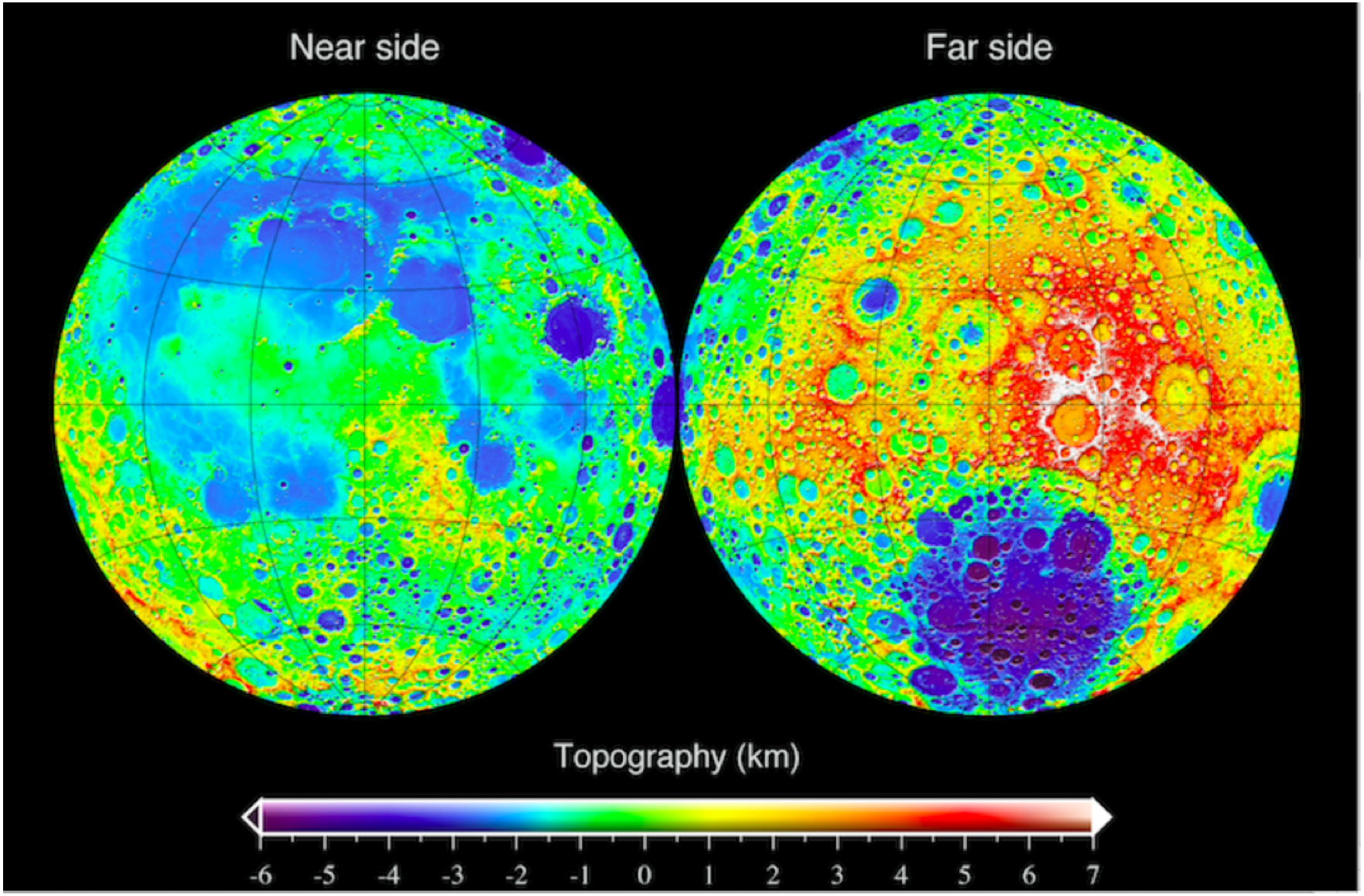
The Moon



Topographic map from Lunar Reconnaissance Orbiter

Basic data

Radius 0.27 of Earth's

Mass 0.01 of Earth's

Orbits Earth with period 27.3 days

Revolves on its axis with this period: tidally locked so one face always points towards the Earth

Orbital eccentricity 0.05, inclined 5 deg to ecliptic

Surface and interior

Many craters, also dark patches called maria, which are mostly on the near side

The far side shows highlands

Maria are filled with (denser) basaltic rock while highlands are composed of less dense rock called gabbro

