Title: Impact cratering and the evolution of planetary surfaces in the solar system â€“ The Chicxulub impact

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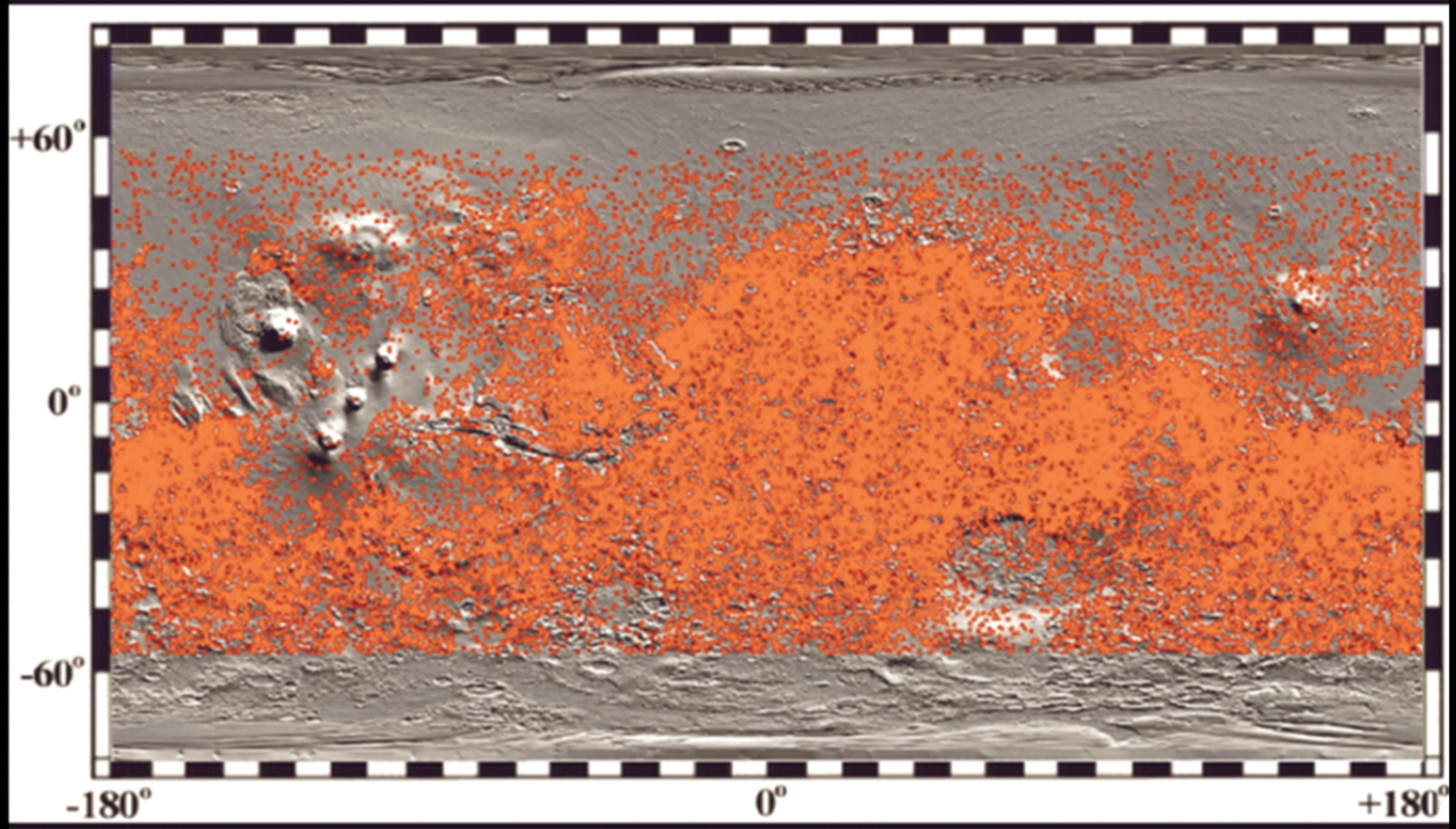
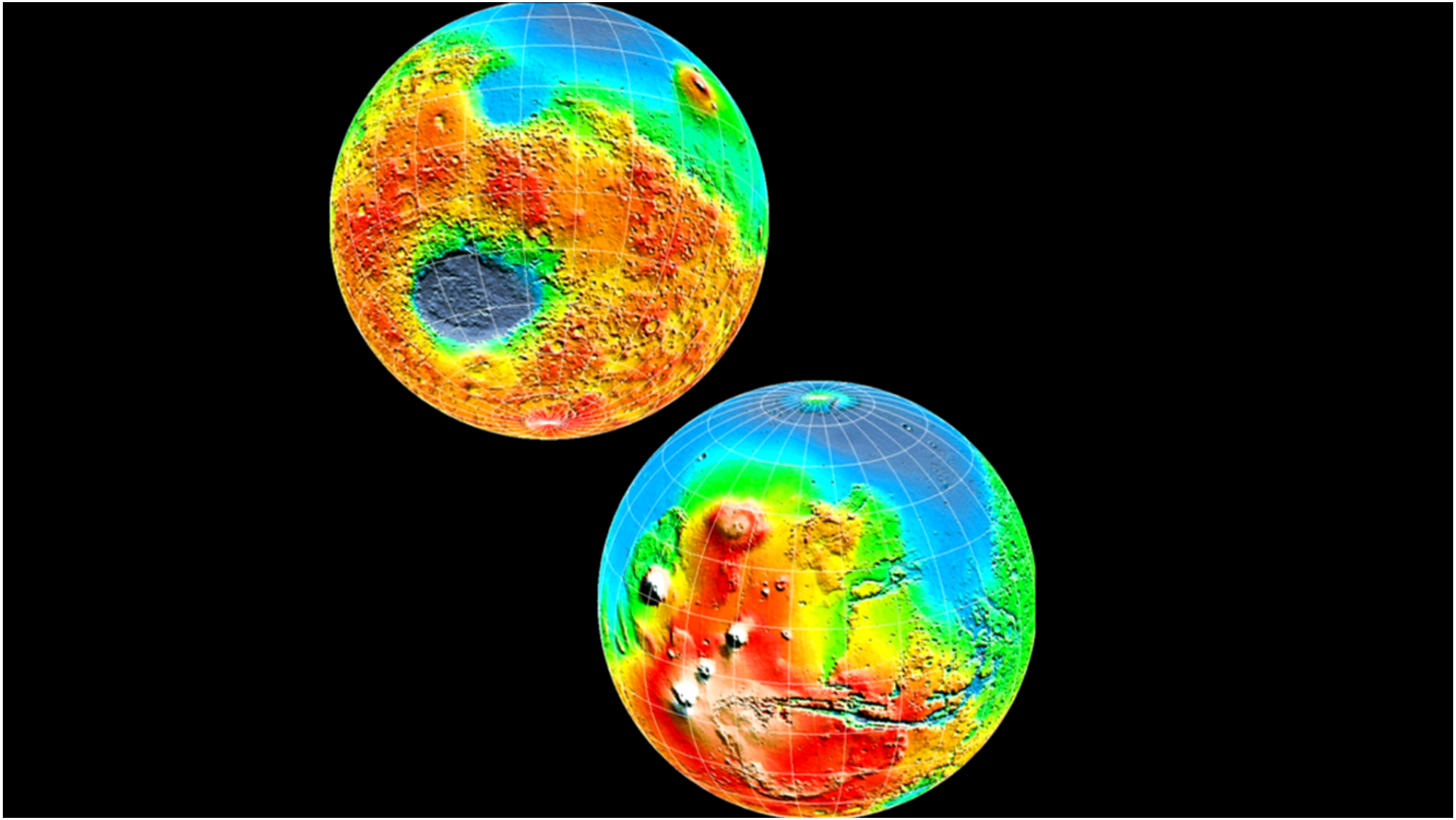
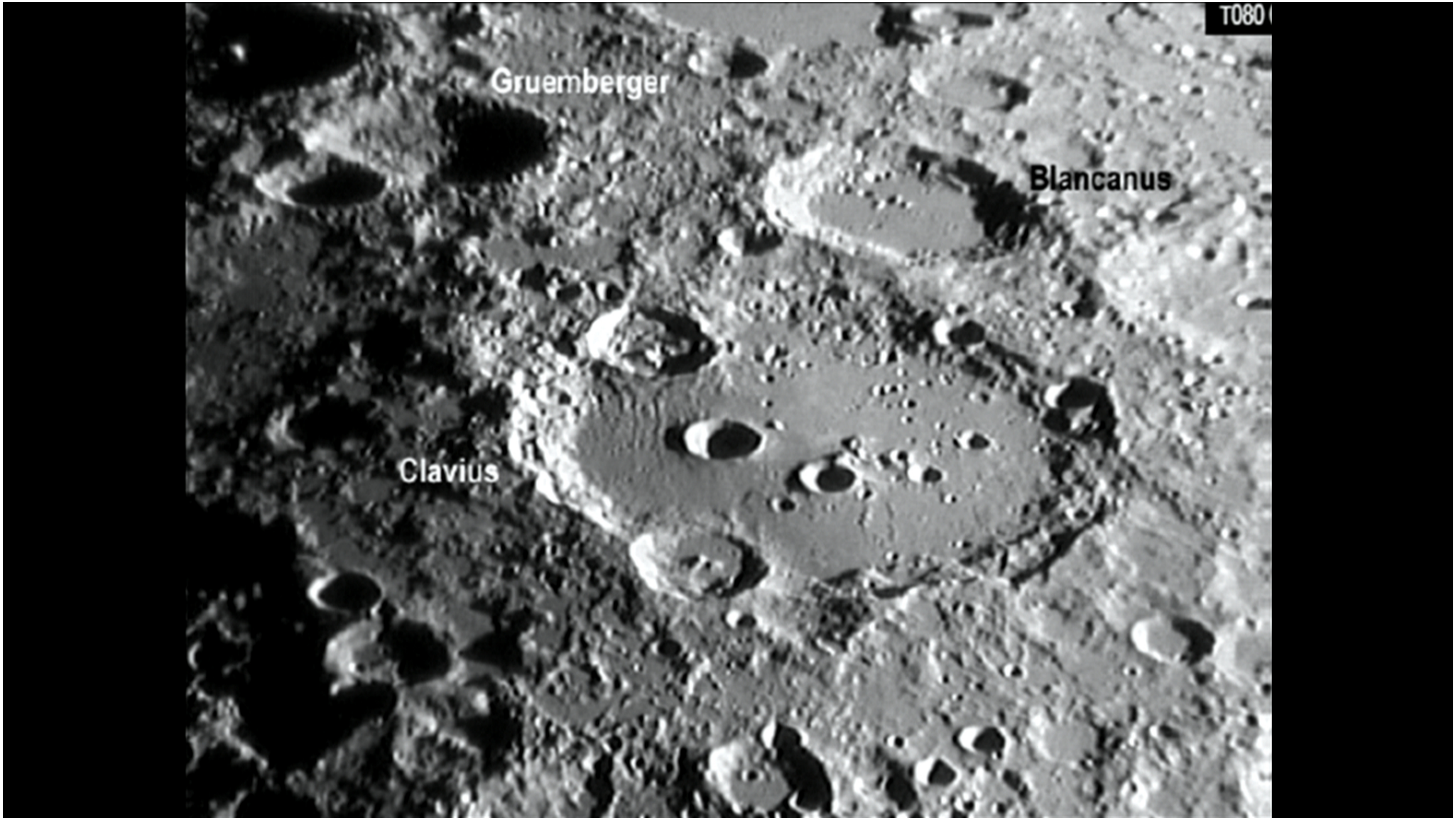
Abstract: Impacts of asteroid and comets constitute major geologic processes shaping the surfaces and evolution of planetary bodies. Impacts produce deep transient cavities, with excavation to deep crustal levels, fragmentation, and removal of large rock volumes. Formation of complex craters involves high pressures and temperatures resulting in intense deformation, fracturing and melting. Here, we analyze the crater-forming impacts and their effects on the EarthÂ´s climate, environment and life-support systems, in relation to the Cretaceous/Paleogene (K/Pg) boundary. The boundary represents one of the major extinction events in the Phanerozoic, which affected about 75 % of species. It is marked by a clay layer globally distributed that is characterized by anomalous contents of iridium and platinum group elements, marking the occurrence of a large bolide impact. Studies have examined the age, stratigraphic correlations and composition of the boundary layer, establishing a genetic association to the Chicxulub impact in the Yucatan peninsula in the Gulf of Mexico. The Chicxulub crater is a ~200 km diameter structure with peak ring and multi-ring morphology. Impact generated a transient cavity some 20-25 km deep resulting in intense deformation and shaking, which is recorded in the breccias and debris flow deposits in the Gulf of Mexico and Caribbean Sea area. Impact was on a shallow carbonate platform and resulted in huge tsunamis and in injection of CO2 and sulfur components into the atmosphere. Effects of impacts in the environment and climate of the Earth have been intensely investigated, mainly in relation to the mass extinction, where the affectation in the evolution patterns was profound and long-lasting. Effects of the K/Pg impact on the ecosystems extended for a long period of several millions of years. The disappearance of large numbers of species including complete groups severely affected the biodiversity and ecosystem composition in the marine and continental realms.

