Iapetus' ridge,
the remnant of a global contraction event

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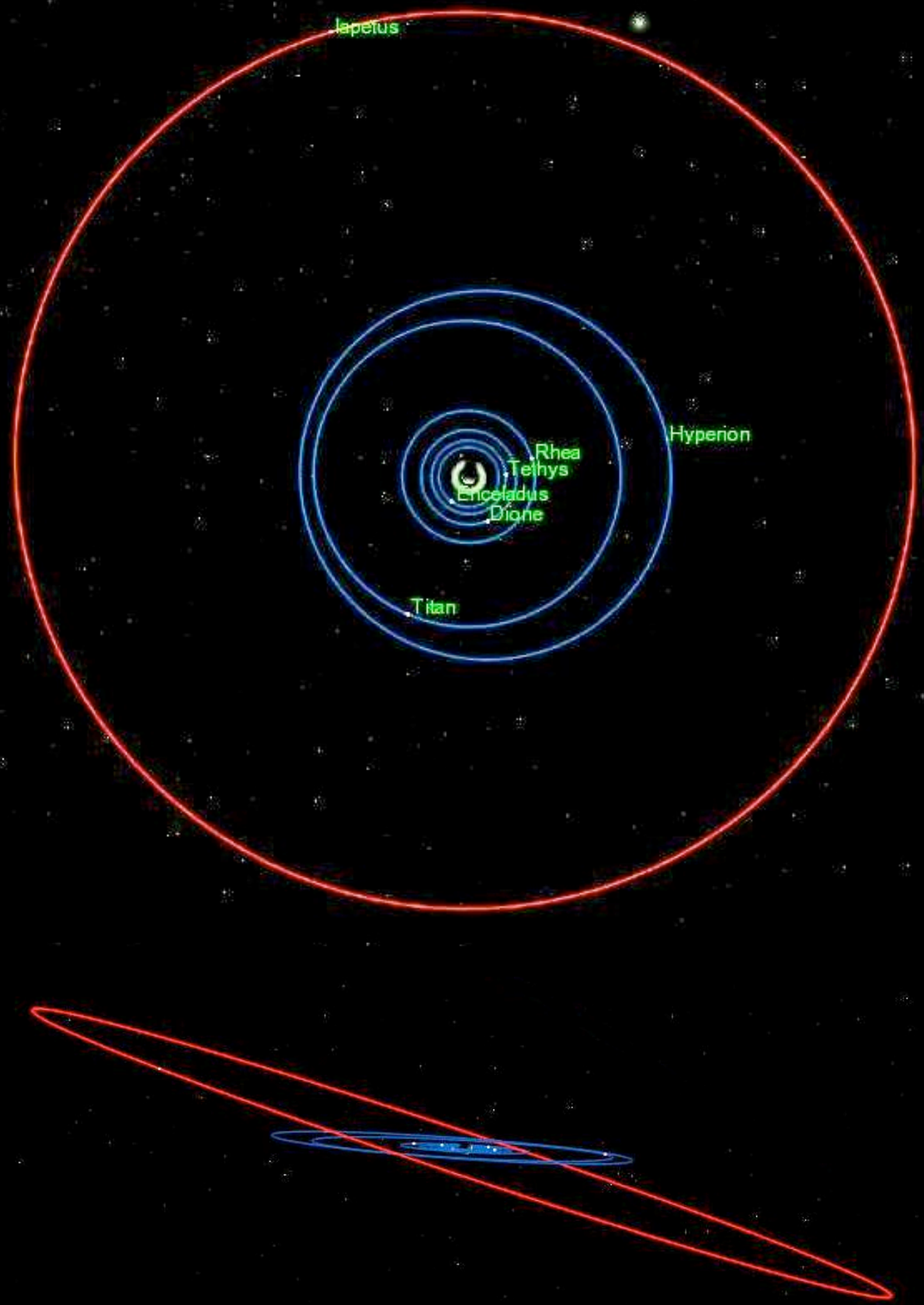
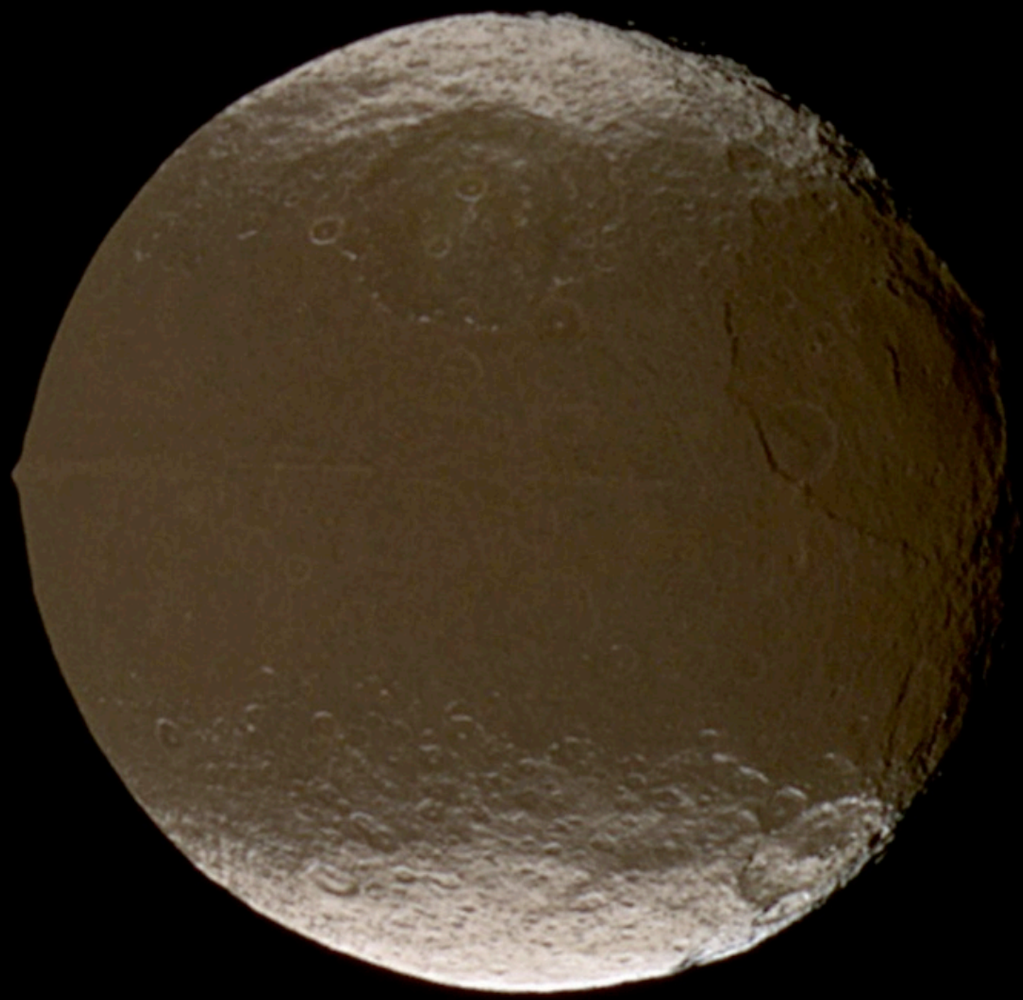
Cassini 2007 flyby of Iapetus
NASA/JPL/Space Science Institute


