Geology of the Moon

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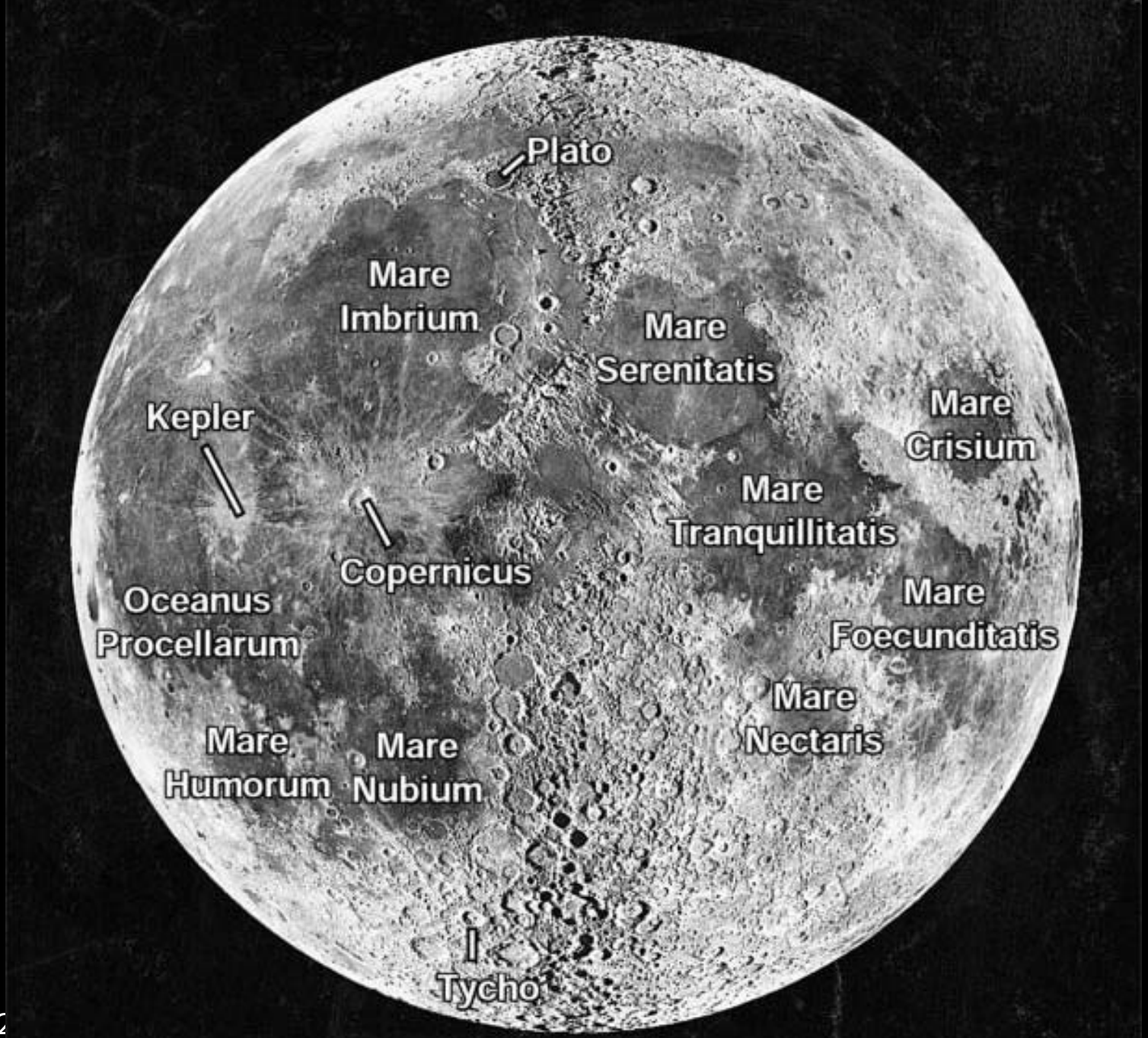
Lunar Geology

- The near side of the Moon is dominated by two types of terrain.
  - The maria (singular mare) are smooth, dark lava flows that cover 17% of the Moon.
  - The brighter highlands (terrae) which are completely covered in craters.


Plato
Mare
Imbrium
Mare
Serenitatis
Kepler
Mare
Crisium
Mare
Tranquillitatis
Copernicus
Oceanus
Procellarum
Mare
Foecunditatis
Mare
Nectaris
Mare
Humorum
Mare
Nubium
Tycho

Grand Teton National Park, Wyoming

Blue Ridge Mountains, North Carolina

Age of the Lunar Surface

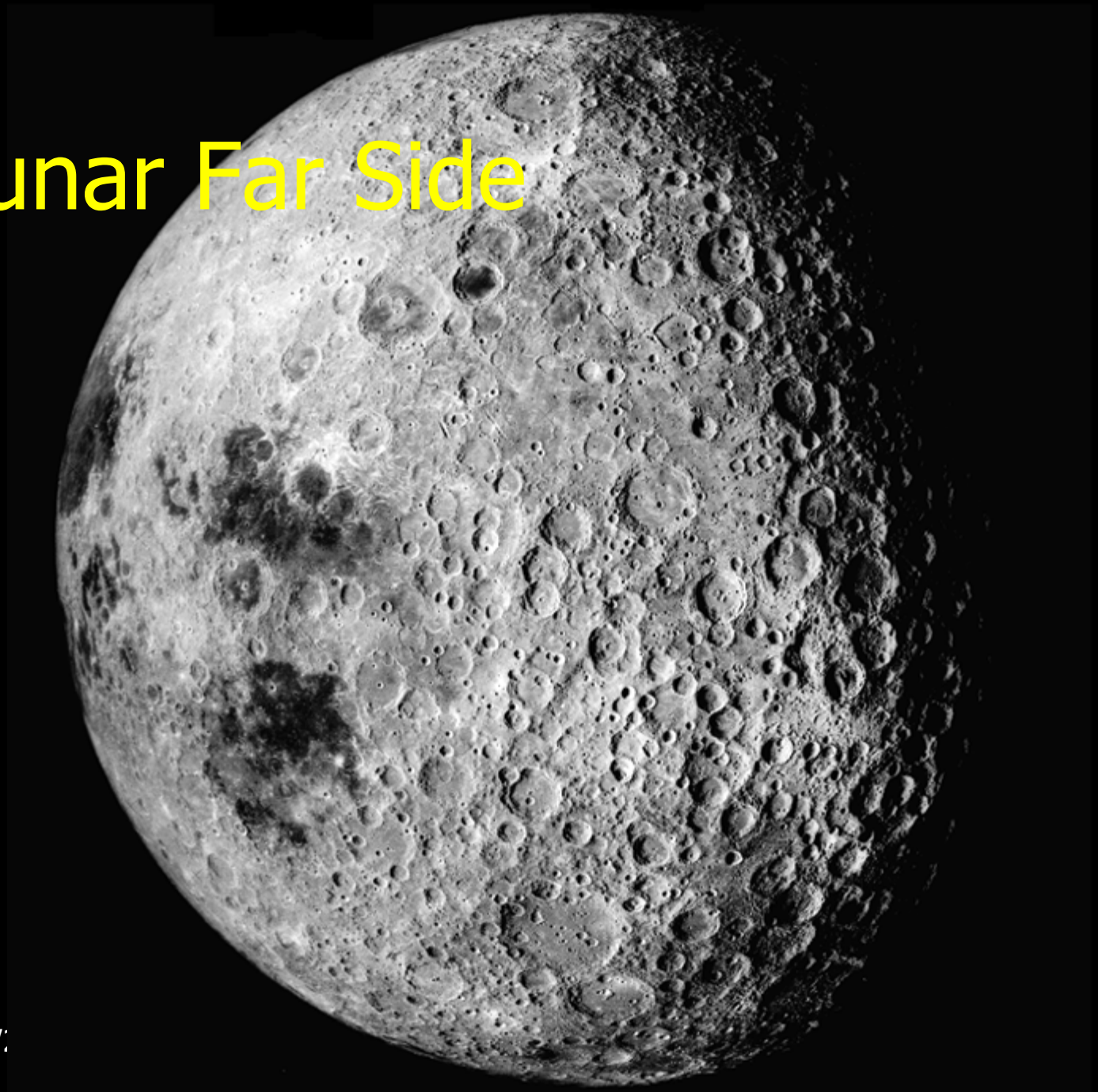
- The amount of cratering can be used to determine the age of the parts of the lunar surface.
  - The highlands have many more impact craters which means that they have been exposed to space longer (that is, they are older) than the maria.
  - Scientists can count the number of craters per square km and use that to determine the age of the surface.