Martian Impact Craters

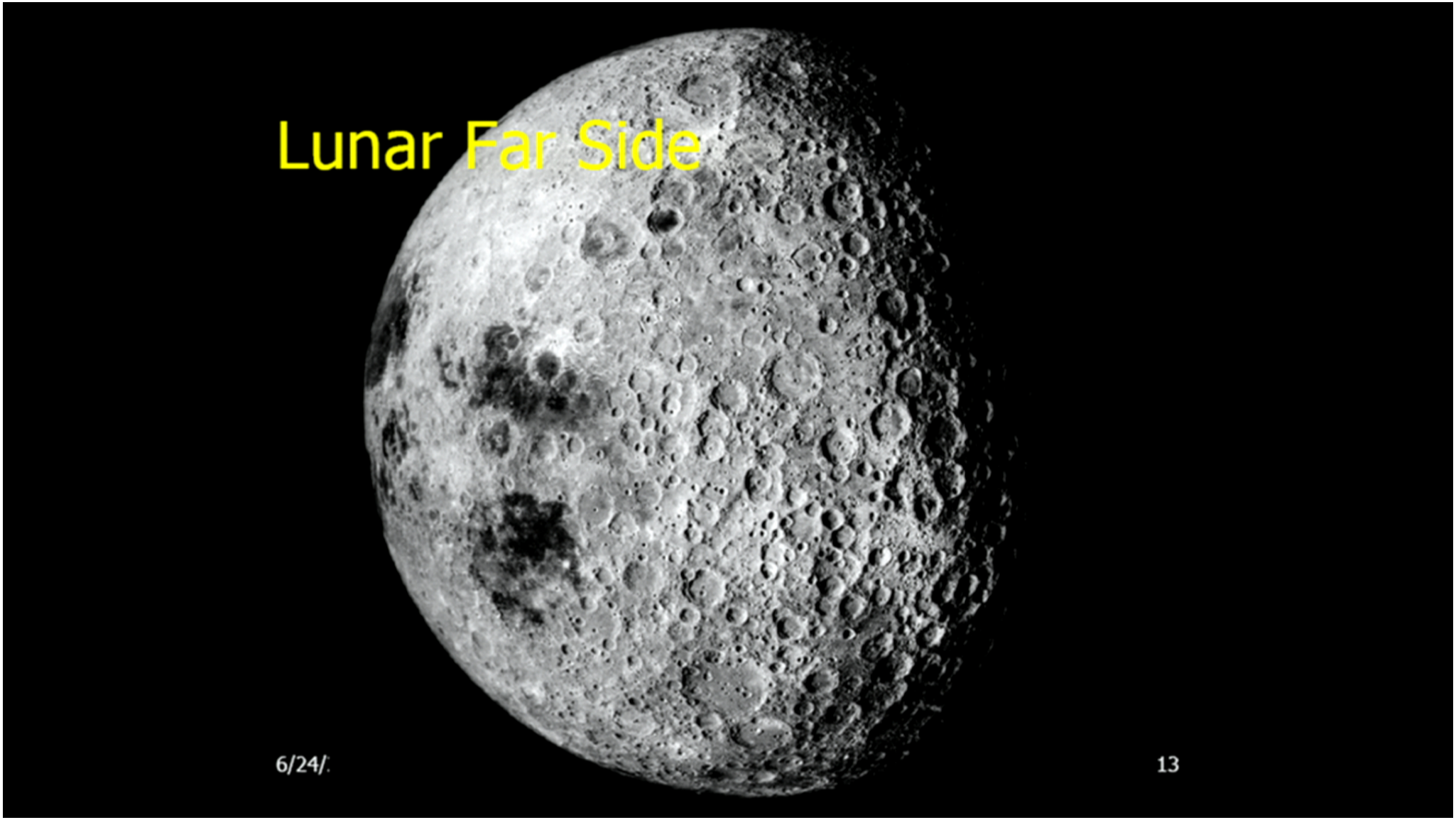


Craters > 4km from *Barlow* database over Mars shaded relief from MOLA

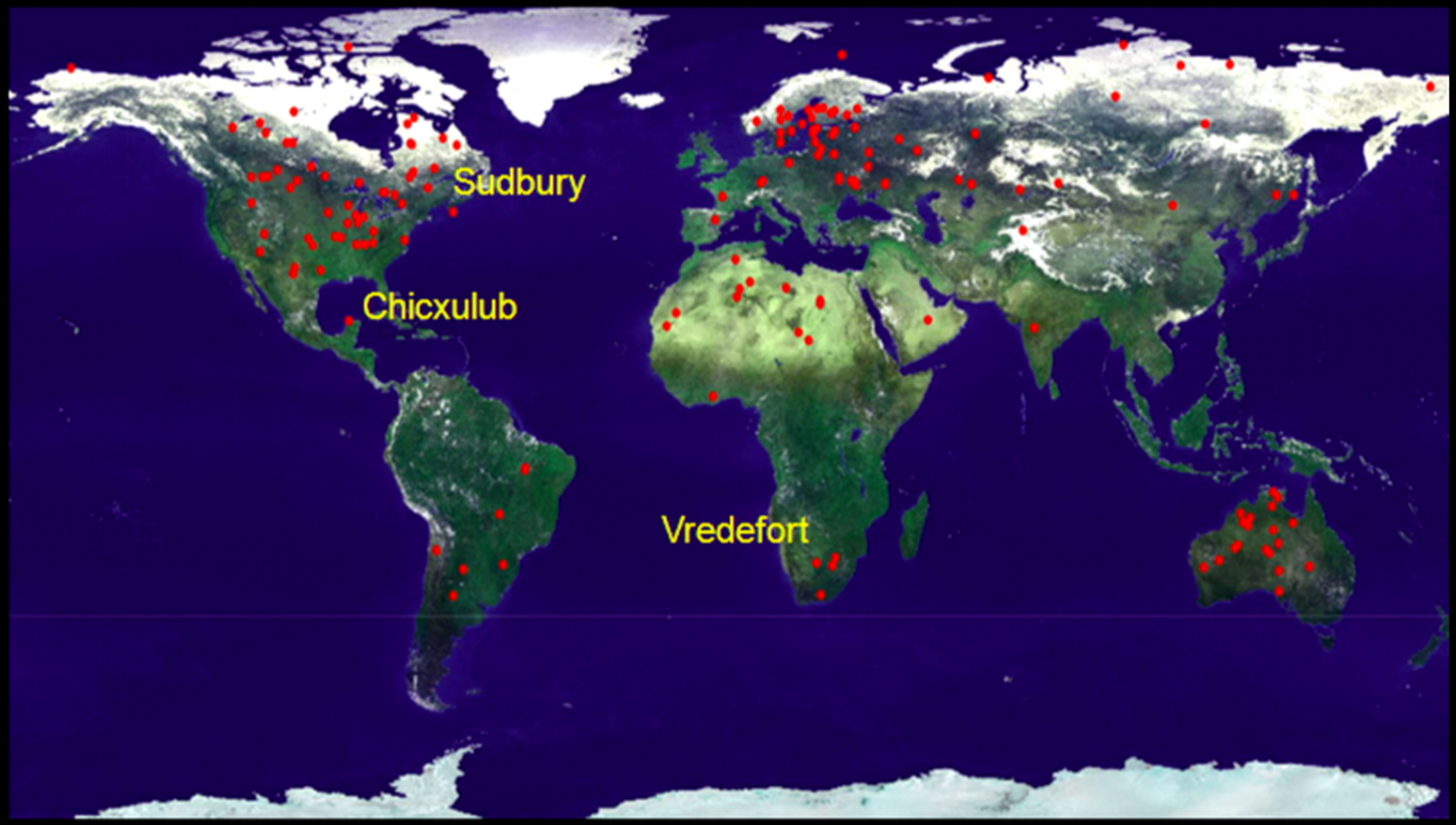



Gruemberger
Blancanus
Clavius


PERIMETER
INSTITUTE
FOR THEORETICAL PHYSICS

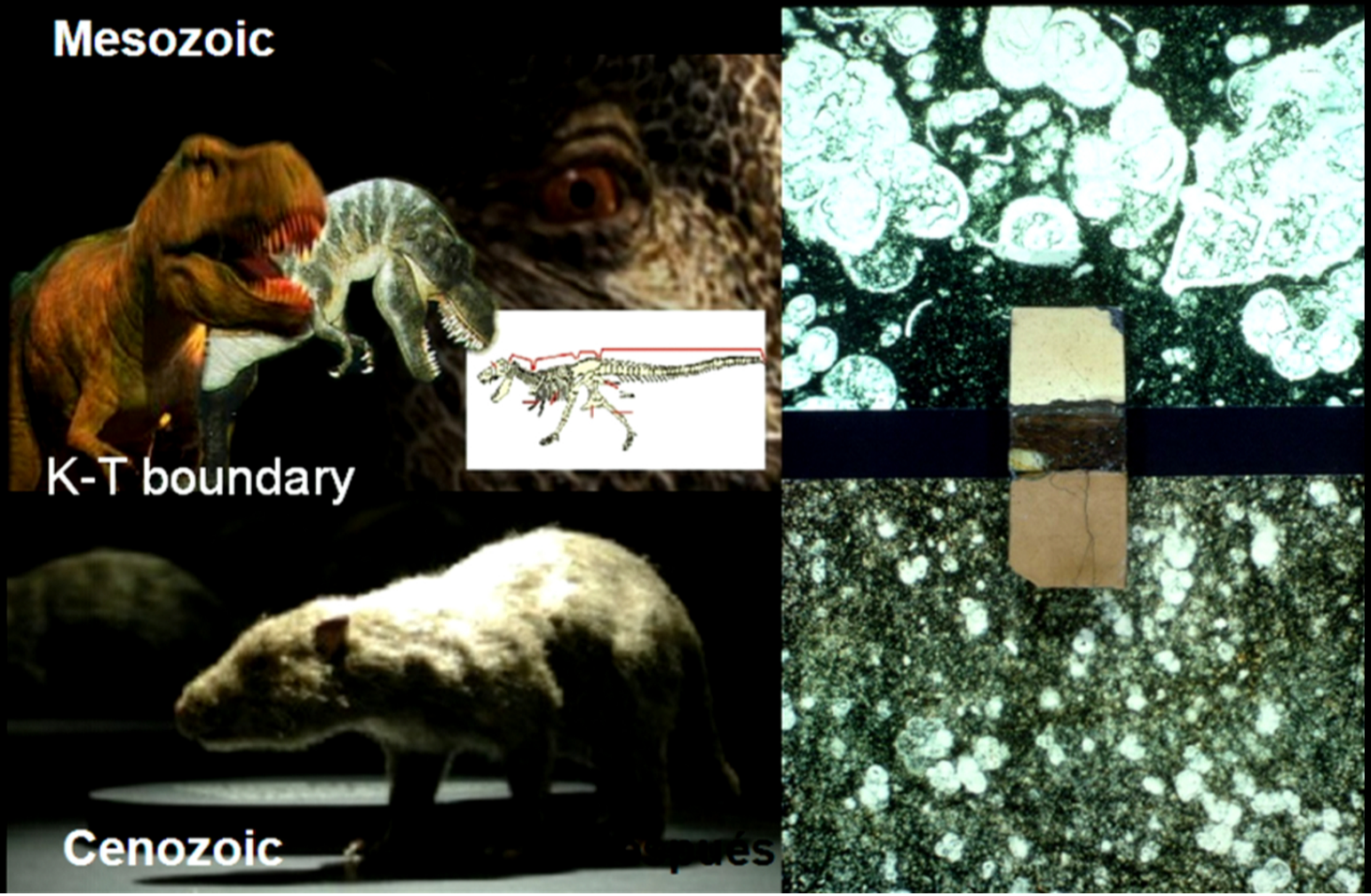

Lunar Far Side
6/24/.
13

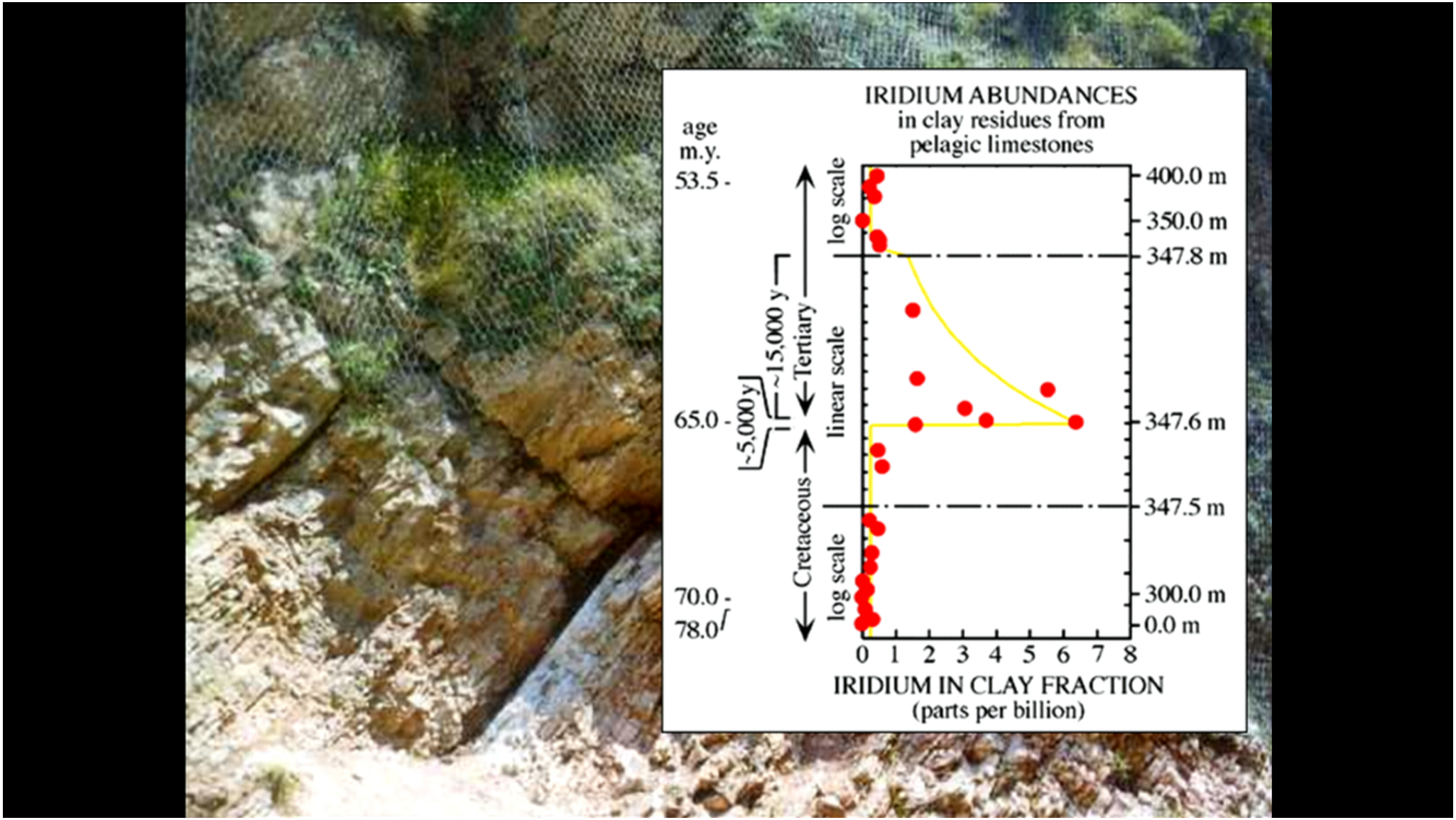
~170-180 Cráteres de Impacto en la Tierra



