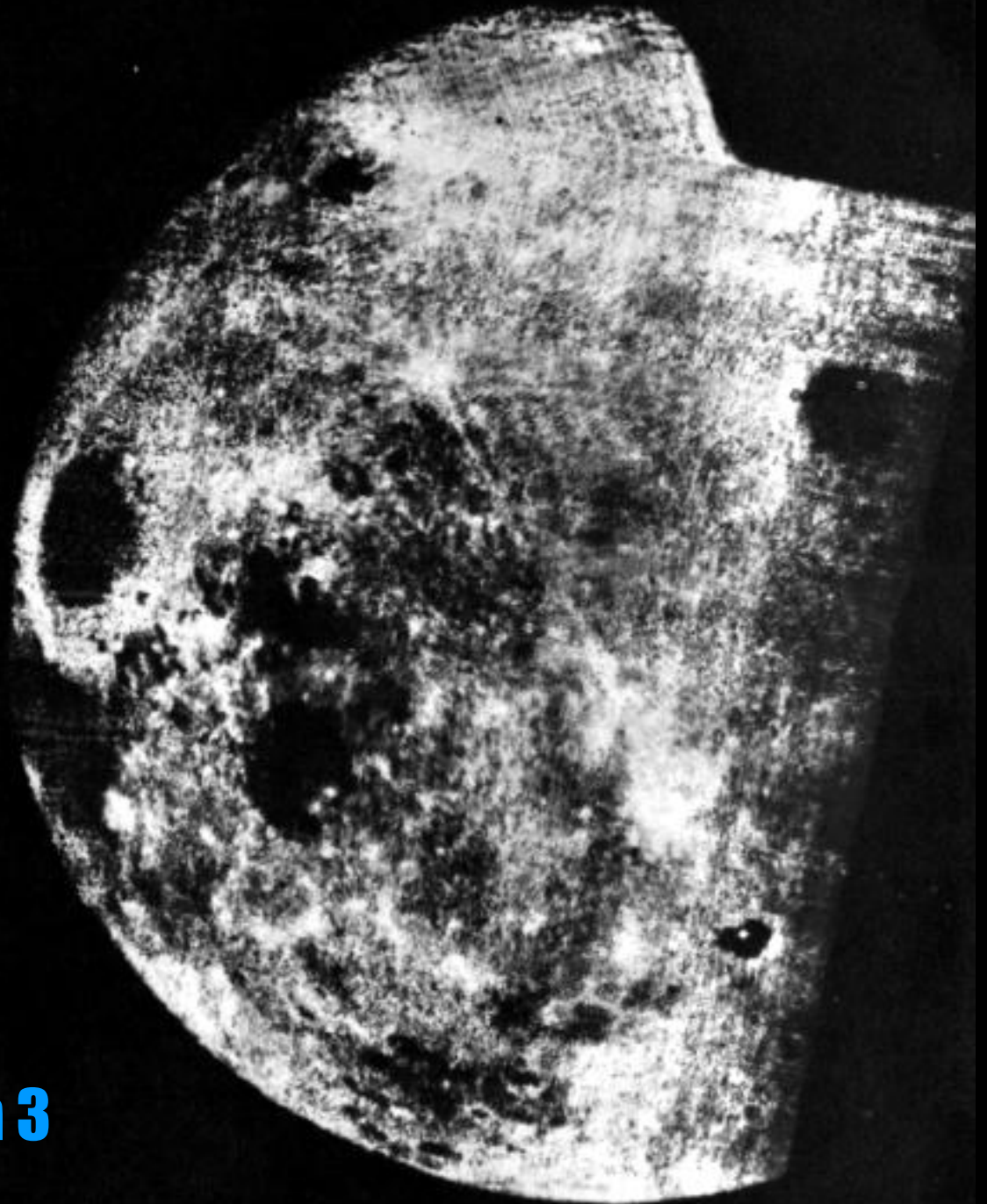
Luna 3

04 Oct 1959

Two Years After
**Sputnik I – First
Human View
of Lunar Farside**



Luna 3





Yuri Gagarin

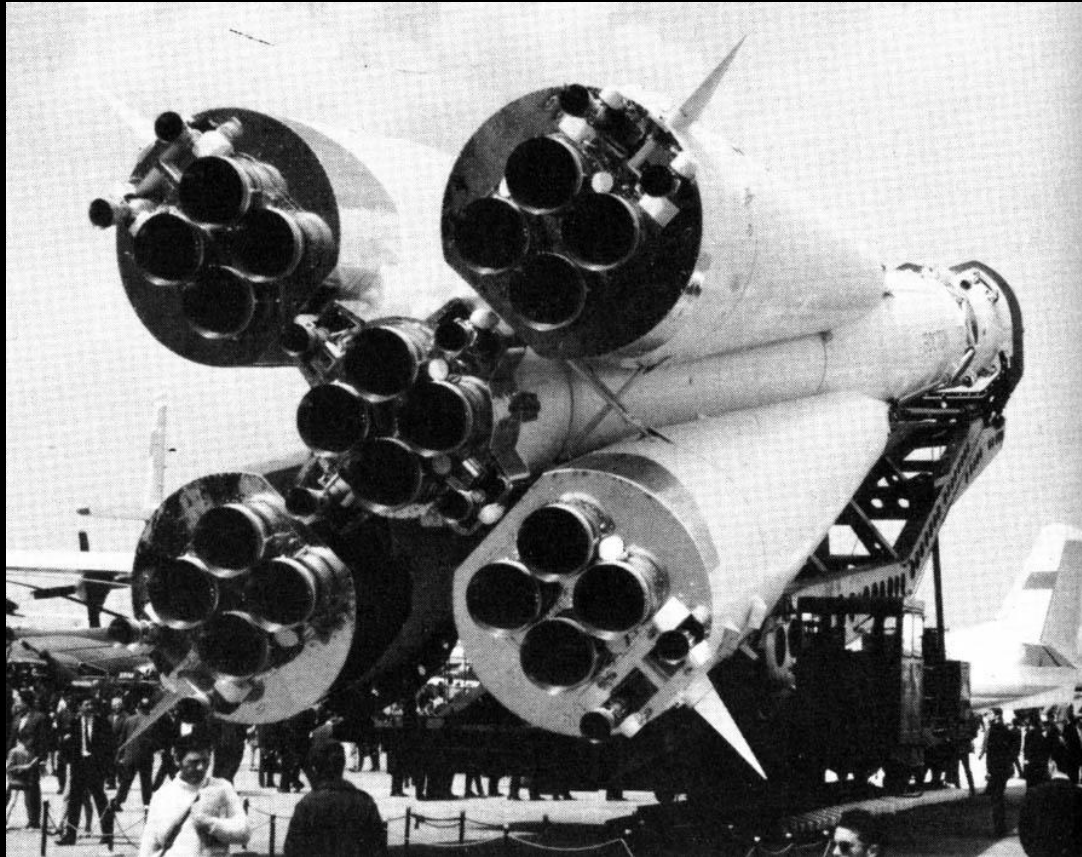
1935-1968

**First Human
to Orbit
Earth
(One Orbit)**

12 Apr 1961

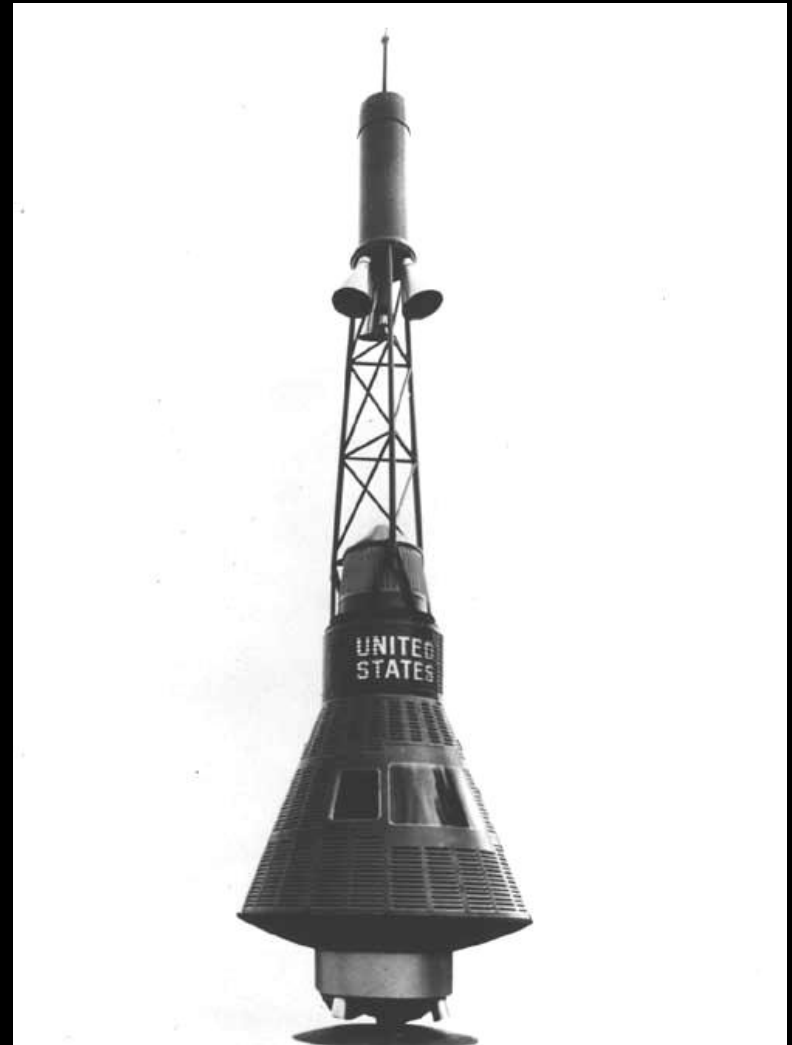
**Vostok 1 Mission
Kedr Spacecraft**

Gagarin Vostok Booster



Ironically, on 27 March 1968 he and his flight instructor died in a MIG-15UTI "Fagot" on a routine training flight near Kirzhach

Mercury Program 1958-1963



Alan Shepard

1923-1998

**Second Human
into Space
(Suborbital)**

05 May 1961

**Mercury 3 Mission
Freedom 7 Craft**



Shepard Suborbital Splashdown Rescue

05 May 1961



President John F. Kennedy

12 Sept 1962

**Rice University
Houston, TX**

***“We choose to go
to the Moon in
this decade and
do the other things, not because they are
easy, but because they are hard.”***

Stated to Congress in May 1961



Project Ranger

(1961-1965)

26 Jan 1962 – Ranger 3*

23 Apr 1962 – Ranger 4*

18 Oct 1962 – Ranger 5*

30 Jan 1964 – Ranger 6*

28 Jul 1964 – Ranger 7

17 Feb 1965 – Ranger 8

21 Mar 1965 – Ranger 9

**Hard landings for imaging and
testing of lunar surface**

*** = Unsuccessful**





Lunar Surveyor Program (1966-1968)

30 May 1966 – Surveyor 1

20 September 1966 – Surveyor 2*

17 April 1967 – Surveyor 3

14 Jul 1967 – Surveyor 4*

08 Sep 1967 – Surveyor 5

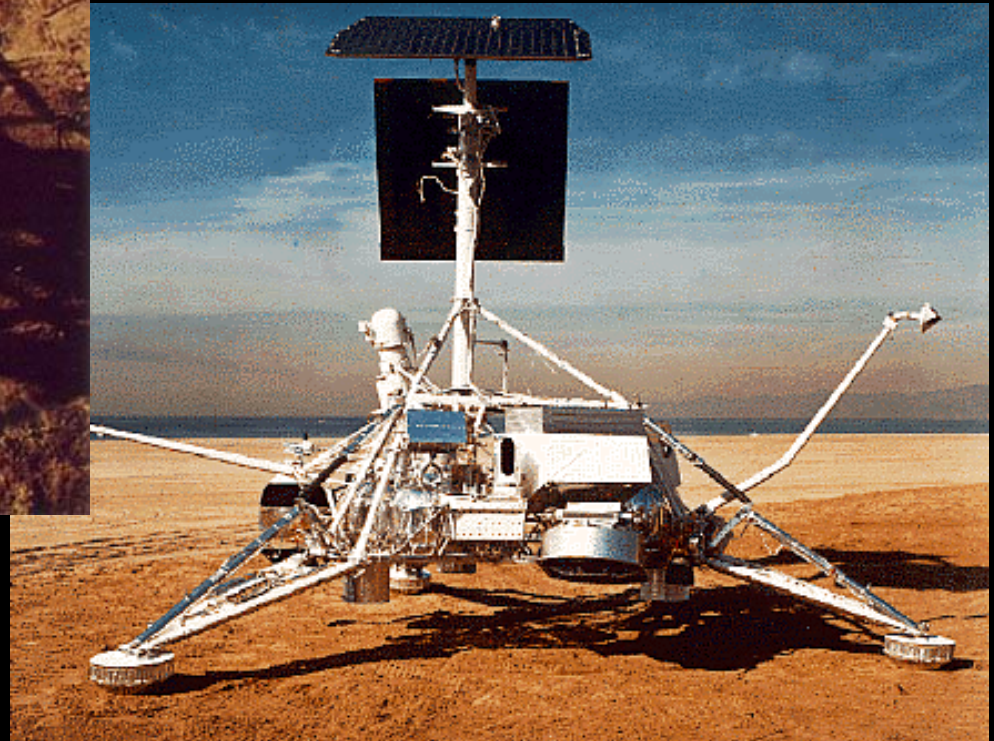
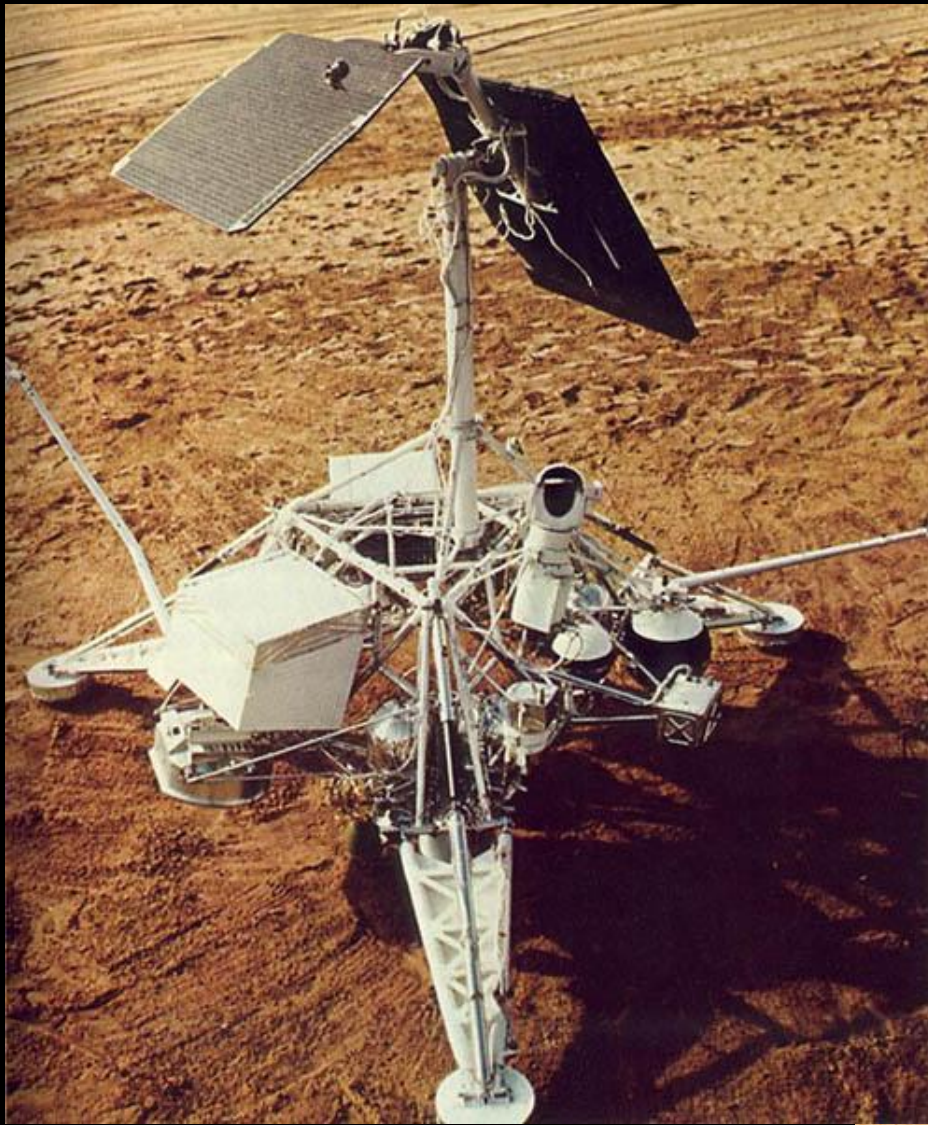
07 Nov 1967 – Surveyor 6