Mare Imbrium lava flow

Basalt lava flow, Hawaii

Highlands

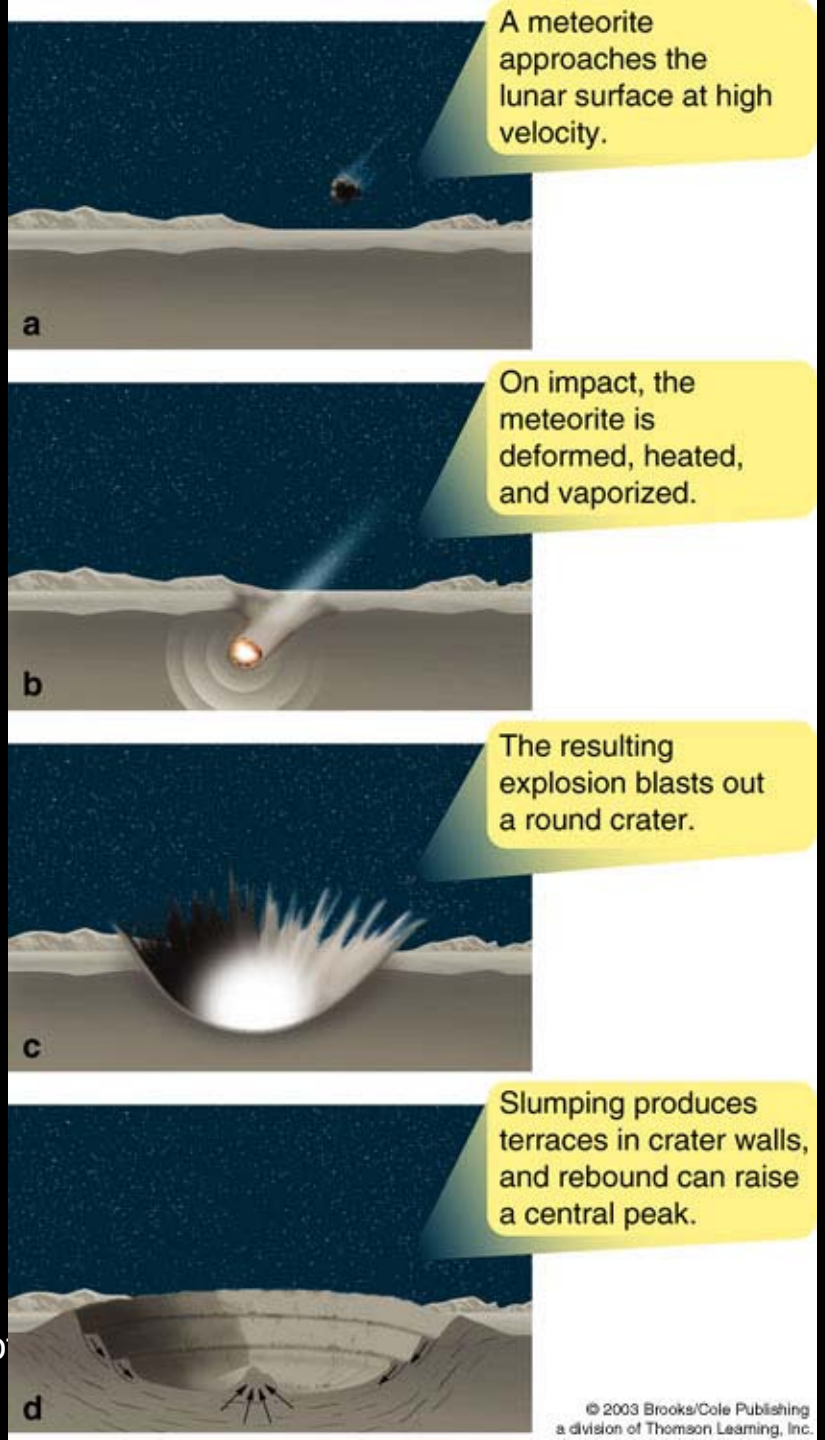
Lunar Far Side



Impact Cratering

- Impact Craters are created when meteoroids, asteroids, and comets strike the moon.
  - The objects are typically traveling 10-20 km/s.
  - Very roughly, the crater is usually about 10 times the diameter of the impactor.

Cratering


A meteorite approaches the lunar surface at high velocity.
a
On impact, the meteorite is deformed, heated, and vaporized.
b
The resulting explosion blasts out a round crater.
c
Slumping produces terraces in crater walls, and rebound can raise a central peak.
d
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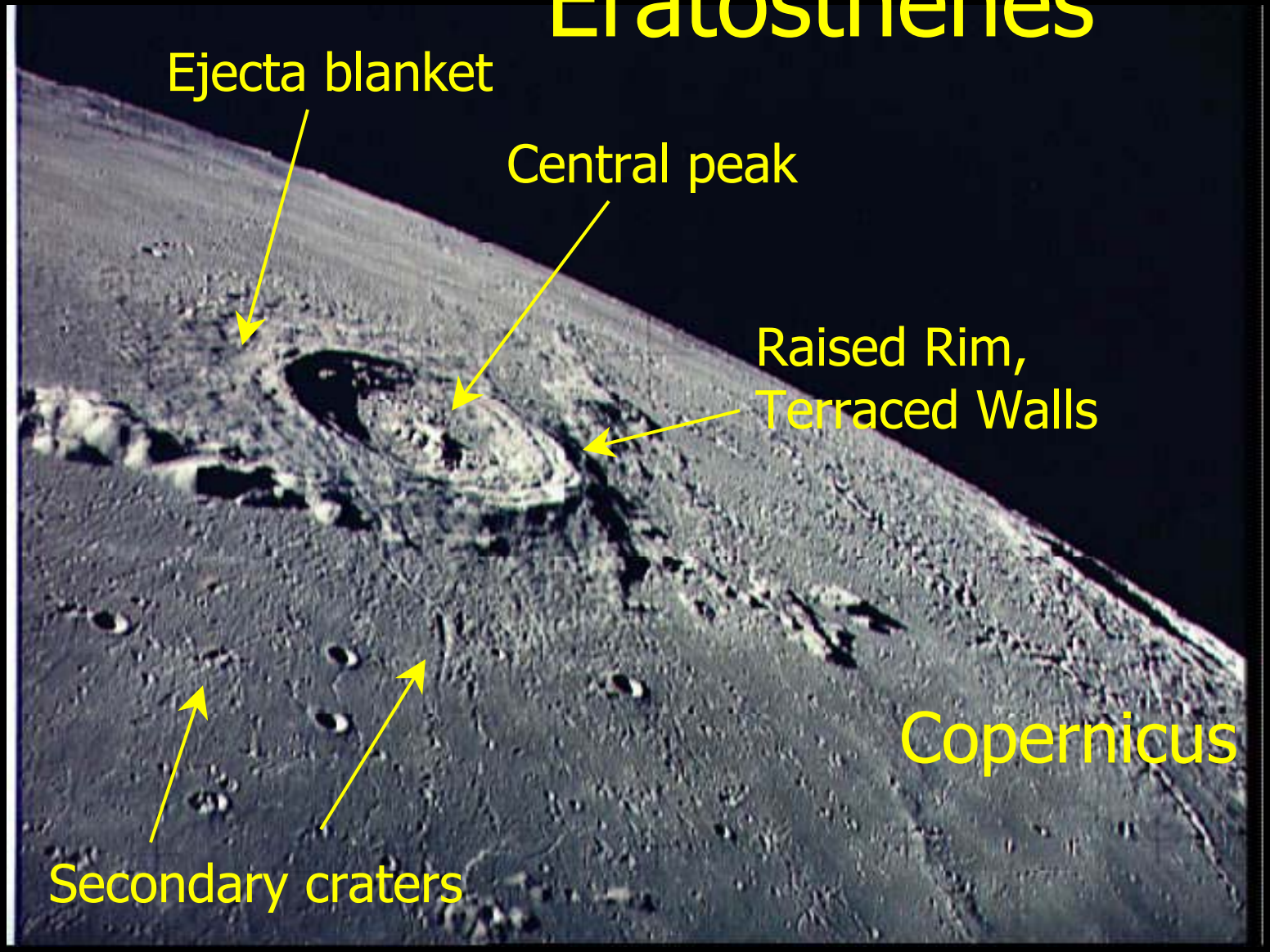
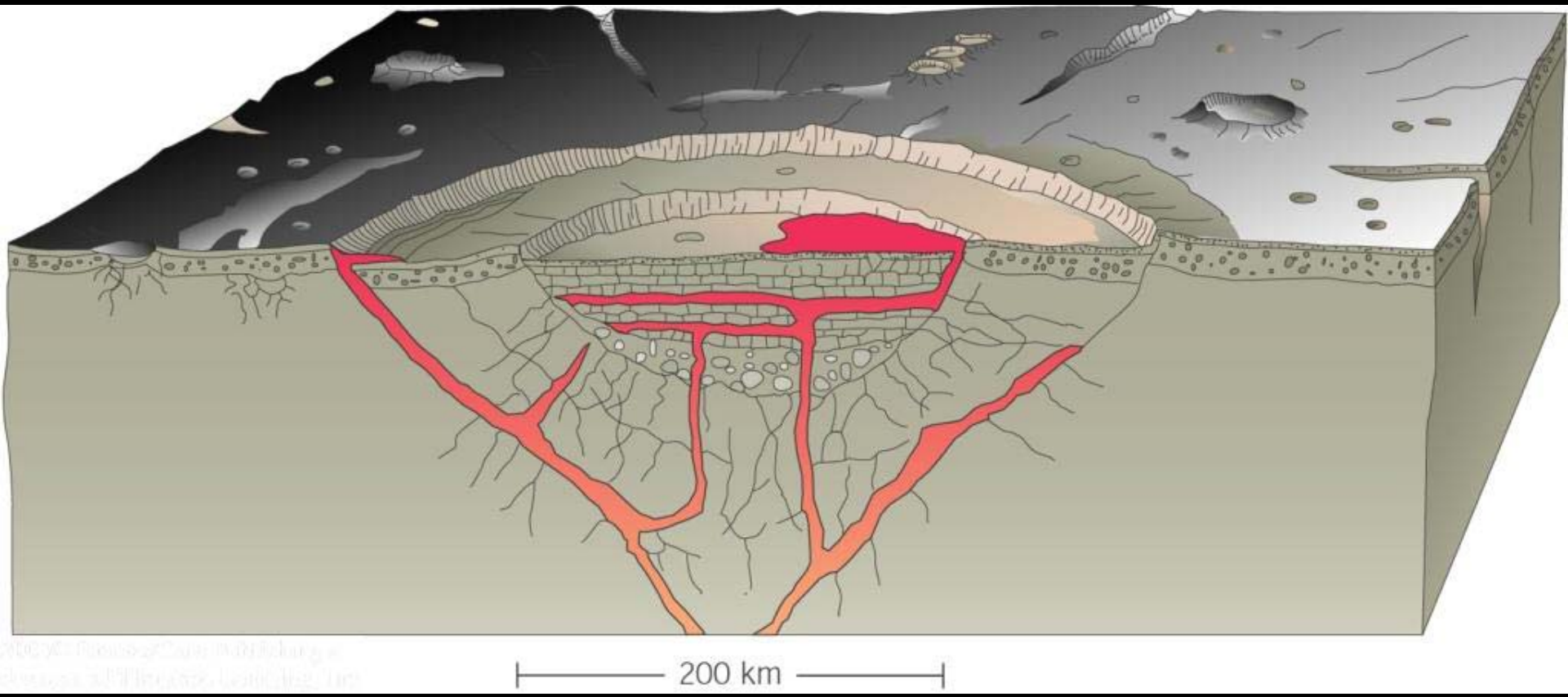
Eratosthenes