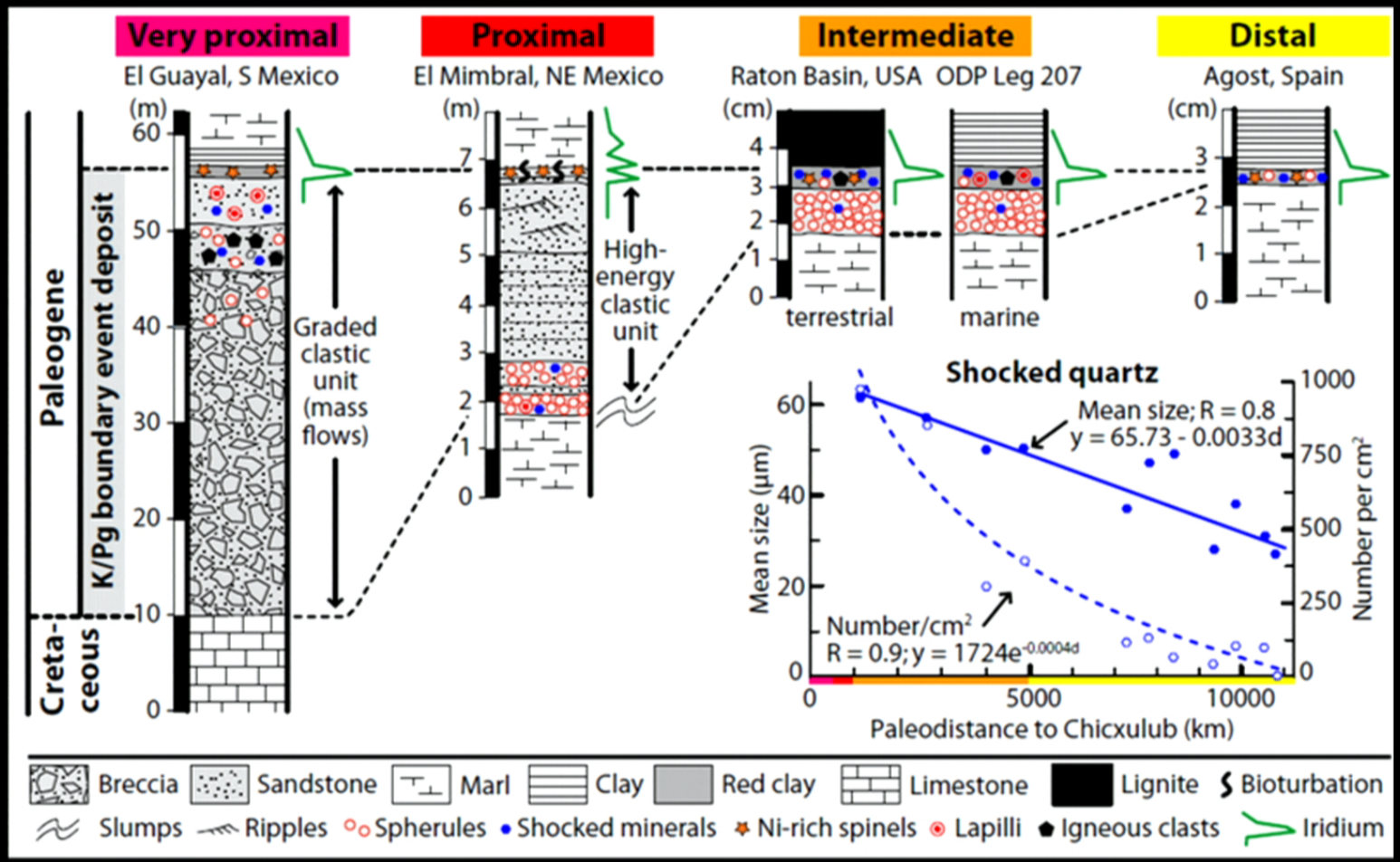
Tres Cráteres Complejos Multi-Anillo

Chicxulub impact: End-Cretaceous extinction

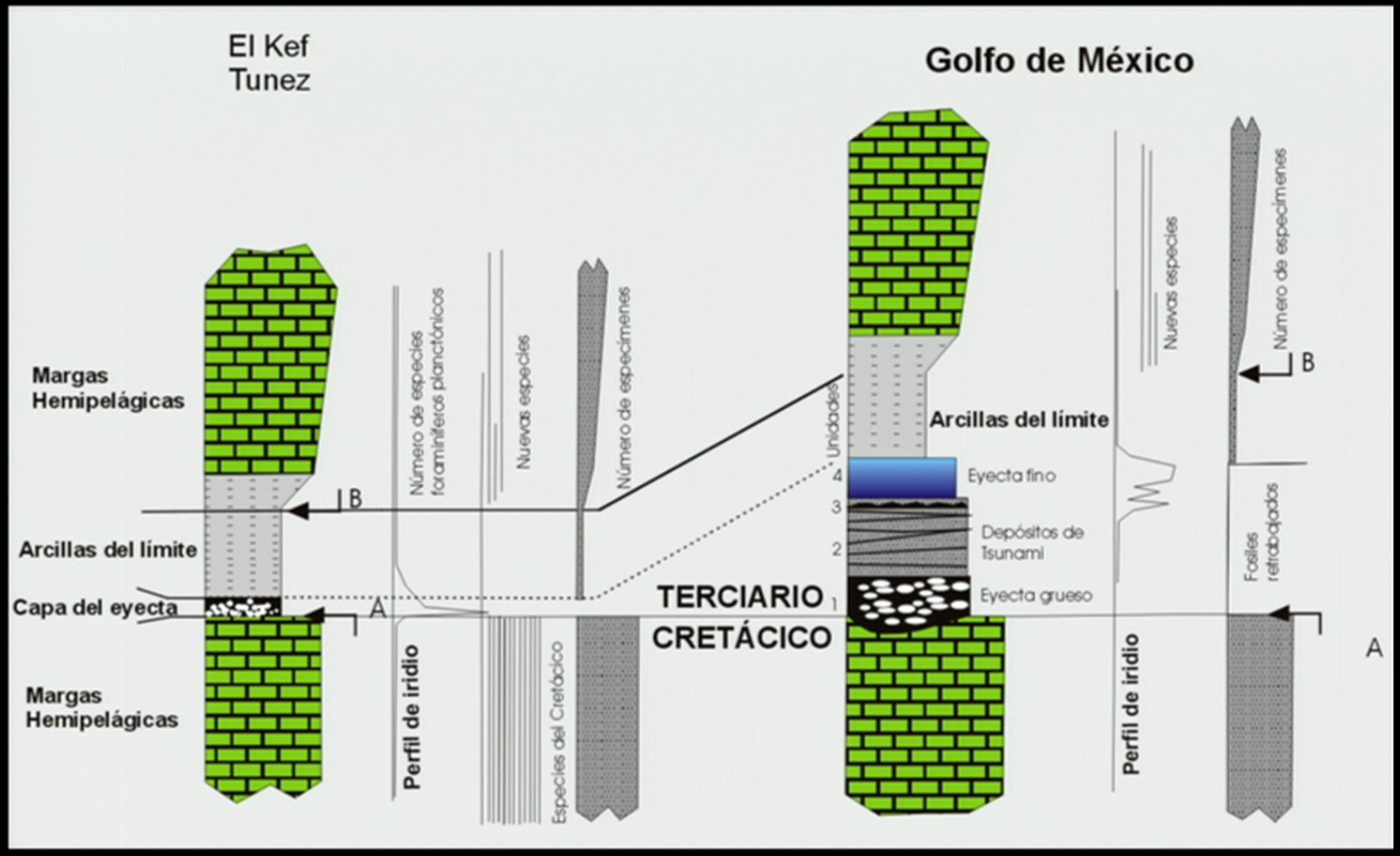



IRIDIUM ABUNDANCES
in clay residues from
pelagic limestones
age
m.y.
53.5 -
65.0 -
70.0 -
78.0
log scale
linear scale
log scale
Tertiary
Cretaceous
~15,000 y
~5,000y
400.0 m
350.0 m
347.8 m
347.6 m
347.5 m
300.0 m
0.0 m
0 1 2 3 4 5 6 7 8
IRIDIUM IN CLAY FRACTION
(parts per billion)