07 Jan 1968 – Surveyor 7

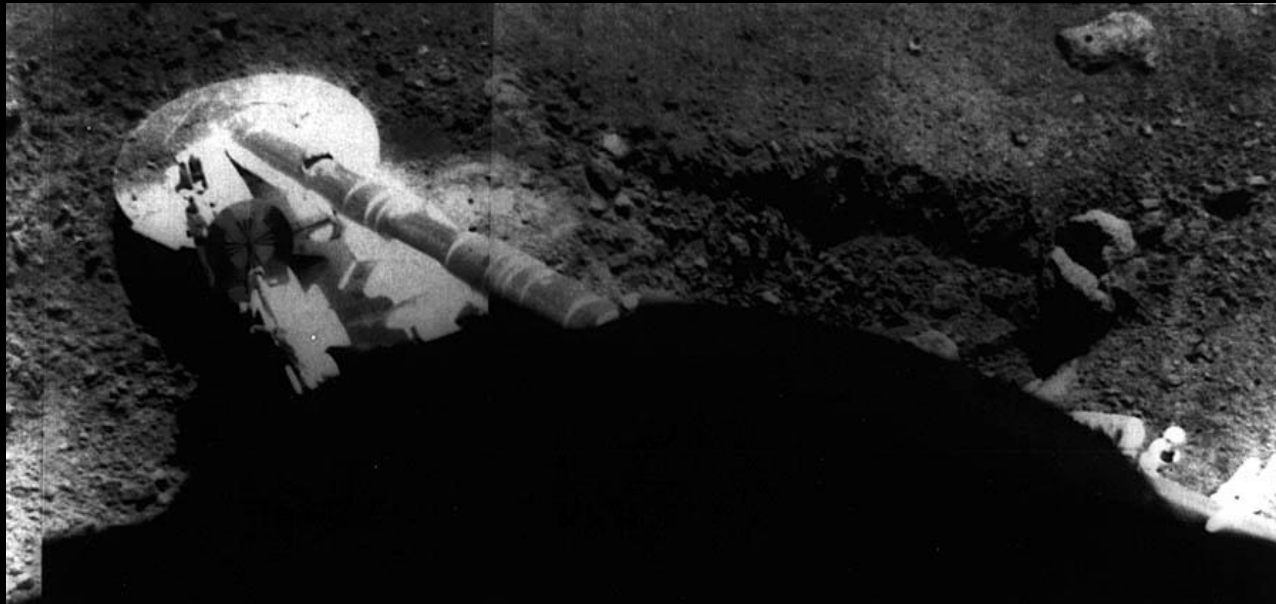
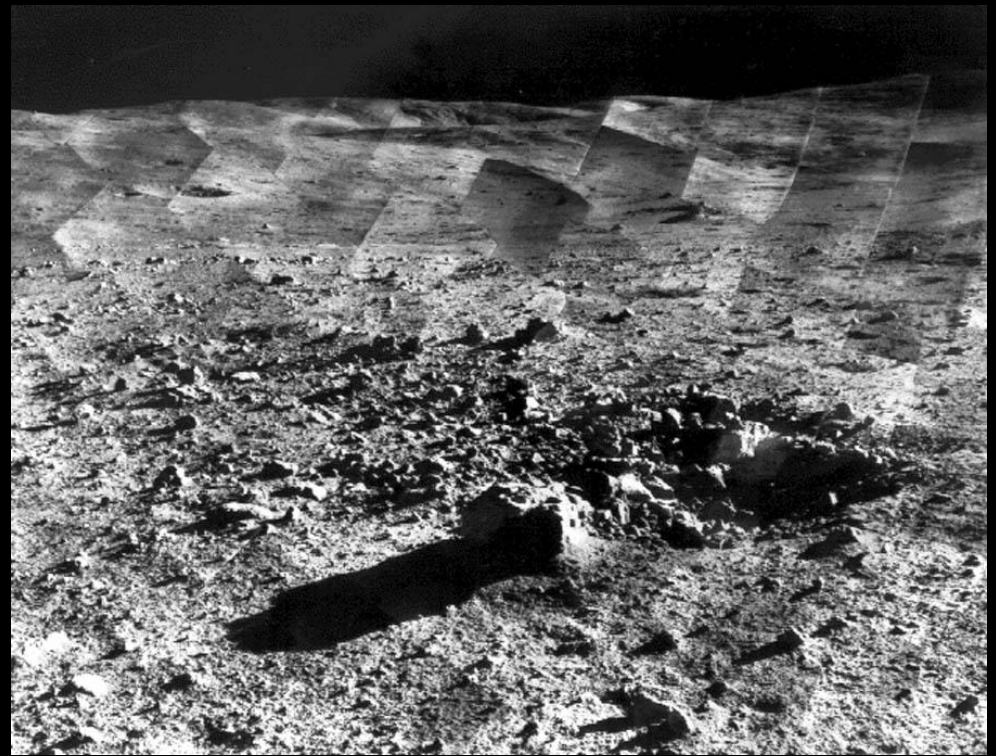
**Soft landing for imaging and
testing of lunar surface for
Apollo missions**

*** = Unsuccessful**

Lunar Surveyor Spacecraft



Lunar Surveyor Images from the Moon's Surface



**Program
Developed
Soft-Landing
Capability**

Lunar Orbiter Program (1966-1967)

10 Aug 1966 – Orbiter 1

06 Nov 1966 – Orbiter 2

04 Feb 1967 – Orbiter 3

04 May 1967 – Orbiter 4

01 Aug 1967 – Orbiter 5

**Imaging and mapping
of lunar surface to
focus Apollo missions**

All Successful



Orbiter on Atlas Agena D

Lunar Orbiter Earthrise



Lunar Orbiter Tycho

~108 Ma



Lunar Orbiter Orientale Basin



Apollo 8 – “Earthrise”



Dec 1968

Saturn V Moon Rocket

Vehicle AS-505

363' in Height

33' Wide

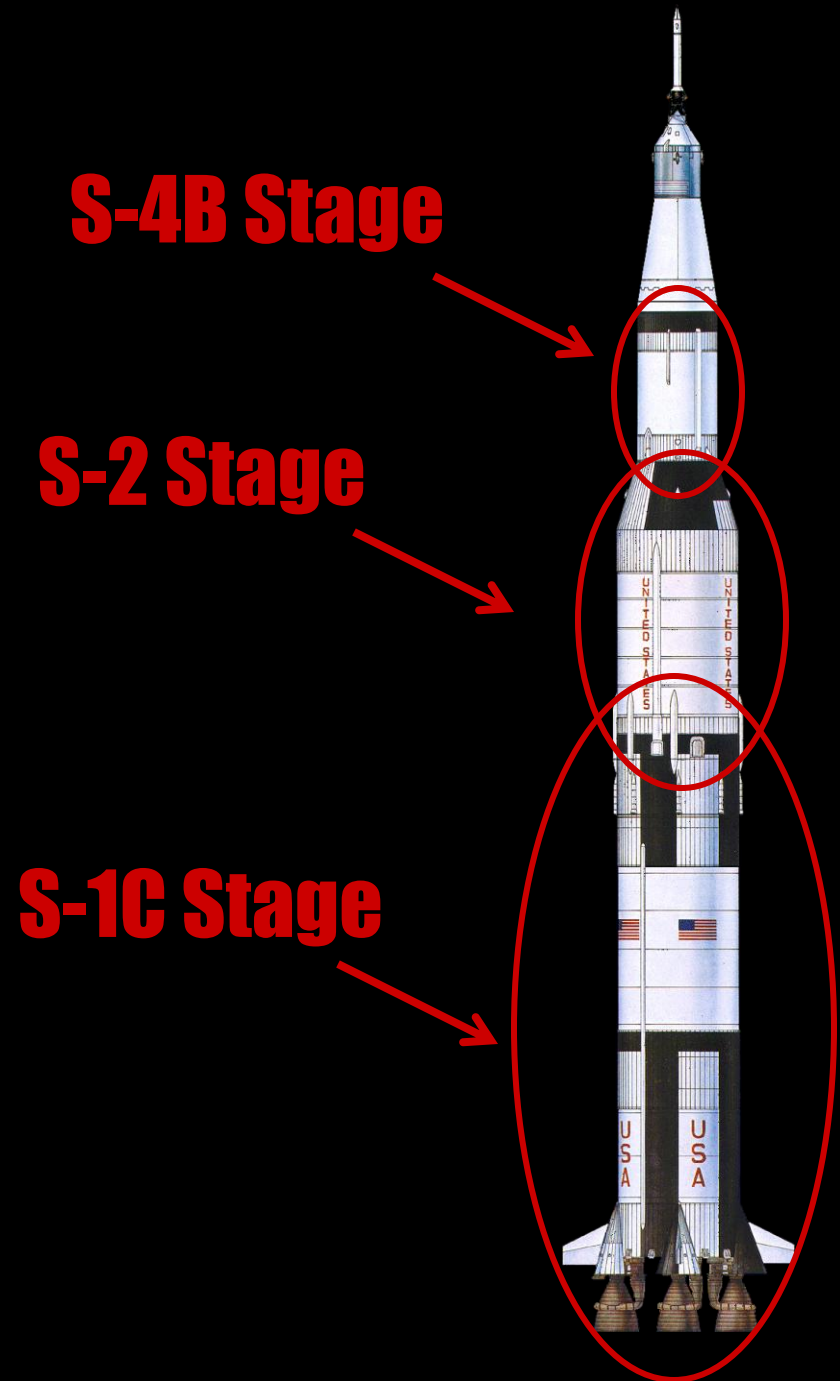
6,391,120# Curb Weight

Engine Thrust:

S-1C = 7,680,000#

S-2 = 1,150,000#

S-4B = 230,000#



Apollo 11

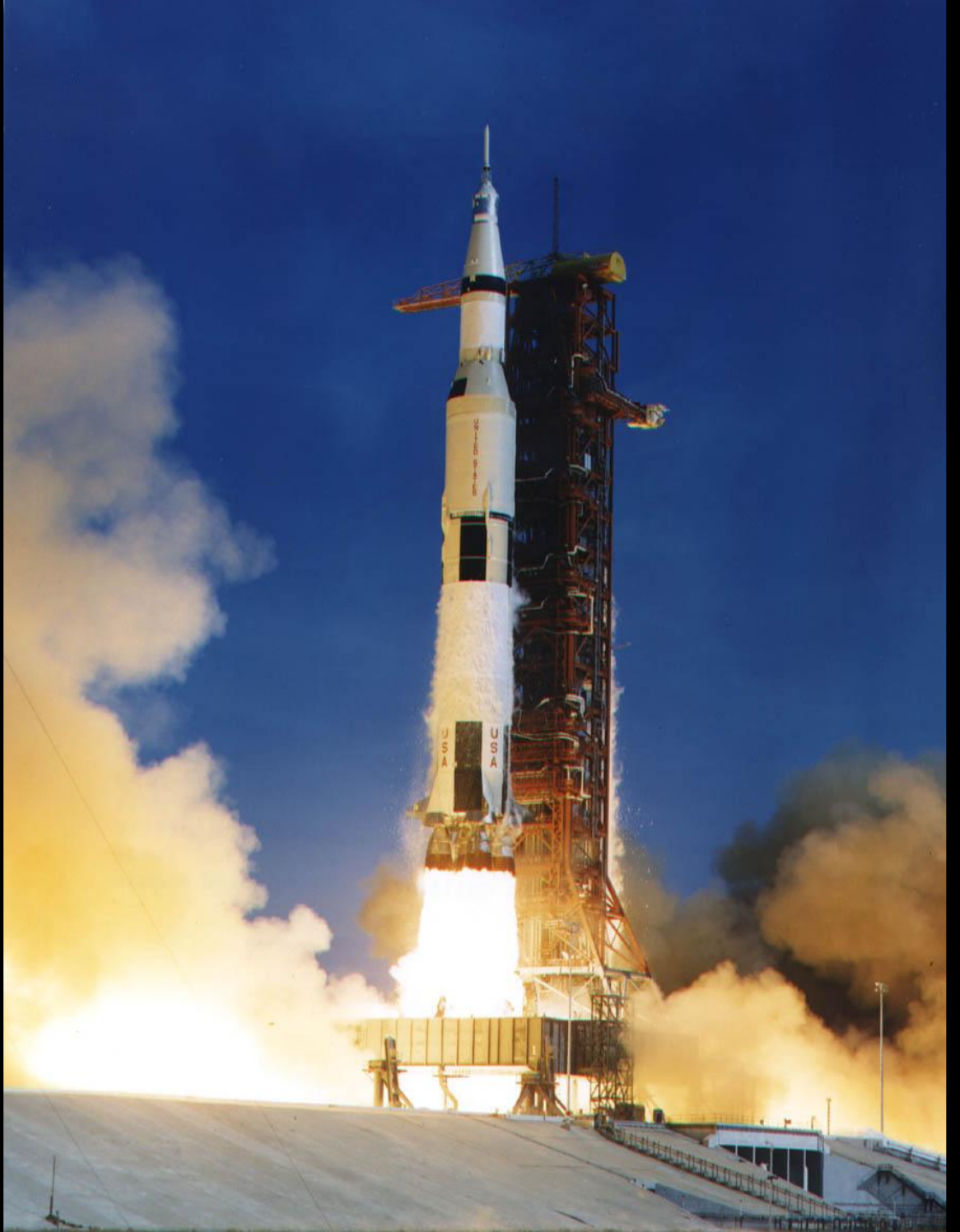
16 Jul 1969



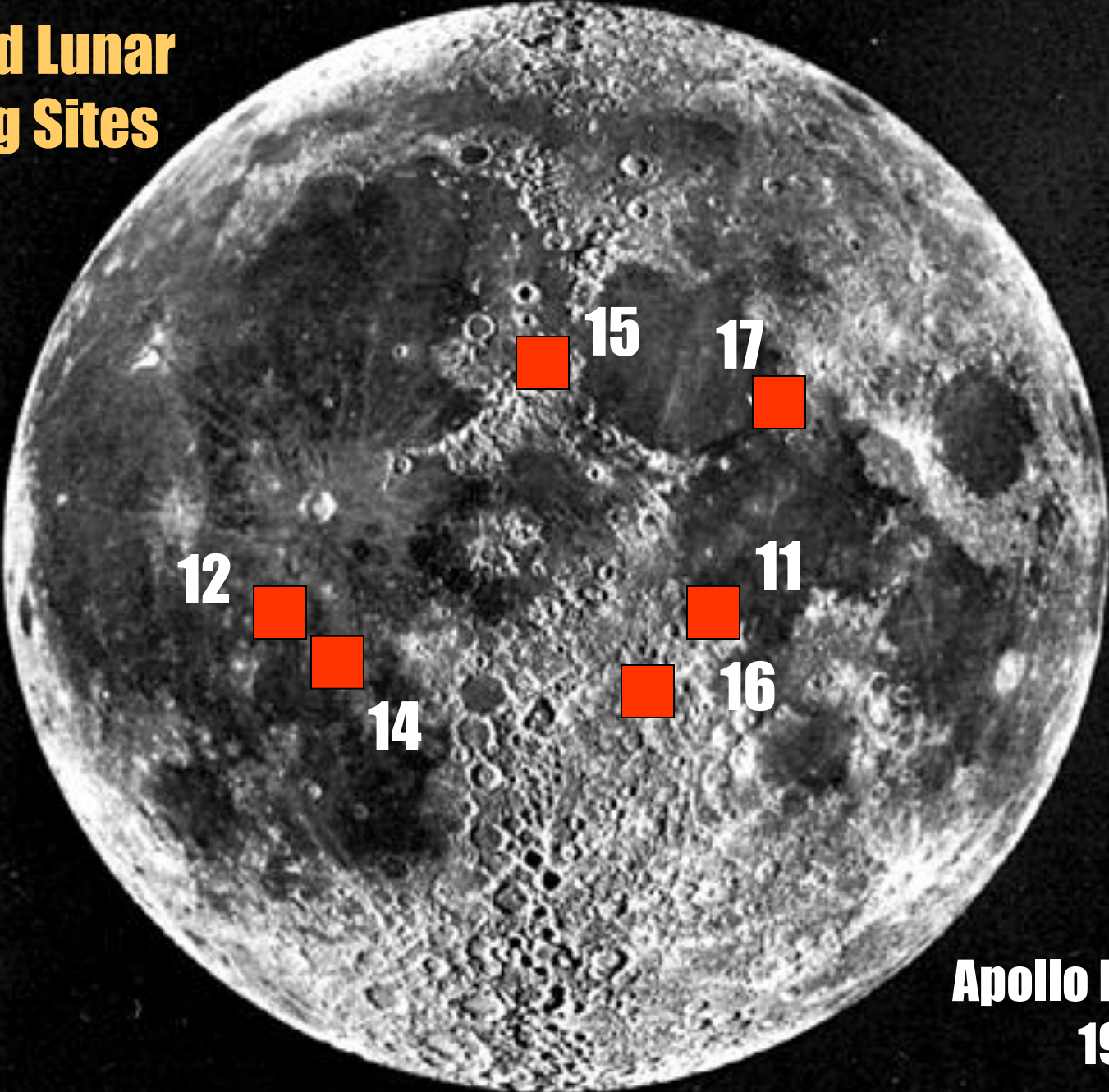
Armstrong
Collins
Aldrin



Apollo 11

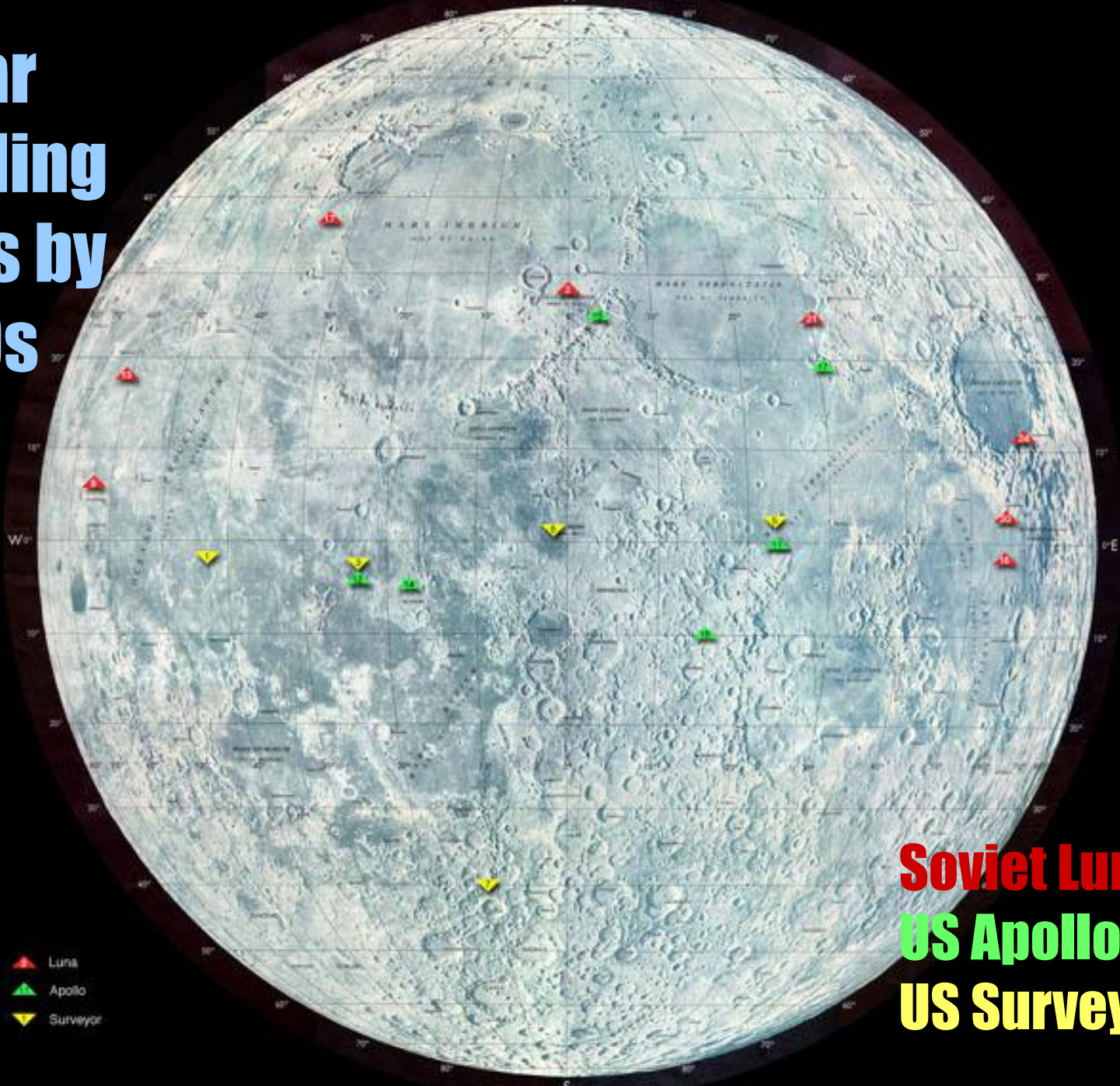


Manned Lunar Landing Sites



**Apollo Missions
1969-1972**

Lunar Landing Sites by 1970s



- ▲ Luna
- ▲ Apollo
- ▲ Surveyor

Soviet Luna (8)
US Apollo (6)
US Surveyor (5)