Iapetus
Hyperion
Rhea
Tethys
Enceladus
Dione
Titan

Mystery 1: Brightness dichotomy

Leading side: dark
Cassini 1705



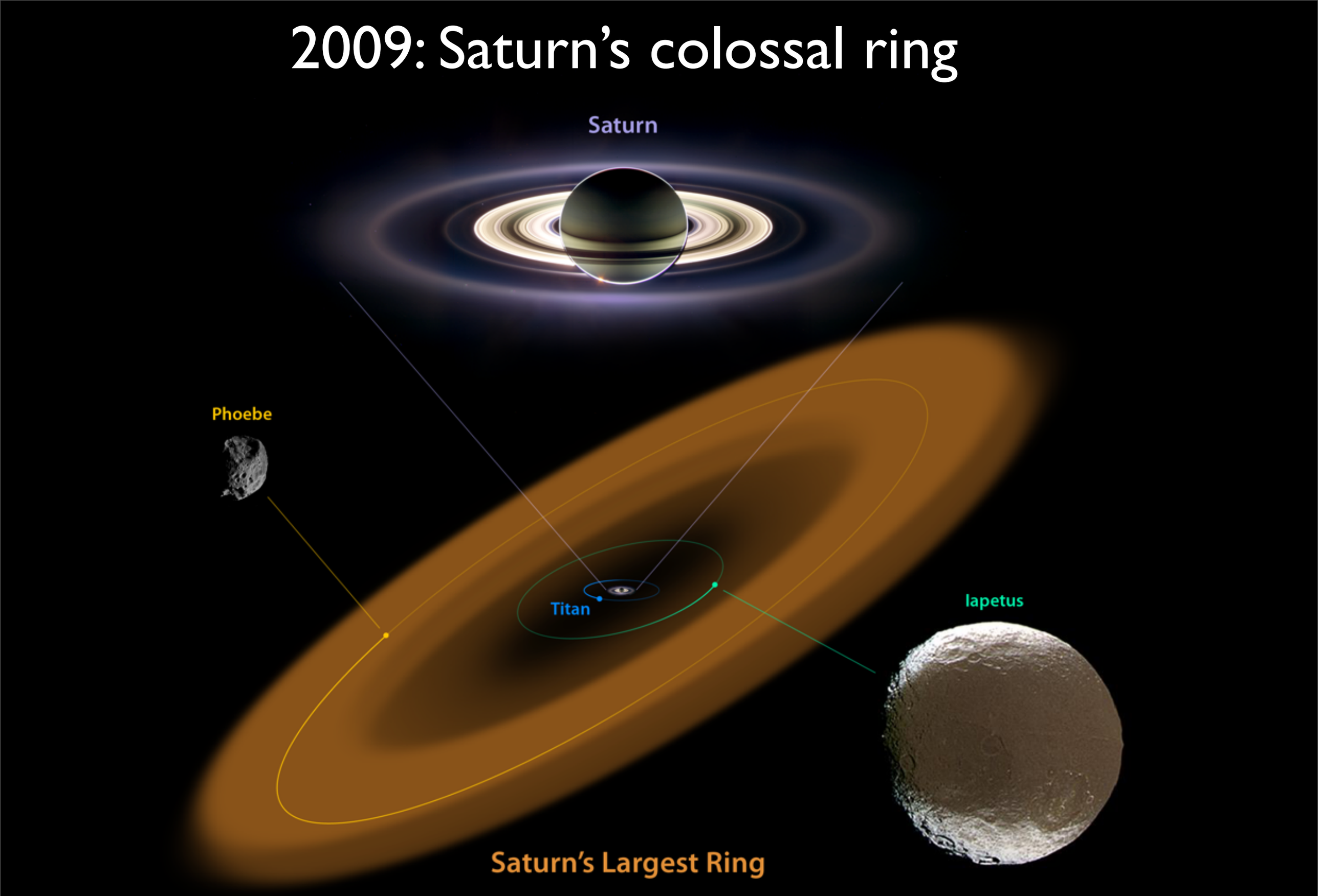
Cassini flyby 2004

Trailing side: bright
Cassini 1671

Cassini flyby 2007

Pictures: NASA/JPL/Space Science Institute

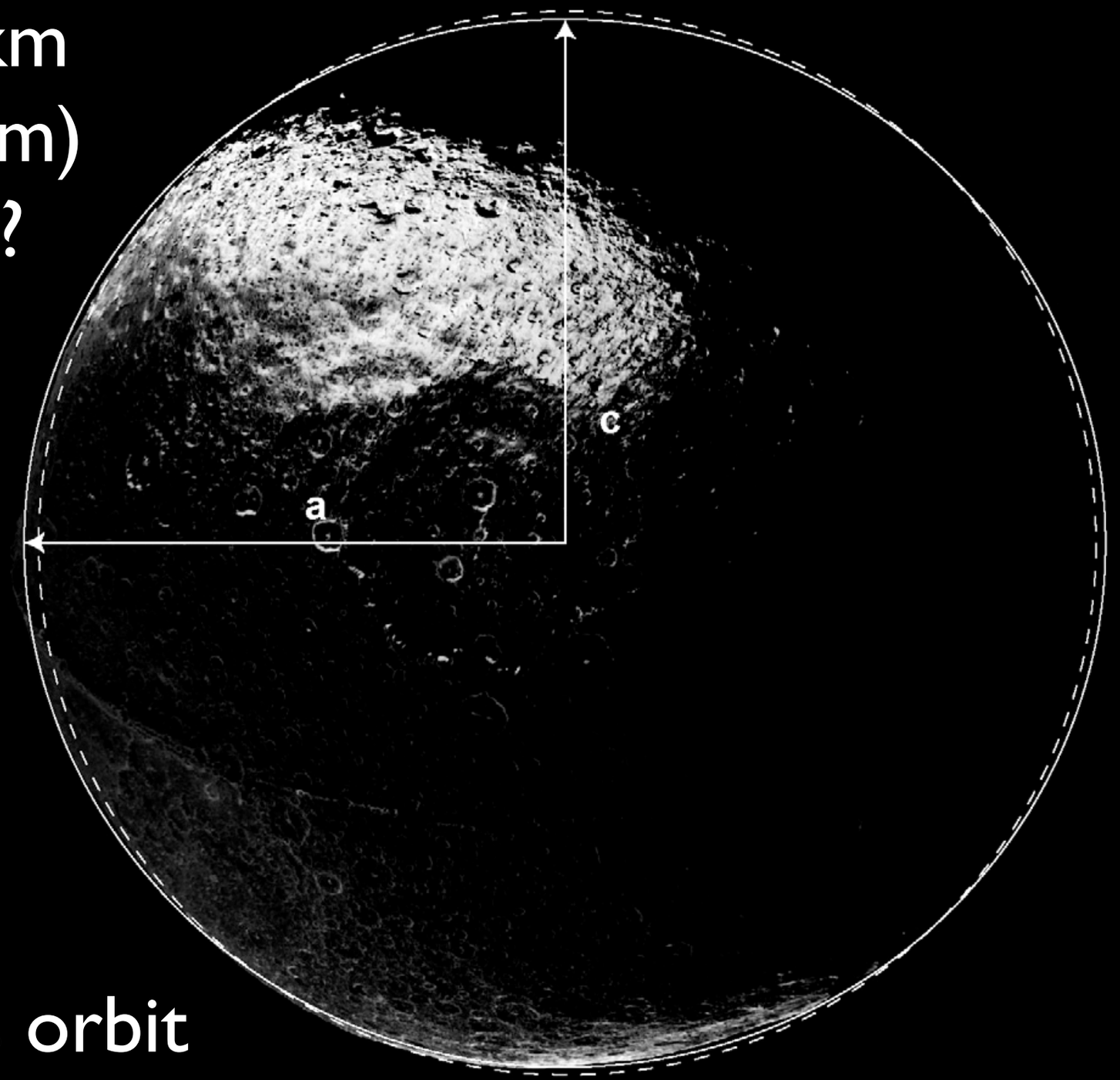
2009: Saturn's colossal ring



Picture: NASA/JPL - Caltech

Mystery II: Anomalous flattening

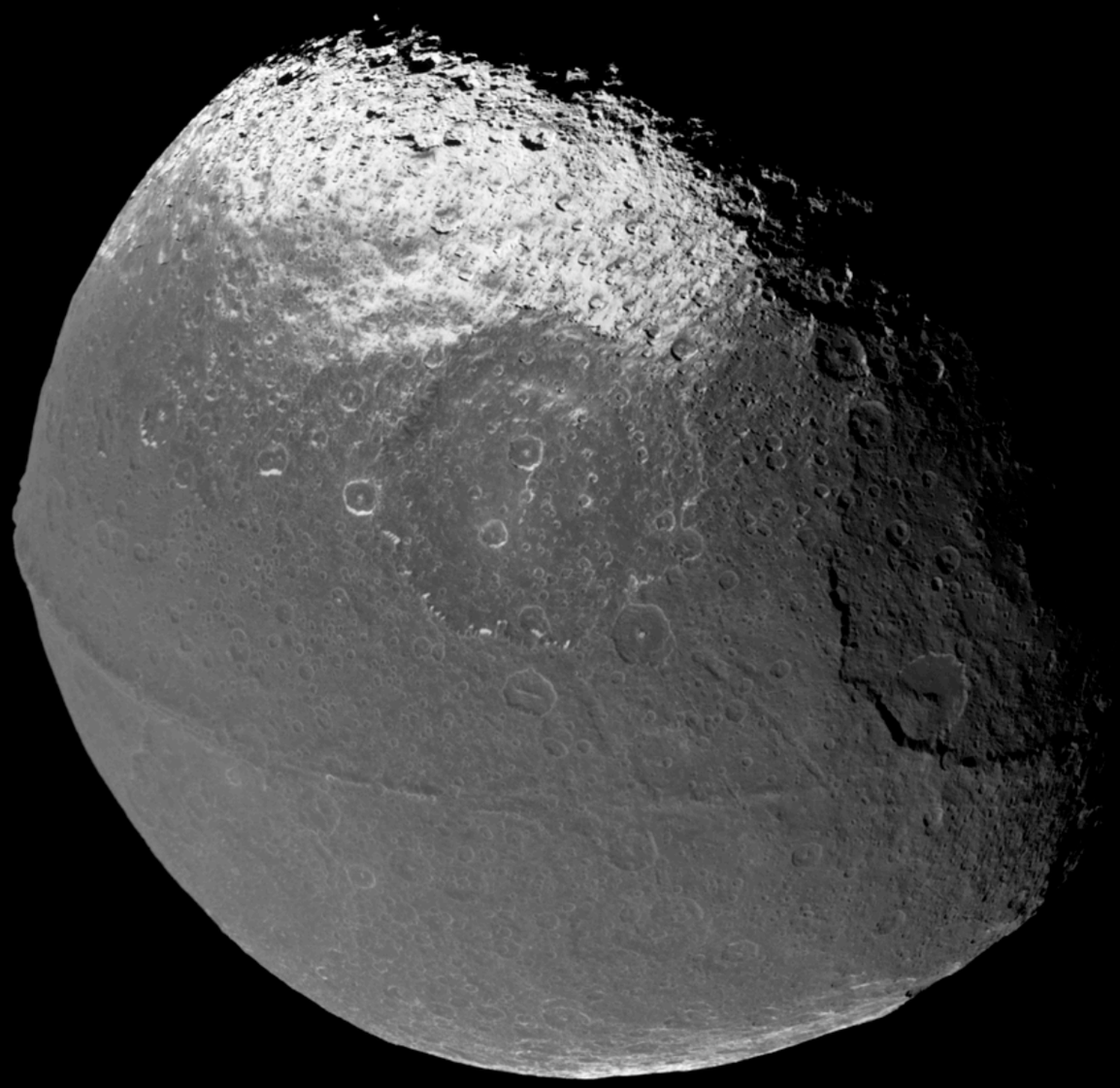
c - a = 35 km
(Earth: 21 km)
~ T=16 h ?