Cretaceous/Tertiary boundary layer


Very proximal
El Guayal, S Mexico
Proximal
El Mimbral, NE Mexico
Intermediate
Raton Basin, USA ODP Leg 207
Distal
Agost, Spain
Paleogene
Creta-ceous
K/Pg boundary event deposit
(m)
(cm)
Graded clastic unit (mass flows)
High-energy clastic unit
terrestrial
marine
Shocked quartz
Mean size; R = 0.8
y = 65.73 - 0.0033d
Number/cm²
R = 0.9; y = 1724e^-0.0004d
Mean size (μm)
Number per cm²
Paleodistance to Chicxulub (km)
Breccia
Sandstone
Marl
Clay
Red clay
Limestone
Lignite
Bioturbation
Slumps
Ripples
Spherules
Shocked minerals
Ni-rich spinels
Lapilli
Igneous clasts
Iridium

K/T clay layer

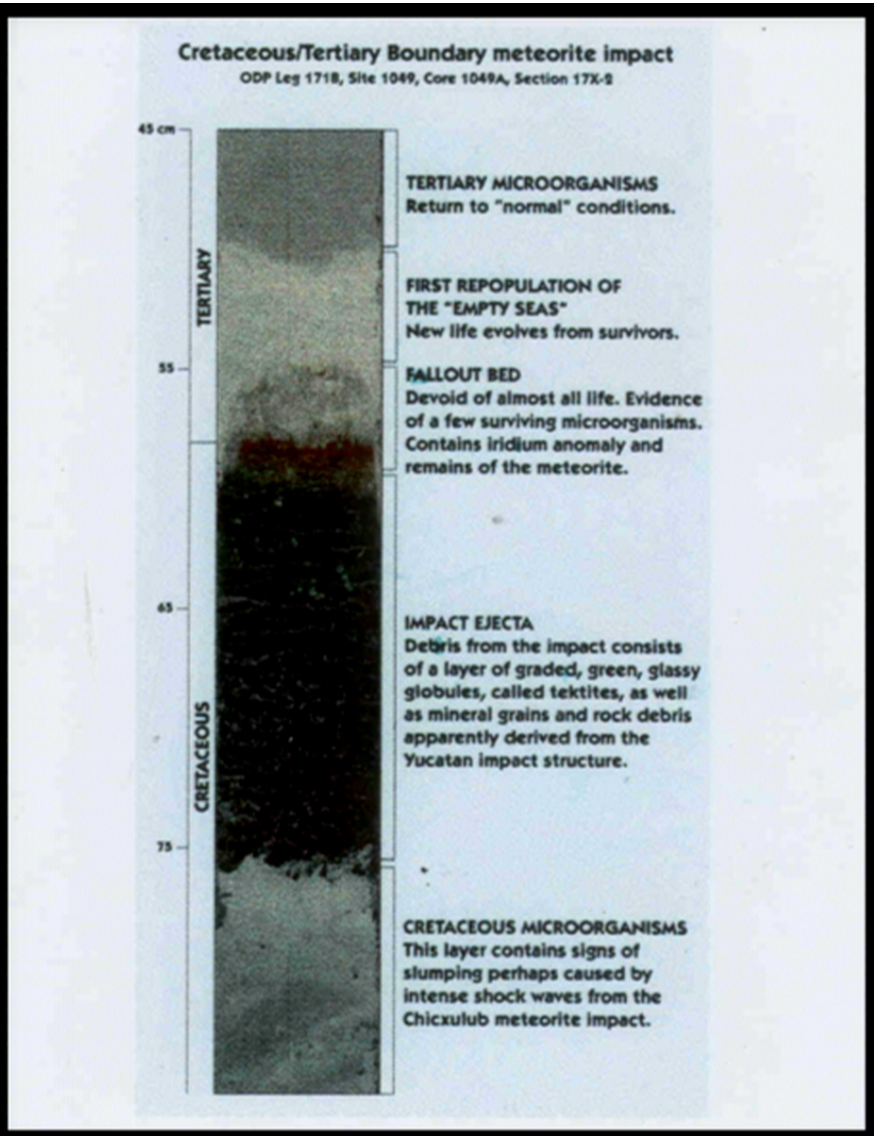


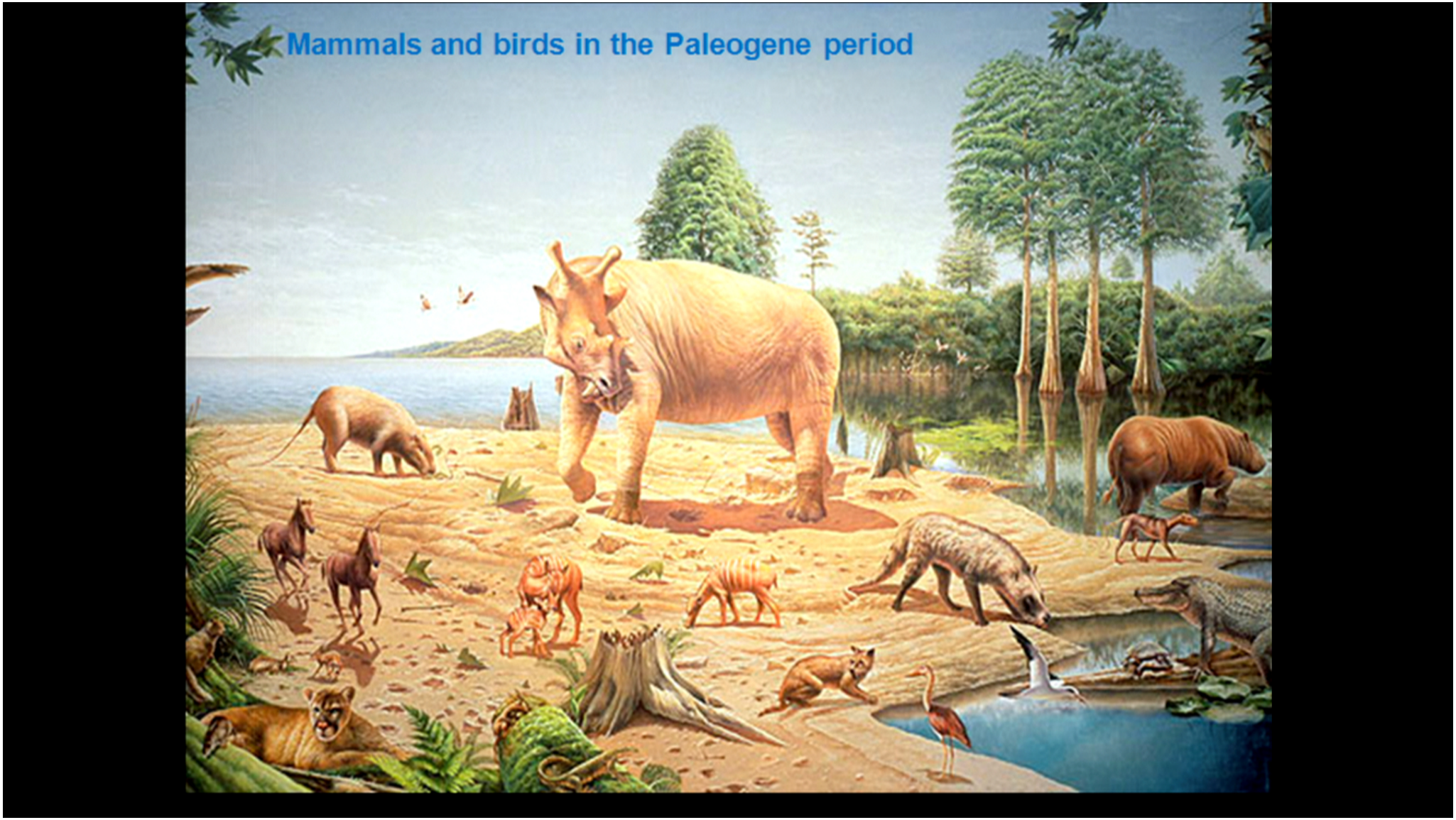
Massive extinction at K-T boundary

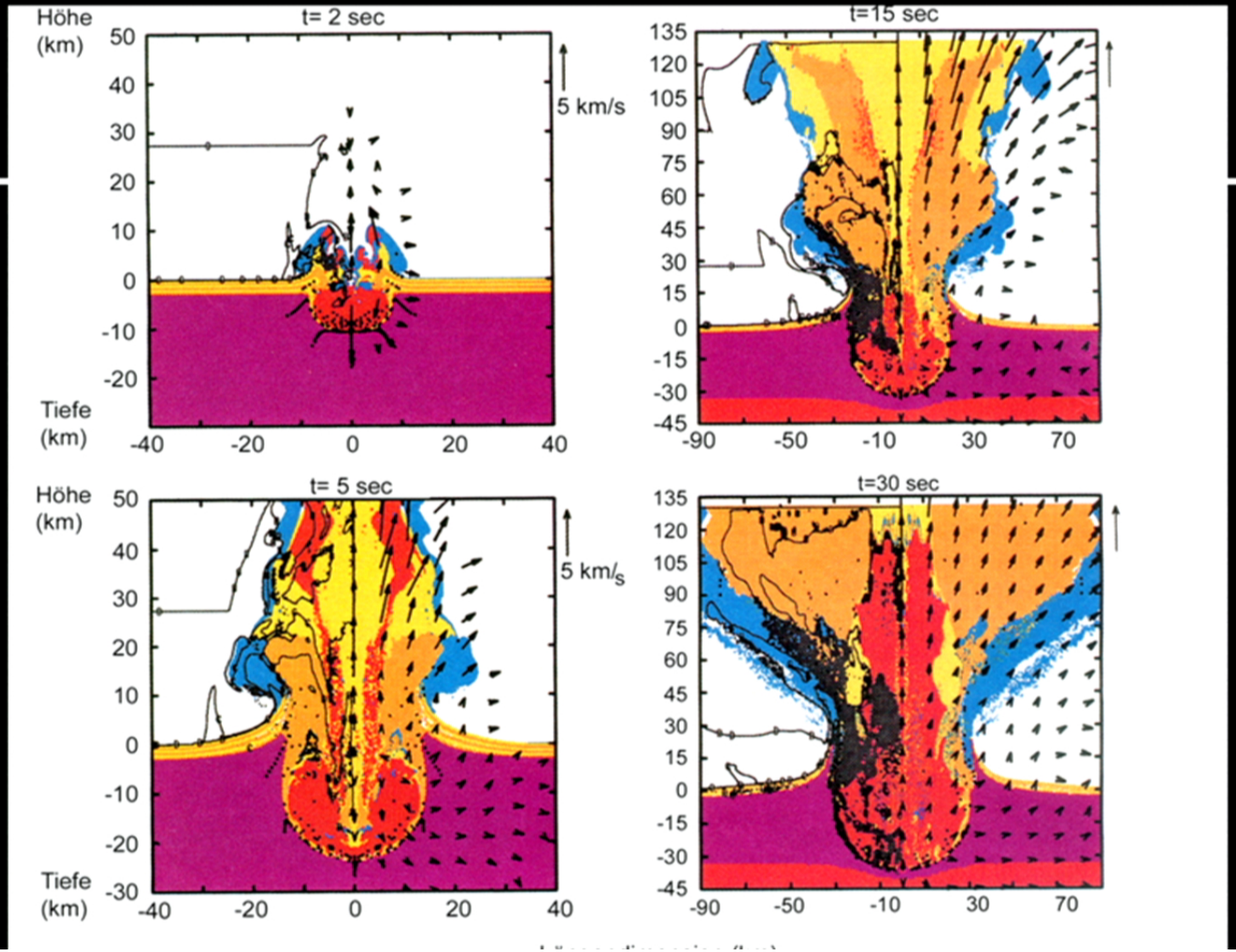
22.25: *The effects of the late Cretaceous mass extinctions. Animals and plants that became extinct are uncoloured, whereas groups that survived the mass extinction are coloured. The extinct groups include the reptiles (1)* Plesiosaurus, *(2)* Mosasaurus, *(3)* Deinonychus, *(4)* Tyrannosaurus, *(5)* Edmontosaurus, *(6)* Brachiosaurus, *(7)* Triceratops, *(8)* Pteranodon*; other animals such as (9) ammonites, (10) some types of sea-urchin and (11) peculiar molluscs known as rudists, and plants such as the* Bennetiales.