Lunar Origin





Mares

Highlands



**Spin-off
From Earth
Collision with
a Mars-sized
Body**



Time

Formation of Imbrian and Orientale Basins = 3.8 Ga

NECTARIAN PERIOD ===== 3.95 Ga

Formation of 10-12 huge multi-ringed basins

PRE-NECTARIAN PERIOD ===== 4.05 Ga

Intense cratering with formation of ~30 multi-ringed basins including Oceanus Procellarum and south polar Aitken basins

Anorthositic lunar crust forms during crystallization of magma ocean

**Moon forms by Mars-sized impact with proto-Earth, hurling pre-lunar materials into near-Earth orbit
Where they collect and form molten proto-moon**

COPERNICAN PERIOD ===== 0 Ma

Formation of crater Tycho ~ 108 Ma

Formation of crater Copernicus ~ 800-900 Ma

ERATOSTHENIAN PERIOD ===== 1.1 Ga

Limited basaltic volcanism (~2.1 Ga)

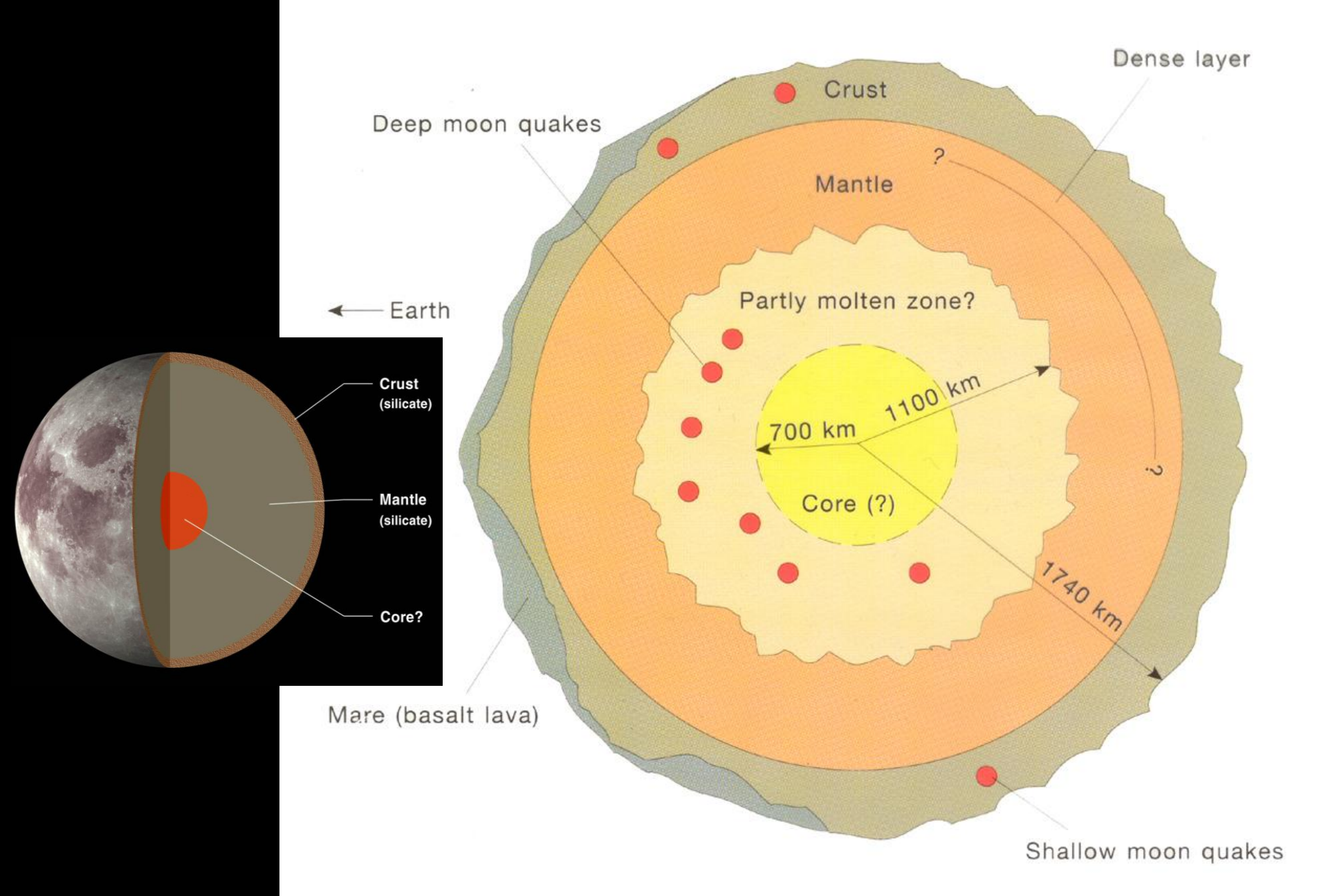
Decreased cratering (<late Imbrian rate)

Basaltic lavas flow into Oceanus Procellarum and Imbrium Basin (~3.2 Ga)

IMBRIAN PERIOD ===== 3.2 Ga

Flooding of multi-ringed craters eventually covering 17% of lunar near side

Impact cratering slows to 1.5% of Nectarian rates



Mass = 0.07349×10^{24} kg; $0.0123 M_e$

Radius = 1737 km; $0.2727 R_e$

Density (ρ) = 3.350 g/cm³; $0.607 \rho_e$

Rotation = 27.322 Days

Revolution = 27.3217 Days

Distance to Sun = 1 AU



Age = 4.6 Ga

Atmos. = ^4He , ^{20}Ne , H_2 , ^{40}Ar , ^{22}Ne , ^{36}Ar , CH_4 , NH_3 , CO_2

Traces of Ionized O, Al, Si, P, Na, Mg

Surface Pressure = 3×10^{-15} bar

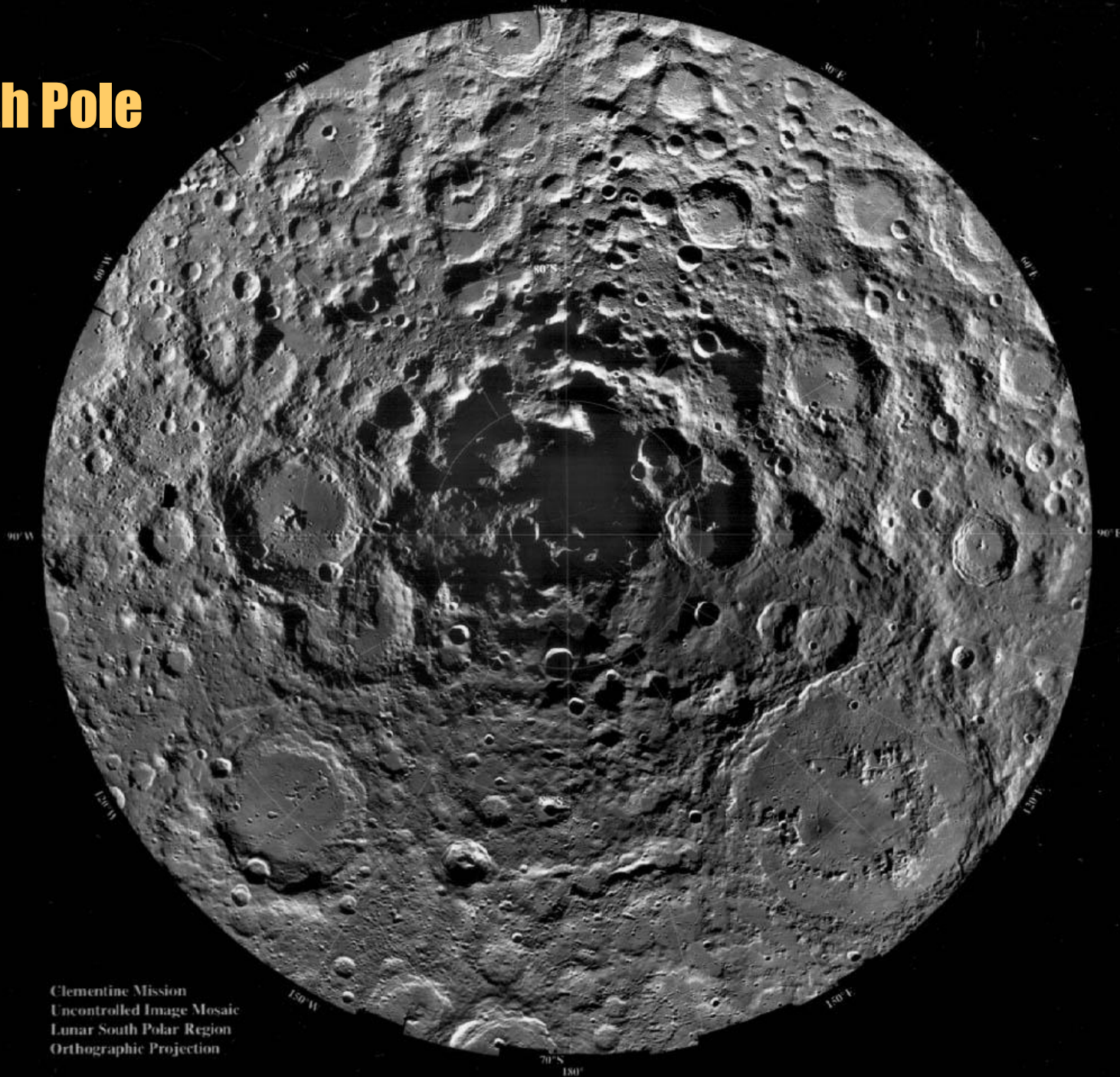
Surface Temperature = $100^\circ\text{K} - 400^\circ\text{K}$

Magnetic Field = $\sim 0.00 B_e$

Gravity Field = $0.165 G_e$



South Pole



Clementine Mission
Uncontrolled Image Mosaic
Lunar South Polar Region
Orthographic Projection

Lunar Farside



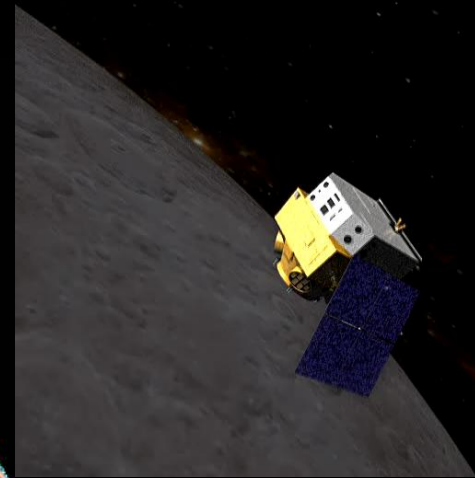
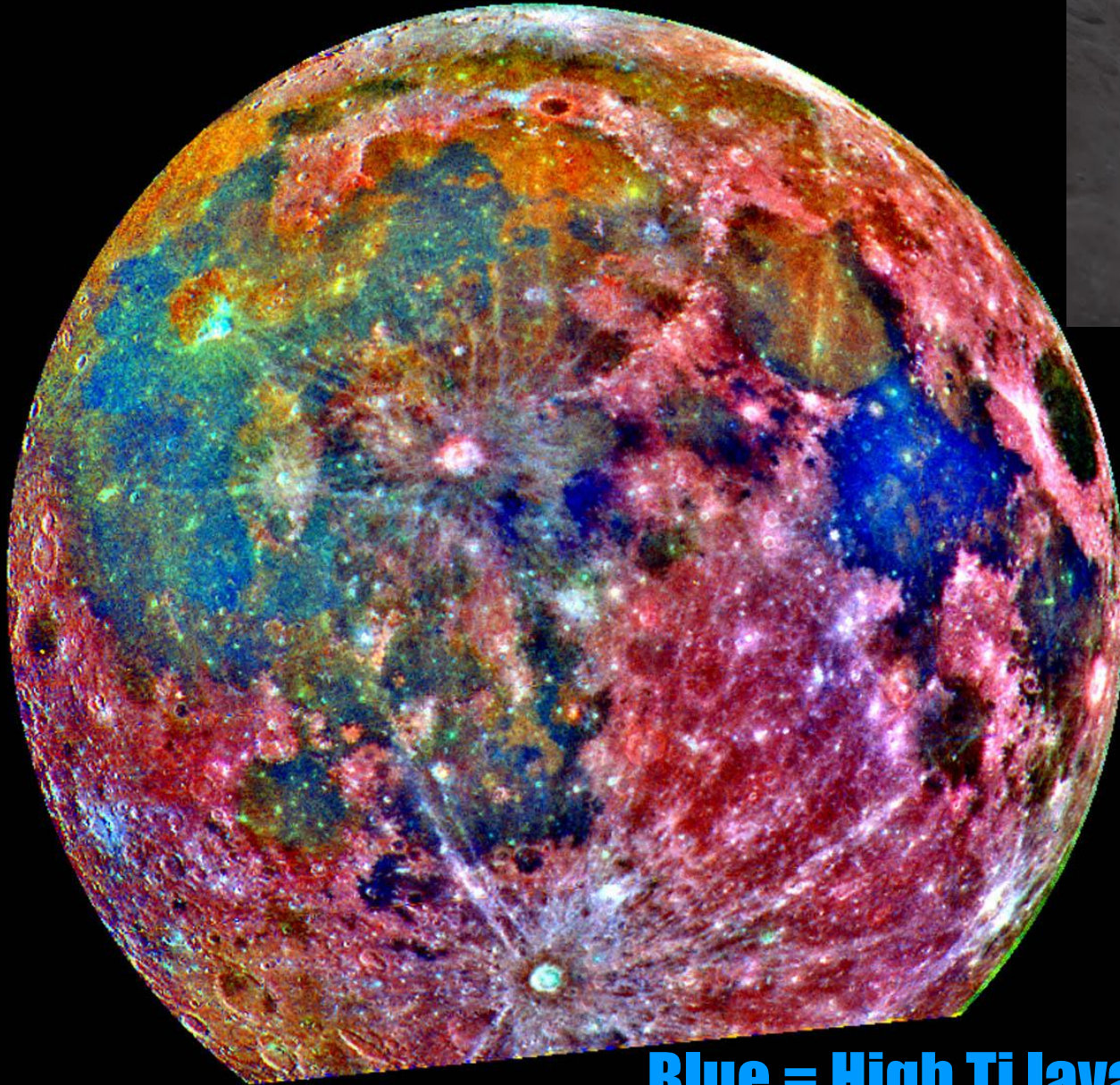
Crater Copernicus ~800-900 Ma



Crater Copernicus

~800-900 Ma





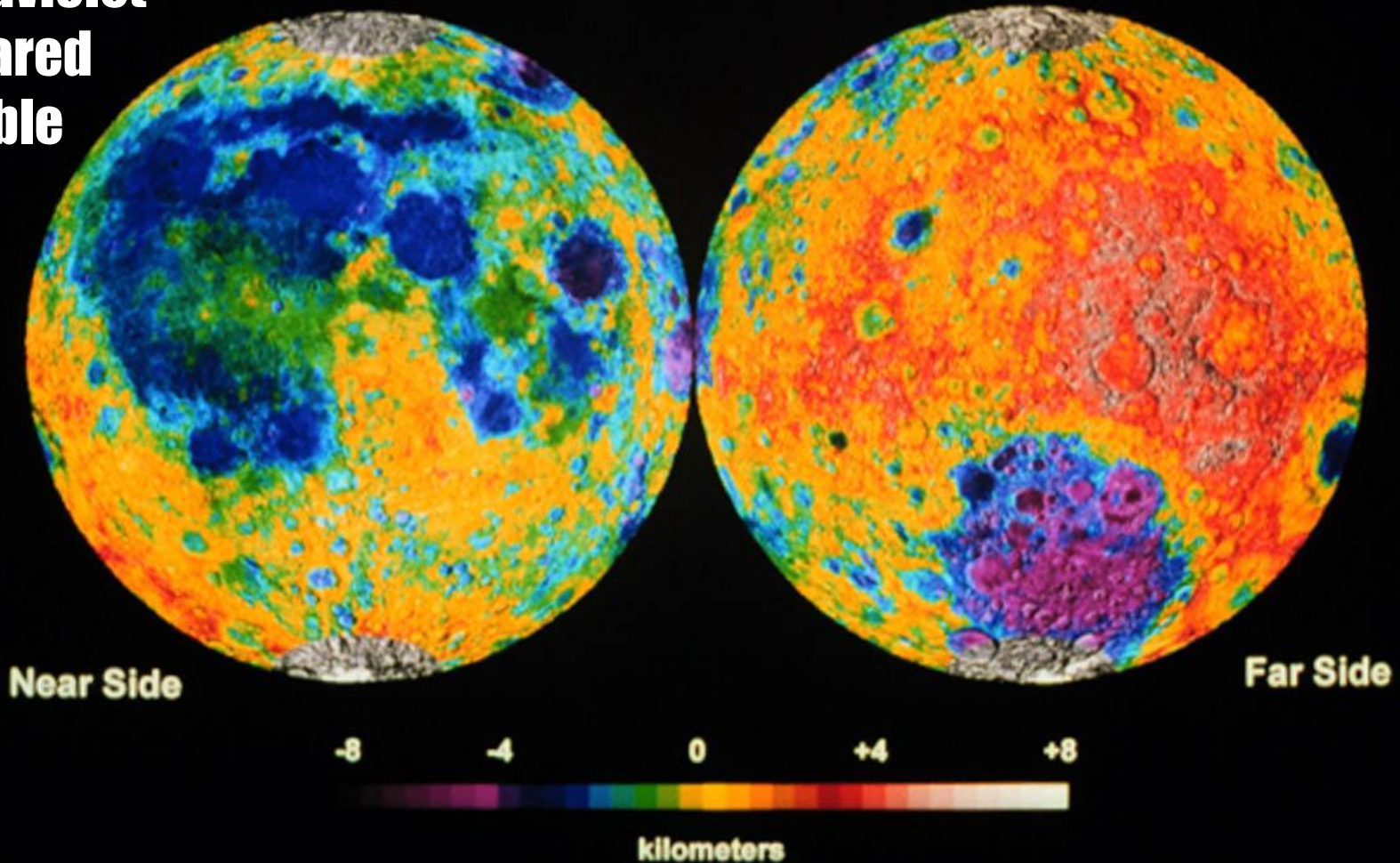
**Galileo fly-bys
in 1990 and 1992
while gaining
speed in earth
orbit to reach
Jupiter by gravity
assist**