Impact Basin



Orientale Basin

Mare Orientale

Why Doesn't the Earth Lokk Like This?

Great Barringer Meteor Crater

- Located in Arizona
- Age 49±3 thousand years
- Diameter 1.2 km
- Created by an iron/nickel meteoroid 120-150 feet across traveling at 7 miles per second.

Manicougan Crater

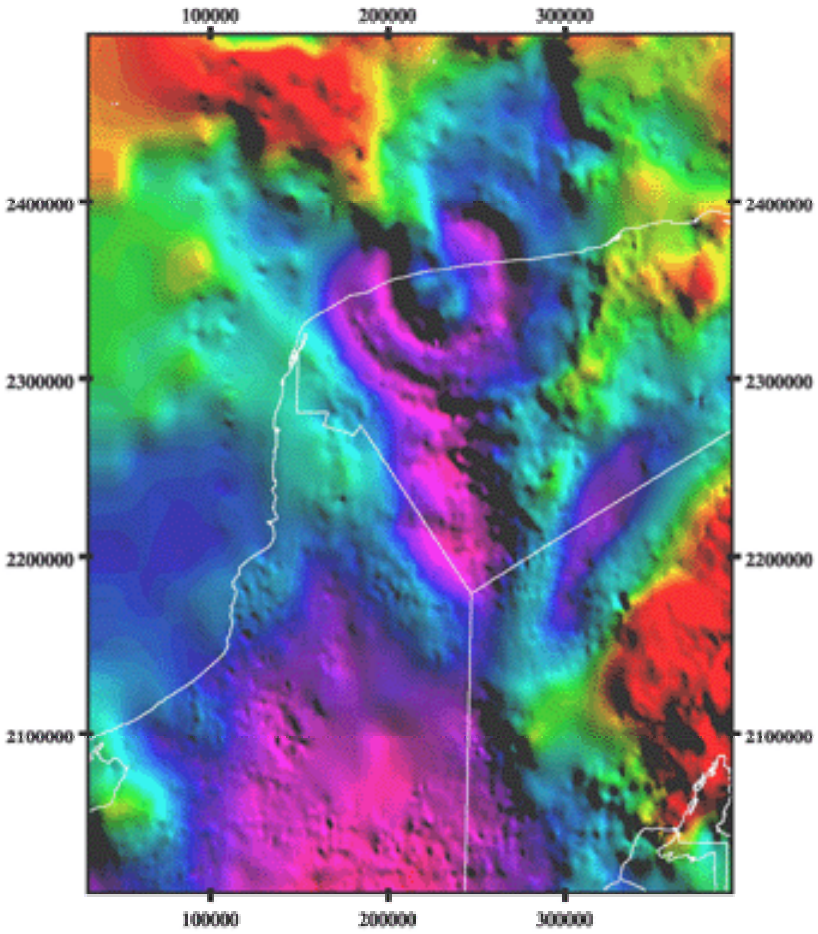