Chicxulub impact

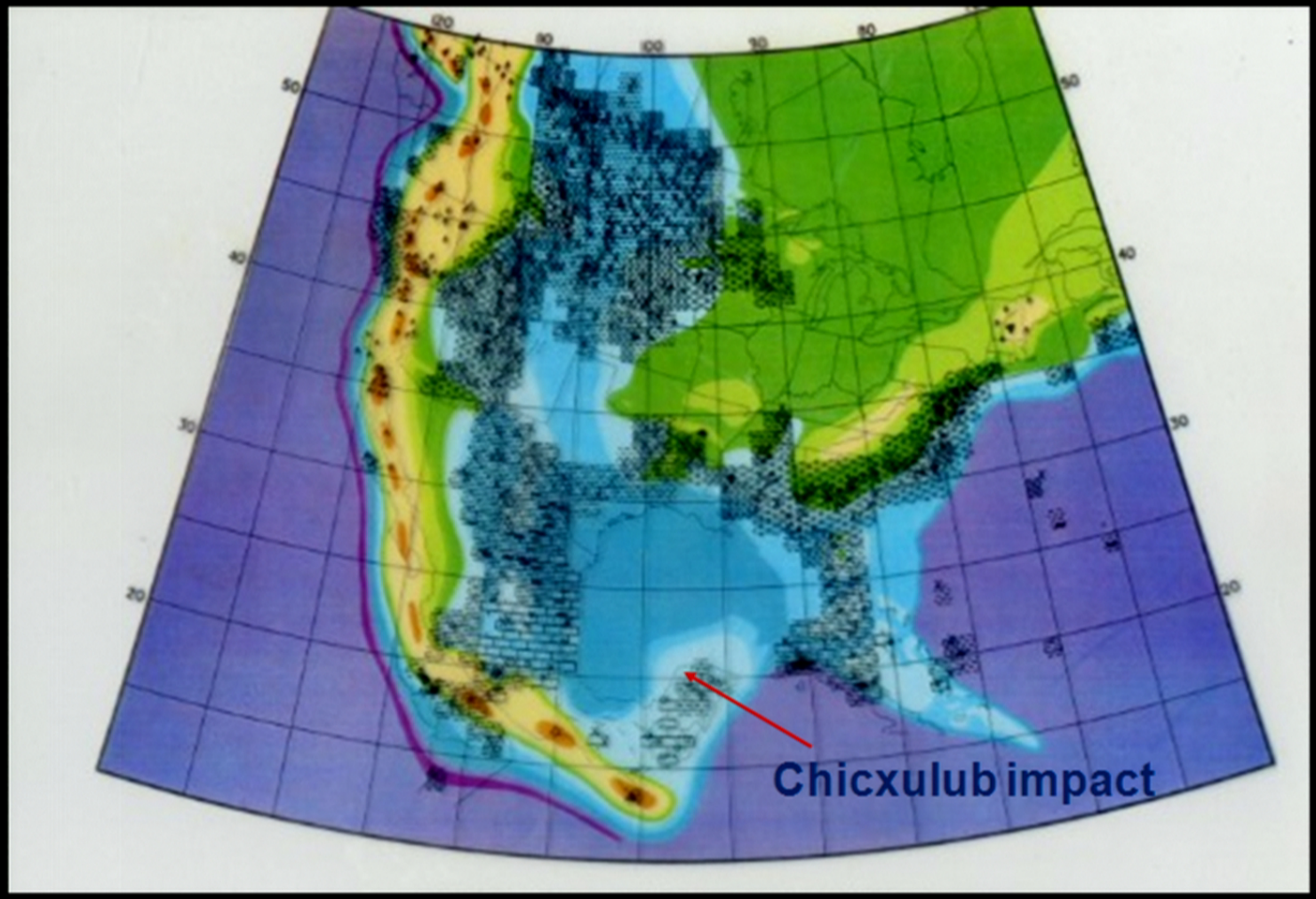
Marine sedimentary record of Chicxulub ejecta Atlantic Ocean



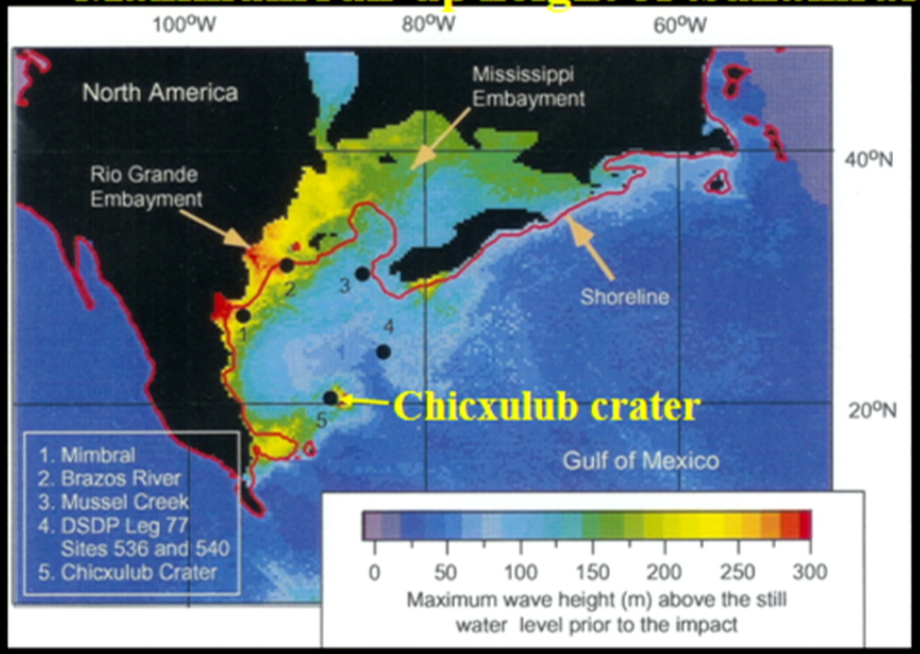

Mammals and birds in the Paleogene period


Höhe
(km)
t= 2 sec
5 km/s
Tiefe
(km)
t=15 sec
t= 5 sec
5 km/s
Tiefe
(km)
t=30 sec

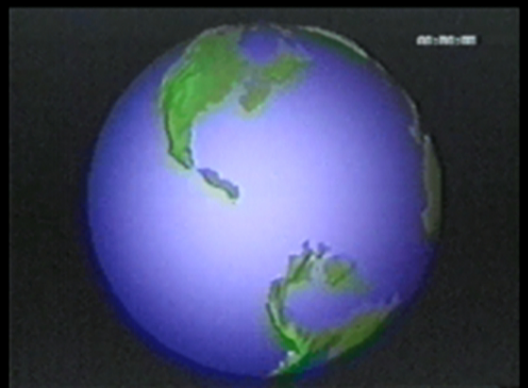
North America in the Late Cretaceous

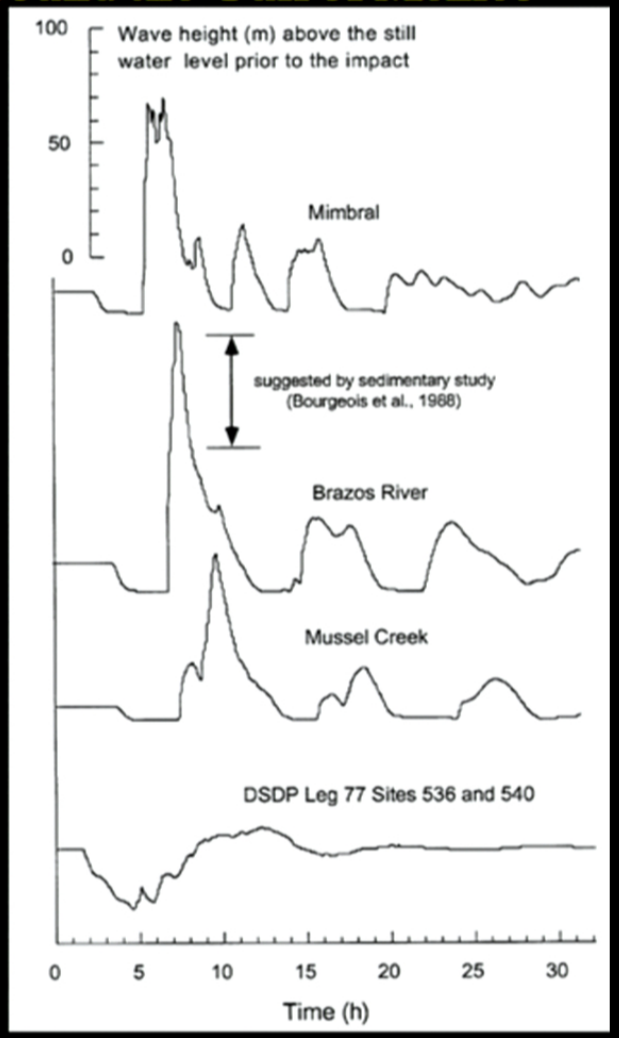


Maximum run-up height of tsunami around the Gulf of Mexico



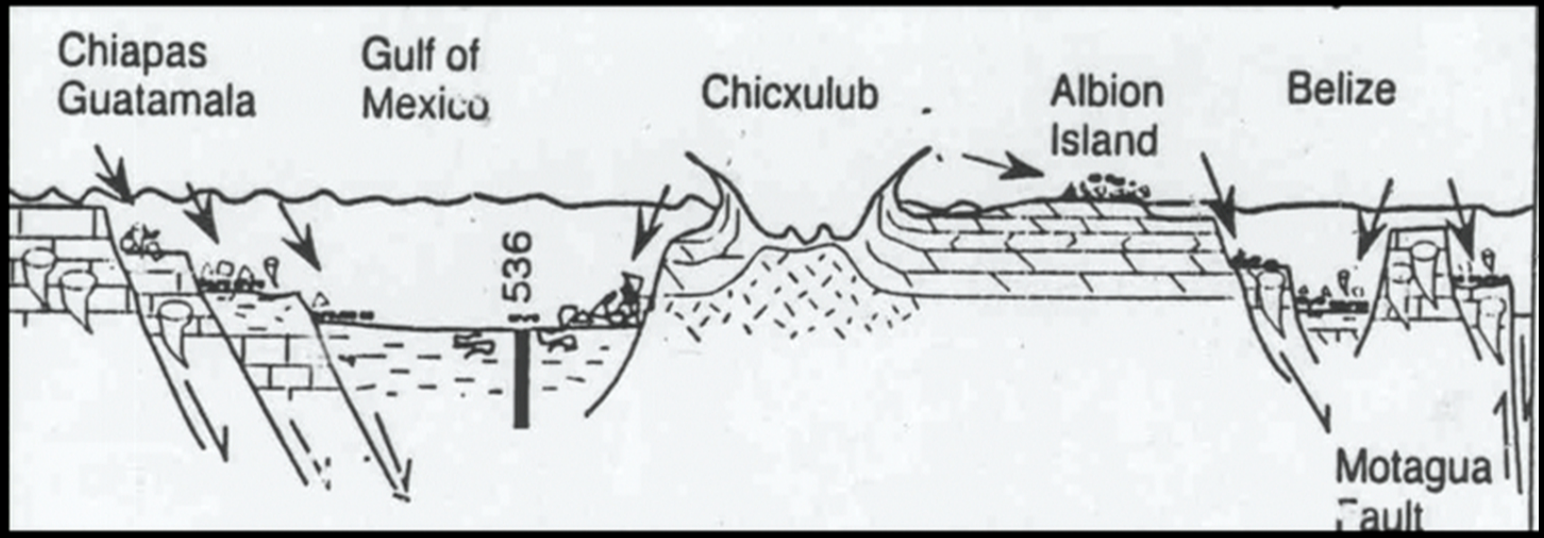
Maximum period: 10 hours , Maximum run up height: 300 m