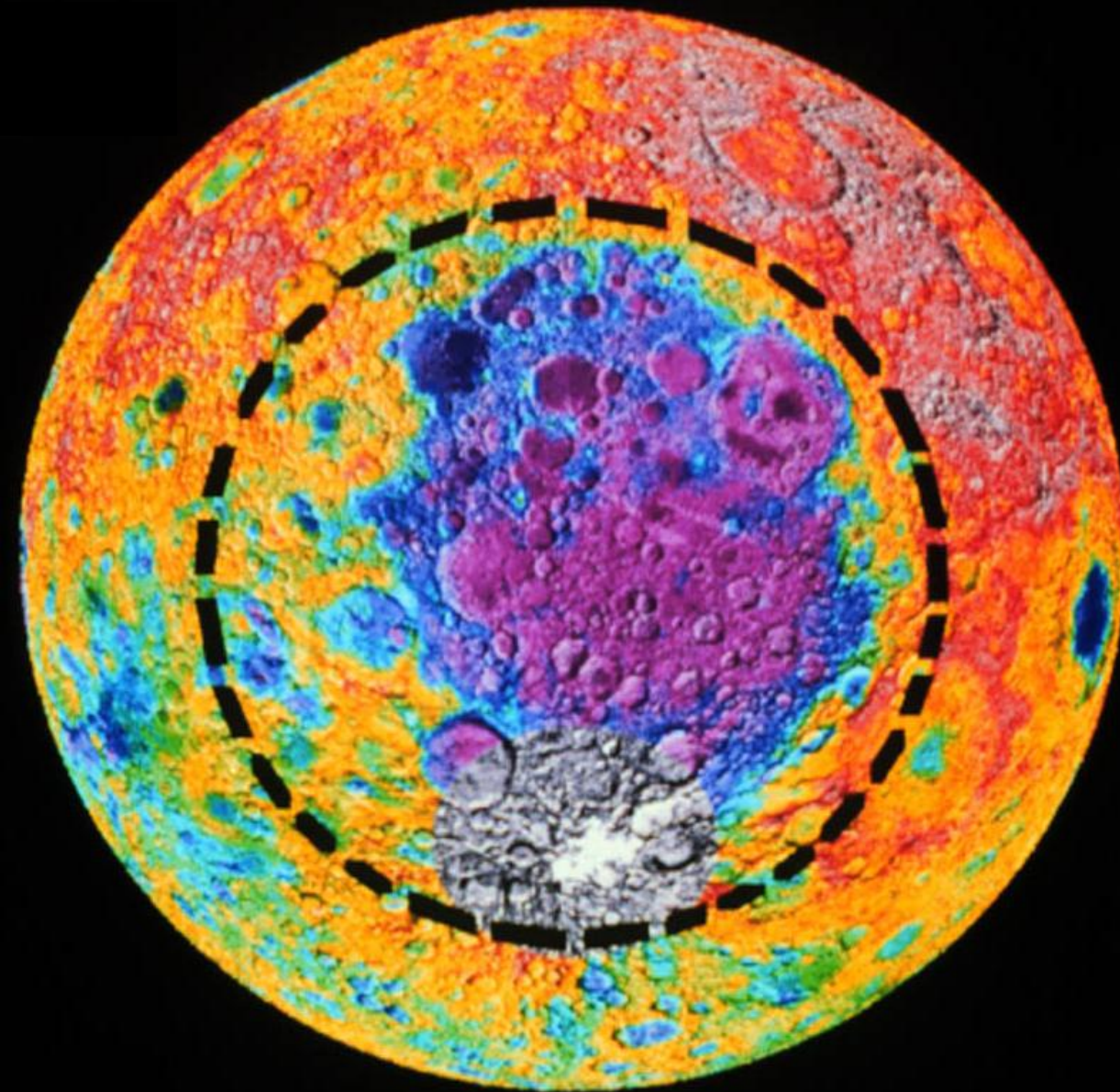
Blue = High Ti lavas; Red = Highlands

Clementine Lunar Recon Orbiter 1994

Clementine Topographic Map of the Moon Equal-area projection

Ultraviolet
Infrared
Visible






Aitken Basin
2600 km across
12 km deep

Biggest Impact
Feature in
Solar System

Water Ice in
Spectral Surveys
Verified by Lunar
Prospector in 1998



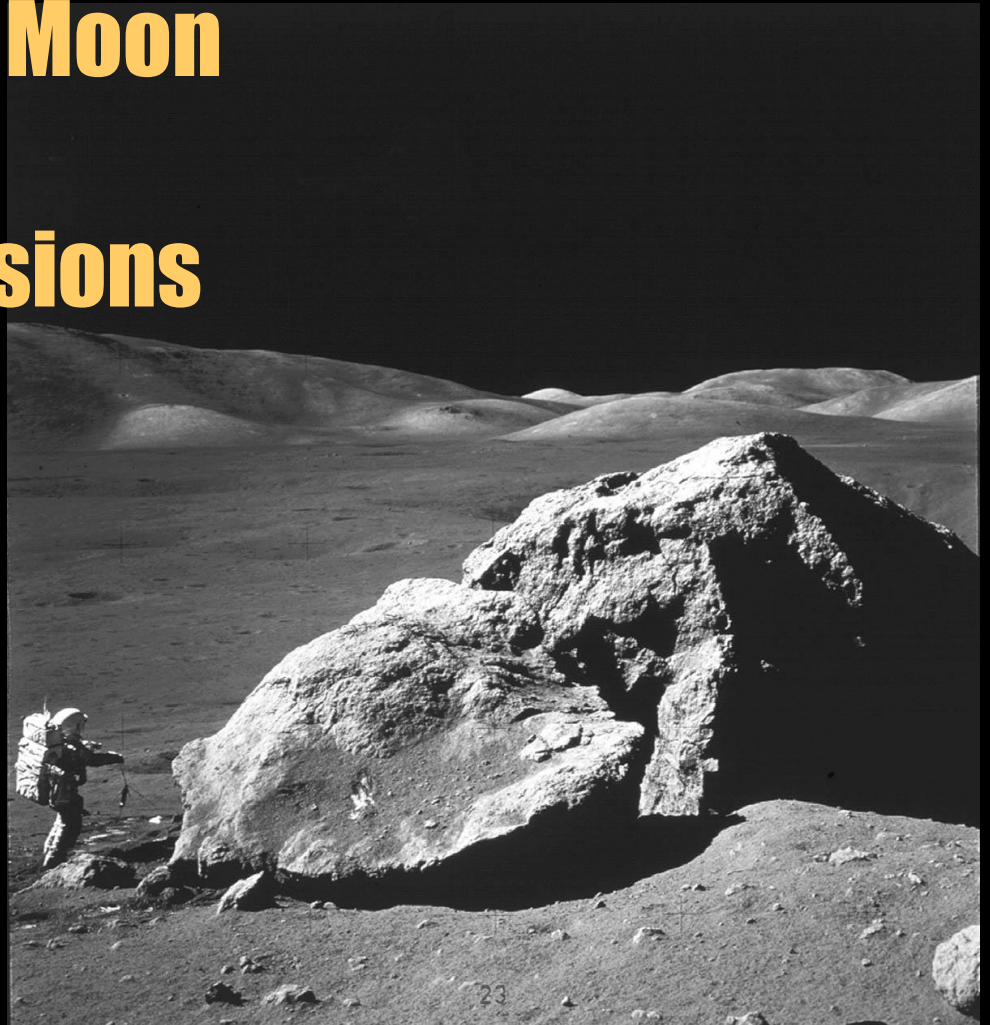
The Petrographic Microscope

**The Field Geologist's
Second Best Friend**

Plutonic Anorthositic Rocks

Oldest Rocks on the Moon