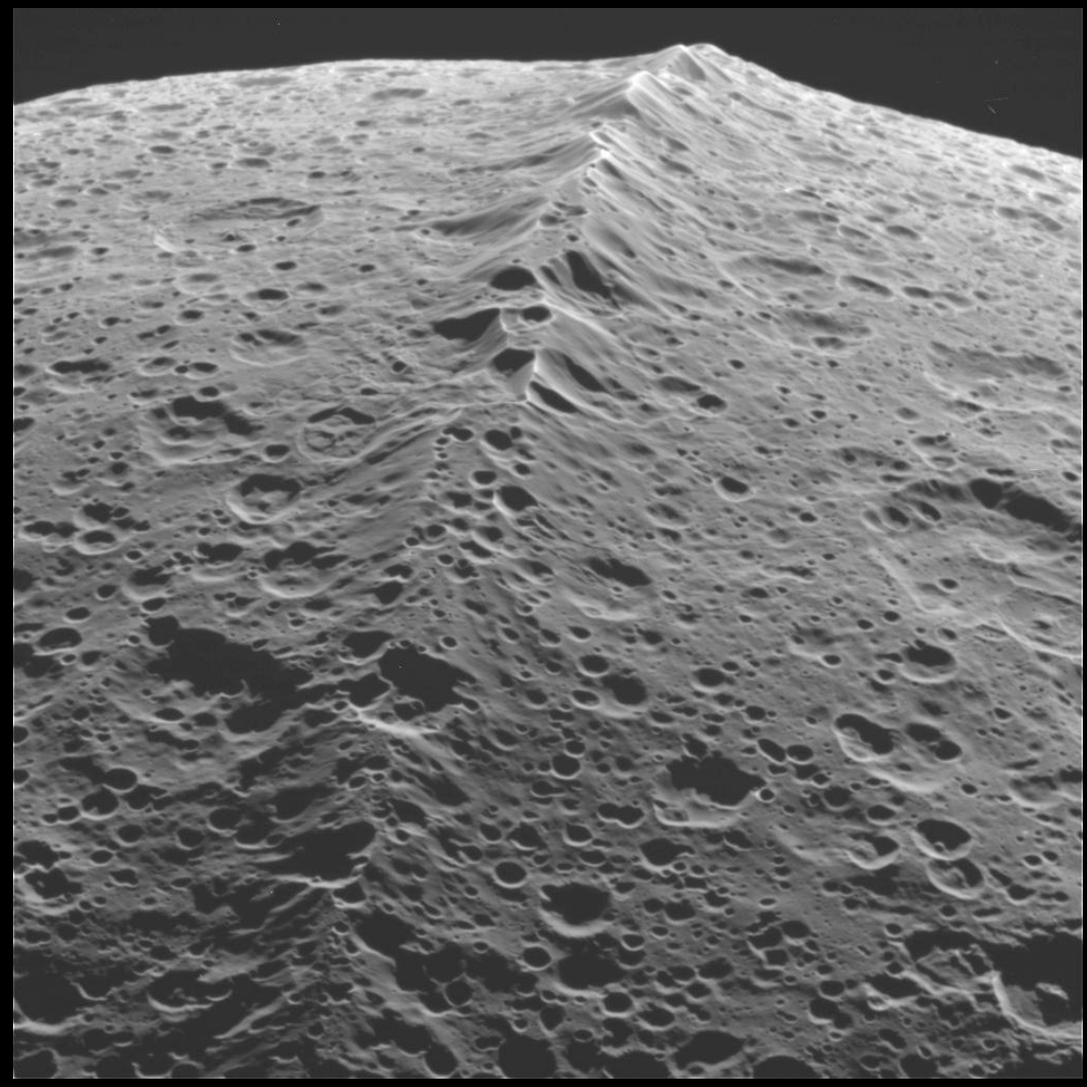
Synchronous orbit
T=79 days

Castillo-Rogez et al., Icarus 190 (2007) 179

Mystery III: Equatorial ridge on Iapetus



Cassini flyby 2004



Cassini flyby 2007

Pictures: NASA/JPL/Space Science Institute

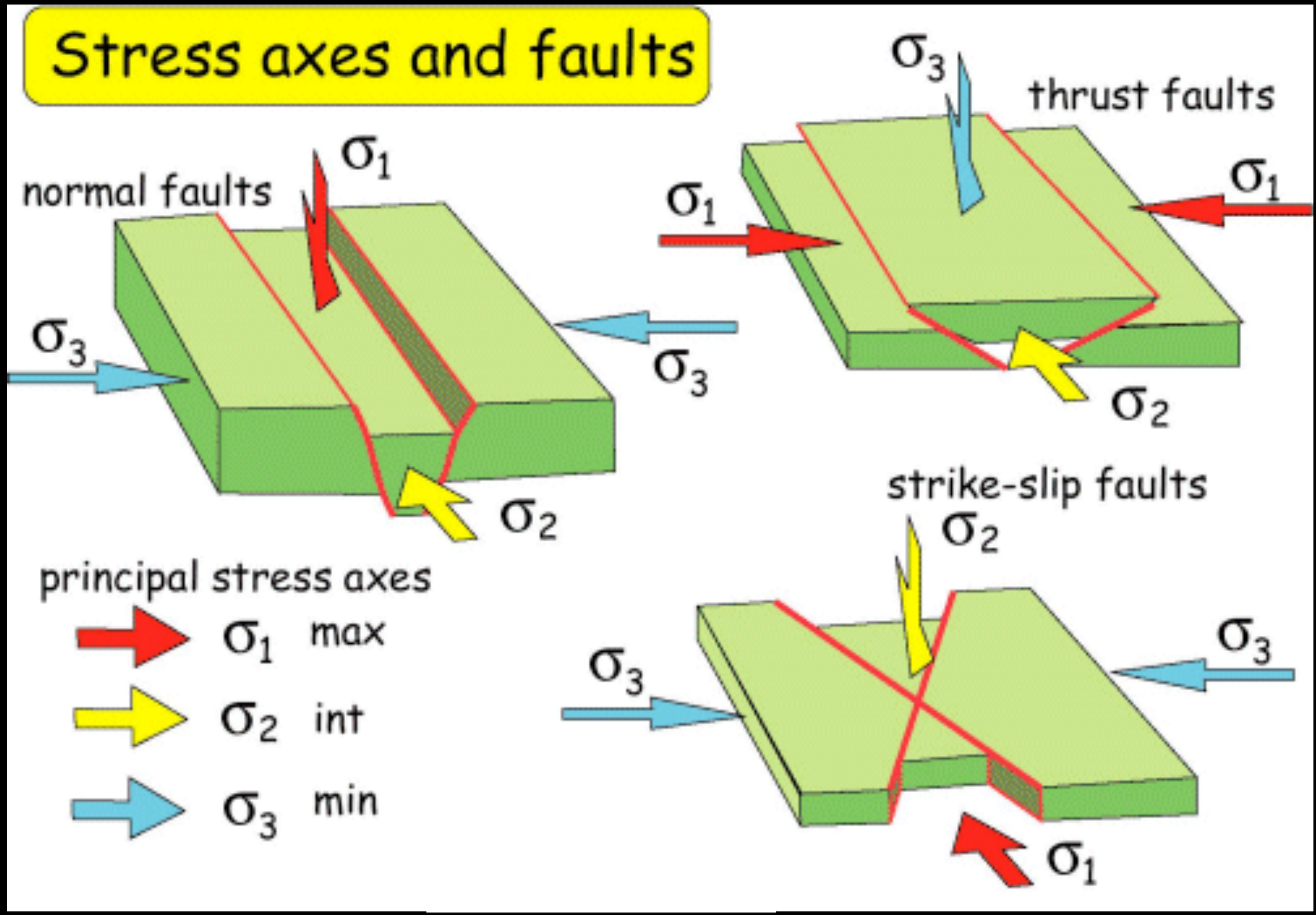
Modeling global tectonics

Global deformation of lithosphere ➡ axial pattern ?

	Lithospheric thickness	Deformation	Pattern
Old model	constant	despinning	wrong
My model	thinner at equator	contraction, expansion	right

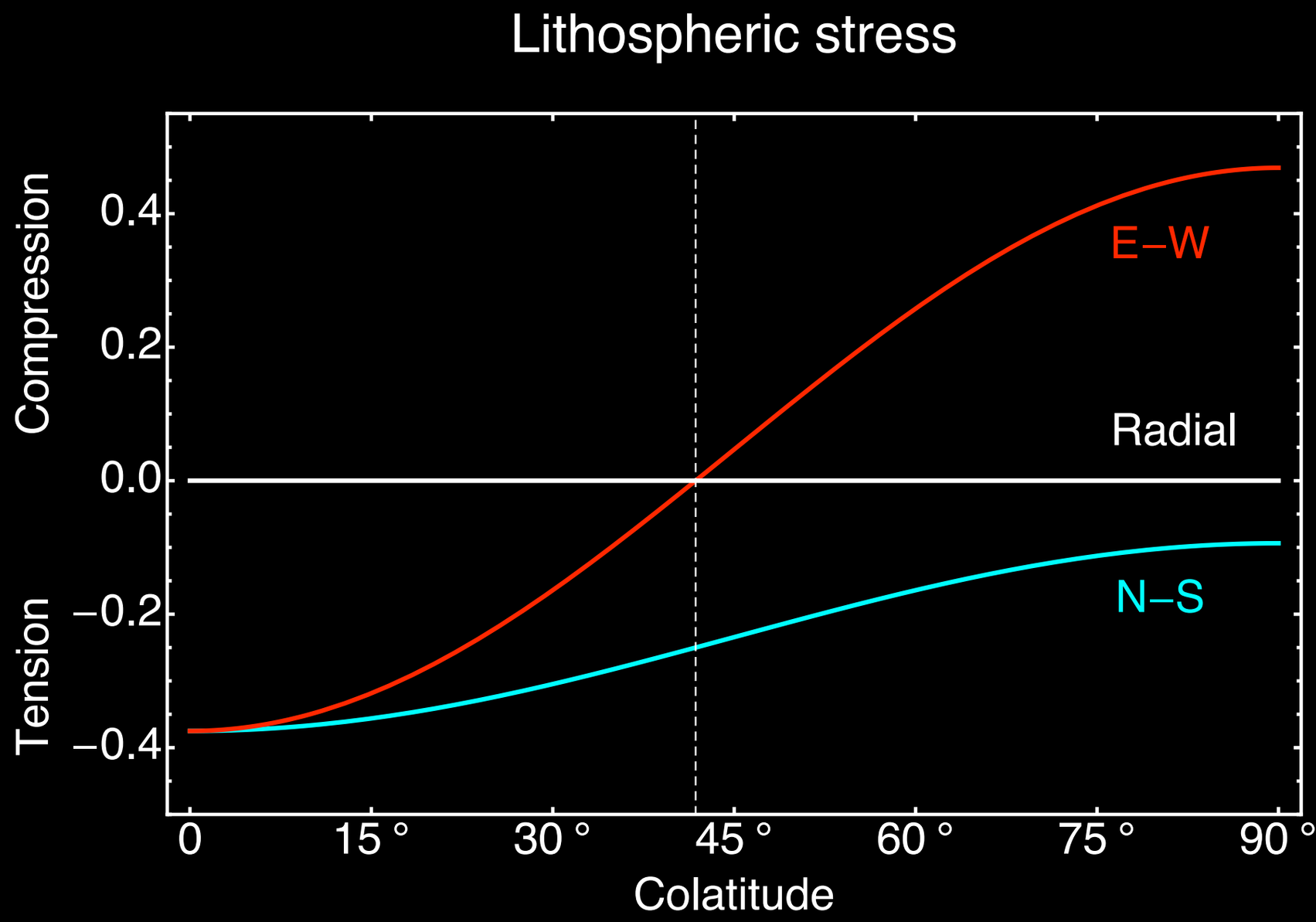
Model: Thin elastic shell with variable thickness