Manicougan Crater

- Located in Quebec, Canada
- Age 214±1 million years
- Diameter 100 km

Clearwater, Quebec, Canada

Chicxulub Crater

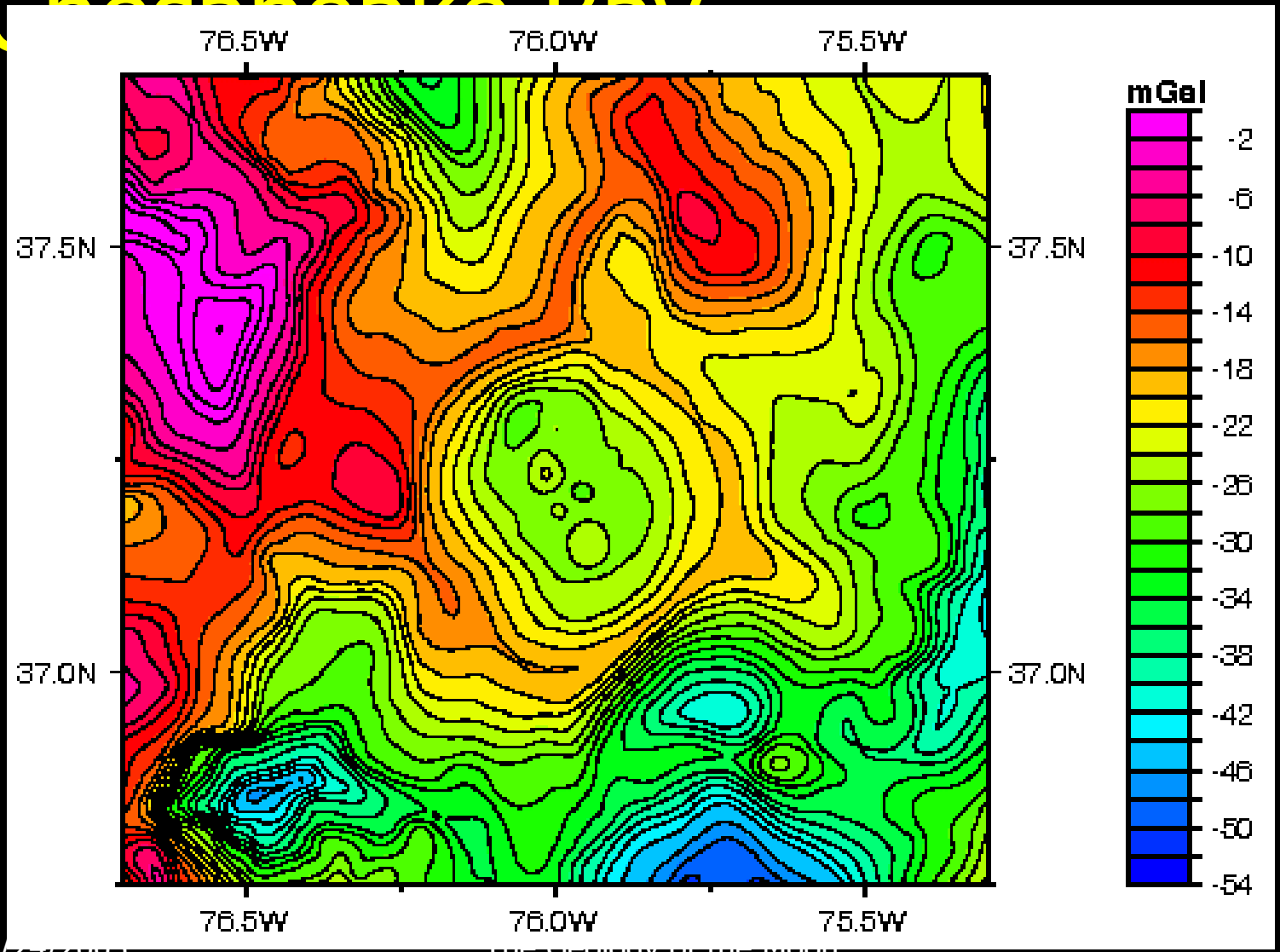
Chicxulub Crater


100000
200000
300000
2400000
2300000
2200000
2100000

Chicxulub Crater

- Located in Yucatan, Mexico