By *Matsui et al. (2002)*

Regional deformation effects in Gulf of Mexico Caribbean Sea
Collapse of carbonate platform
Margin collapse breccias
Tsunami and gravity flow deposits



Earthquake magnitude M > 13-15

Oil reservoirs in impact breccias - Sonda de Campeche Cantarell

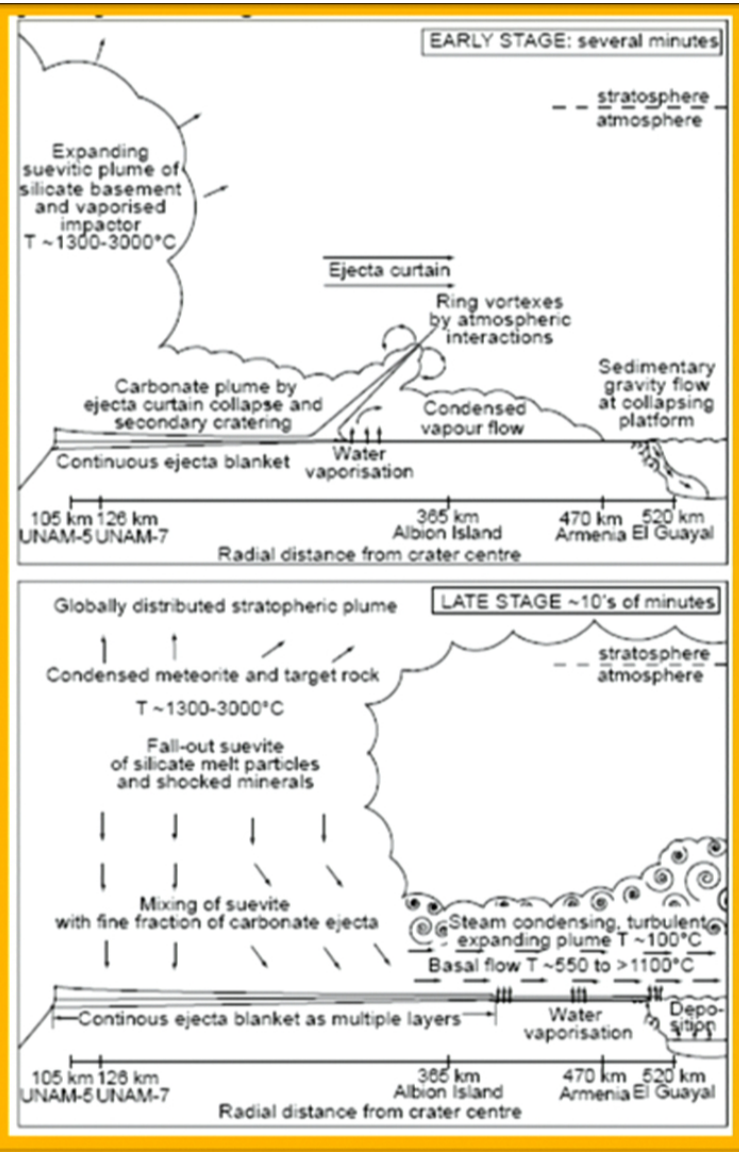
Chicxulub Crater Ejecta Emplacement

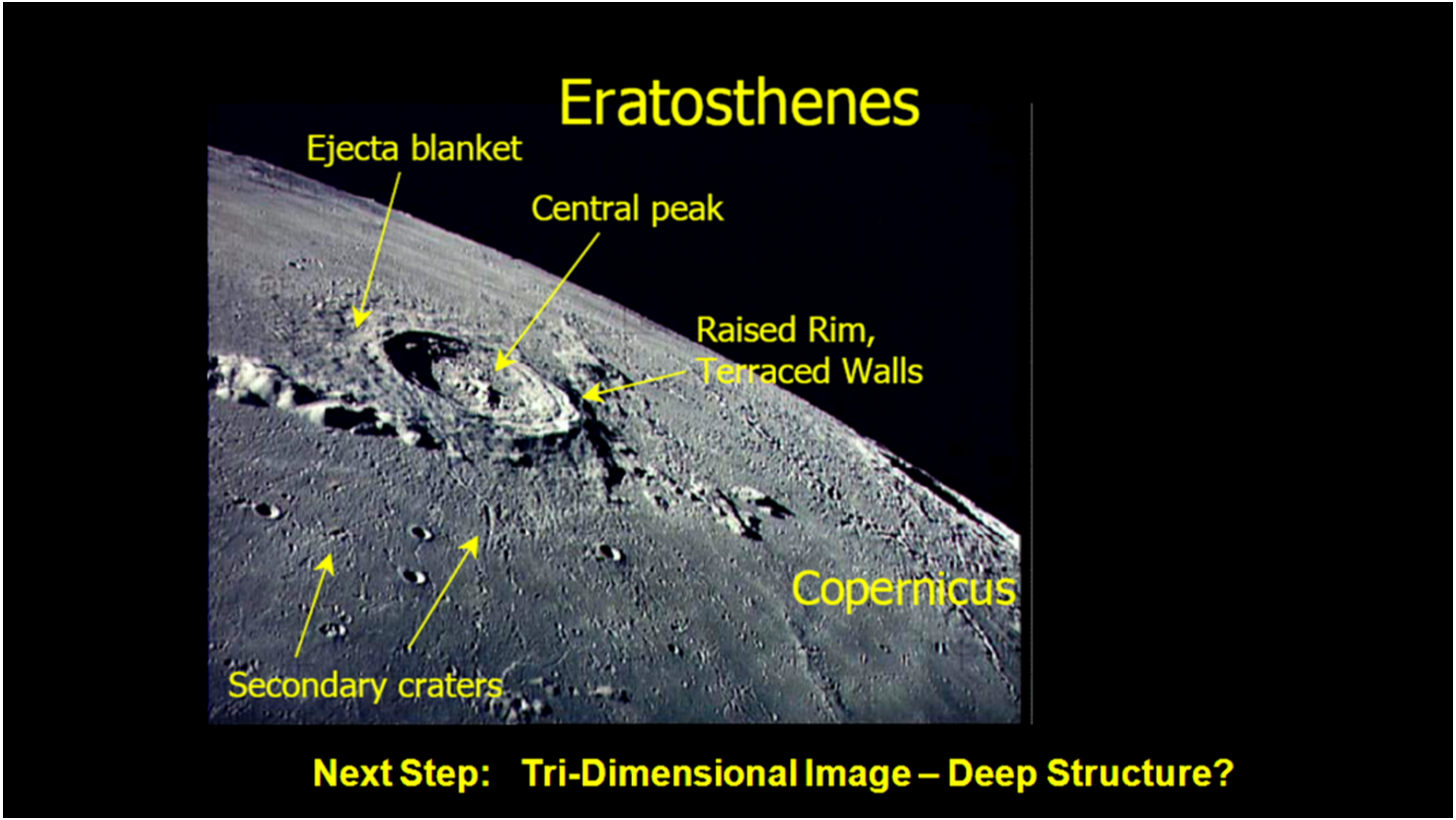
Column Plume Collapse
Eject Curtain
Basal Flows