Stress and faulting



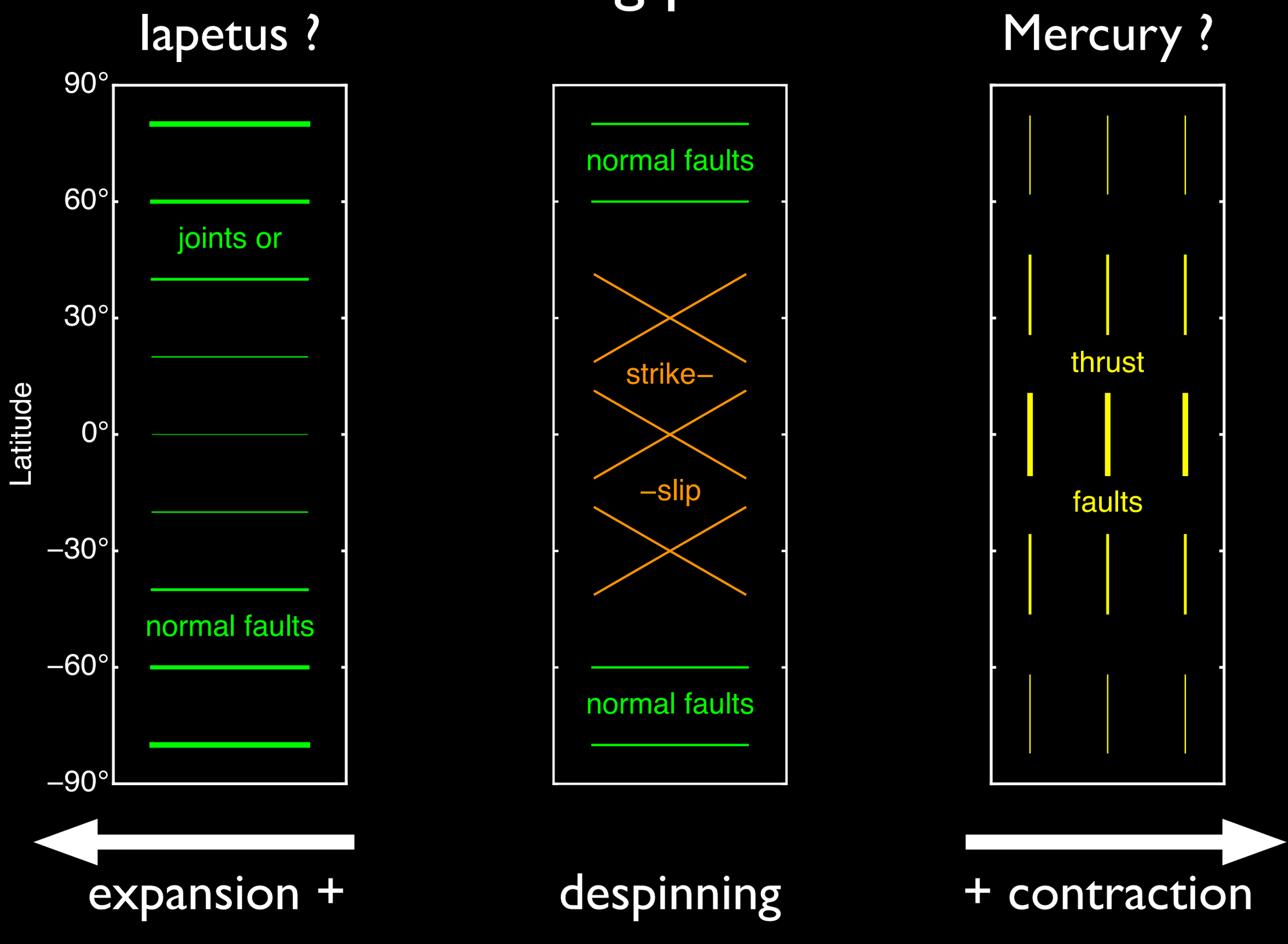
http://www.see.leeds.ac.uk/structure/faults/stress/stress.htm

Lithosphere of constant thickness: despinning

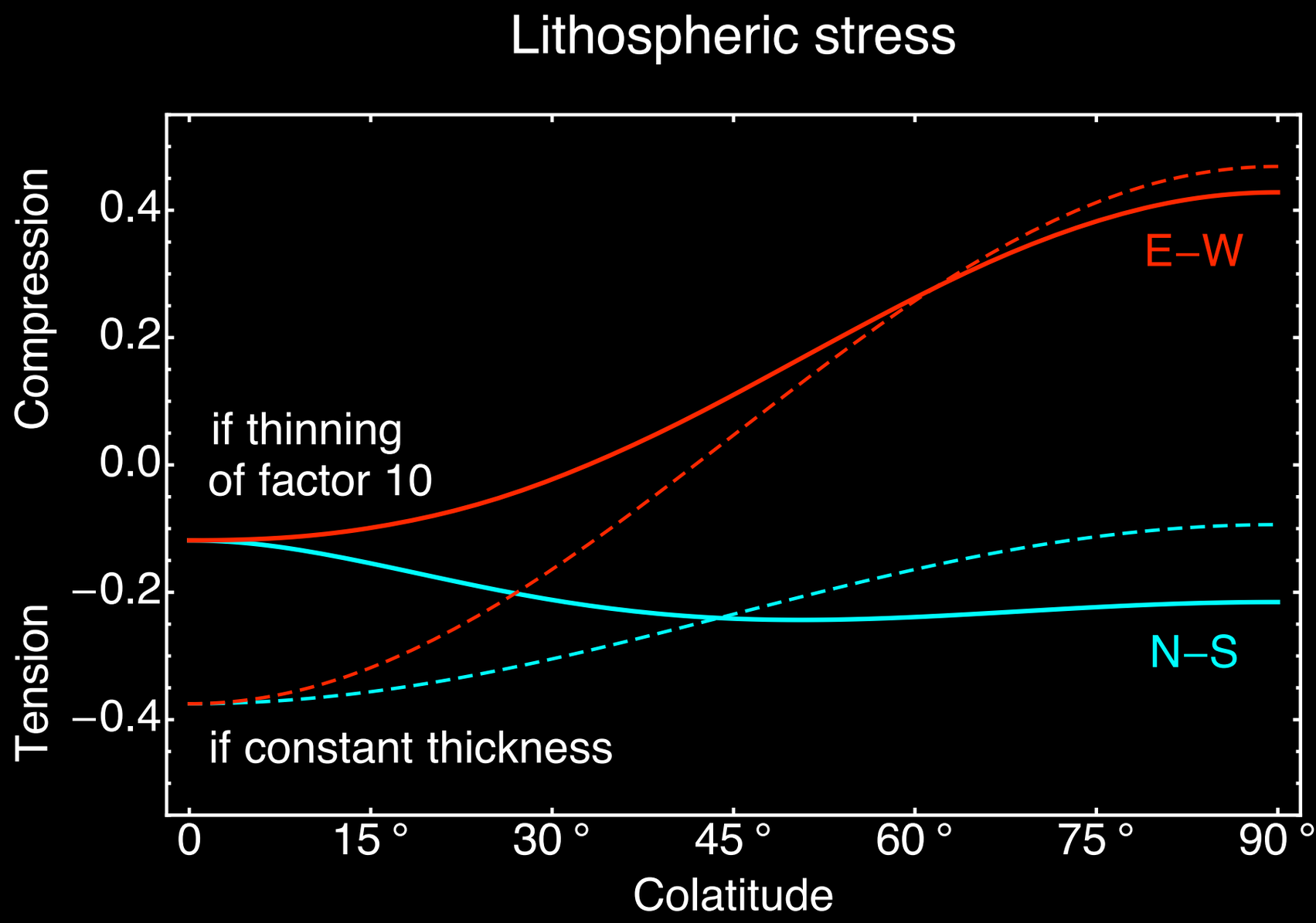


- E-W stress more compressive than N-S stress
- maximum compression at the equator
- maximum extension at the poles

