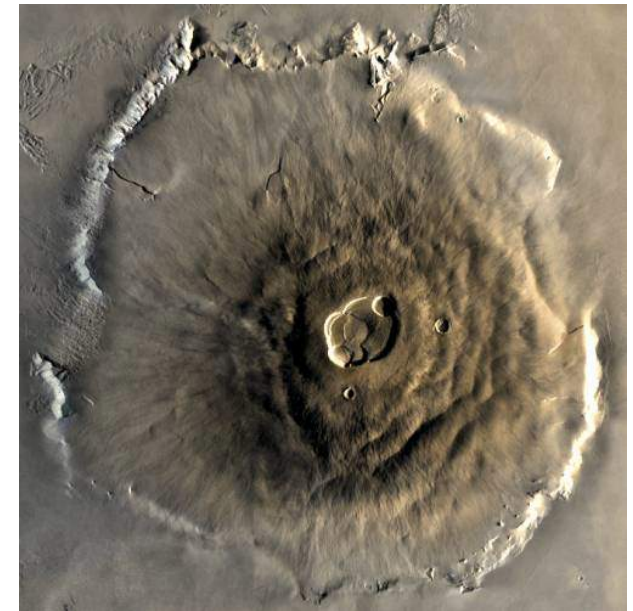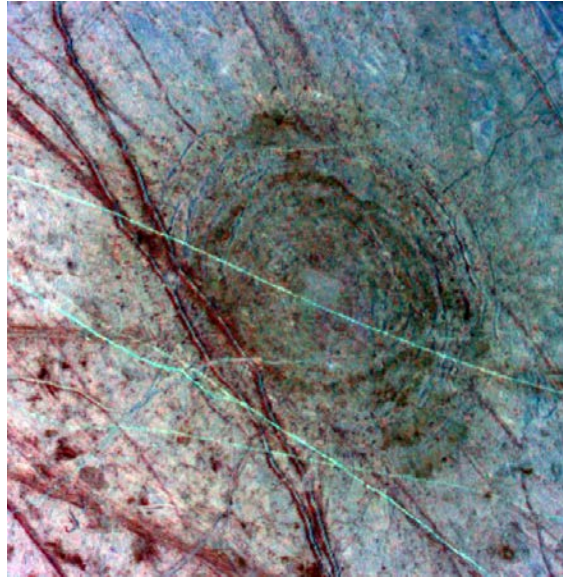# Planetary Surface Processes

Cratering
Gravity
Tectonics
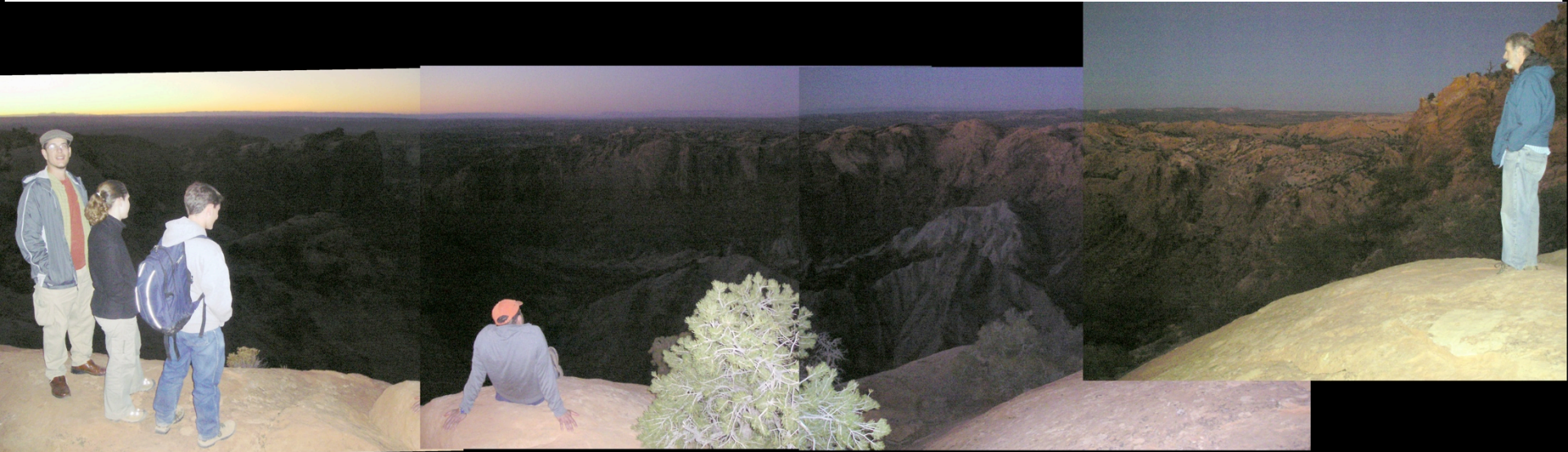Volcanism
Winds
Fluvial
Glacial
Chemical
weathering