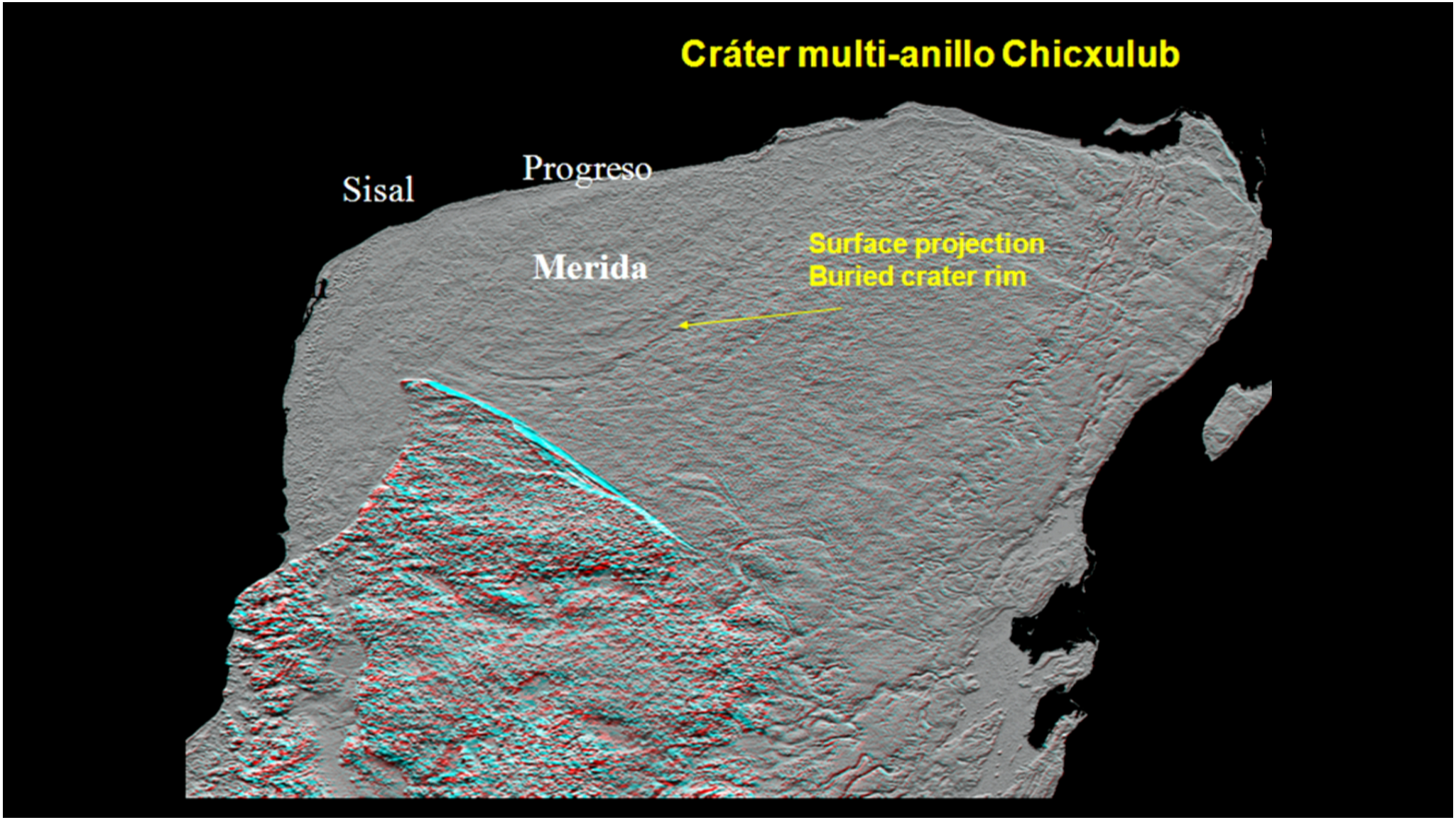
Ballistic ejecta

Crater filling
Proximal ejecta
Eecta blanket

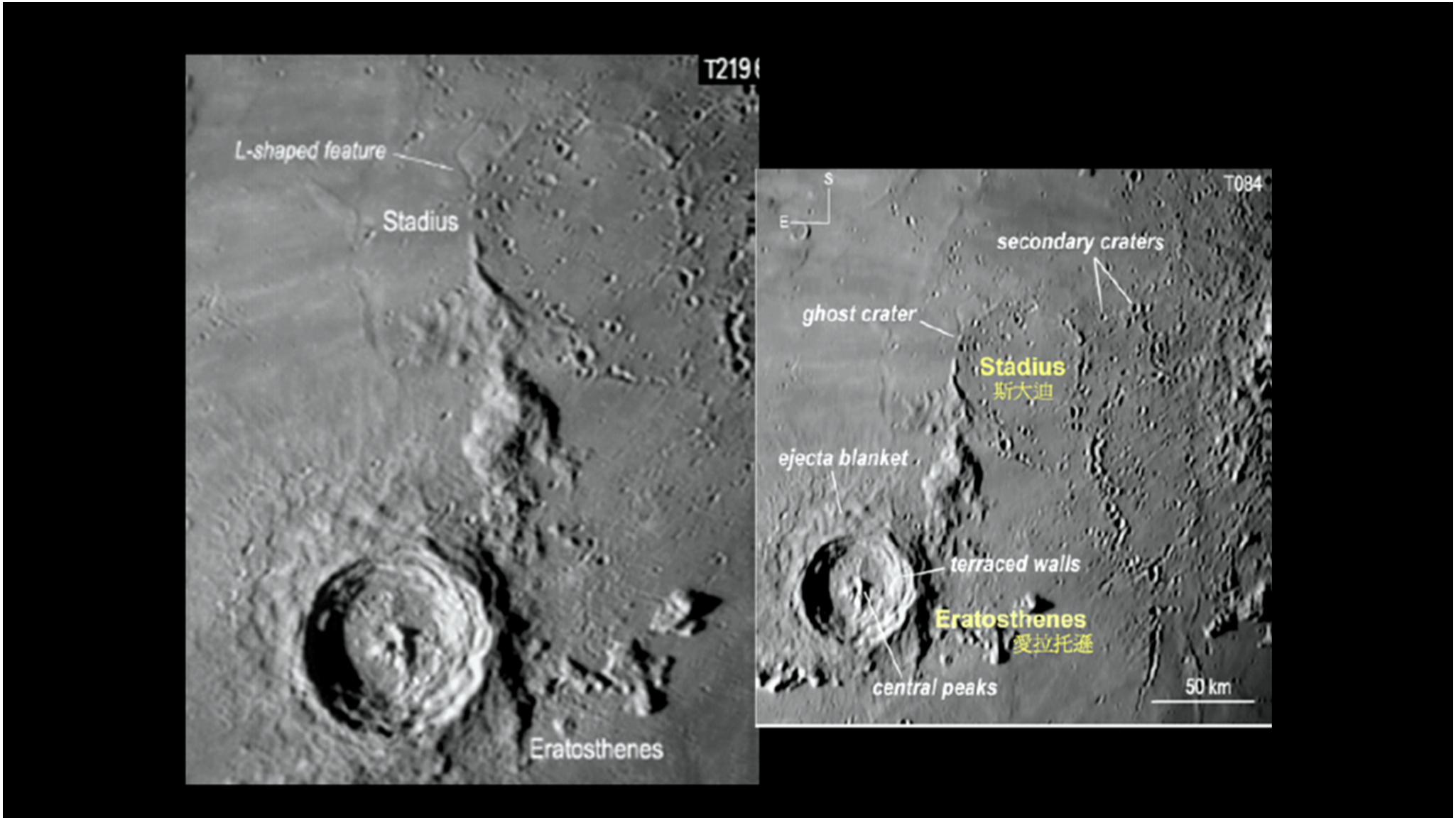
Secondary Cratering
Secondary gravity and
Platform collapses

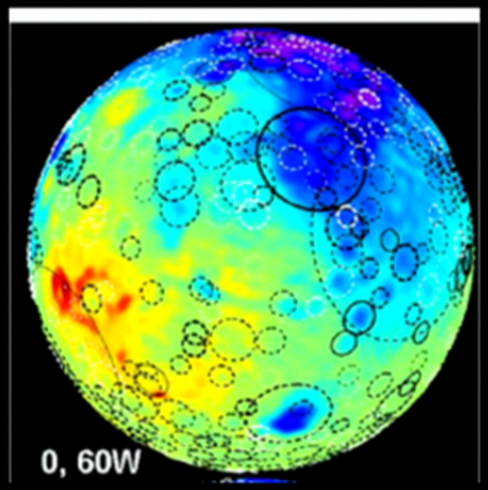


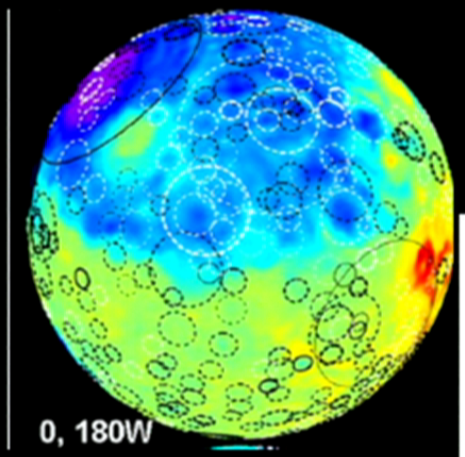

Eratosthenes
Ejecta blanket
Central peak
Raised Rim,
Terraced Walls
Copernicus
Secondary craters
Next Step: Tri-Dimensional Image – Deep Structure?

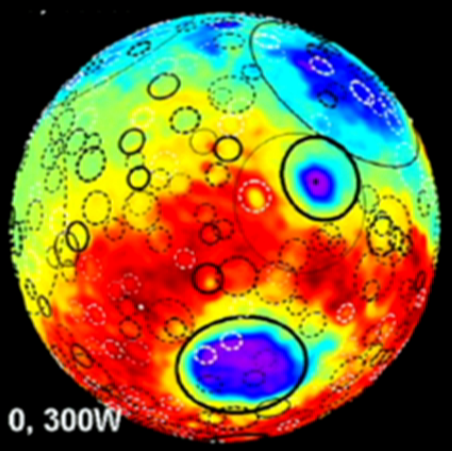

Cráter multi-anillo Chicxulub
Sisal
Progreso
Merida
Surface projection
Buried crater rim


Janssen, Fabricius, Vallis Rheita, Mare Australe
Hatfield 16
Janssen
S
W
N
T228


T219
L-shaped feature
Stadius
Eratosthenes
S
E
T084
secondary craters
ghost crater
Stadius
斯大迪
ejecta blanket
terraced walls
Eratosthenes
愛拉托遜
central peaks
50 km







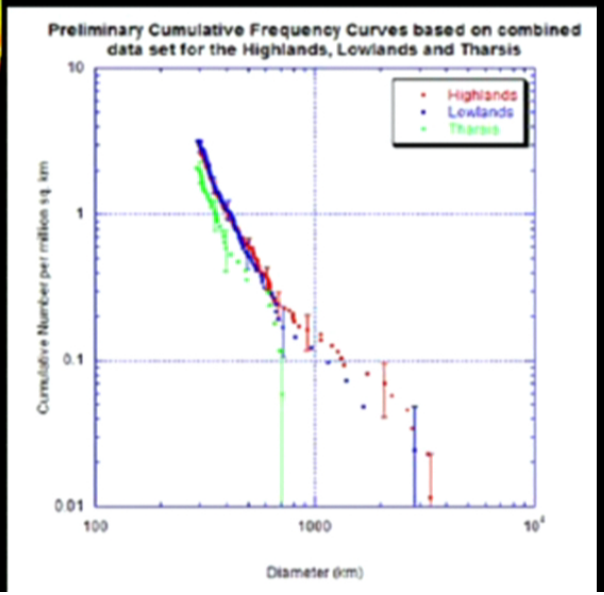
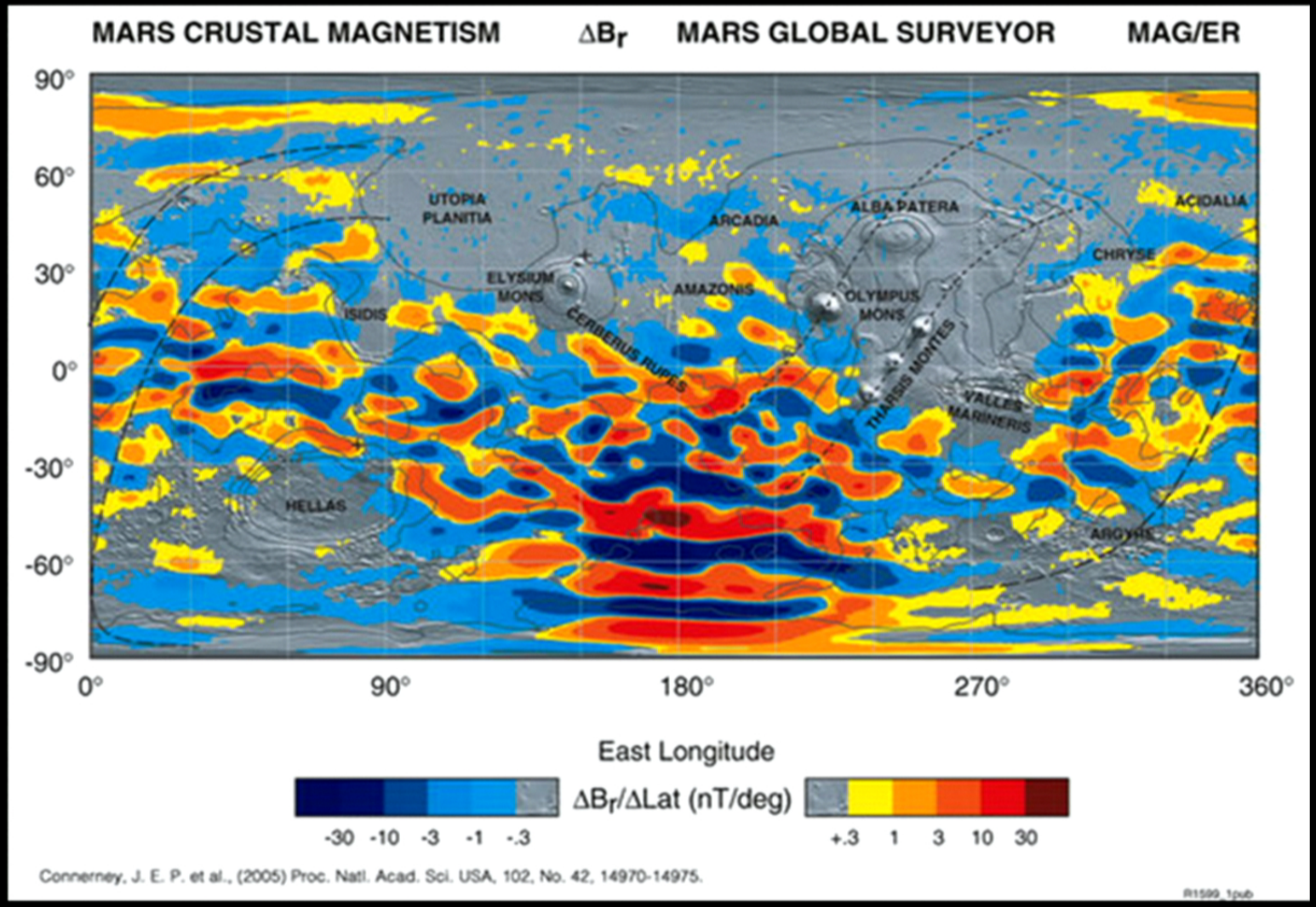
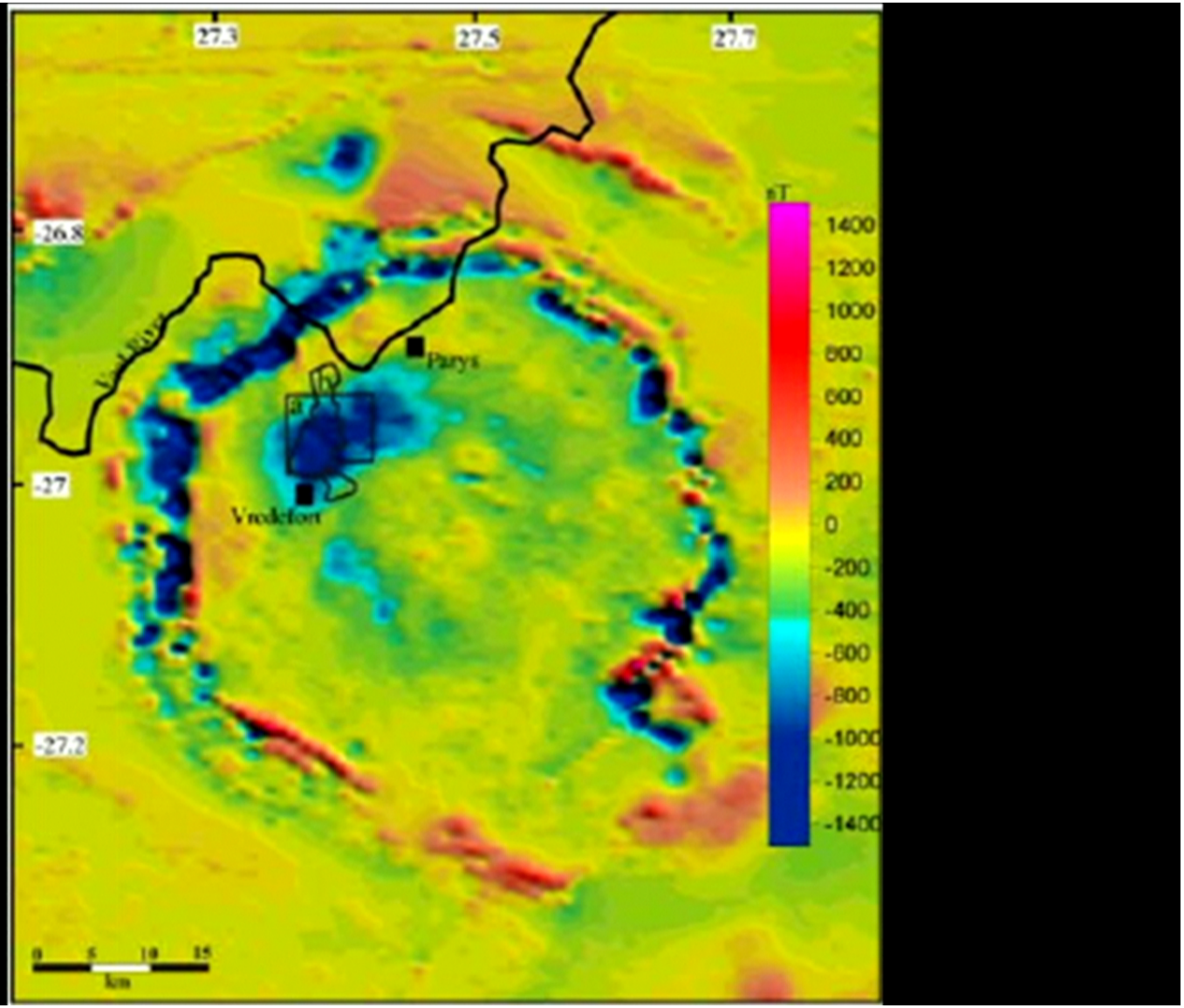
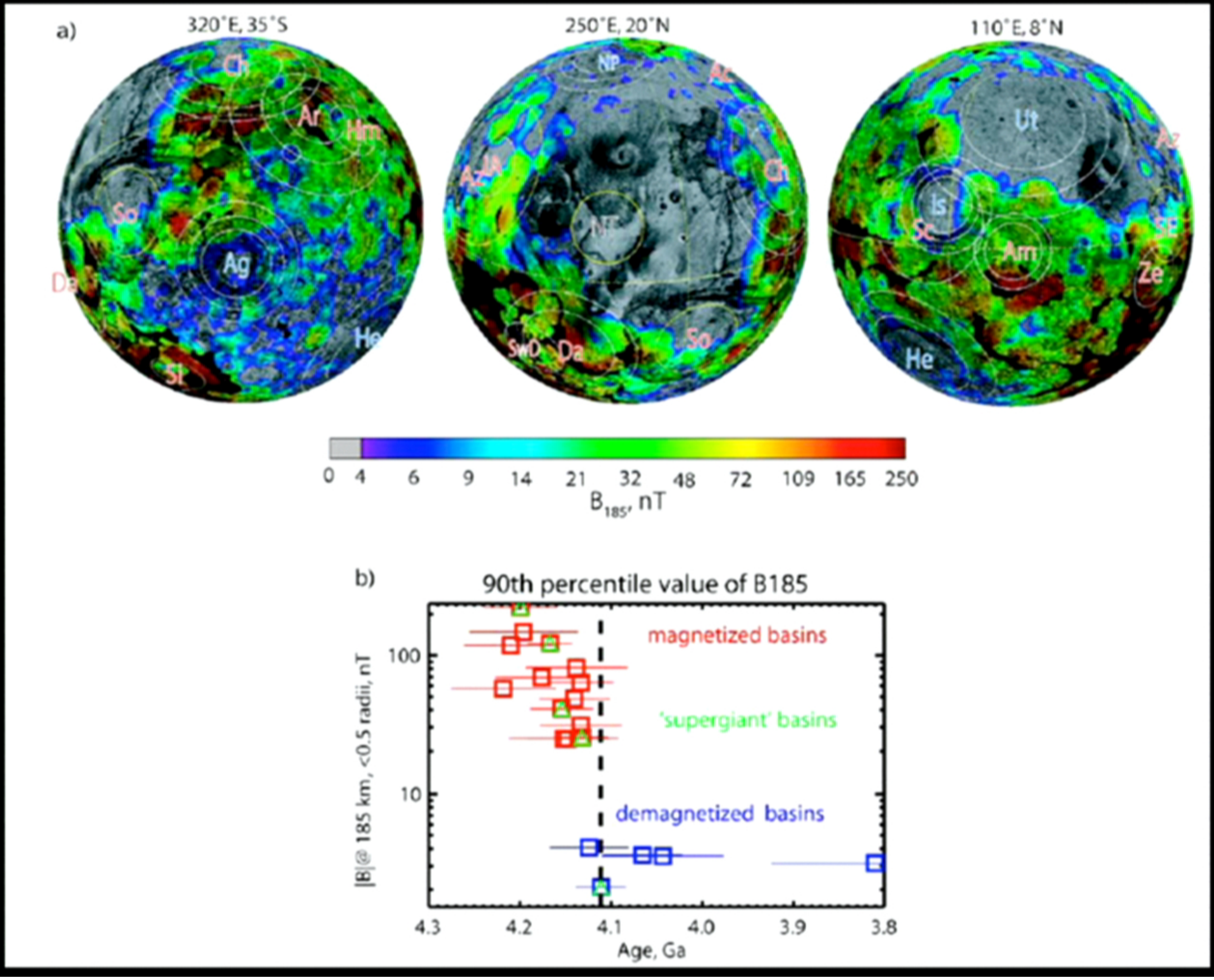