- Age 64.98±0.05 million years
- Diameter of 170 km

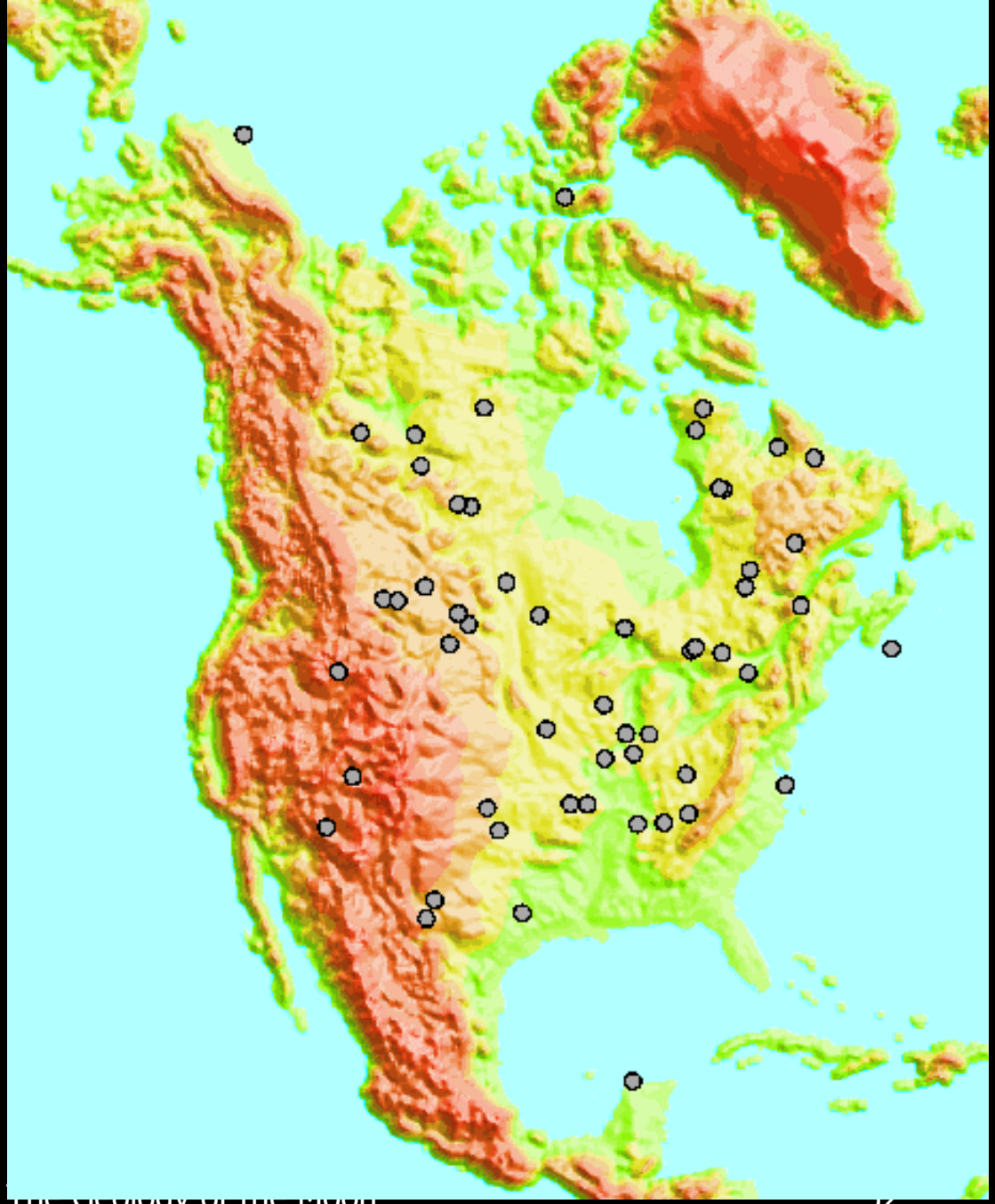
Chesapeake Bay



Chesapeake Bay

- Located in Virgina, USA
- Age 35.5 $\pm$0.6 million years
- Diameter of 85 km

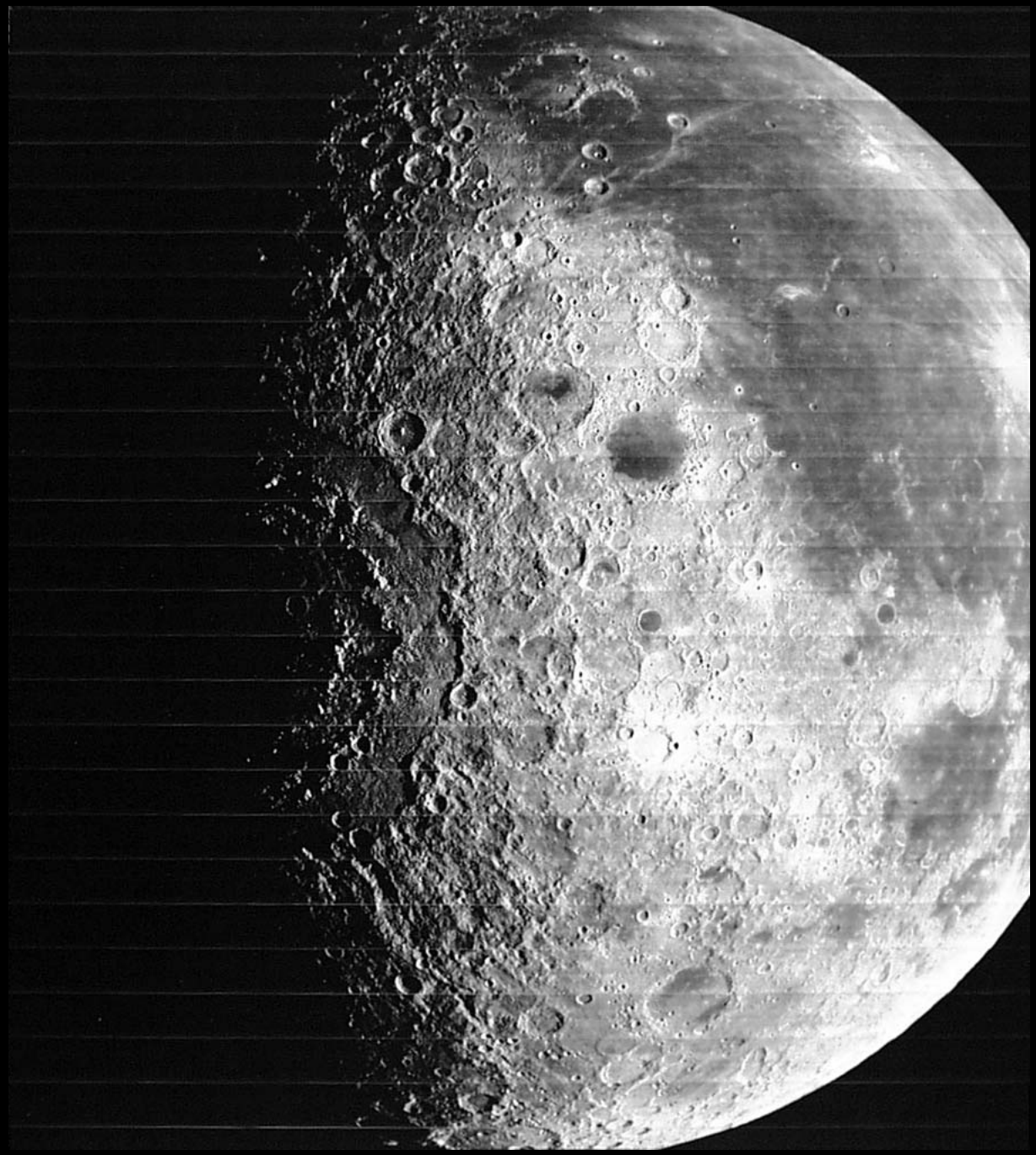
North American Impact Craters

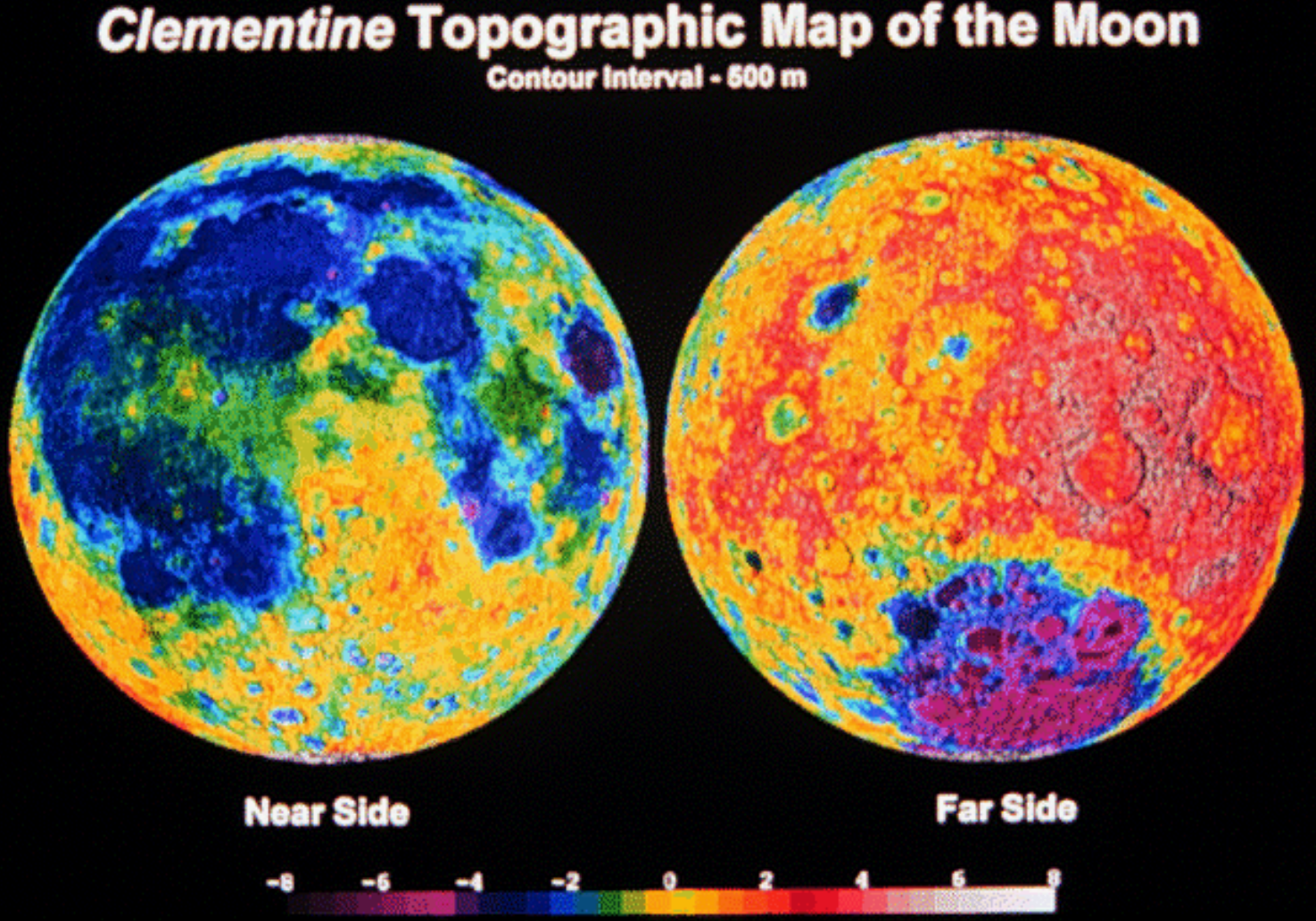