Apollo 16 and 17 Missions



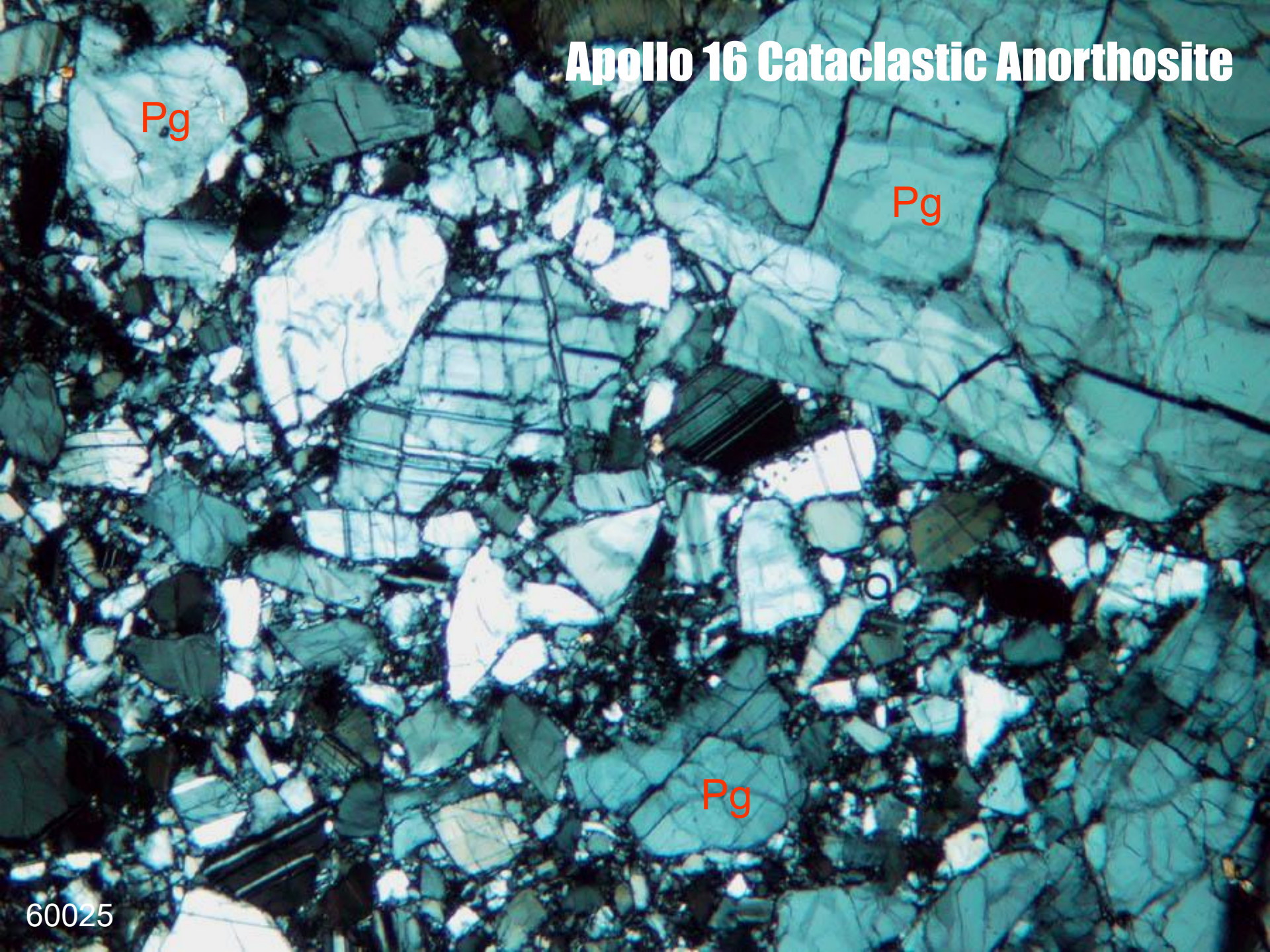
Apollo 16 Cataclastic Anorthosite

Pg

Pg

Pg

60025



Apollo 16 Cataclastic Anorthosite

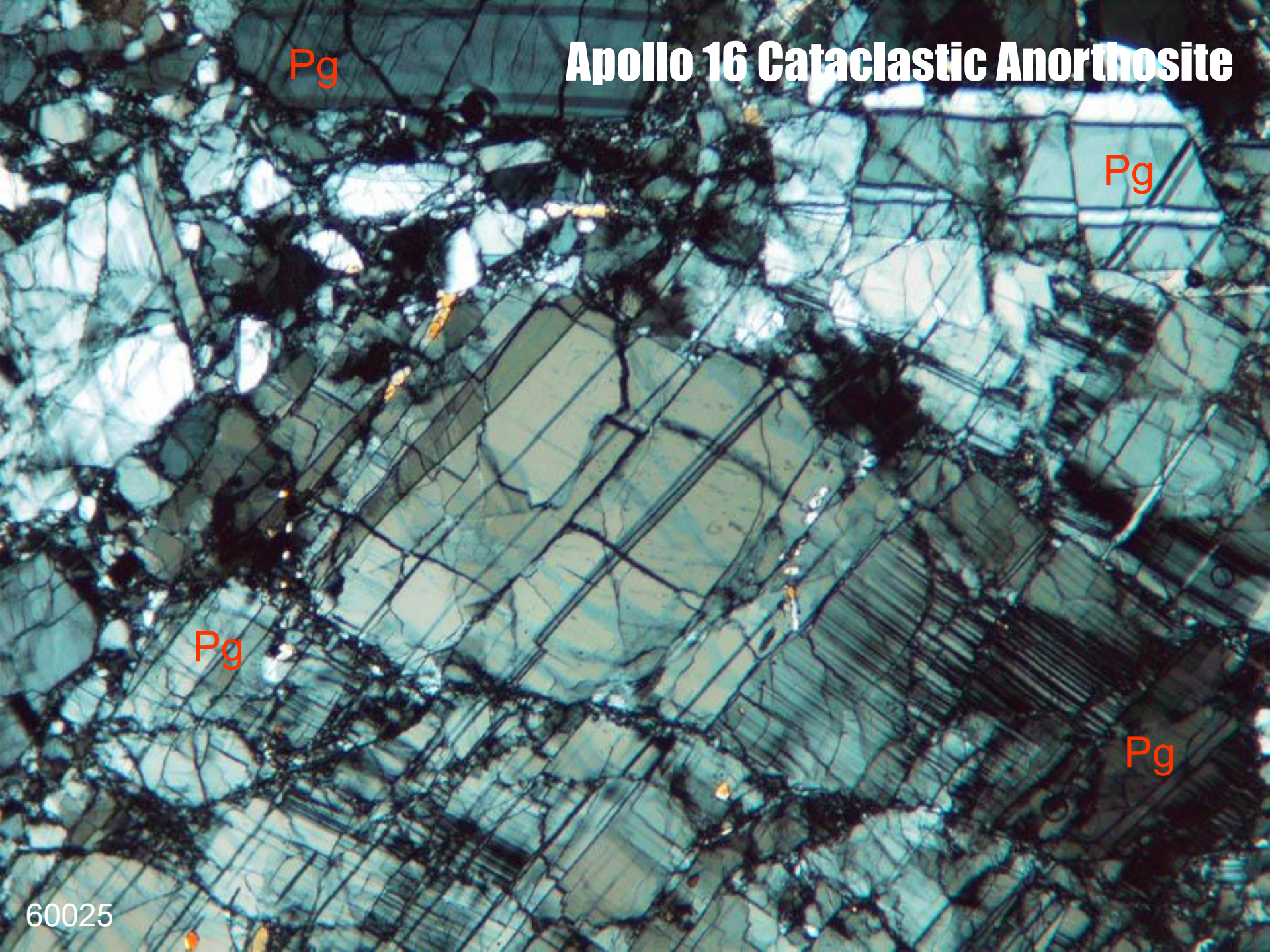
Pg

Pg

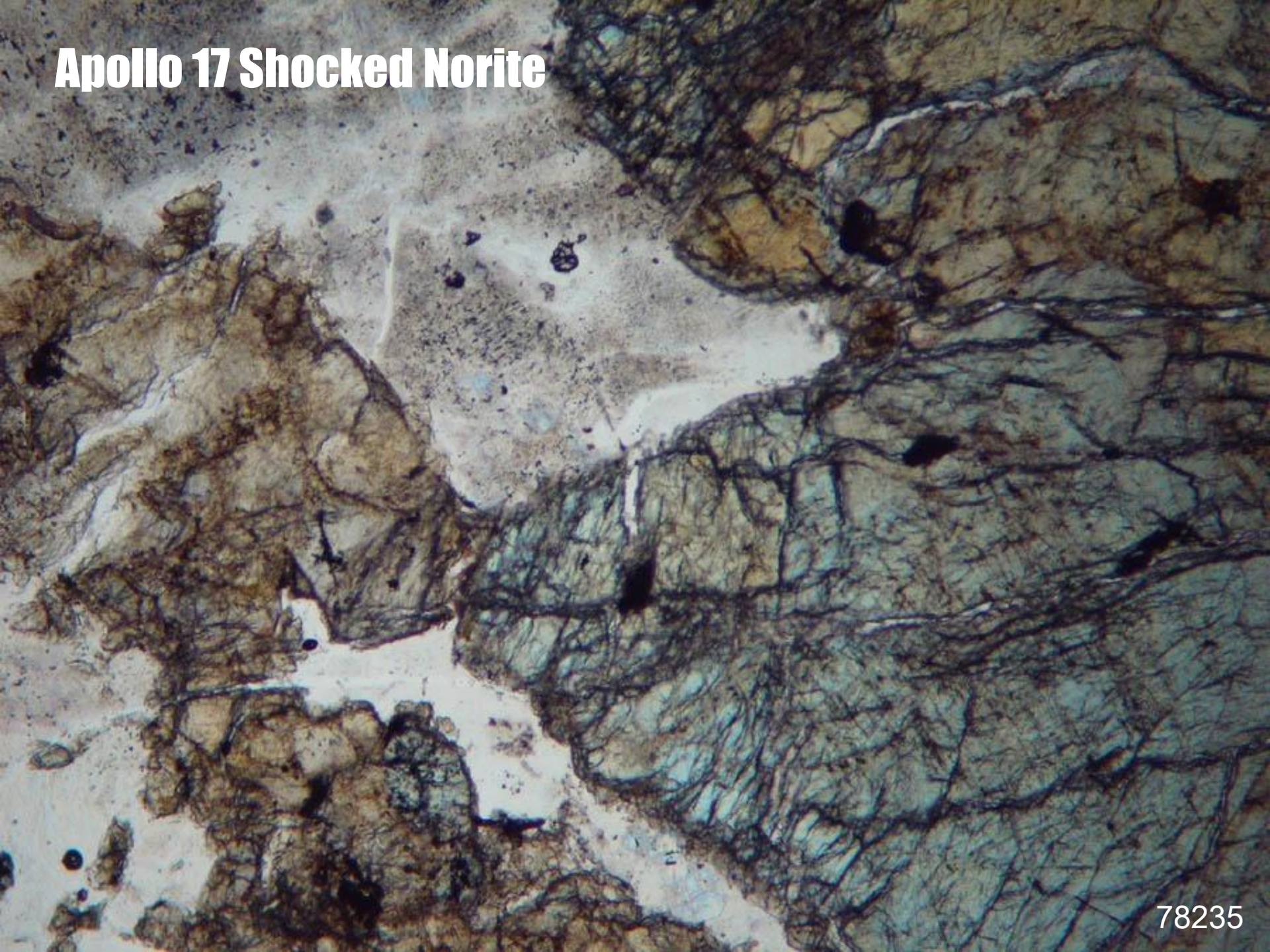
Pg

Pg

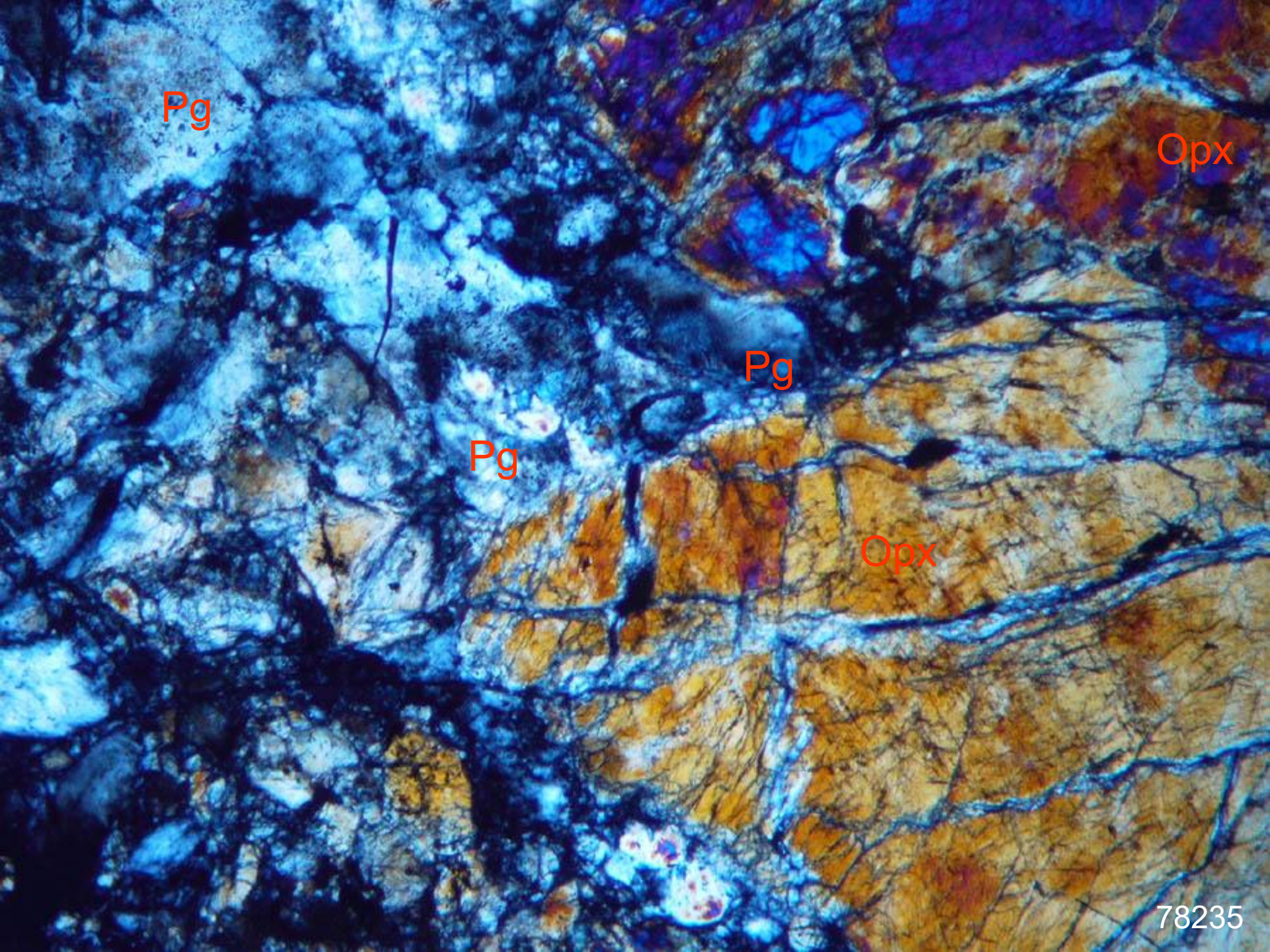
60025



Apollo 17 Shocked Norite



78235



Pg

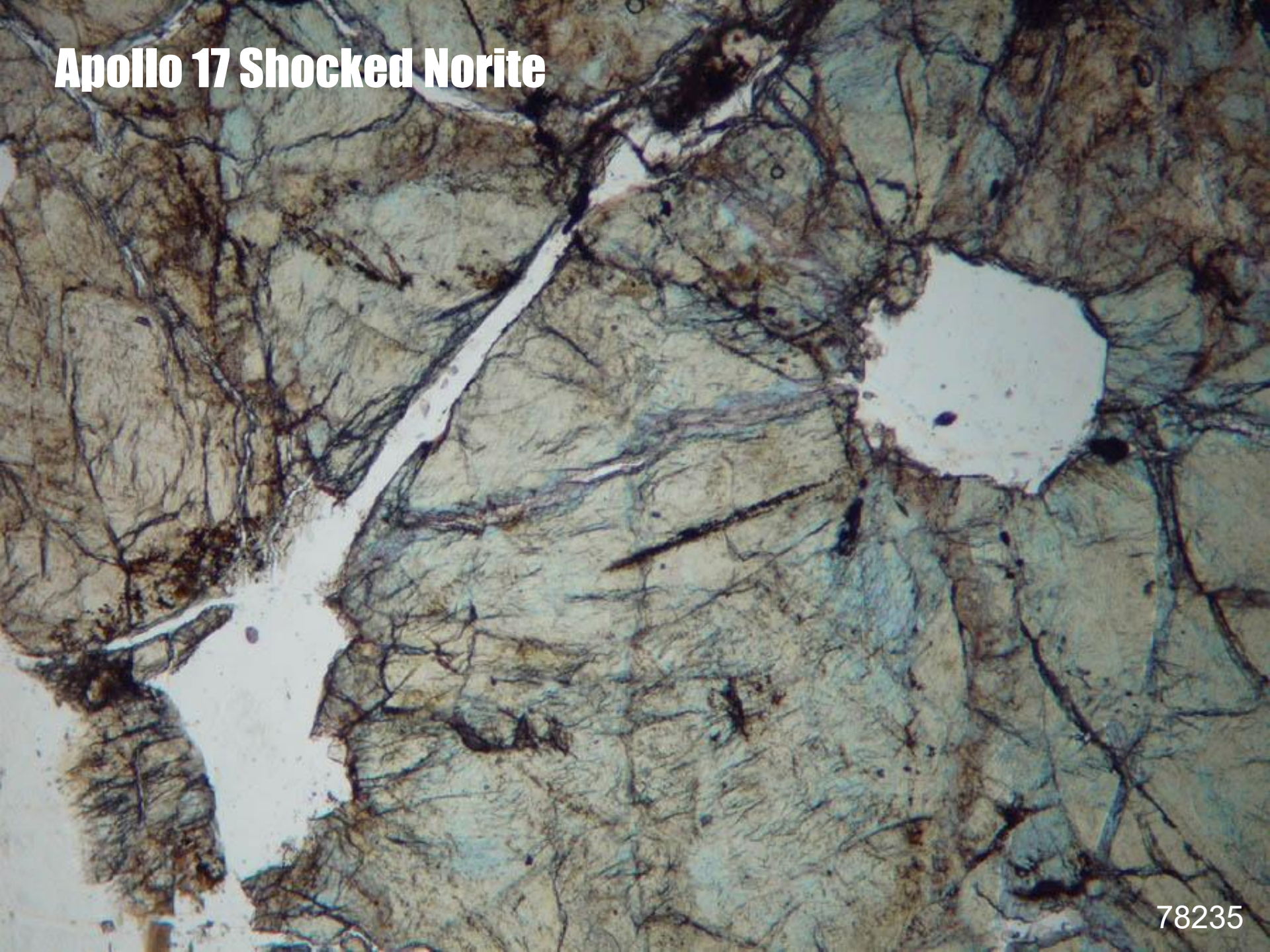
Opx

Pg

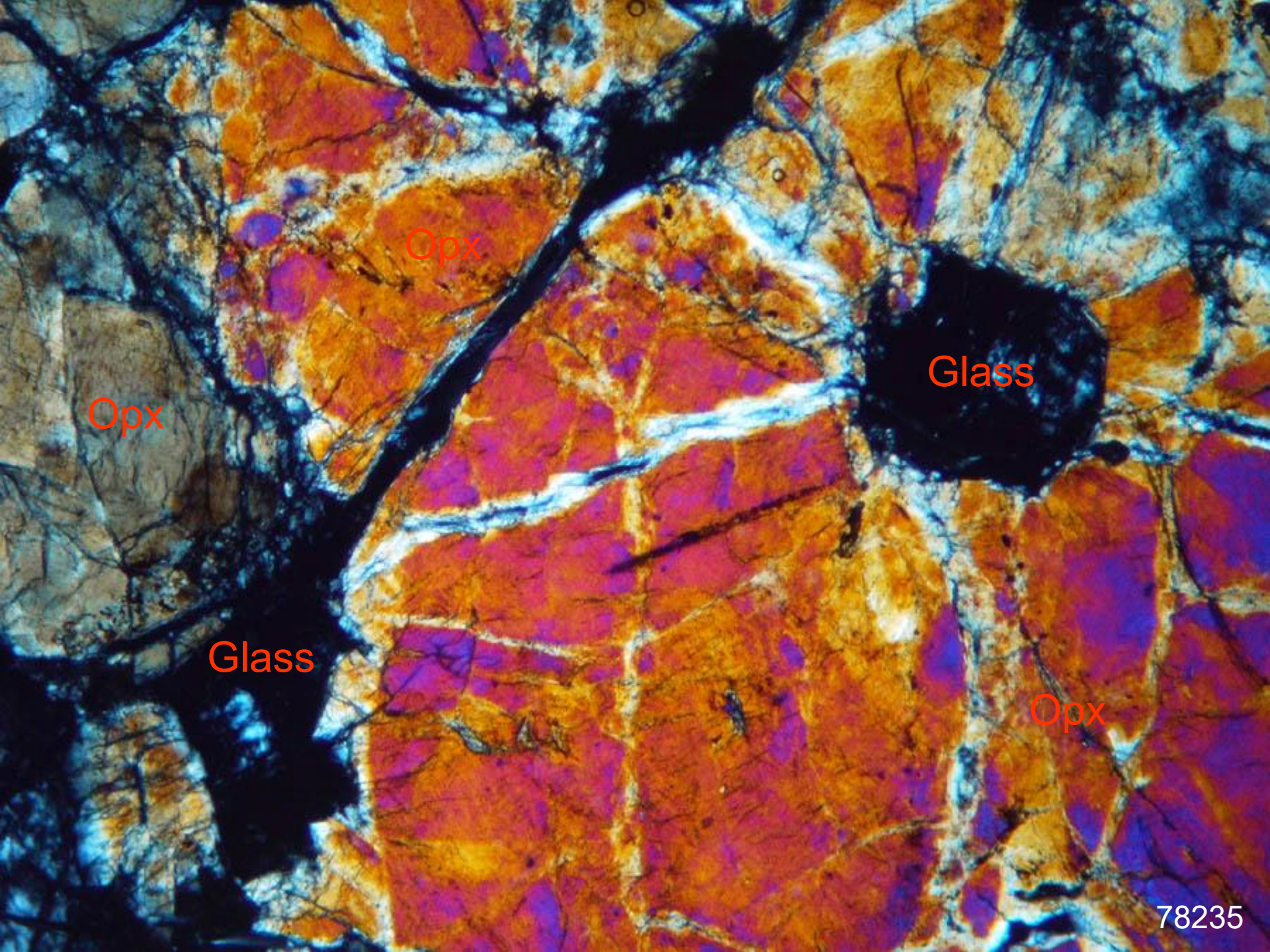
Pg

Opx

Apollo 17 Shocked Norite



78235



Opx

Opx

Glass

Glass

Opx

78235