Meteor (Barringer) Crater, AZ

Upheaval Dome, UT

Upheaval Dome, UT

Clearwater Lakes, Quebec

Simple craters

Contact and compression stage

- Most of projectile's energy, momentum transferred to target rocks

- $t_{cc} \approx 2R/v_i$

- Rankine-Hugoniot equations can be solved for pressure

- At few km/s, energy per unit mass ≈ that of TNT

Recreating the Moon on Earth
Cinder Lakes, Flagstaff, Arizona

USGS   http://astrogeology.usgs.gov

Cinder Lake Crater Field, AZ

The Sedan Test -- Plowshare Program

July 6, 1962

A thermonuclear device was lowered into the desert alluvium to a depth of 194m in Yucca Flat, NV.

The fusion-fission blast had a yield equivalent to 104 kilotons of TNT, and lifted a dome of earth 90m above the desert floor before it vented at 3s after detonation.
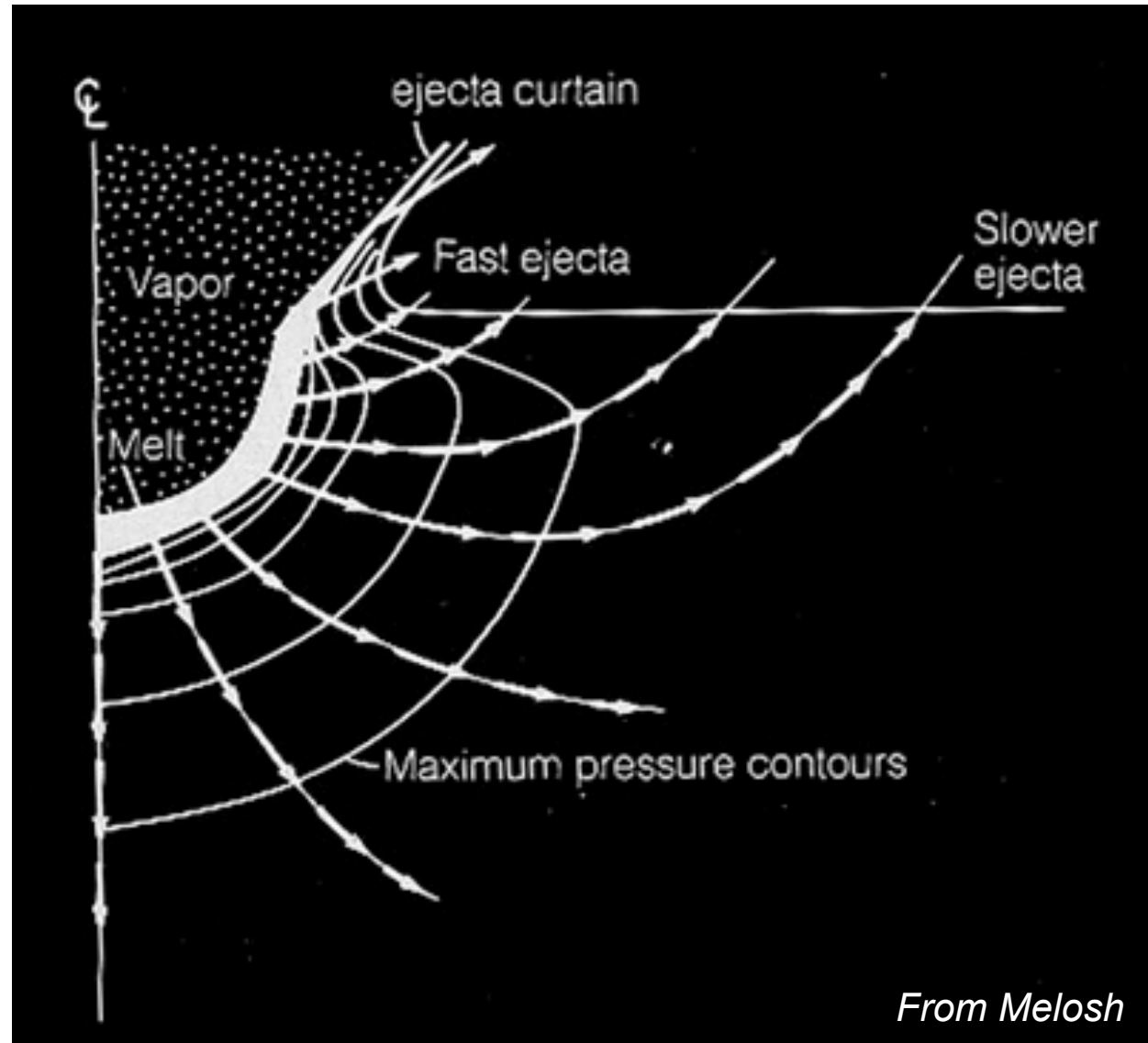
The explosion displaced more than 11,000,000 tons of soil, and the resulting crater is 100m deep with a diameter of about 390m. A circular area of the desert floor five miles across was obscured by fast-expanding dust clouds moving out horizontally from the base surge, similar to a pyroclastic surge. The blast caused seismic waves equivalent to an earthquake of 4.75 on the Richter scale.