Lithosphere of constant thickness: faulting patterns

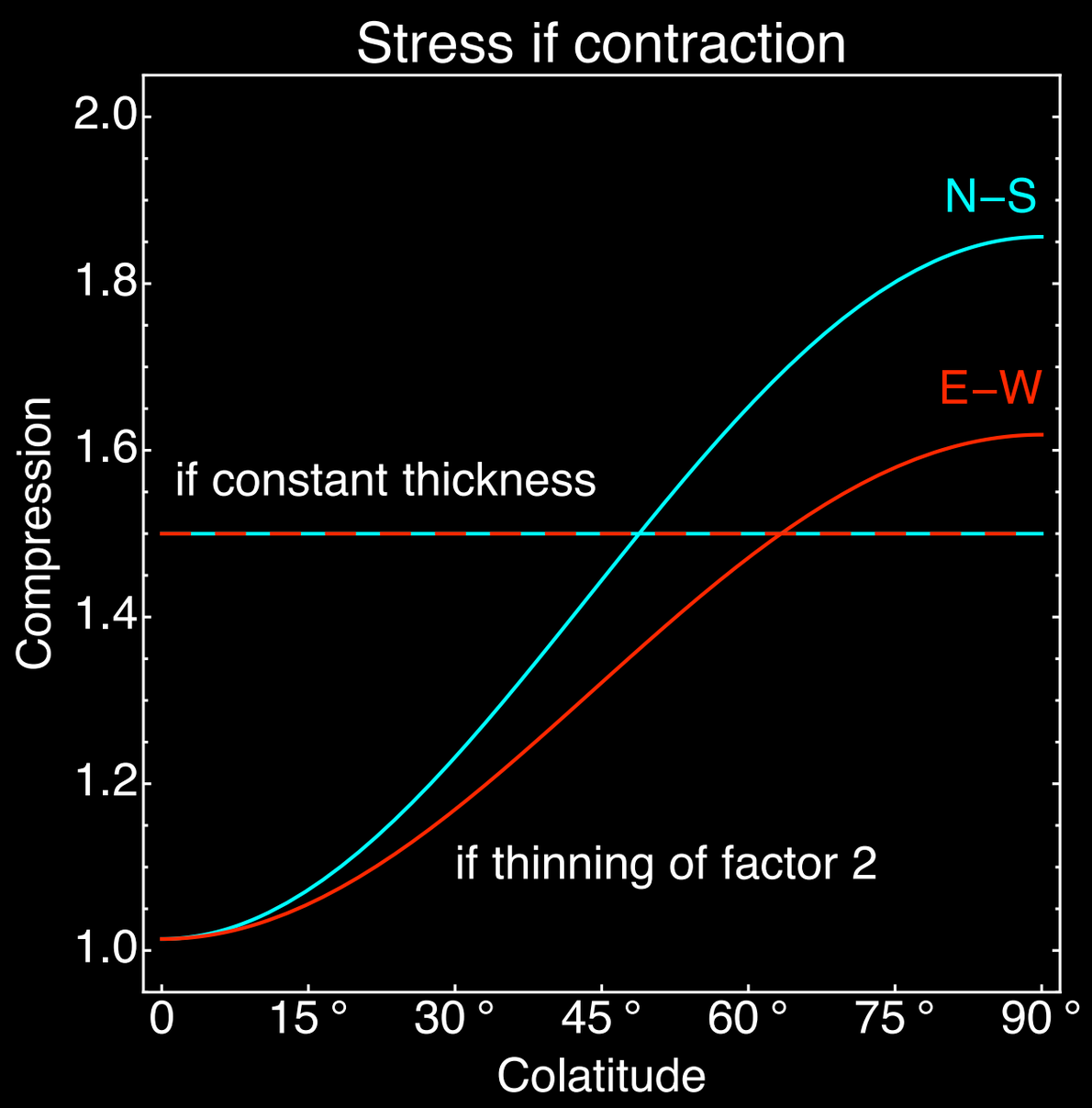


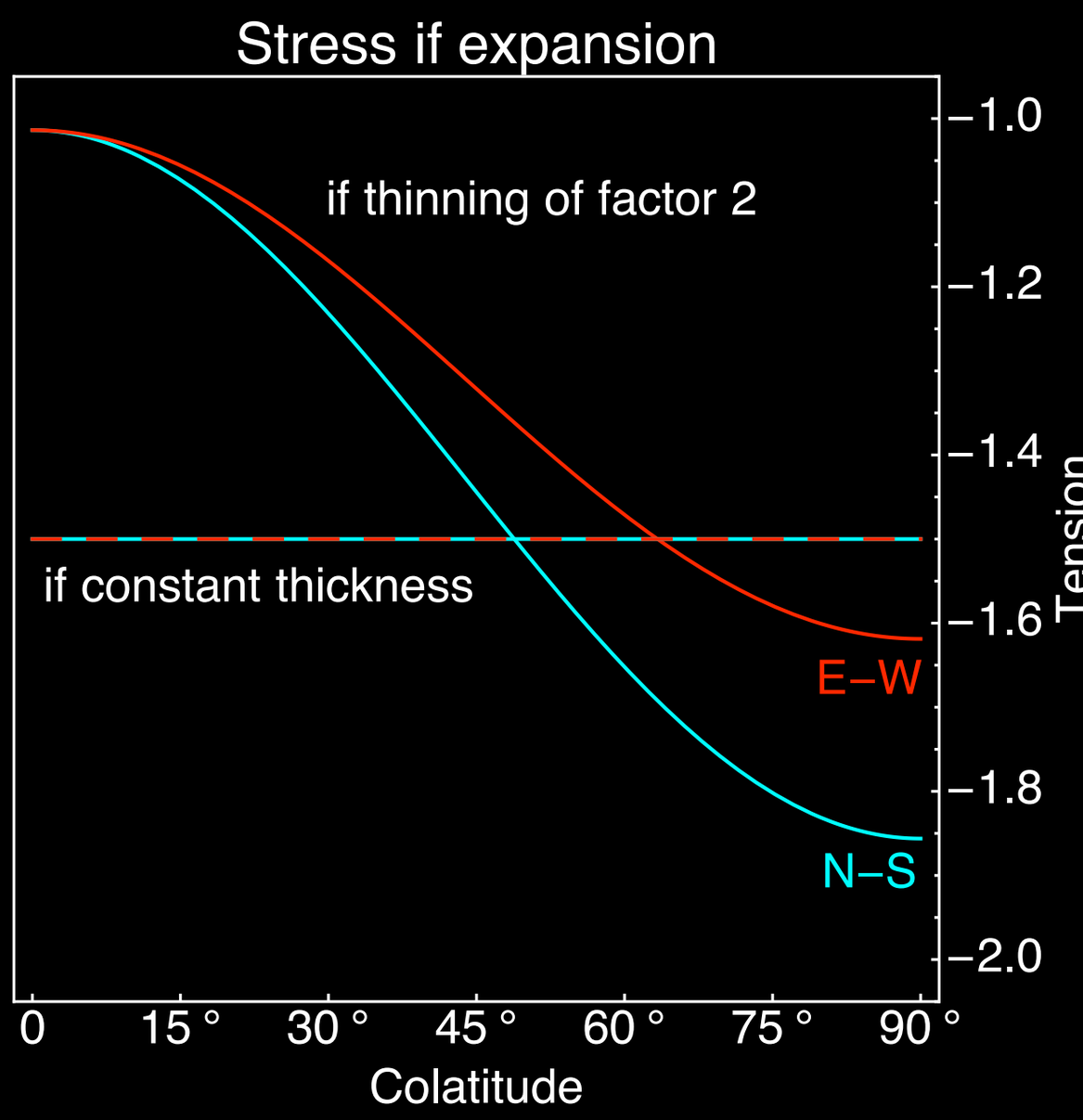
Lithosphere thinner at equator: despinning



- E-W stress still more compressive than N-S stress
- faulting pattern weakly affected

