Planetary Surface Processes

- Cratering
- Gravity
- Tectonics
- Volcanism
- Winds
- Fluvial
- Glacial
- Chemical weathering
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 \( \approx \) that of TNT
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

From Melosh
Collapse/Modification Stage

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

*Kring (2007)*
Victoria Crater as viewed by Opportunity

Squyres et al. (2009)
Complex craters
Simple vs. complex craters

Worthington (1908)
Simple vs. complex craters

(a)

Size Unit (SU) ≈ 0.1D

(b)

Final crater rim

Ejecta

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

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

Kring (2006)
Central uplifts should be shorter than crater rims...

\[ h_{cp} \approx 0.1d \text{ (Mars)} \]

[Garvin et al., 2003]
For $D \sim R_p$, normal rules do not apply...
Multi-ring basins

From Melosh
Multi-ring basins
Multi-ring basins
Crater ejecta

- Continuous and discontinuous ejecta
- Secondary crater chains
Ejecta rays
Marquette Island, Meridiani Planum
Layered / “fluidized” ejecta

Barlow (2010)
Atmospheric effects

- Can slow down / break up meteoroids, producing crater clusters
- Significant when displaced mass $\sigma_\rho A/\sin\theta \approx$ meteoroid’s mass
  - Likelihood of breakup $\sim \sigma_\rho / R \rho \sin\theta$
- No craters smaller than $\sim 3$ km on Venus! (Few $< 30$ km)
Central pit craters

Ganymede

Form on Mars, icy moons via:

1) target volatile vaporization?
2) collapse of weak icy crust?
3) excavation into liquid?
Other oddities

Very oblique impact? (<5°)

Binary asteroid?

Subsurface structure?