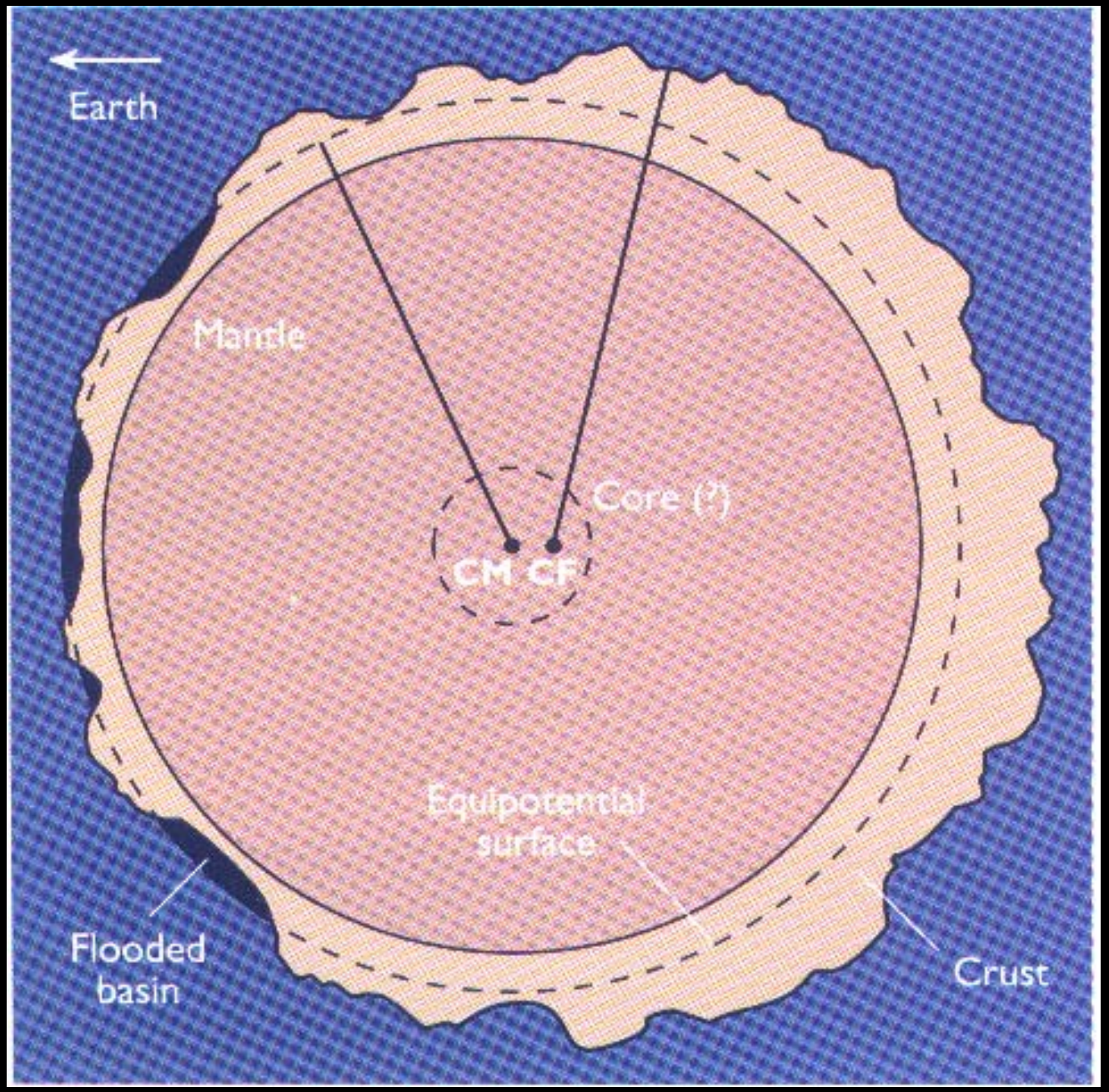
Vredefort Crater

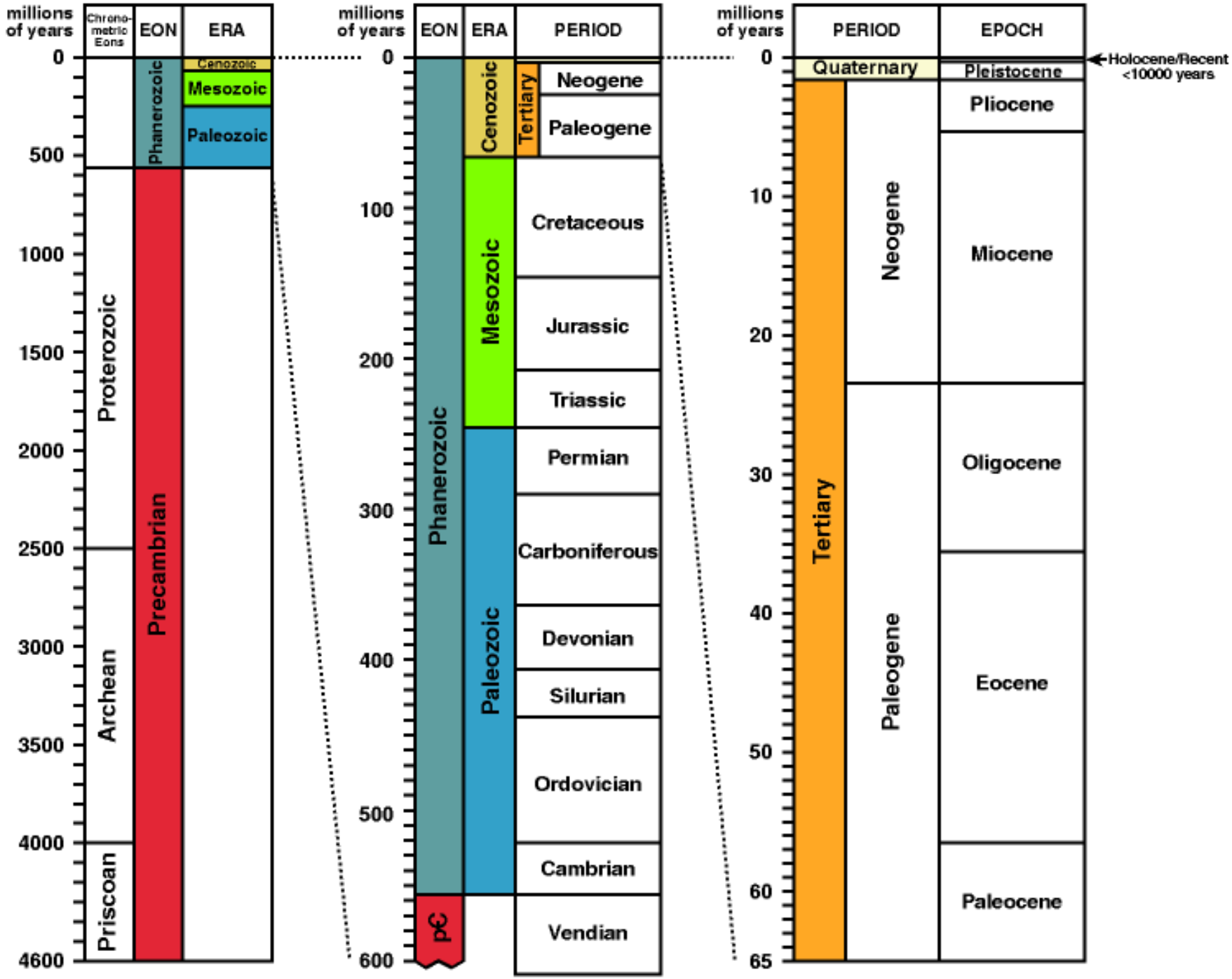
Vredefort Impact Crater

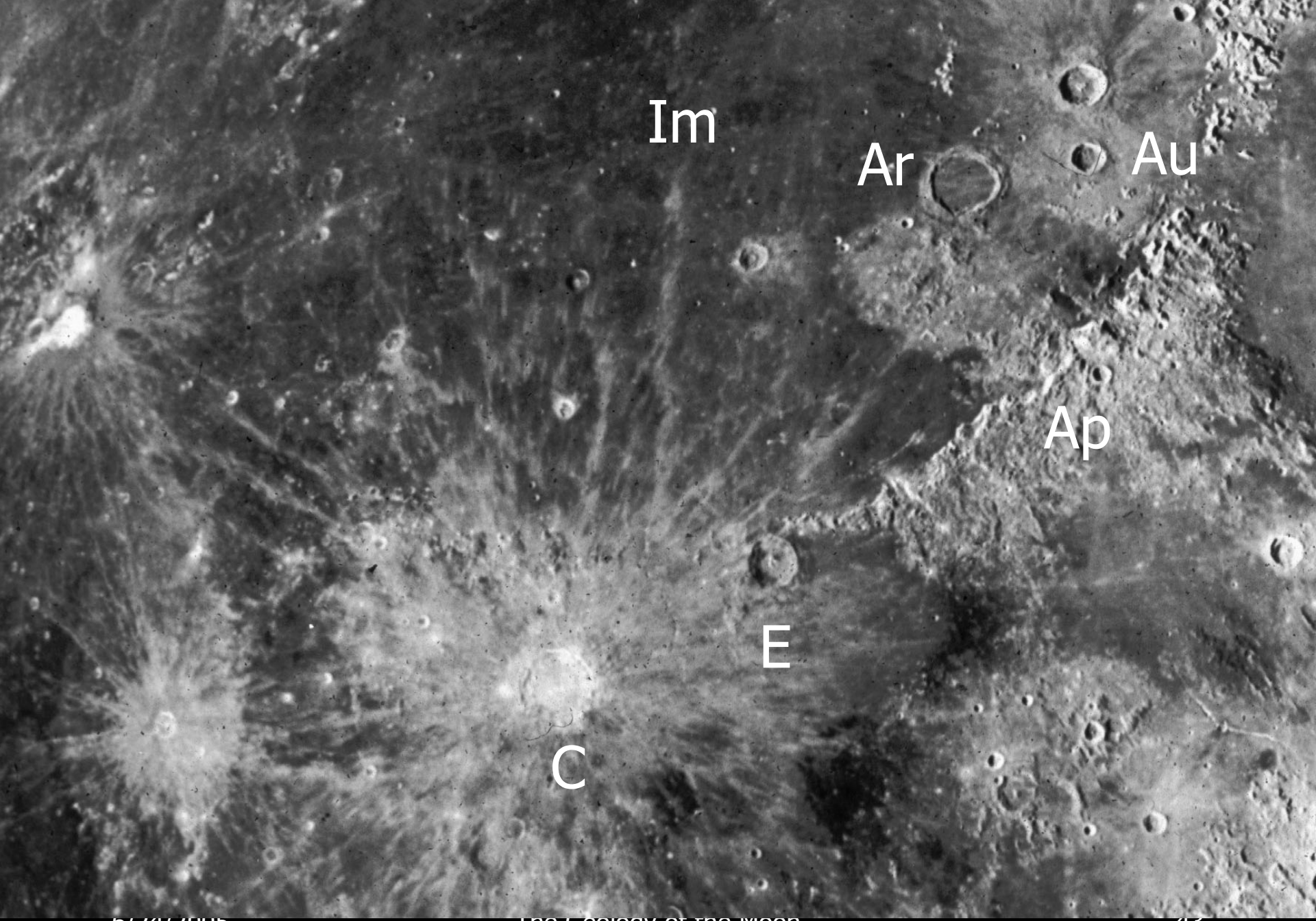
- The Vredefort Crater in South Africa is the largest remaining impact crater on the Earth.
- Age 2.023 ±0.004 billion years
- Diameter 300 km