Lithosphere thinner at equator: contraction or expansion

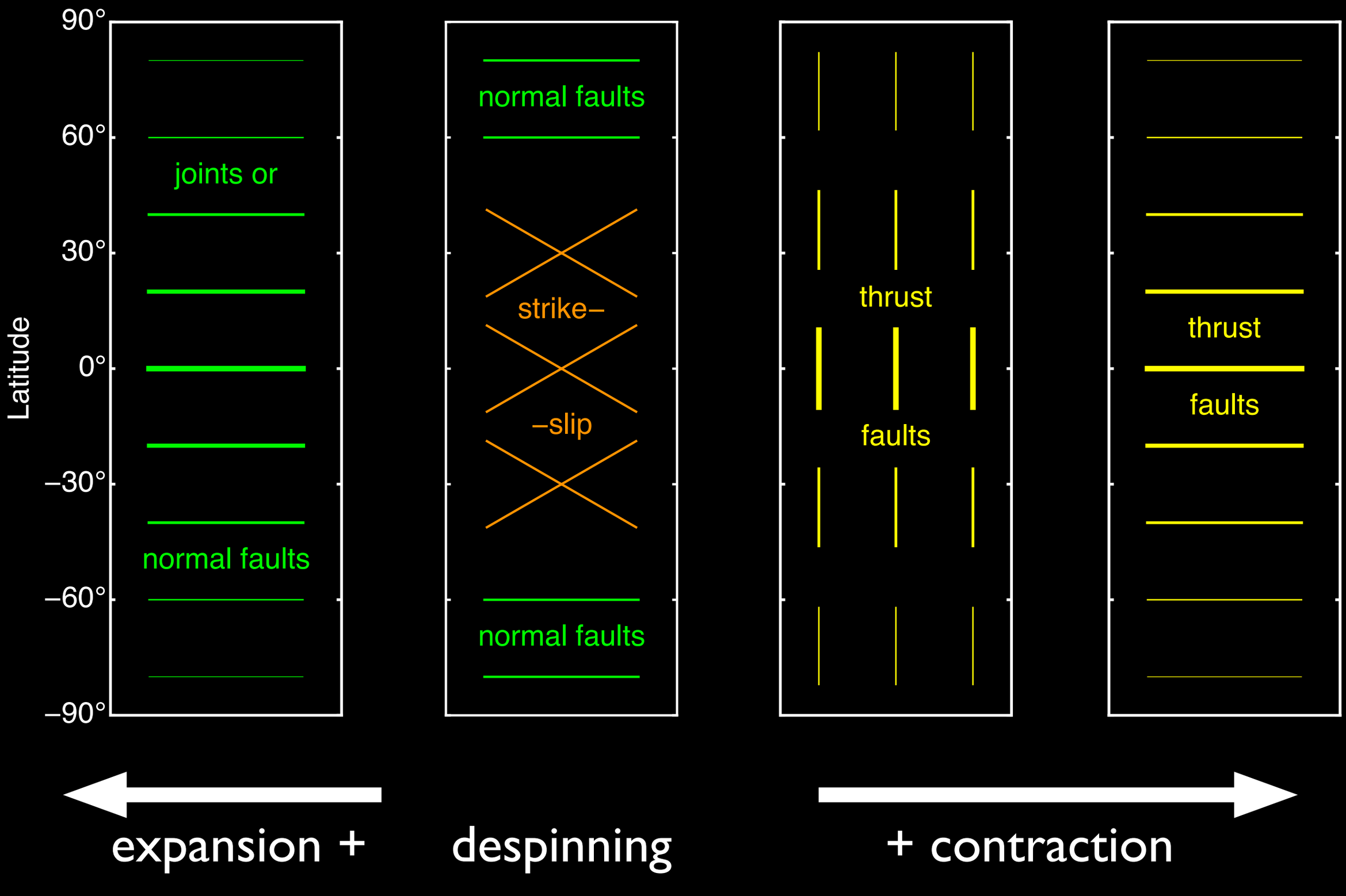




- N-S stress > E-W stress
- maximum compression at equator

- N-S stress < E-W stress
- maximum extension at equator

Lithosphere thinner at equator: faulting patterns



Formation of Iapetus' ridge

Scenarios:

A. Contraction, despinning later ($T_0 \sim 16h$)

B. Contraction during despinning ($T_0 \sim 16h$):

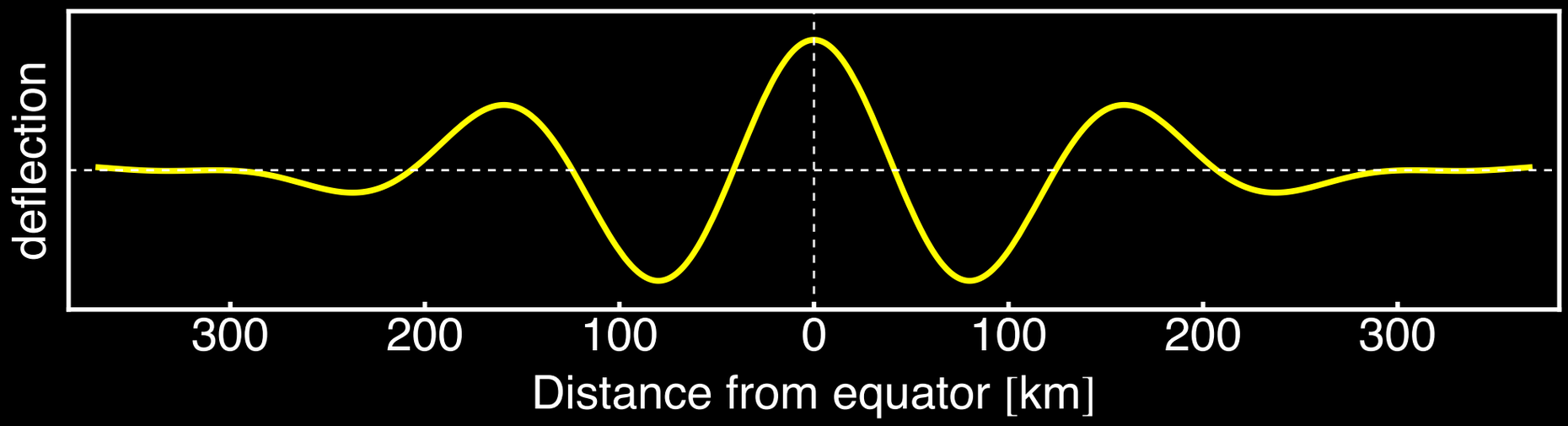
E-W thrust faults if $\Delta R > 13$ km

C. Expansion and despinning:

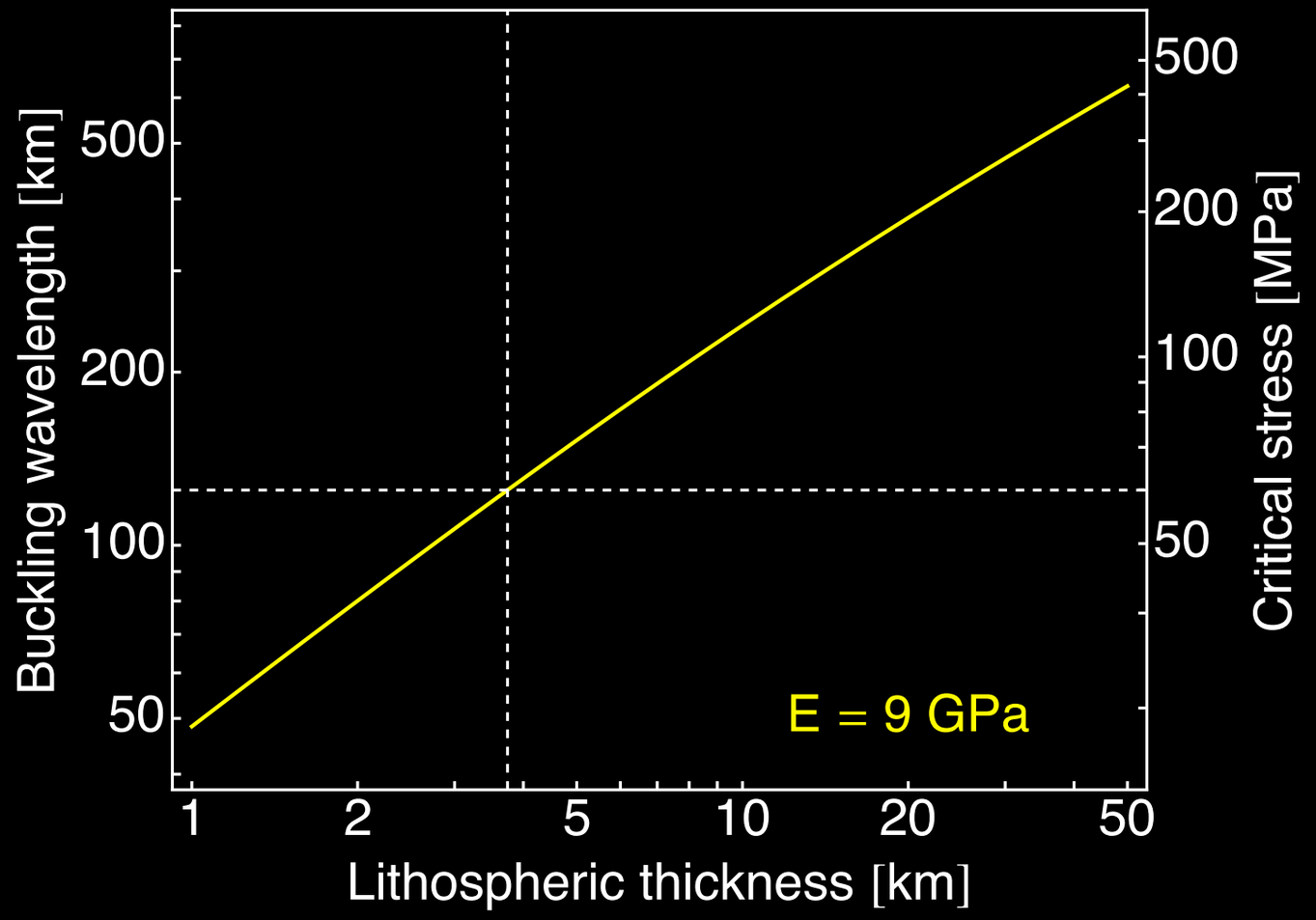
E-W joint ⇒ dike

Picture: NASA/JPL/Space Science Institute

Elastic buckling with variable thickness



Critical wavelength and stress



Yield stress ice ~
a few MPa

if E ÷ 1000
then
stress ÷ 10
thickness x 10

Conclusions on Iapetus' ridge

1. lithosphere thinner at equator

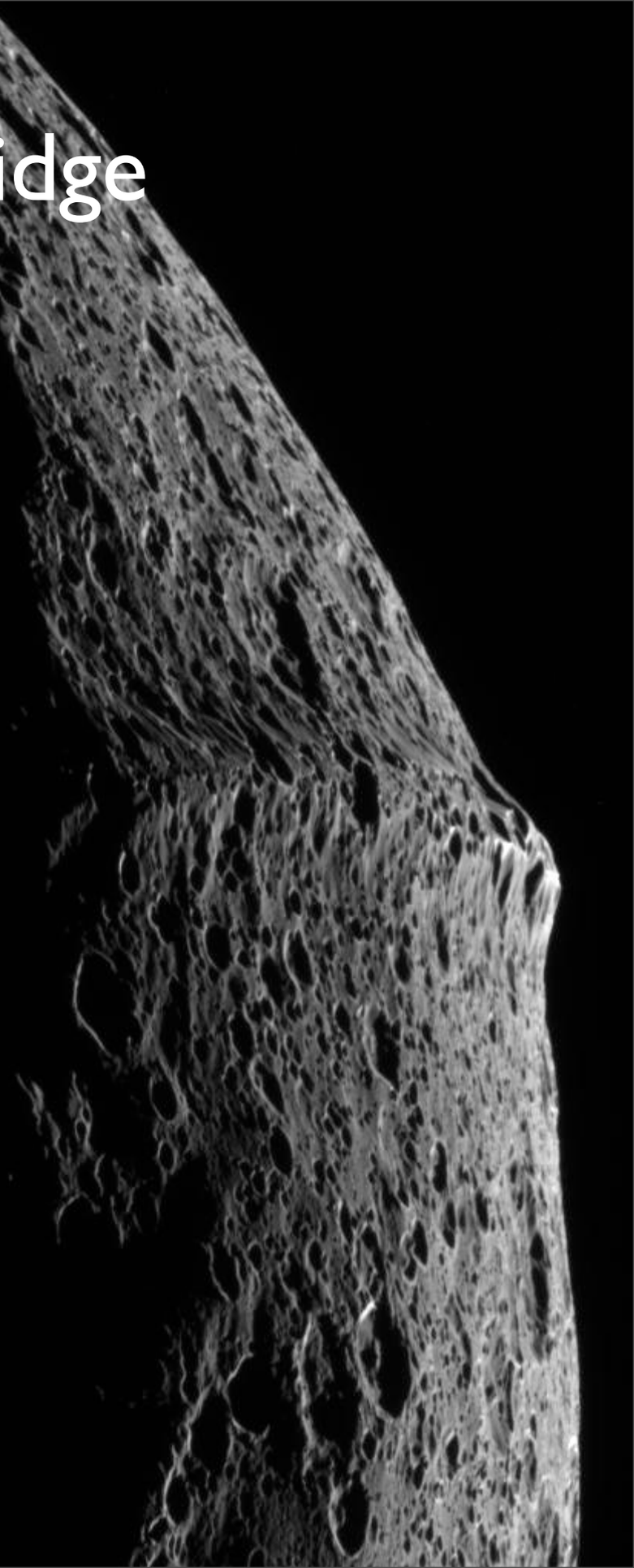
   + contraction/expansion

2. no despinning tectonics:

   initial period ~16h ?

3. no elastic buckling:

   critical stress too high

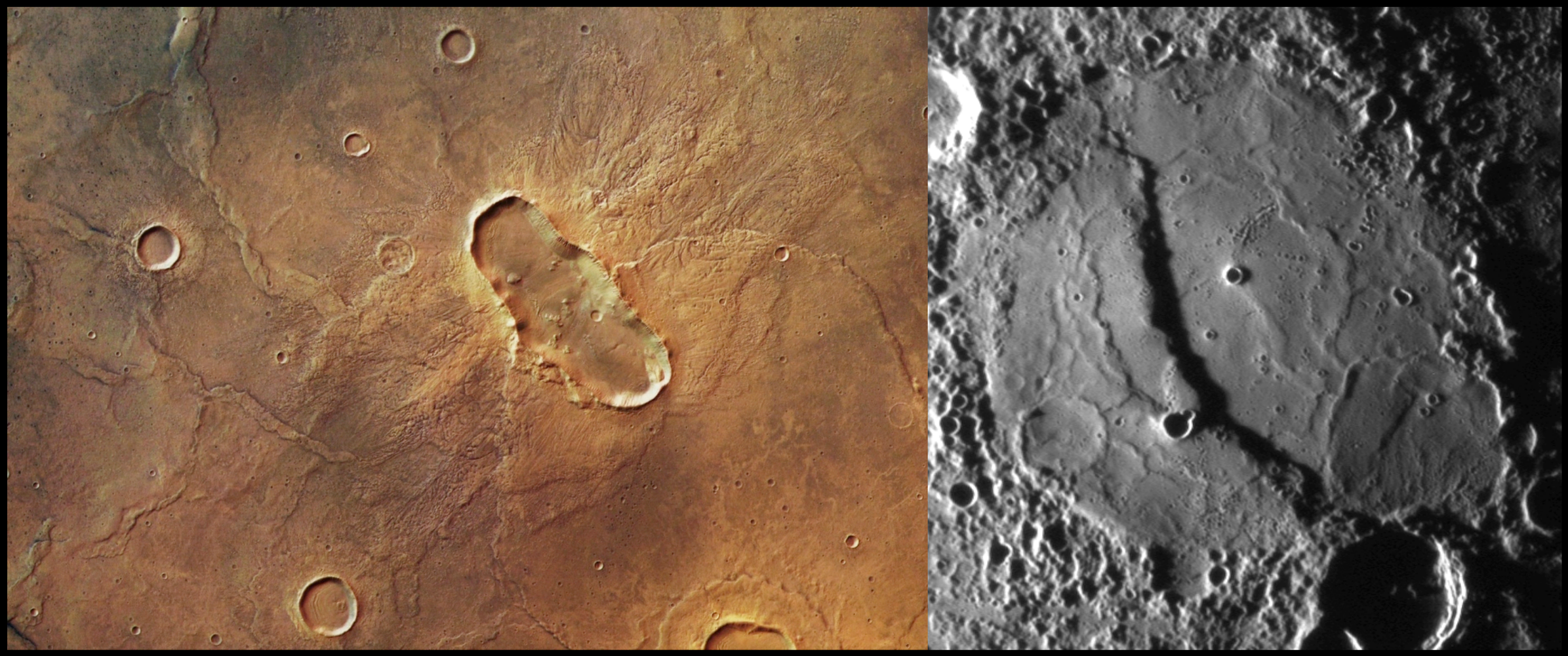


Picture: NASA/JPL/Space Science Institute

Other planets

Mars: wrinkle ridges

Mercury: lobate scarps



References:

Beuthe M., 2008. Thin elastic shells with variable thickness for lithospheric flexure of one-plate planets, Geophys. J. Int. 172, 817.

Beuthe M., 2010. East-west faults due to planetary contraction, Icarus (in press).

Left: Hesperia Planum imaged by HRSC on Mars Express (ESA/DLR/FU Berlin)
Right: MESSENGER, 2nd flyby (NASA/Johns Hopkins University Applied Physics Laboratory/Arizona State University/Carnegie Institution of Washington)

Acknowledgments

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