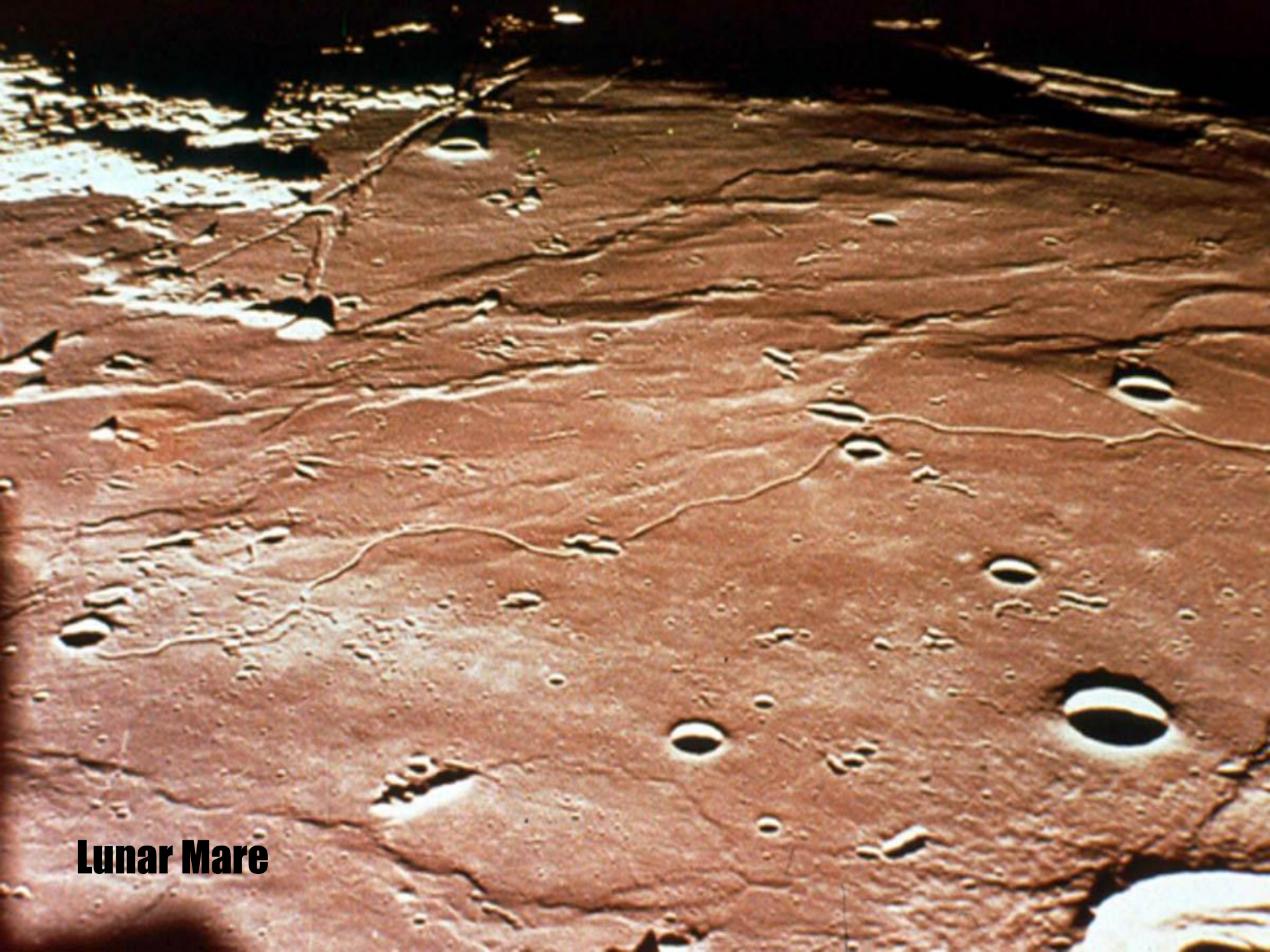
Mare Basalts

Porphyritic Basalt - Apollo 12

Olivine Basalt - Apollo 12

High-Ti Basalt – Apollo 17

Volcanic Glass – Apollo 17

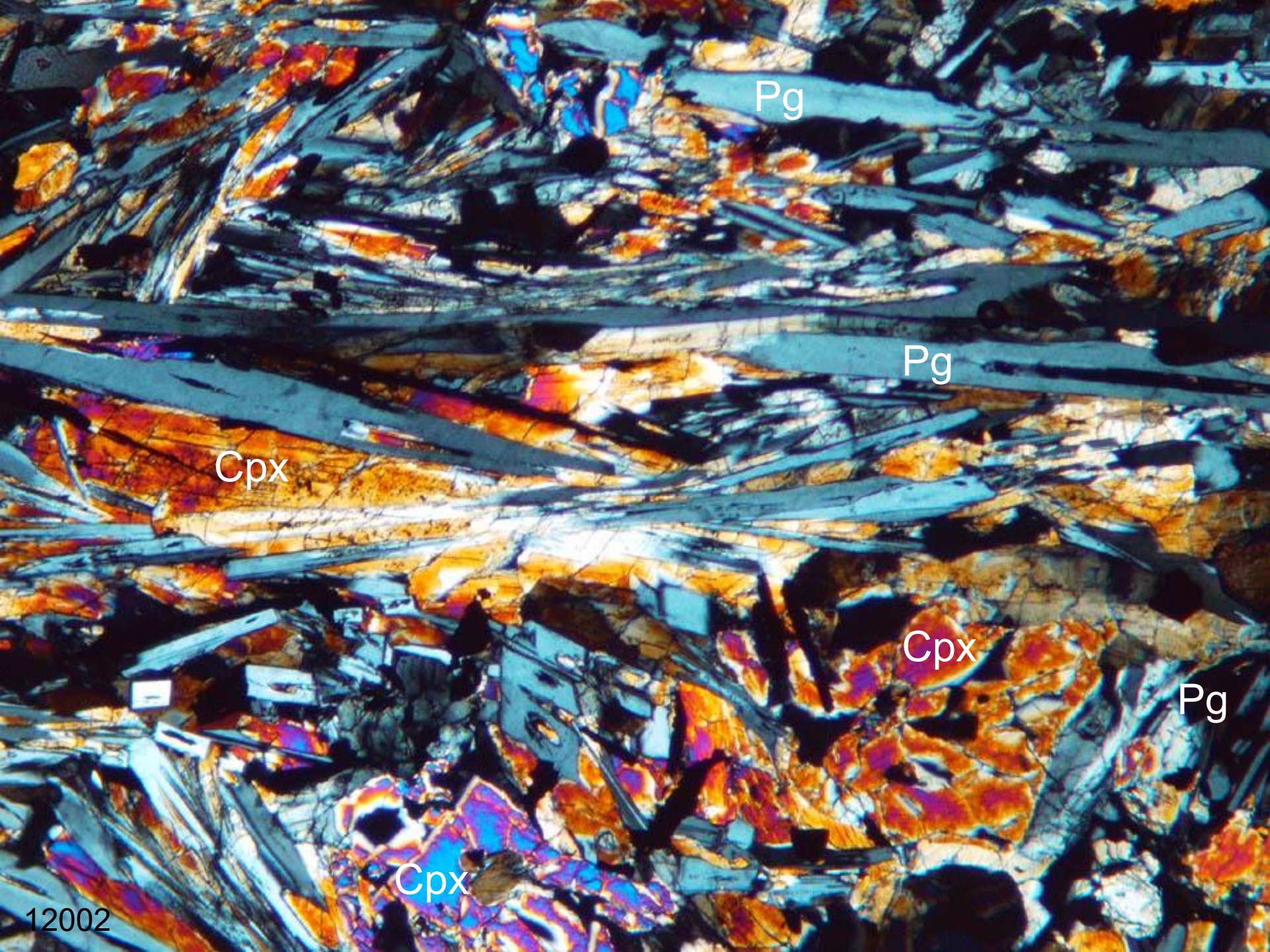


Lunar Mare

Apollo 12 Porphyritic Basalt



12002



Pg

Pg

Cpx

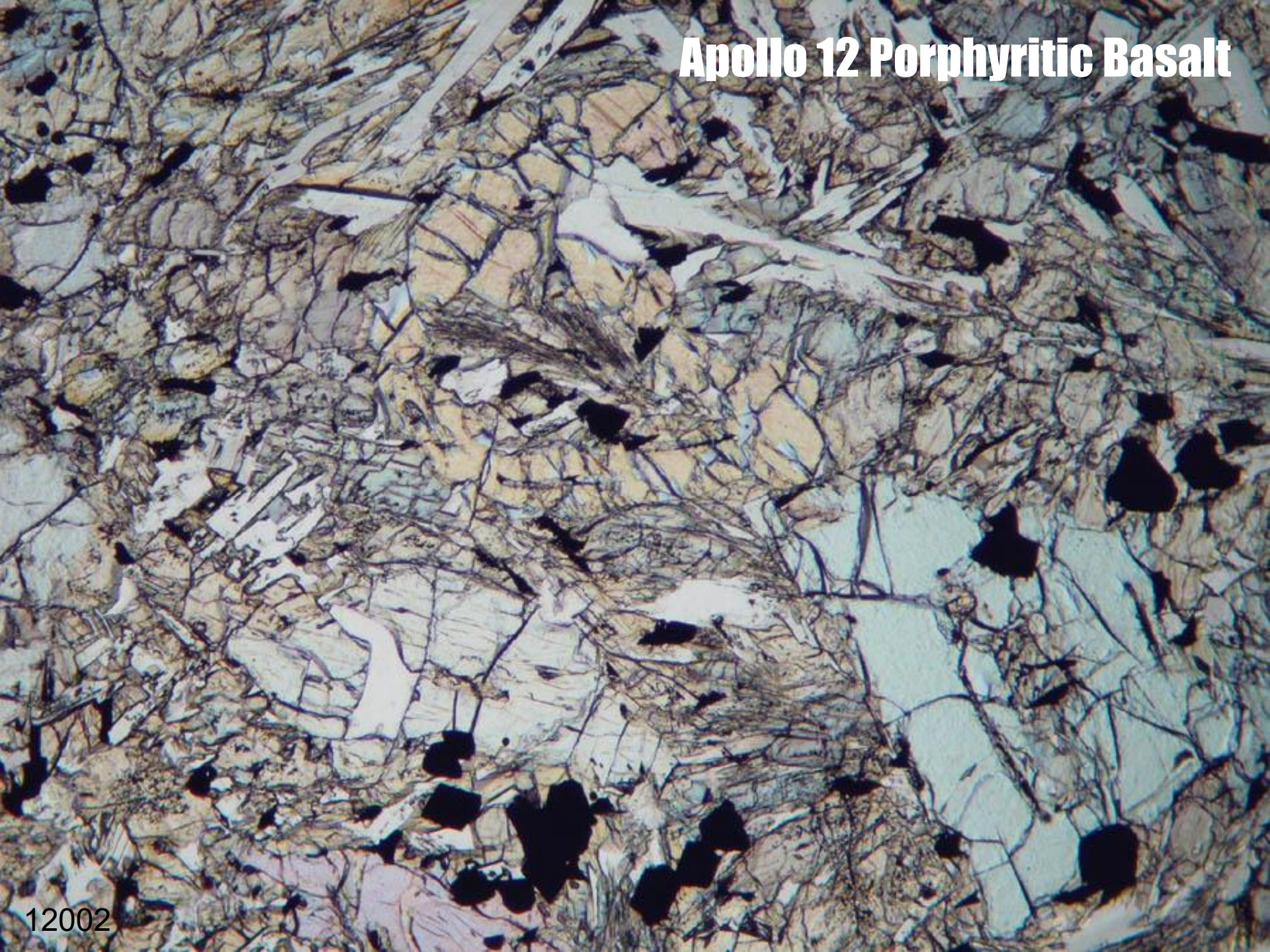
Cpx

Pg

Cpx

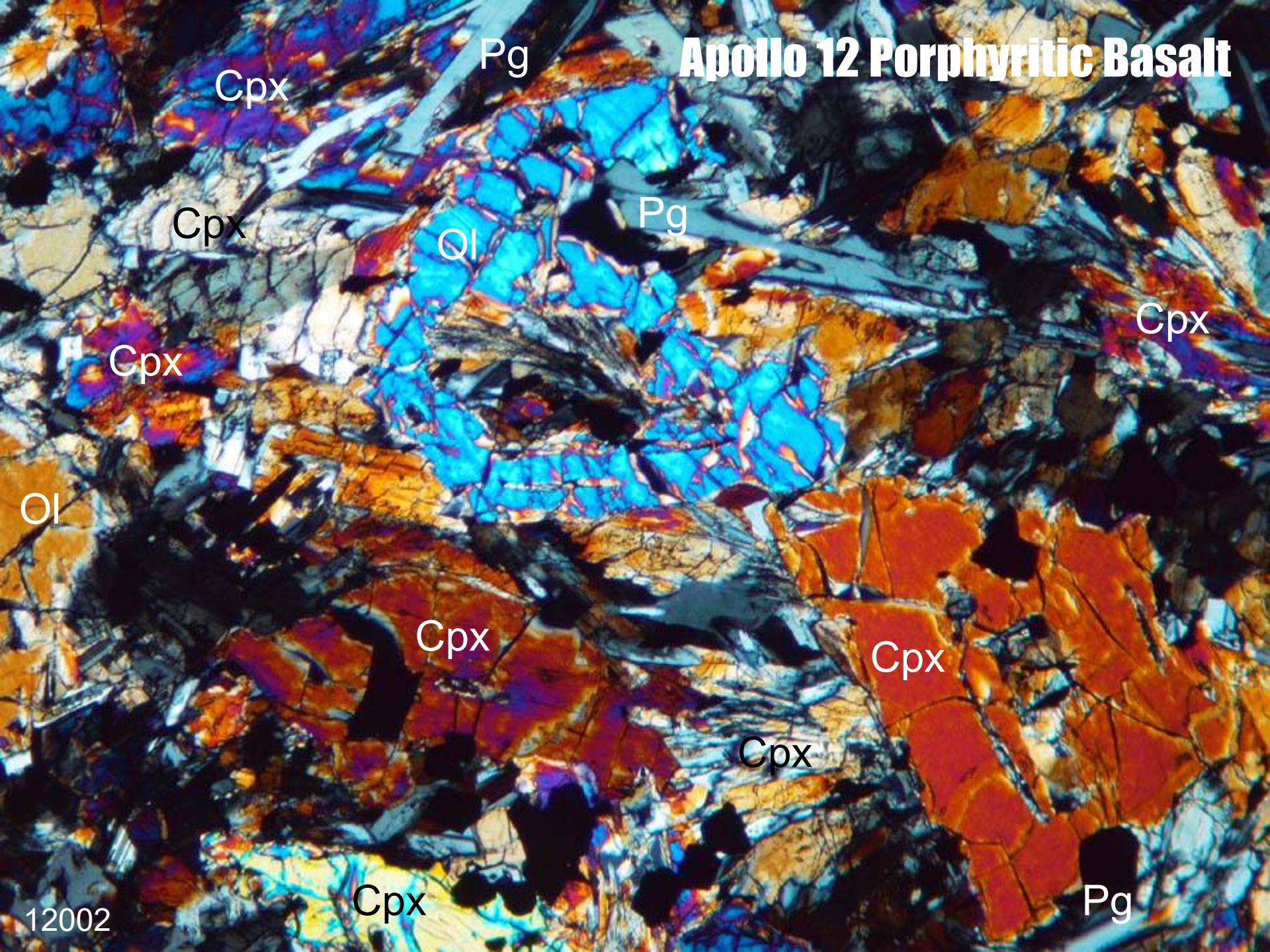
12002

Apollo 12 Porphyritic Basalt



12002

Apollo 12 Porphyritic Basalt



Cpx

Pg

Cpx

OI

Pg

Cpx

Cpx

OI

Cpx

Cpx

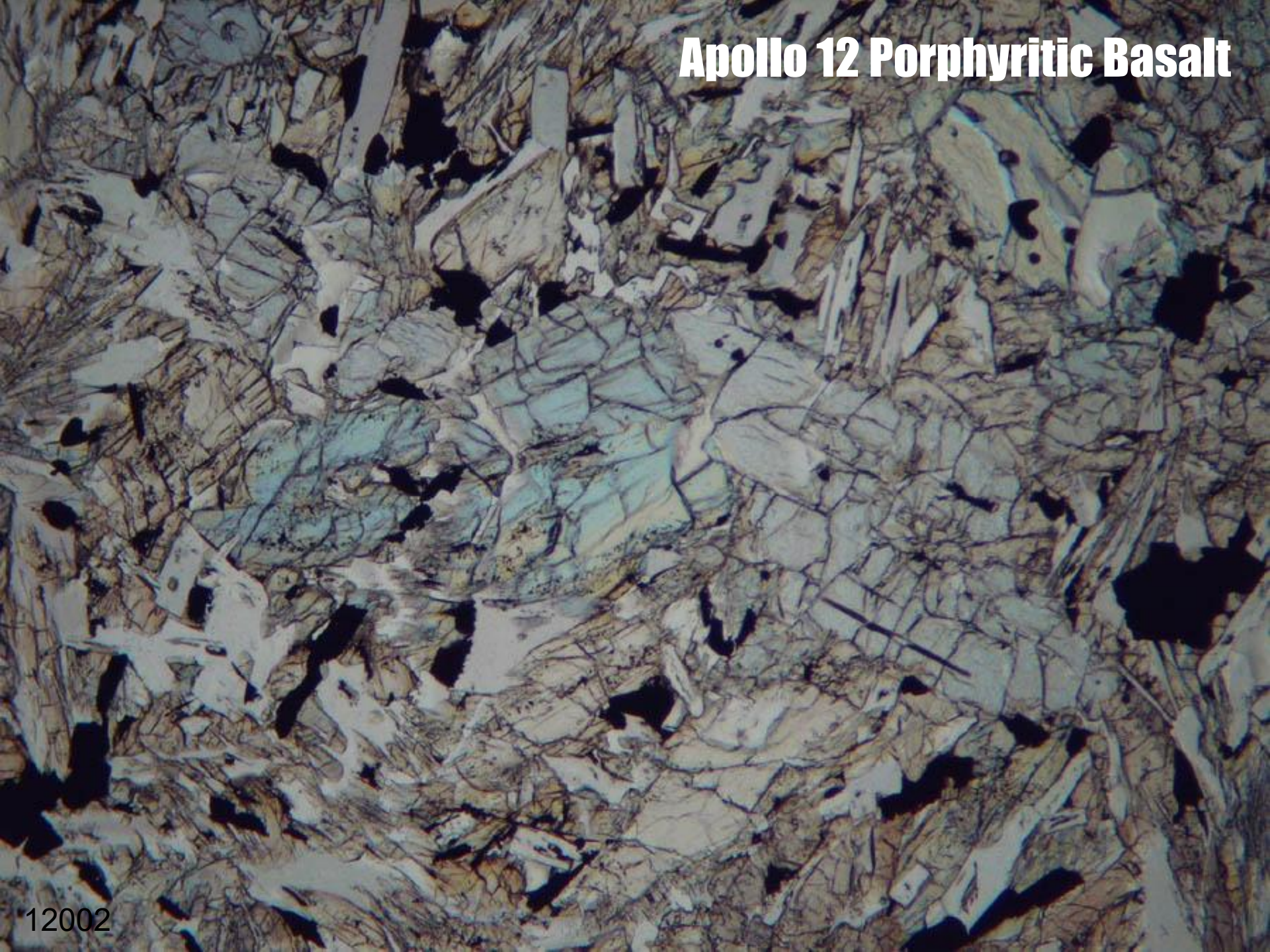
Cpx

12002

Cpx