Fact check from http://www.nv.doe.gov/

The Sedan Test

Ejection/excavation stage

- *Rarefraction wave vaporizes/melts/ fractures rocks*

- $t_{cf} \approx (D/g_p)^{1/2}$

  ~10 s for Meteor crater

  ~13 min for Mare Imbrium

ejecta curtain

Slower ejecta

Vapor

Fast ejecta

Melt

Maximum pressure contours

From Melosh

Collapse/modification stage

- Steep rim of *transient crater* collapses into interior
- $t \approx$ few x $(D/g_p)^{1/2}$
- Final depth $d \approx 0.2D$
- Rim height $h \approx 0.04D$
- Diameter $D \approx 20R$

FOLD

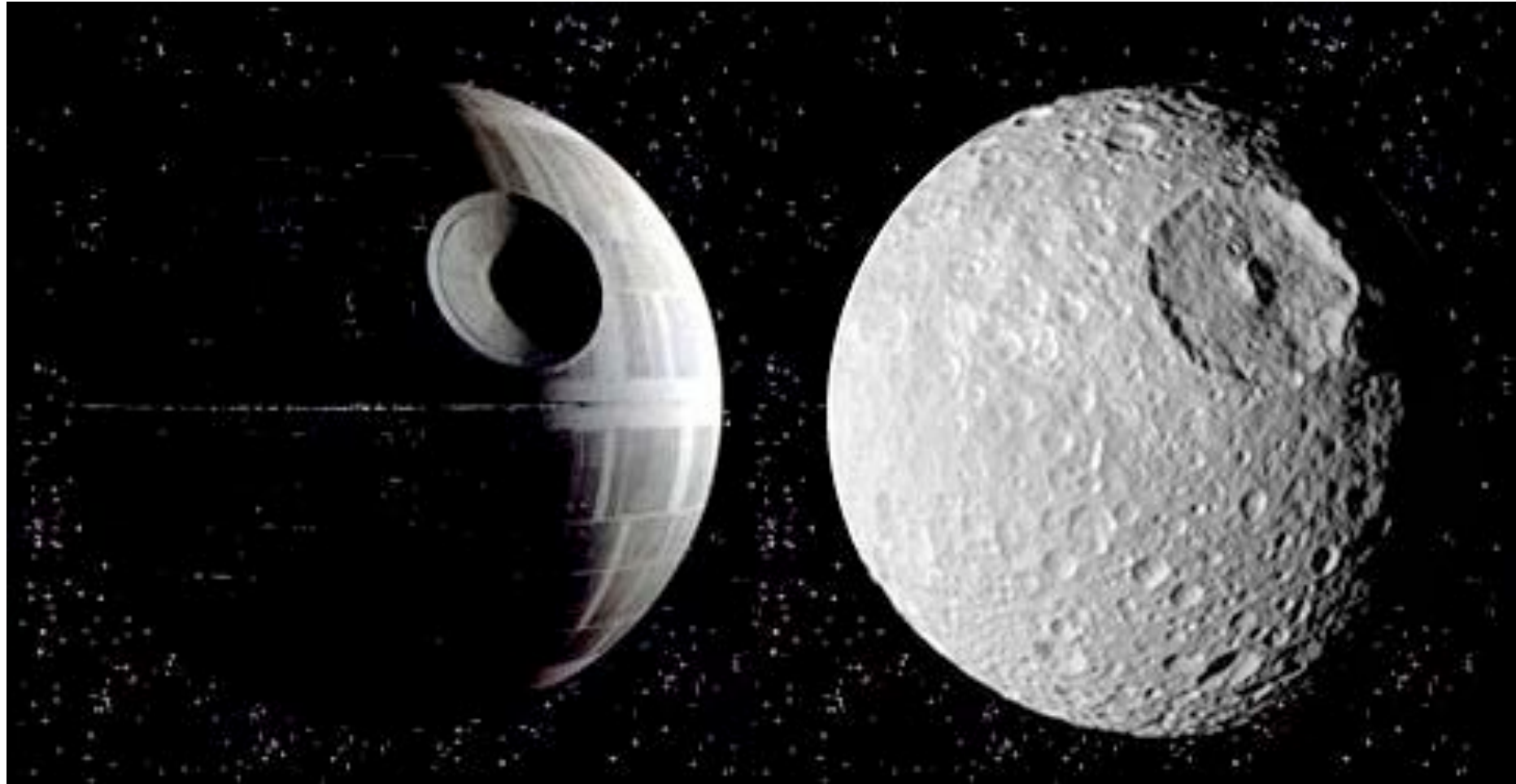PRE-IMPACT HORIZONTAL SURFACE
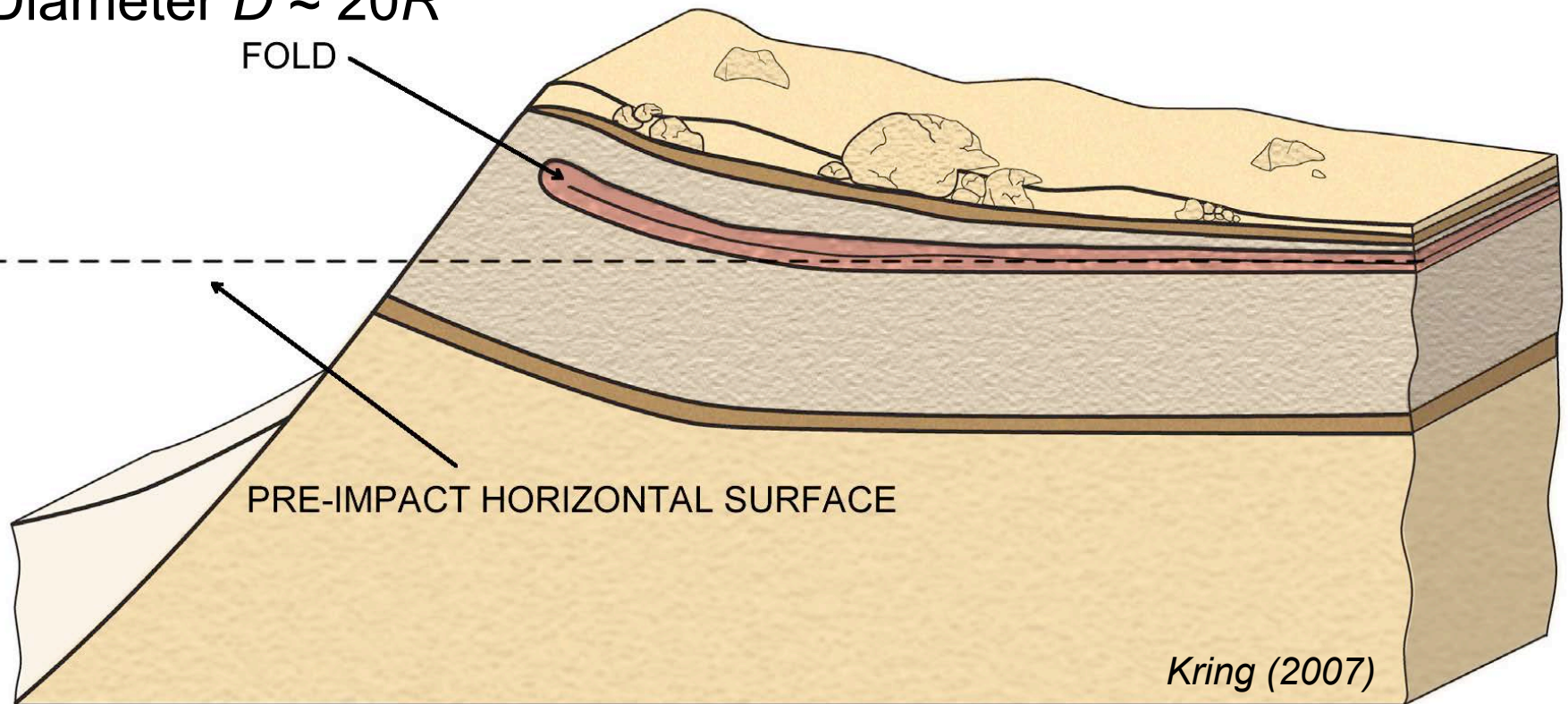
Kring (2007)