Moon has much smaller core than Earth; crust thicker on far side

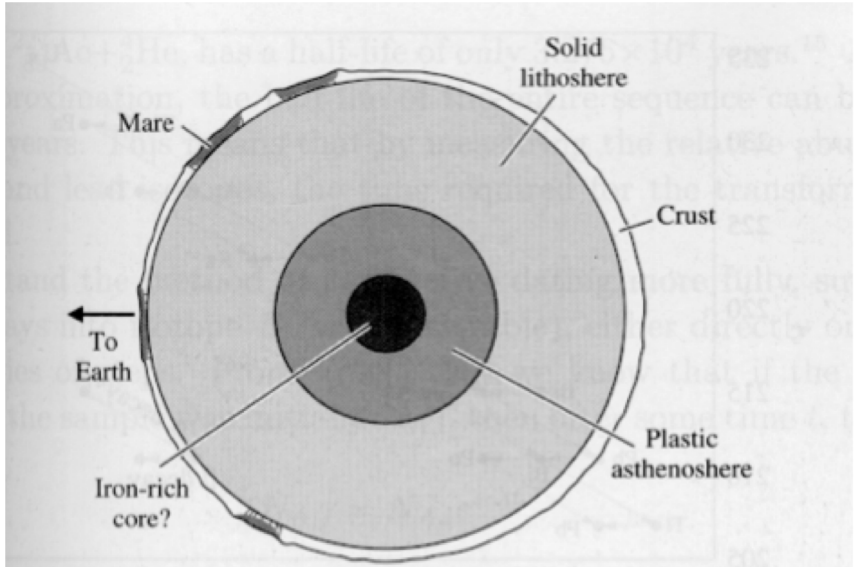


Figure 19.16 The interior structure of the Moon.

Composition of moon rocks is very similar to that of rocks on Earth (similar origin?)

Moon’s crust has few volatile elements, unlike Earth – at one stage it must have been hot enough for long enough for volatiles to be boiled off

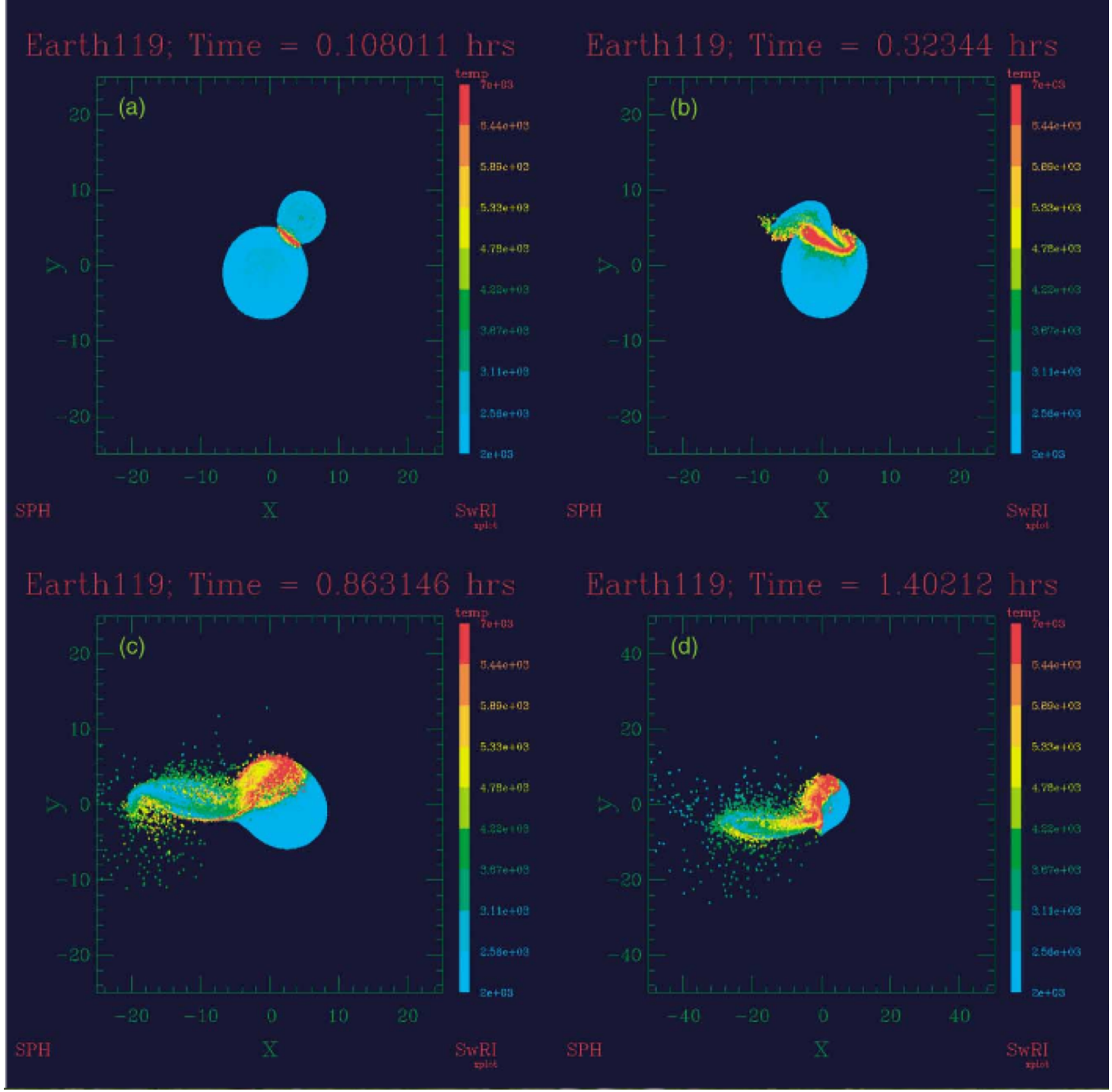
Origin of the Moon via giant impact

Canup (2004) made high-resolution simulations of the origin of the Moon via the impact of a Mars-sized object on the Earth, towards the end of the period when the Earth grew in mass by accretion of planetismals.