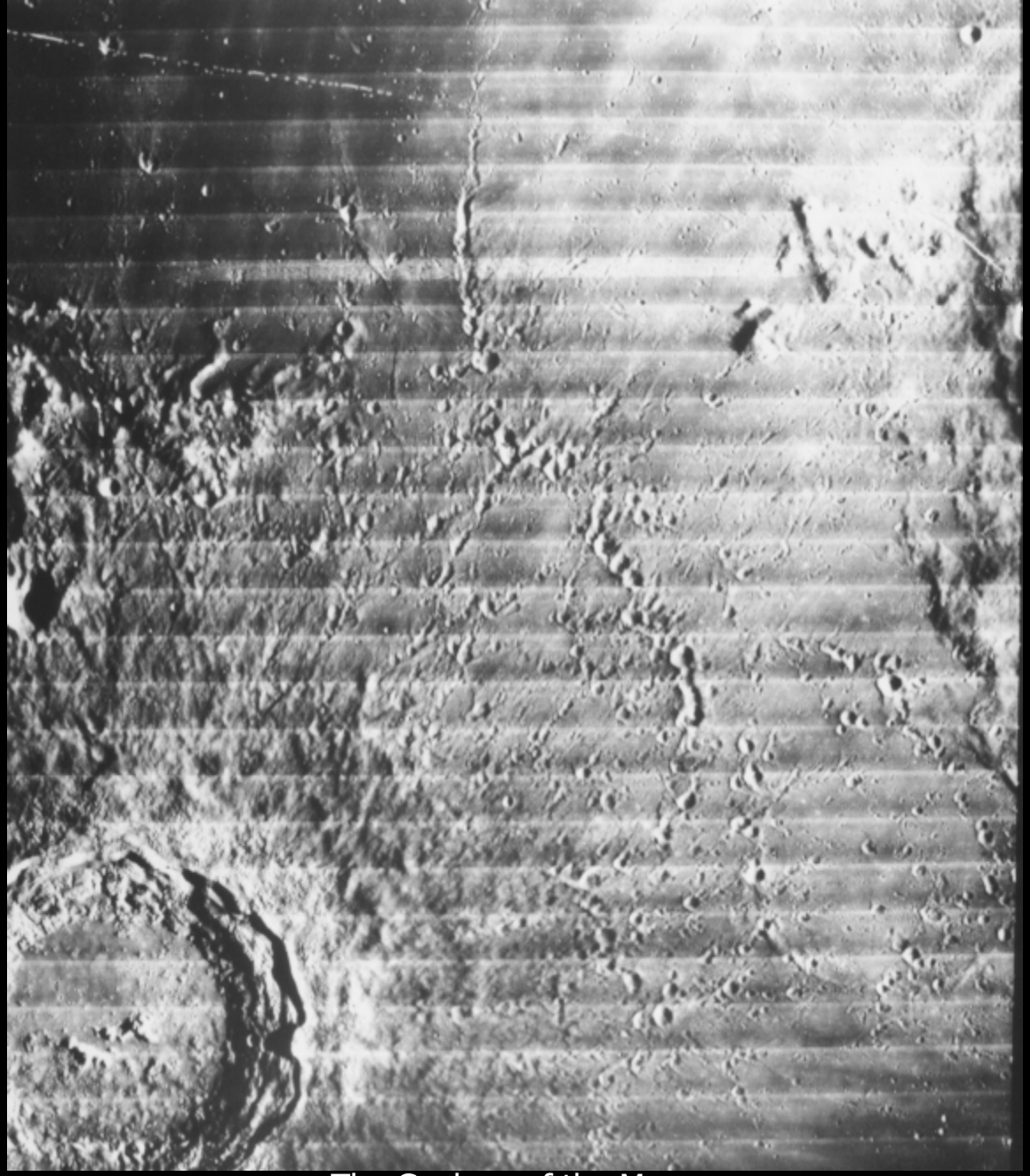



Clementine Topographic Map of the Moon
Contour Interval - 500 m
Near Side
Far Side
-8
-6
-4
-2
0
2
4
6
8


Earth
Mantle
Core (?)
CM CF
Equipotential surface
Flooded basin
Crust

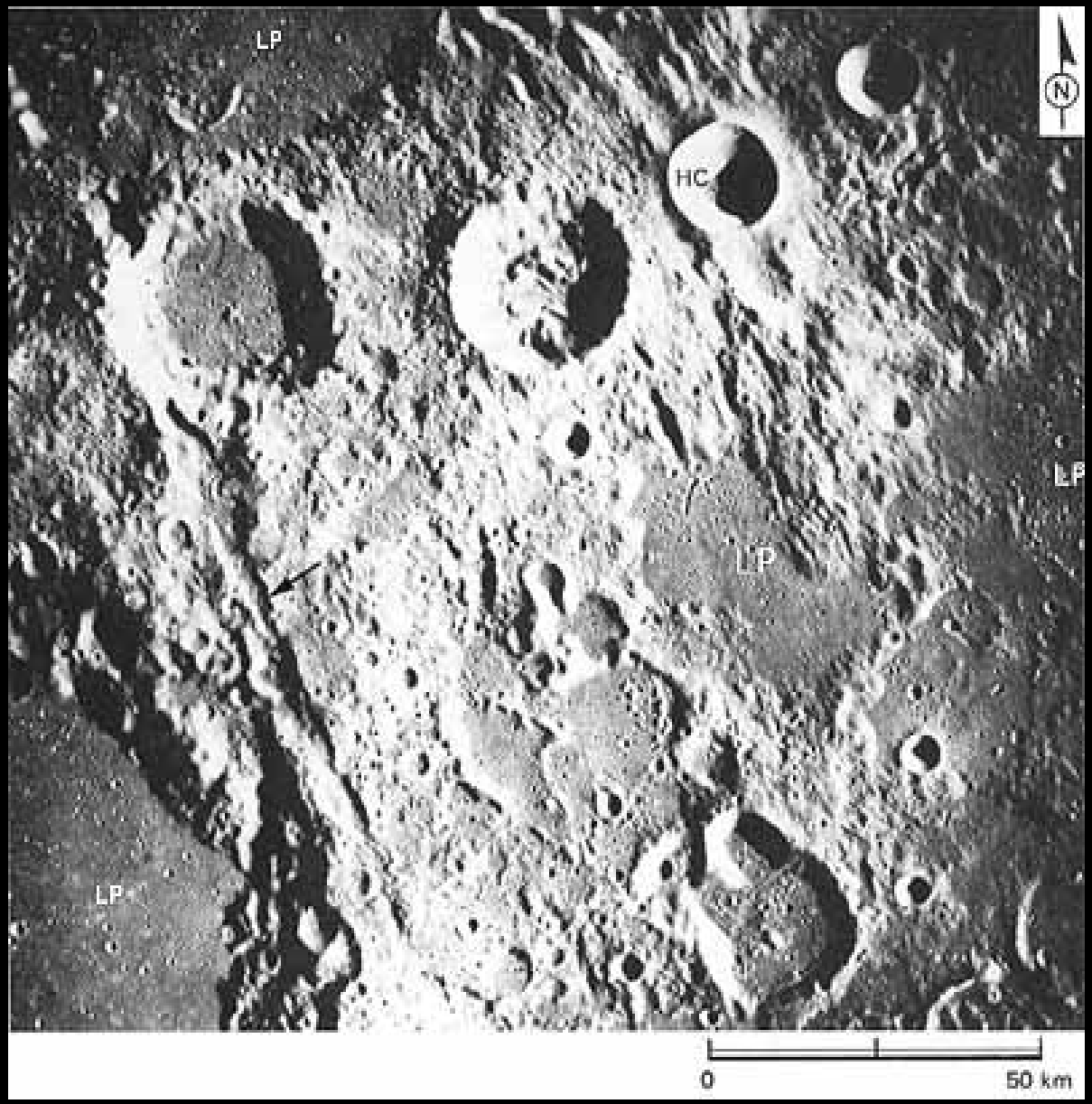

millions of years
Chrono-metric Eons
EON
ERA
PERIOD
EPOCH
0
500
1000
1500
2000
2500
3000
3500
4000
4600
Cenozoic
Mesozoic
Paleozoic
Phanerozoic
Precambrian
Proterozoic
Archean
Priscoan
100
200
300
400
500
600
Tertiary
Neogene
Paleogene
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Vendian
pC
10
20
30
40
50
60
65
Quaternary
Pleistocene
Pliocene
Miocene
Oligocene
Eocene
Paleocene
Holocene/Recent
<10000 years