Victoria Crater as viewed by Opportunity

Impact Breccia

Fractured In Place

Bedrock

Pre-Impact Surface

2.3 m
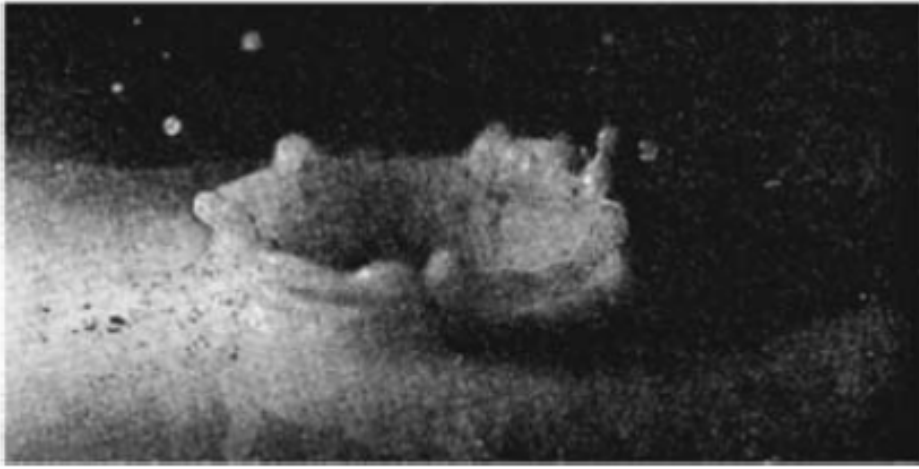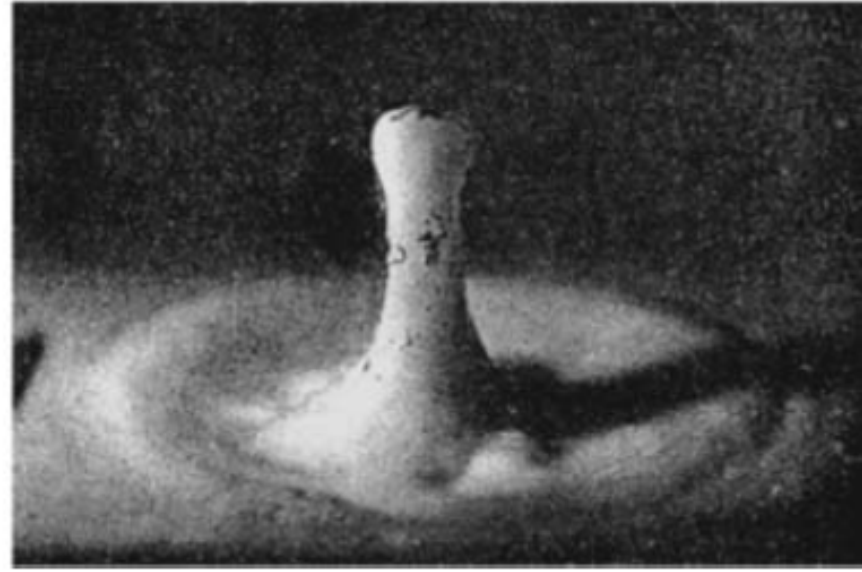
Squyres et al. (2009)

Complex craters

Simple vs. complex craters

Worthington (1908)

Simple vs. complex craters

$SU \approx 0.1D$

Ejecta

Crater-fill deposits (impact melt rocks and/or impact breccias)