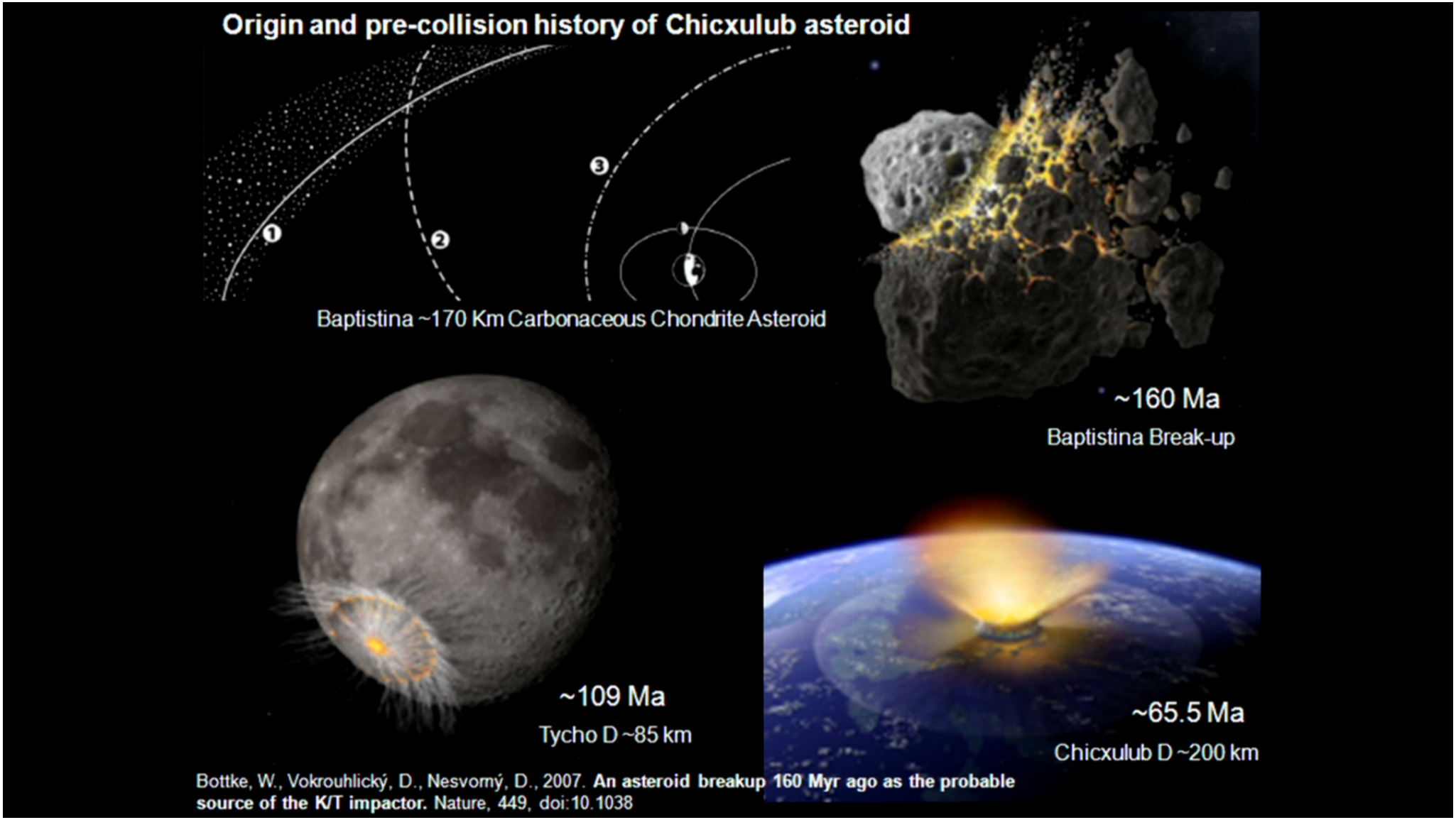
Figure 3. Global distribution of likely impact basins >300 km, plotted on crustal thickness. Equatorial views are shown at three different longitudes. Visible impact basins are plotted as solid rings, buried basins as dashed rings. QCDs identified in topography are plotted as black rings, while white rings represent CTAs with no corresponding QCD (new basins uncovered using the crustal thickness model). Red, regions of thicker crust. Blue, regions of thinner crust. Note the larger percentage of non-QCD CTAs in the lowlands compared to the highlands.


MARS CRUSTAL MAGNETISM
ΔBr
MARS GLOBAL SURVEYOR
MAG/ER
90°
60°
30°
0°
-30°
-60°
-90°
0°
90°
180°
270°
360°
UTOPIA PLANITIA
ARCADIA
ALBA PATERA
ACIDALIA
CHRYSE
ELYSIUM MONS
AMAZONIS
OLYMPUS MONS
ISIDIS
CERBERUS RUPES
THARSIS MONTES
VALLES MARINERIS
HELLAS
ARGYRE
East Longitude
ΔBr/ΔLat (nT/deg)
-30 -10 -3 -1 -.3
+.3 1 3 10 30
Connerney, J. E. P. et al., (2005) Proc. Natl. Acad. Sci. USA, 102, No. 42, 14970-14975.
R1599_1pub

Aeromagnetic anomaly Vredefort




a)
320°E, 35°S
250°E, 20°N
110°E, 8°N
0 4 6 9 14 21 32 48 72 109 165 250
B185, nT
b)
90th percentile value of B185
magnetized basins
'supergiant' basins
demagnetized basins
|B|@ 185 km, <0.5 radii, nT
Age, Ga


Origin and pre-collision history of Chicxulub asteroid
1
2
3
Baptistina ~170 Km Carbonaceous Chondrite Asteroid
~160 Ma
Baptistina Break-up
~109 Ma
Tycho D ~85 km
~65.5 Ma
Chicxulub D ~200 km
Bottke, W., Vokrouhlický, D., Nesvorný, D., 2007. An asteroid breakup 160 Myr ago as the probable source of the K/T impactor. Nature, 449, doi:10.1038

Thanks
Muchas gracias