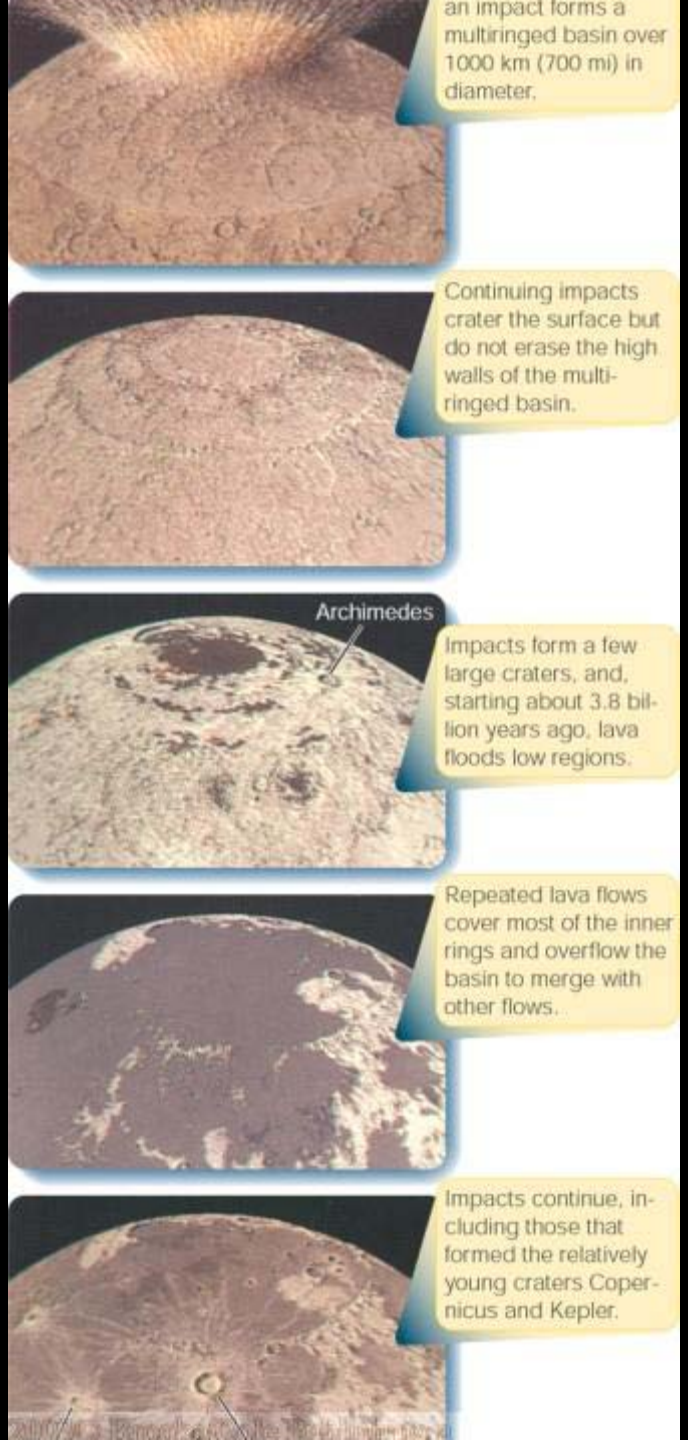

Im
Ar
Au
Ap
E
C

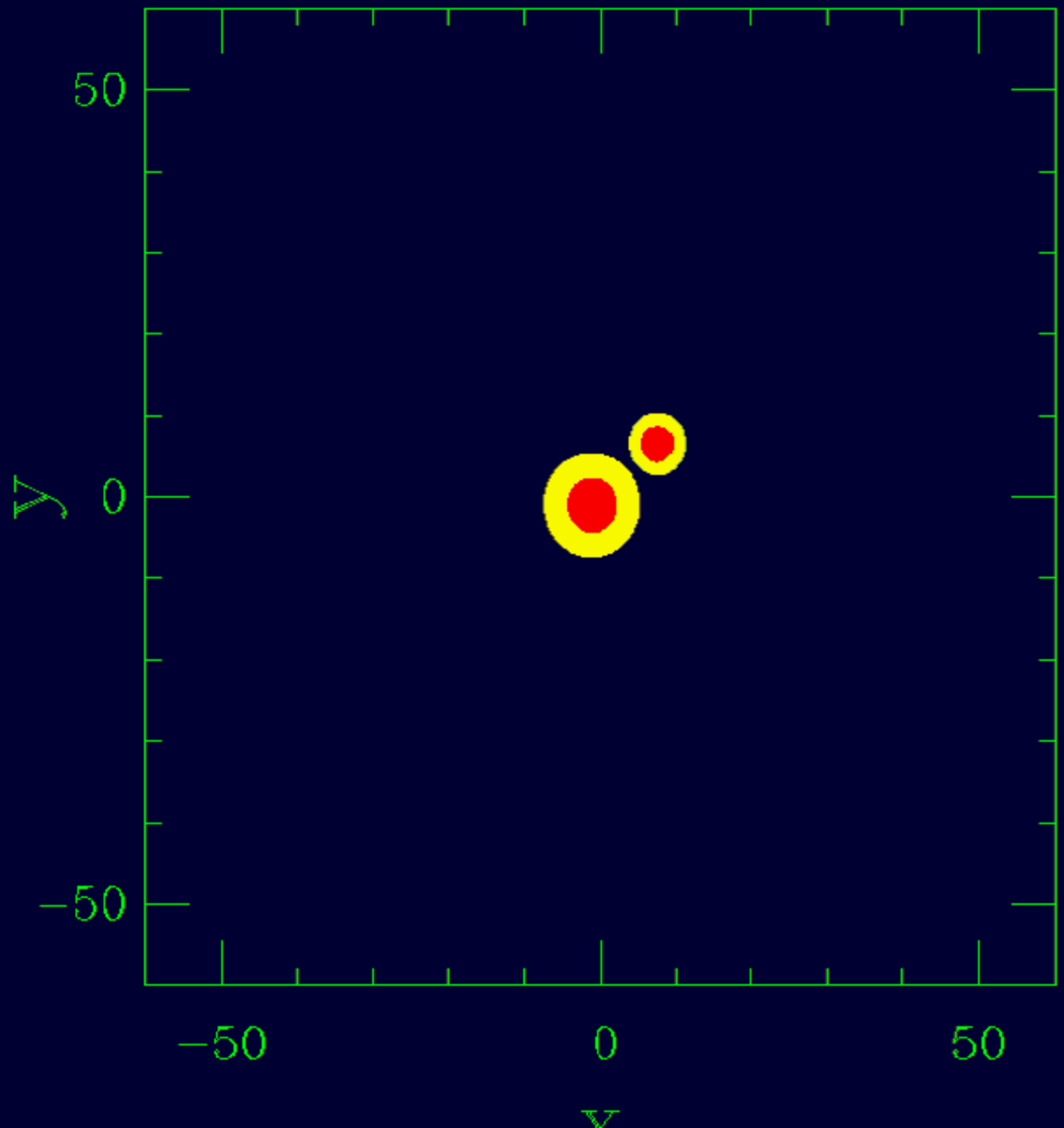



AS15
1541

An area centered about 900 km southeast of the Imbrium basin, illustrating the radial fracturing and sculpturing of terra materials by the basin forming event. The arrow points to a 120 km long fracture that cuts the rims of the partly visible crater Albategnius in the lower left of the photograph and the crater Halley toward the upper left. It and similar trending fractures elsewhere in this picture are radial to the Imbrium basin and are related to its formation. The crater Hipparchus C (HC) is superposed on a fracture and, therefore, is younger than the Imbrium basin and the Imbrium sculpture. Light plains forming materials (LP) are younger than the Imbrium event, as indicated by the absence of fractures and the scarcity of superposed craters. Light plains deposits are a major stratigraphic unit of the terra regions.




an impact forms a multiringed basin over 1000 km (700 mi) in diameter.
Continuing impacts crater the surface but do not erase the high walls of the multi-ringed basin.
Archimedes
Impacts form a few large craters, and, starting about 3.8 billion years ago, lava floods low regions.
Repeated lava flows cover most of the inner rings and overflow the basin to merge with other flows.
Impacts continue, including those that formed the relatively young craters Copernicus and Kepler.


50
0
−50
y
−50
0
50
x

Lunar History

Time in past (aeons ago)	Event
4.5	Accretion of Moon in Earth Orbit
4.5-4.2	Differentiation of crust and mantle; plutonism, volcanism, impact mixing and melting.
4.2	Crustal solidification and formation of oldest preserved basins.
4.2-3.92	Formation of at least 30 pre-Nectarian basins
3.92	Nectaris basin impact, beginning Nectarian Period
3.92-3.84	Formation of 10 Nectarian basins, including Serenitatis and Crisium
3.84	Imbrium basin impact, eruption of oldest dated intact mare lava flows, beginning Imbrian Period
3.8	Formation of last large basin (Orientale), marking Early Imbrian-Late Imbrian boundary.

Lunar History

Time in past (aeons ago)	Event
3.8-3.2	Eruption of most voluminous mare lavas and pyroclastics; continued diminished impact cratering
3.2	Imbrian-Eratosthenian Period boundary
3.2-1.1	Continued mare volcanism and impact cratering
1.1	Eratosthenian-Copernican Period boundary
0.81	Copernicus impact
0.11	Tycho impact