D = Final crater (rim-to-rim) diameter
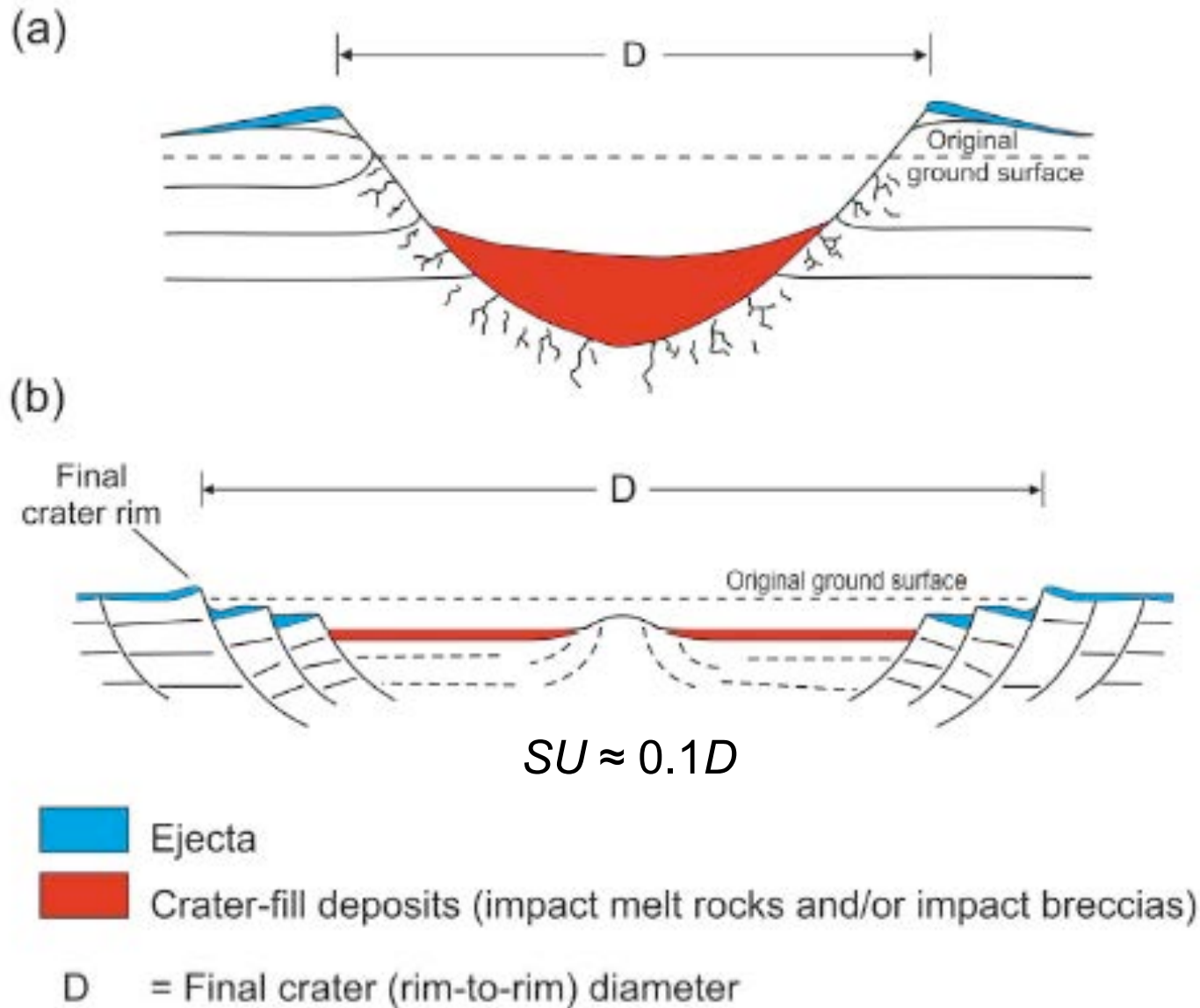
Simple vs. complex craters
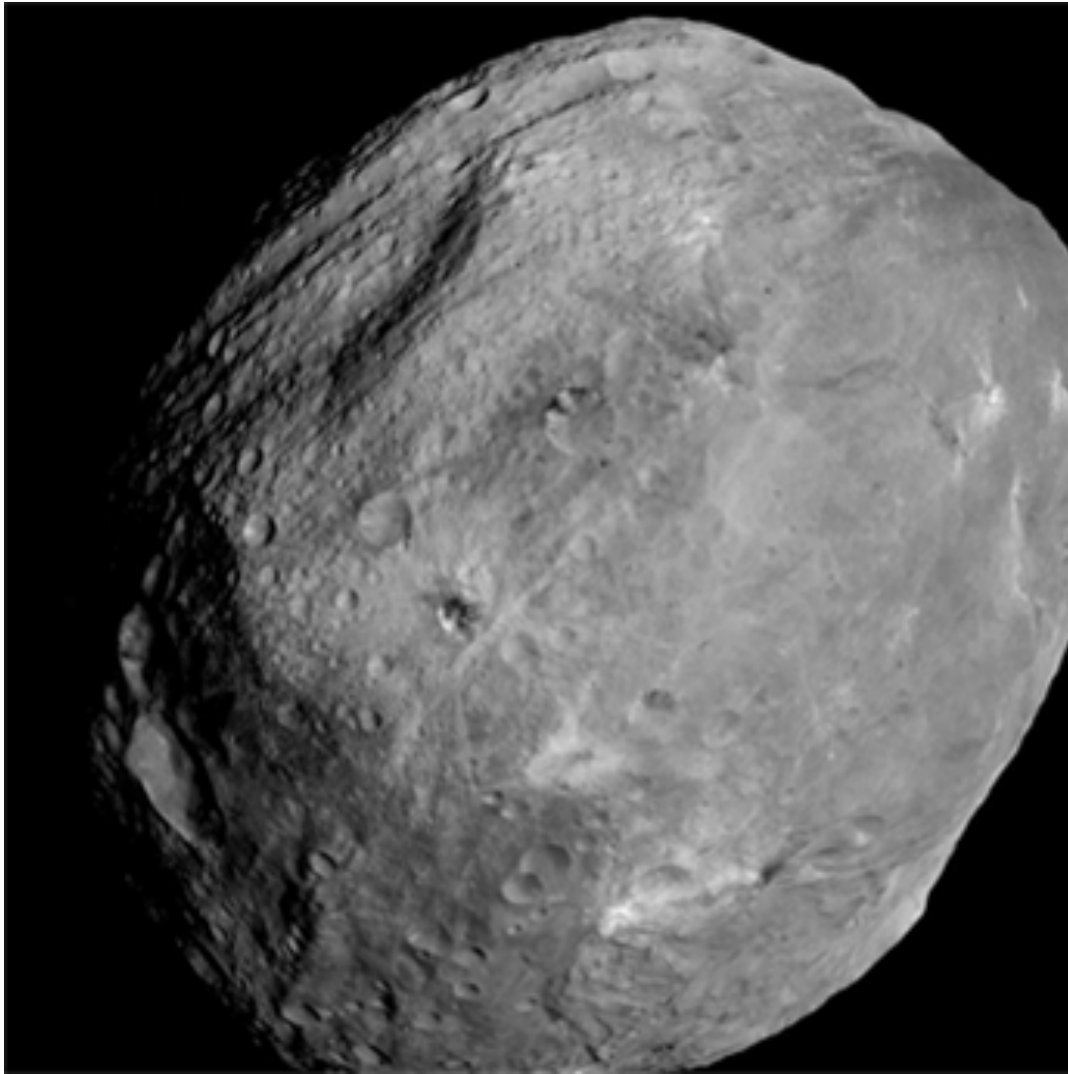