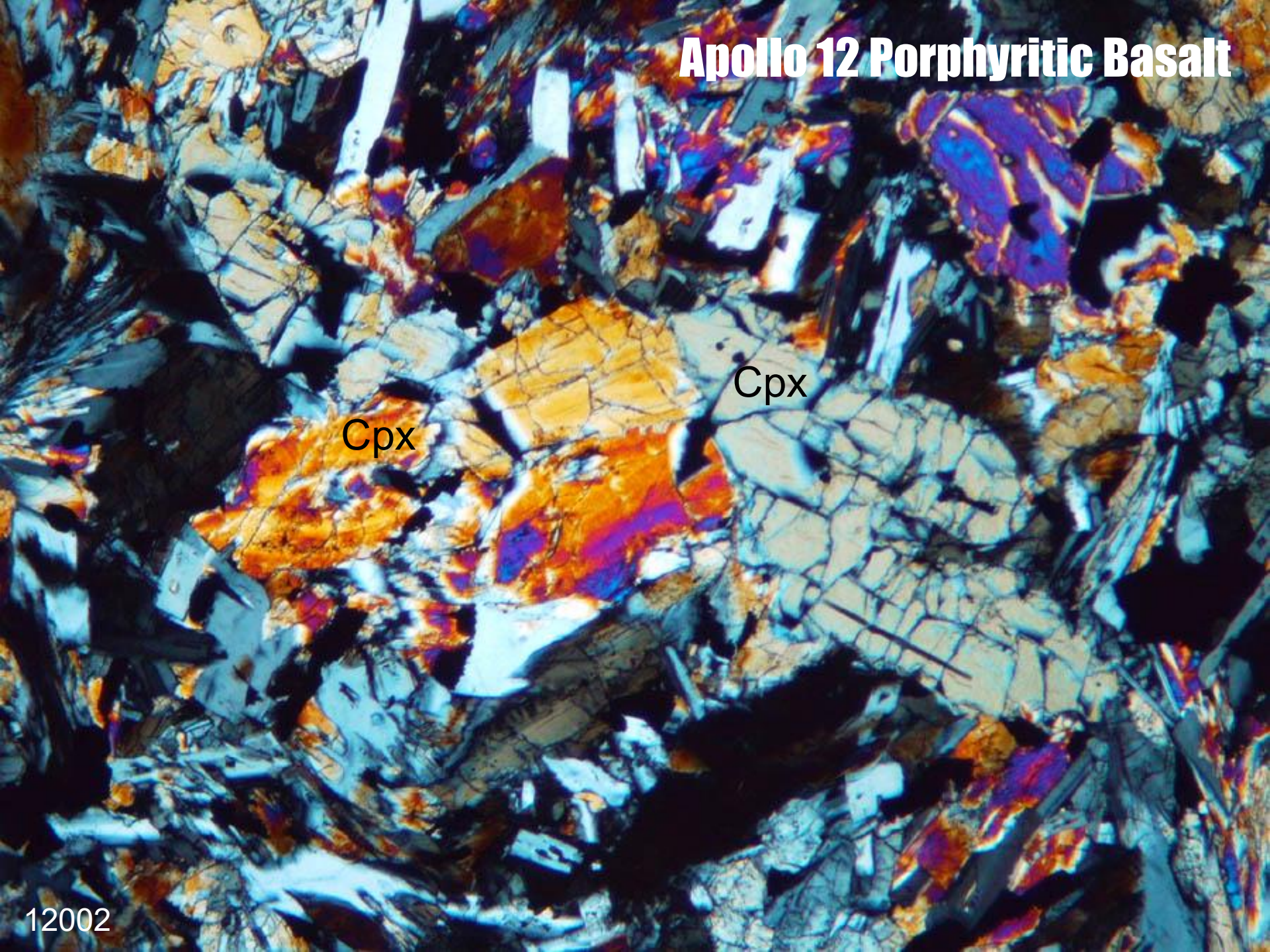
Pg

Apollo 12 Porphyritic Basalt



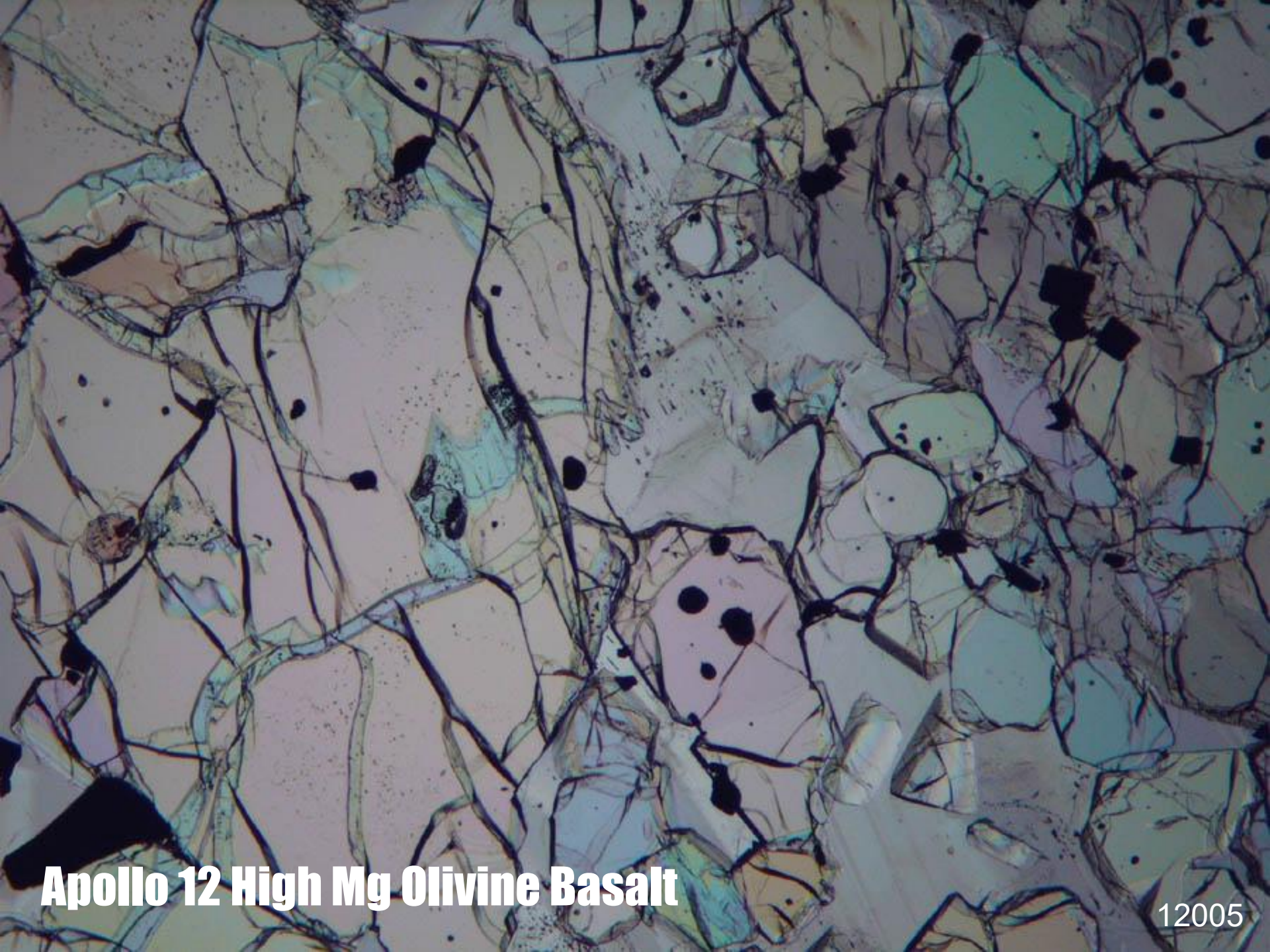
12002

Apollo 12 Porphyritic Basalt

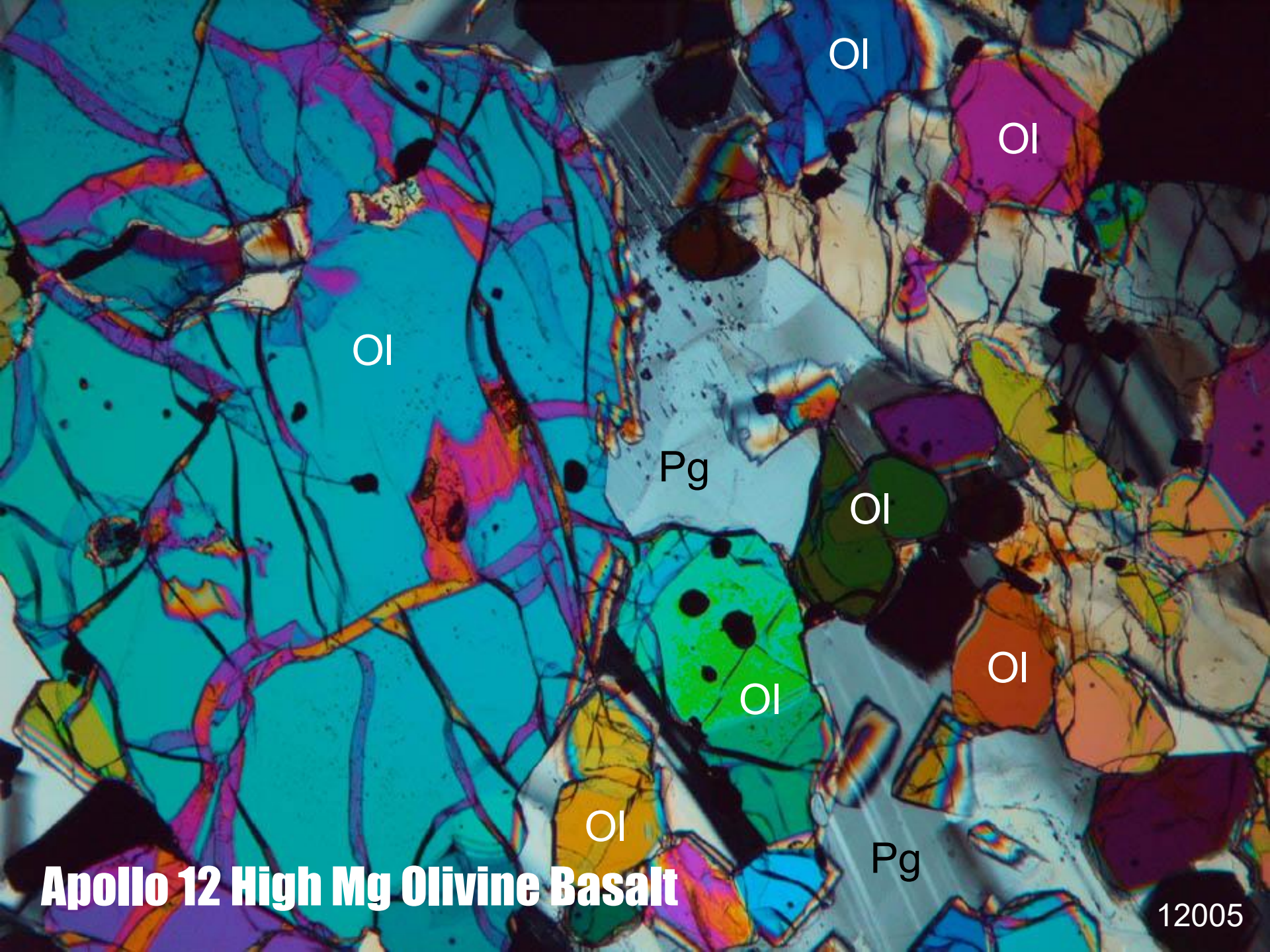


Cpx

Cpx

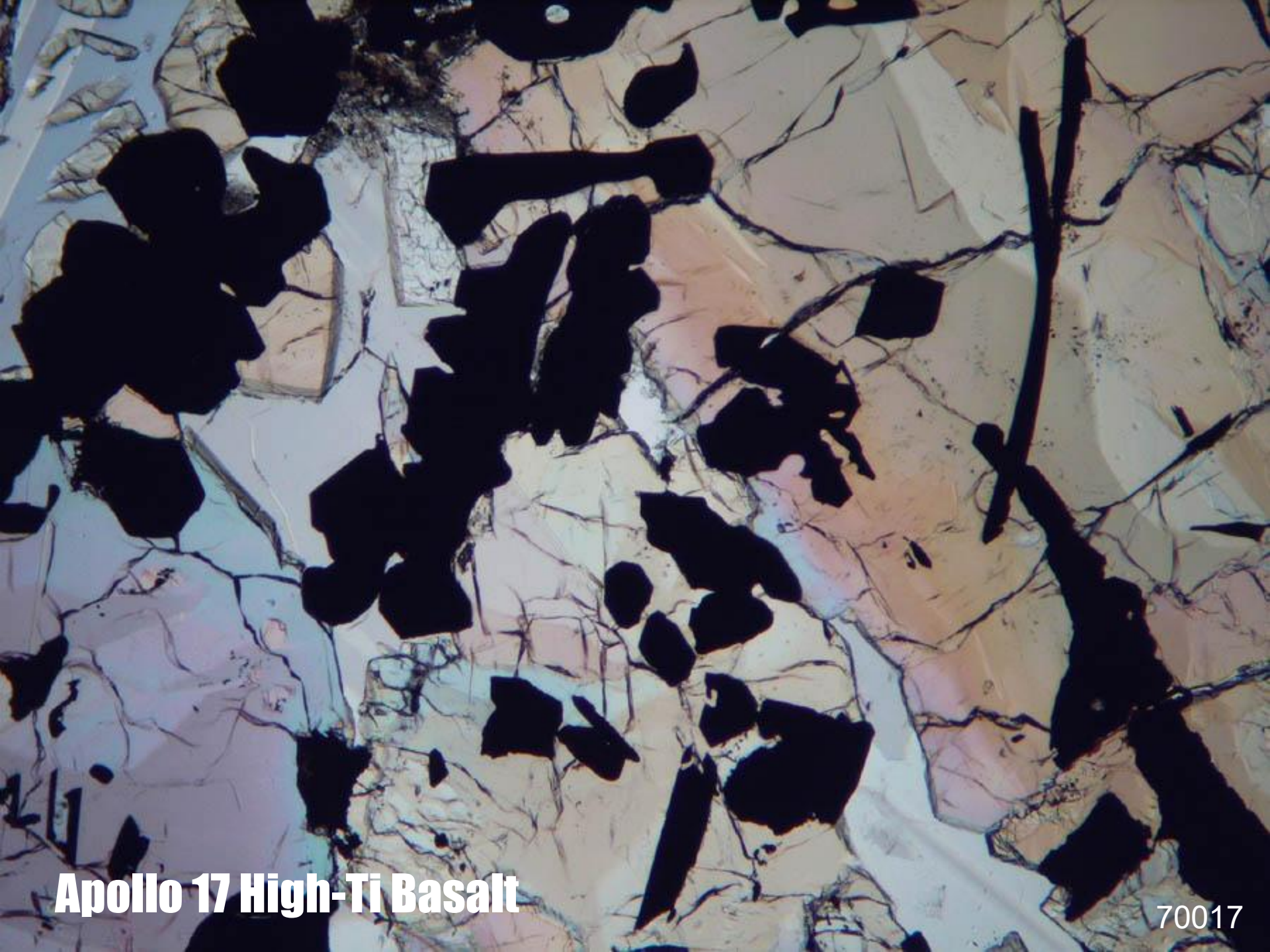


Apollo 12 High Mg Olivine Basalt



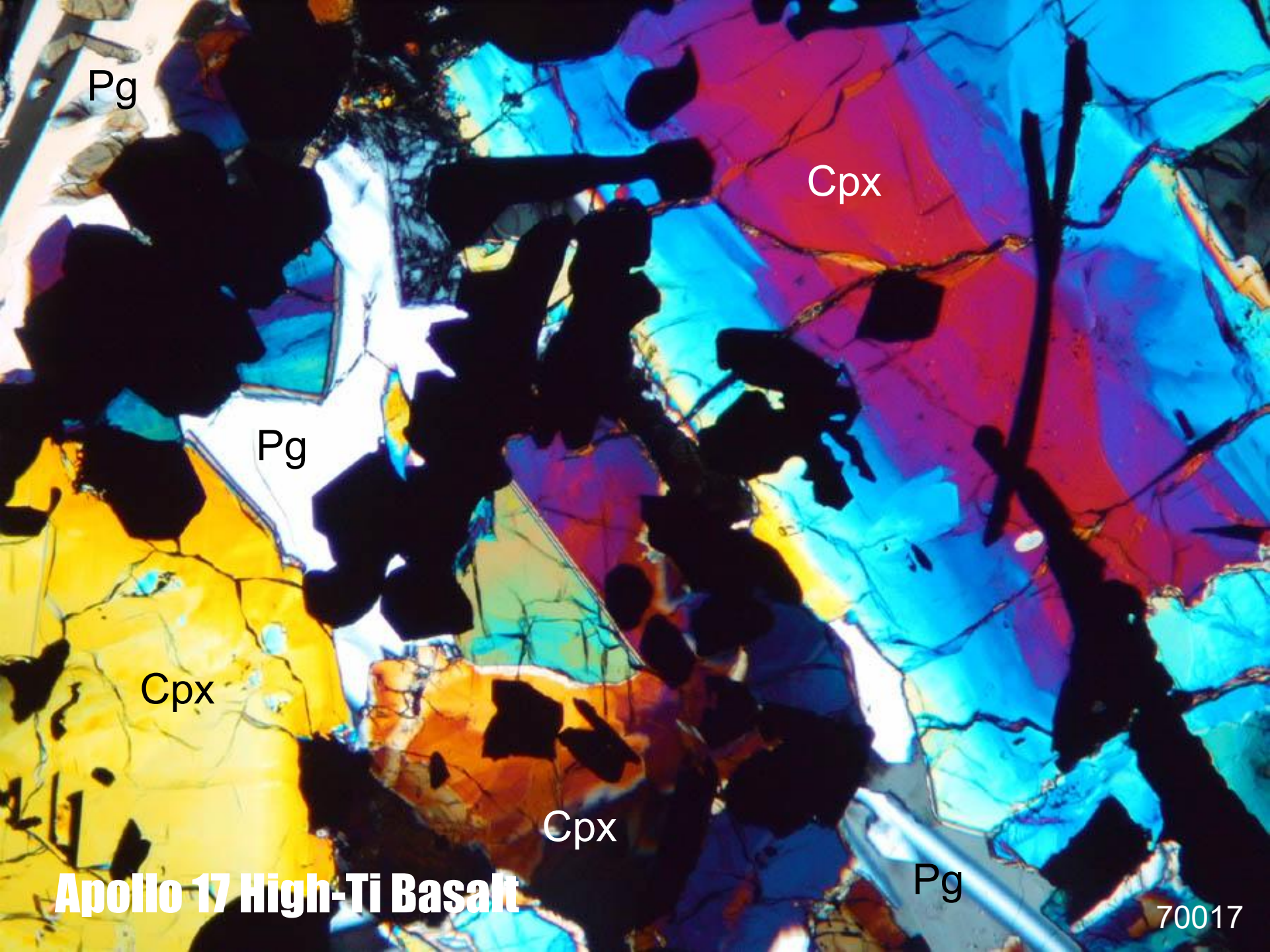
Apollo 12 High Mg Olivine Basalt

12005



Apollo 17 High-Ti Basalt

70017



Pg

Cpx

Pg

Cpx

Cpx

Pg

Apollo 17 High-Ti Basalt

70017

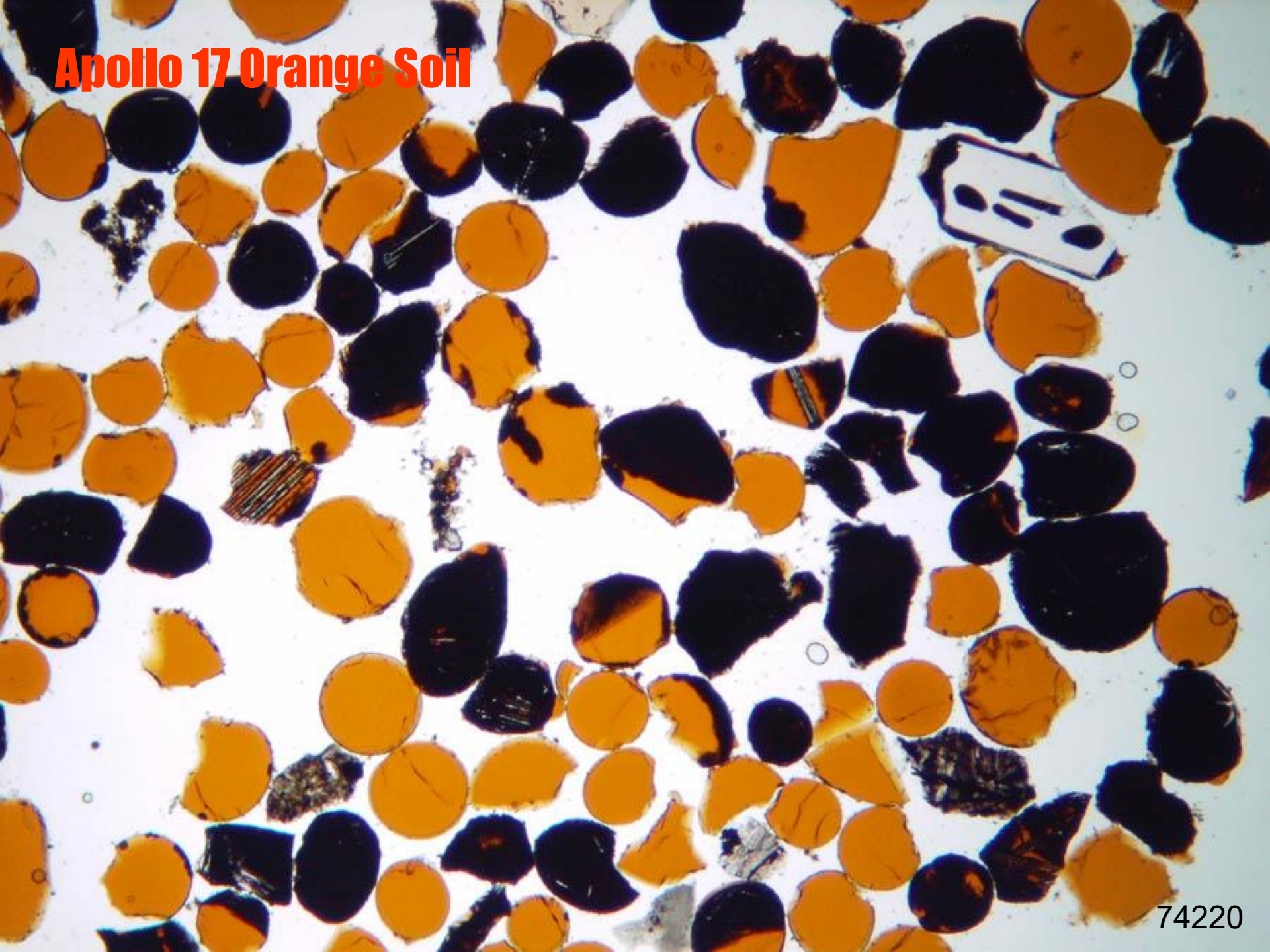
Lunar Breccias and Soils