Kring (2006)

a) Gale Crater

50 km

N

-4500 m 1500 m
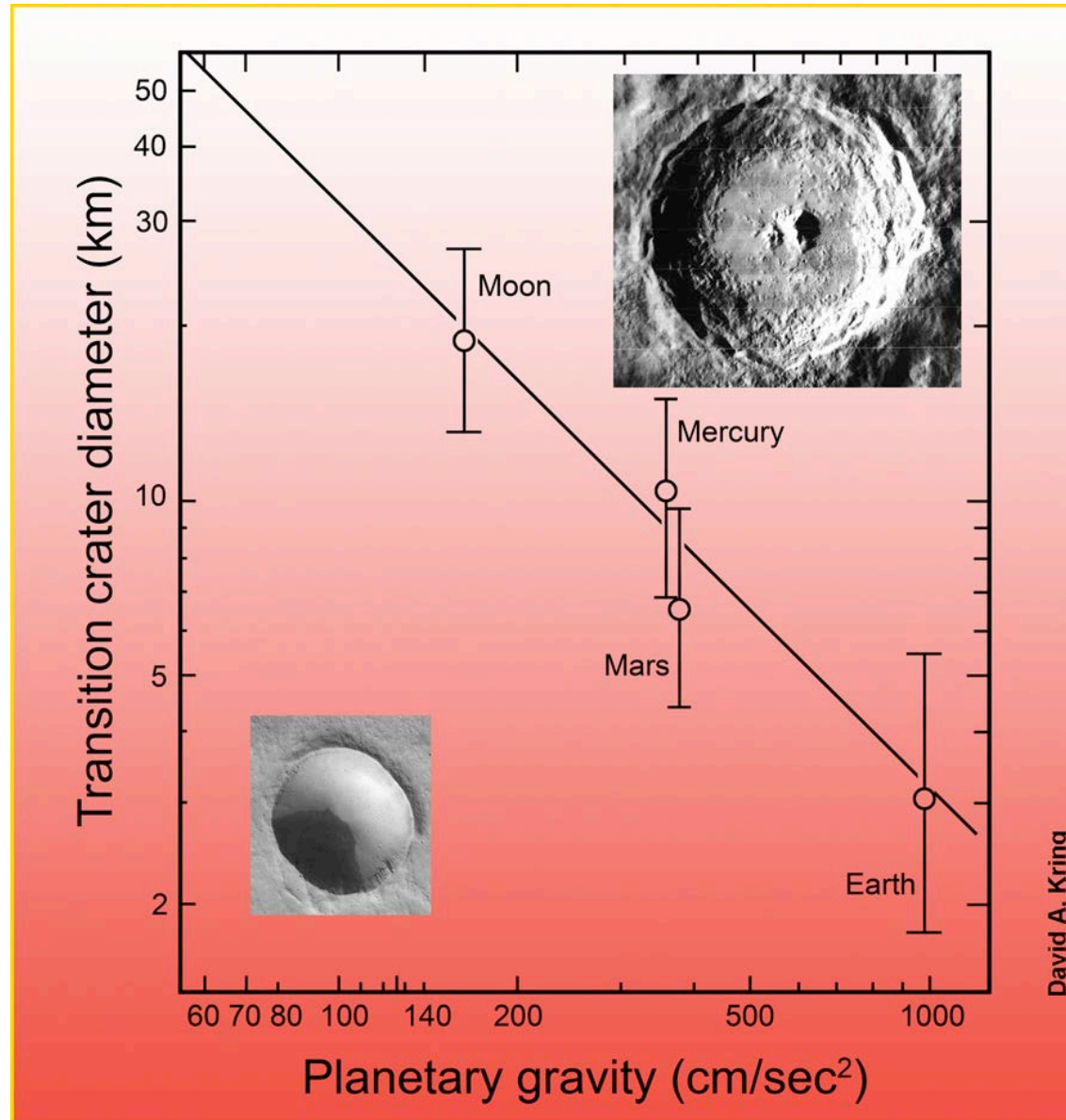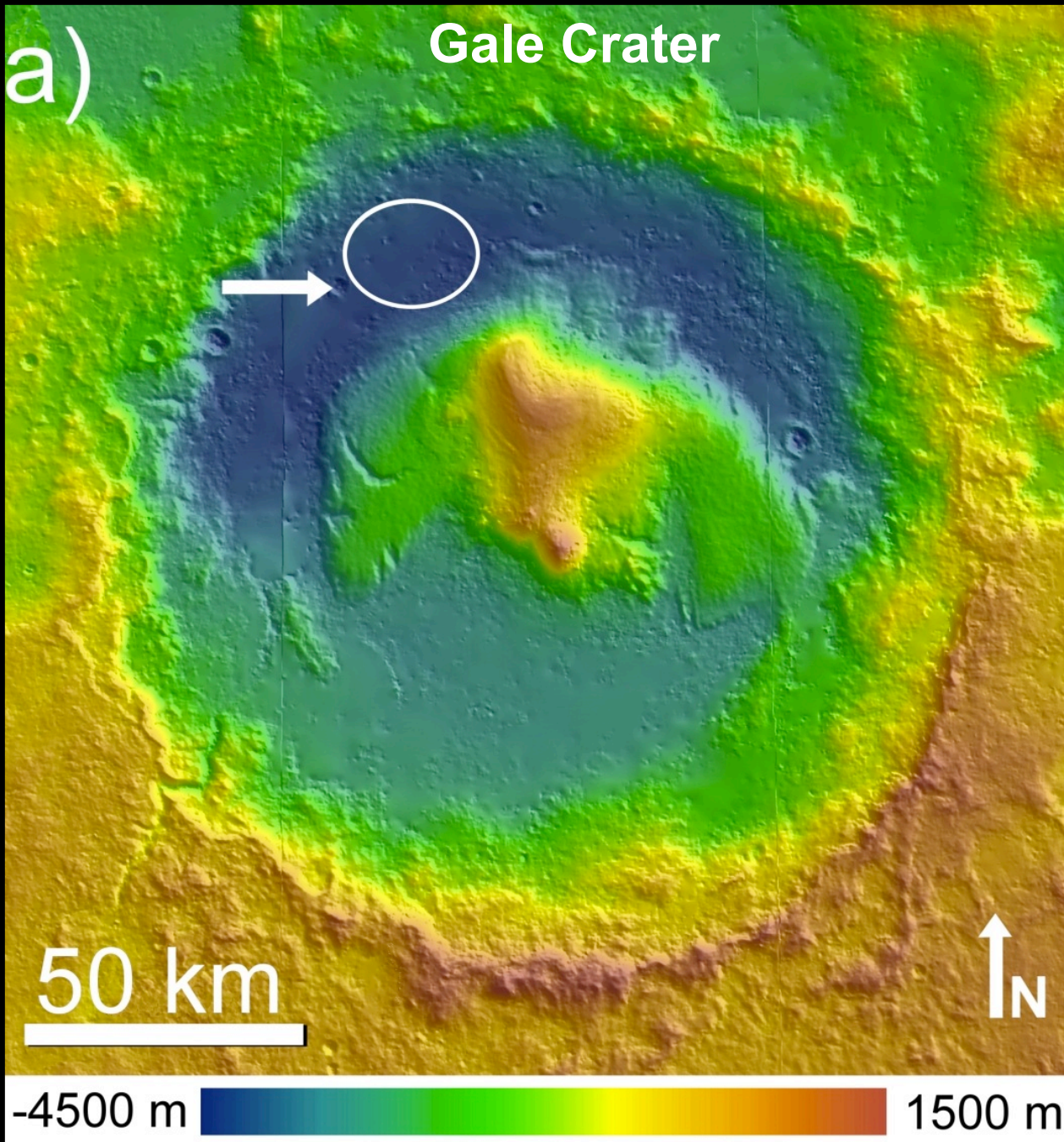
Central uplifts should be shorter than crater rims…

$h_{cp} \approx 0.1d$ (Mars)
[Garvin et al., 2003]

Vesta

July 24, 2011

For $D \sim R_p$, normal rules do not apply…