Fra Mauro Formation – Apollo 14

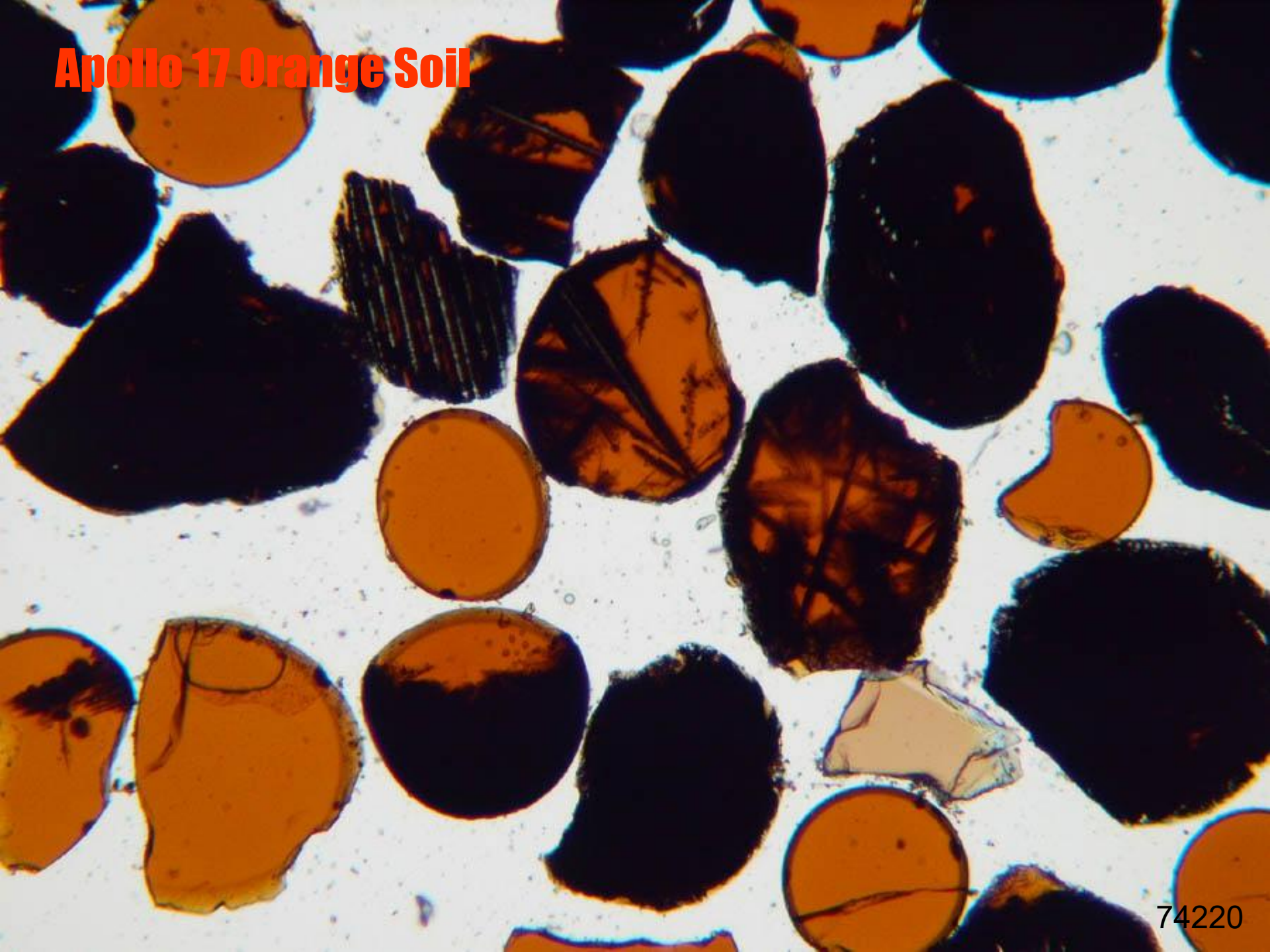
Lunar Highlands – Apollo 16

South Massif – Apollo 17

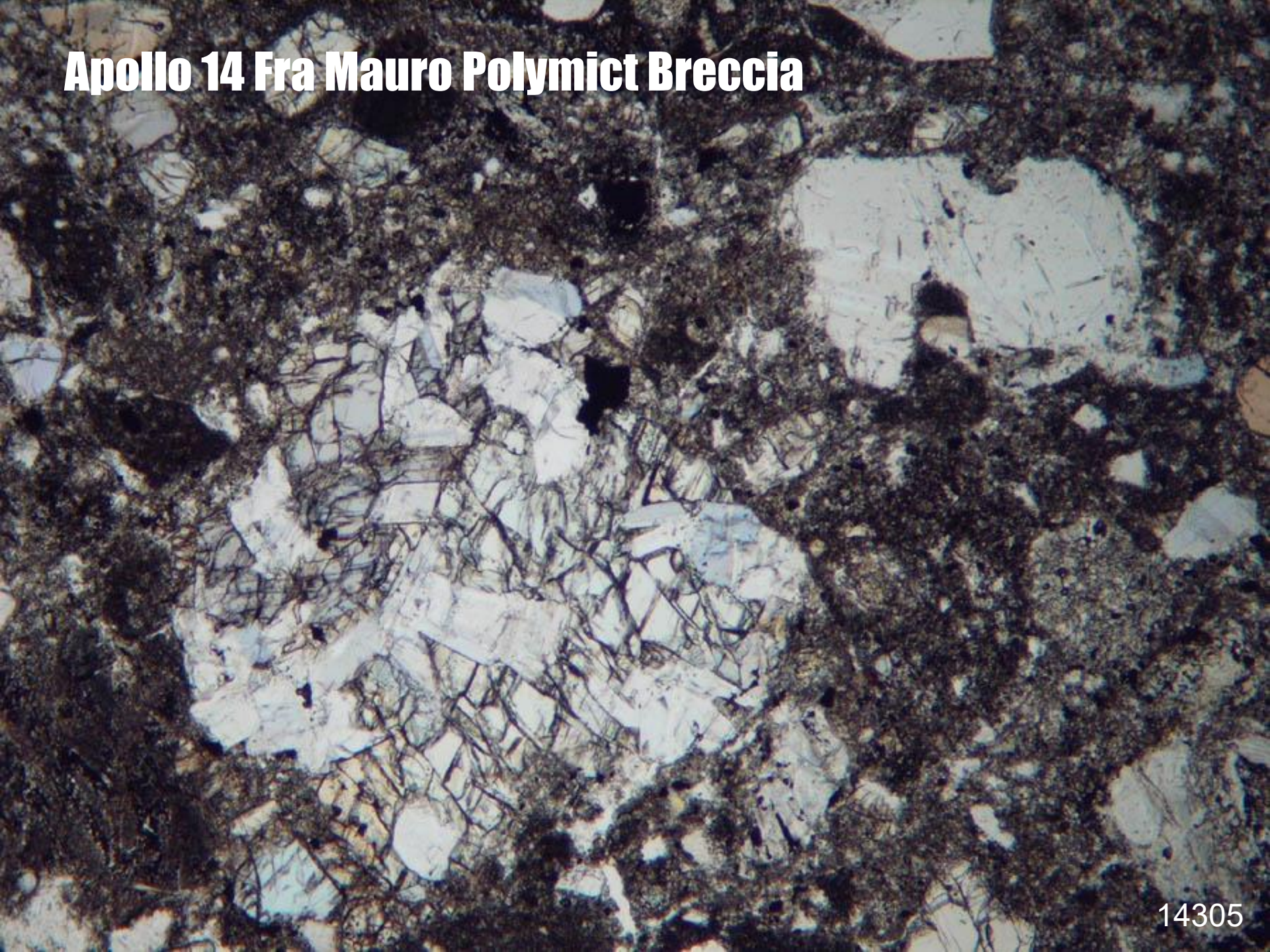
Apollo 17 Orange Soil



Apollo 17 Orange Soil



Apollo 14 Fra Mauro Polymict Breccia



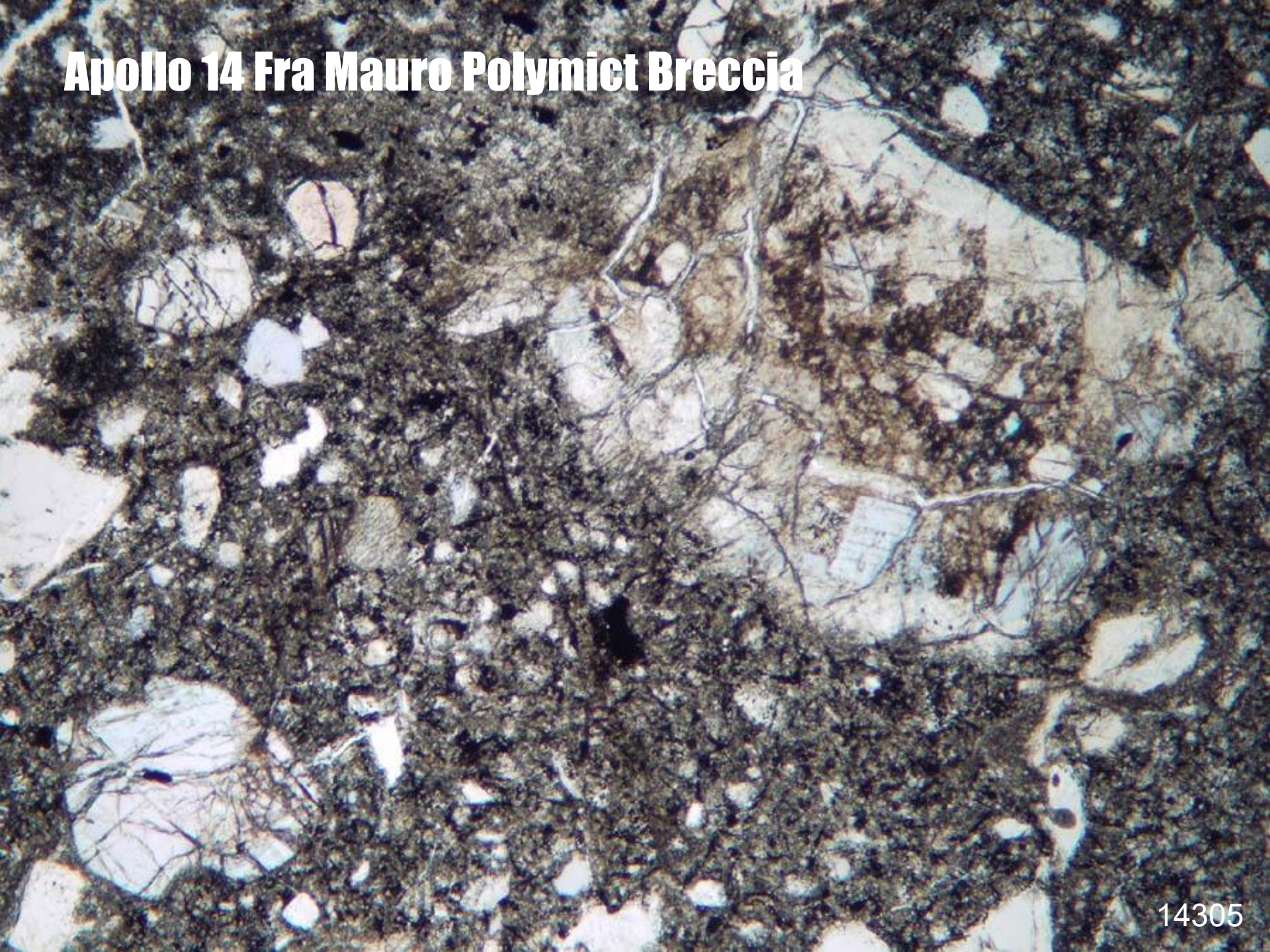
14305



Basalt Clast

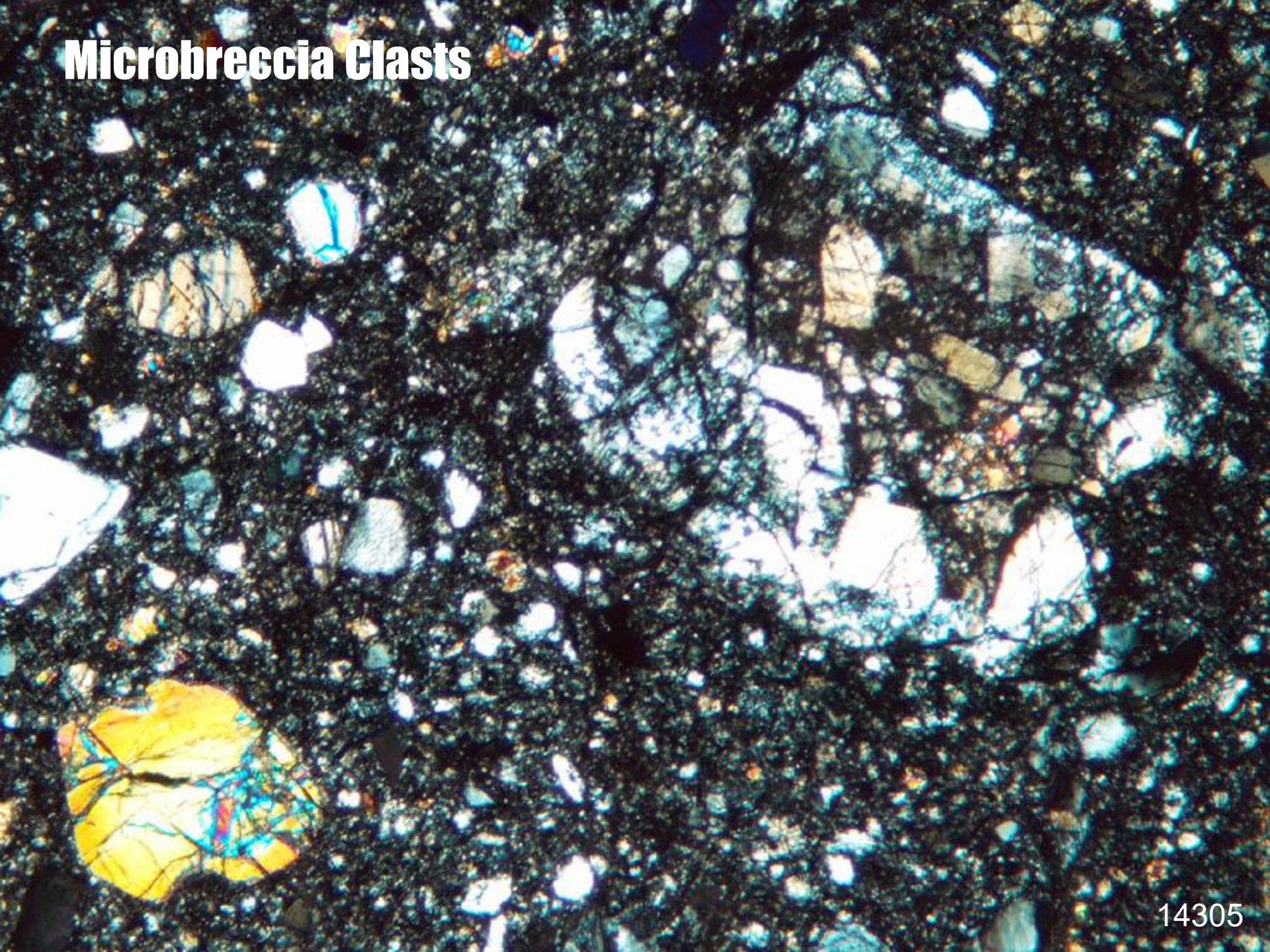
Pg

Apollo 14 Fra Mauro Polymict Breccia



14305

Microbreccia Clasts



**Thanks For
Attending!!**



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For Free Downloads**