Impact velocity ~9 km/s

Impactor's iron core is mostly re-accreted by Earth

Material from mantle orbits Earth and accretes to form the Moon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Earth119; Time = 0.32344 hrs
(b)
Earth119; Time = 0.863146 hrs
(c)
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(d)
temp
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5.44e+03
5.89e+03
5.33e+03
4.78e+03
4.22e+03
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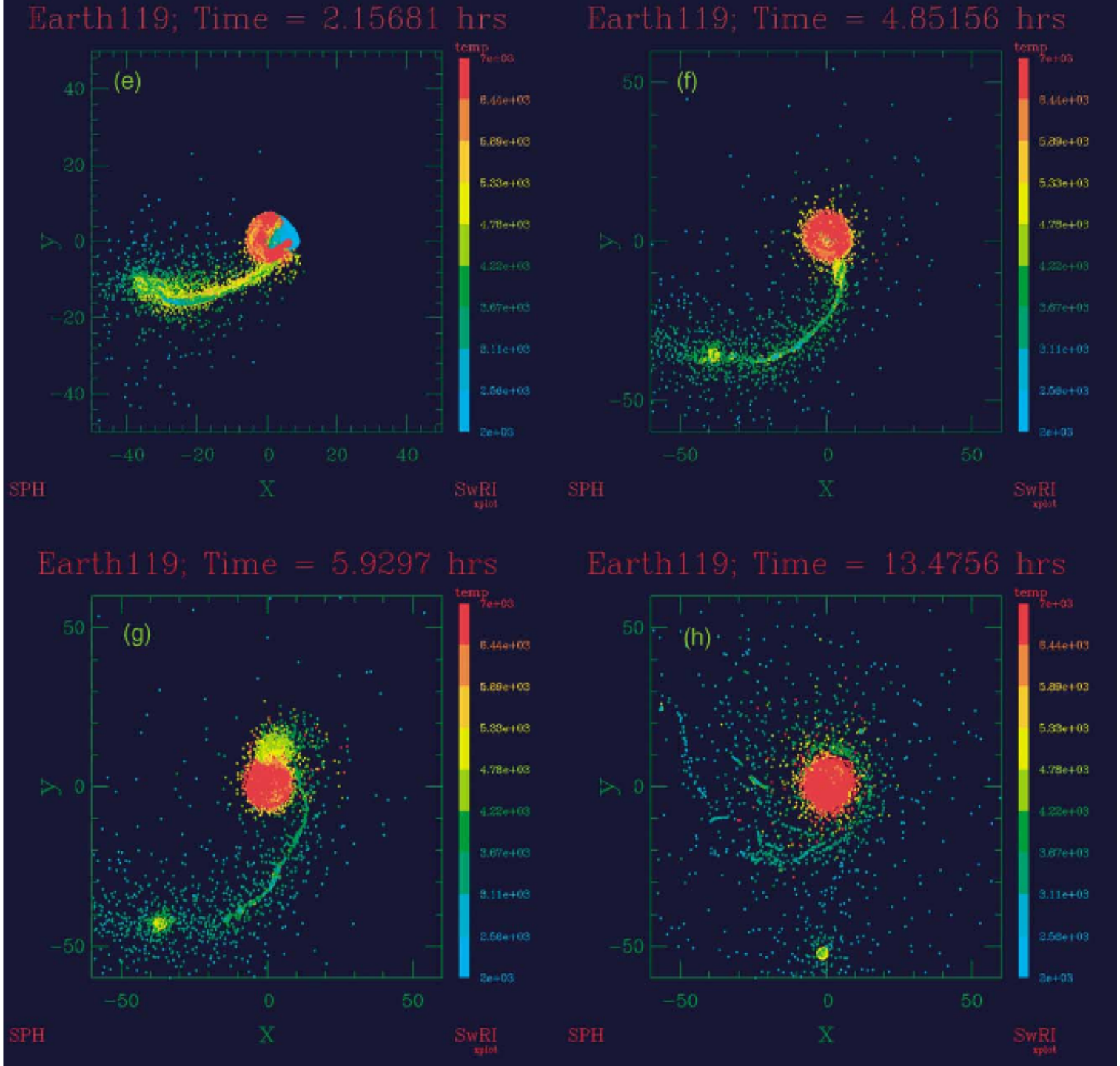
2e+03
SPH
X
Y
SwRI
xplot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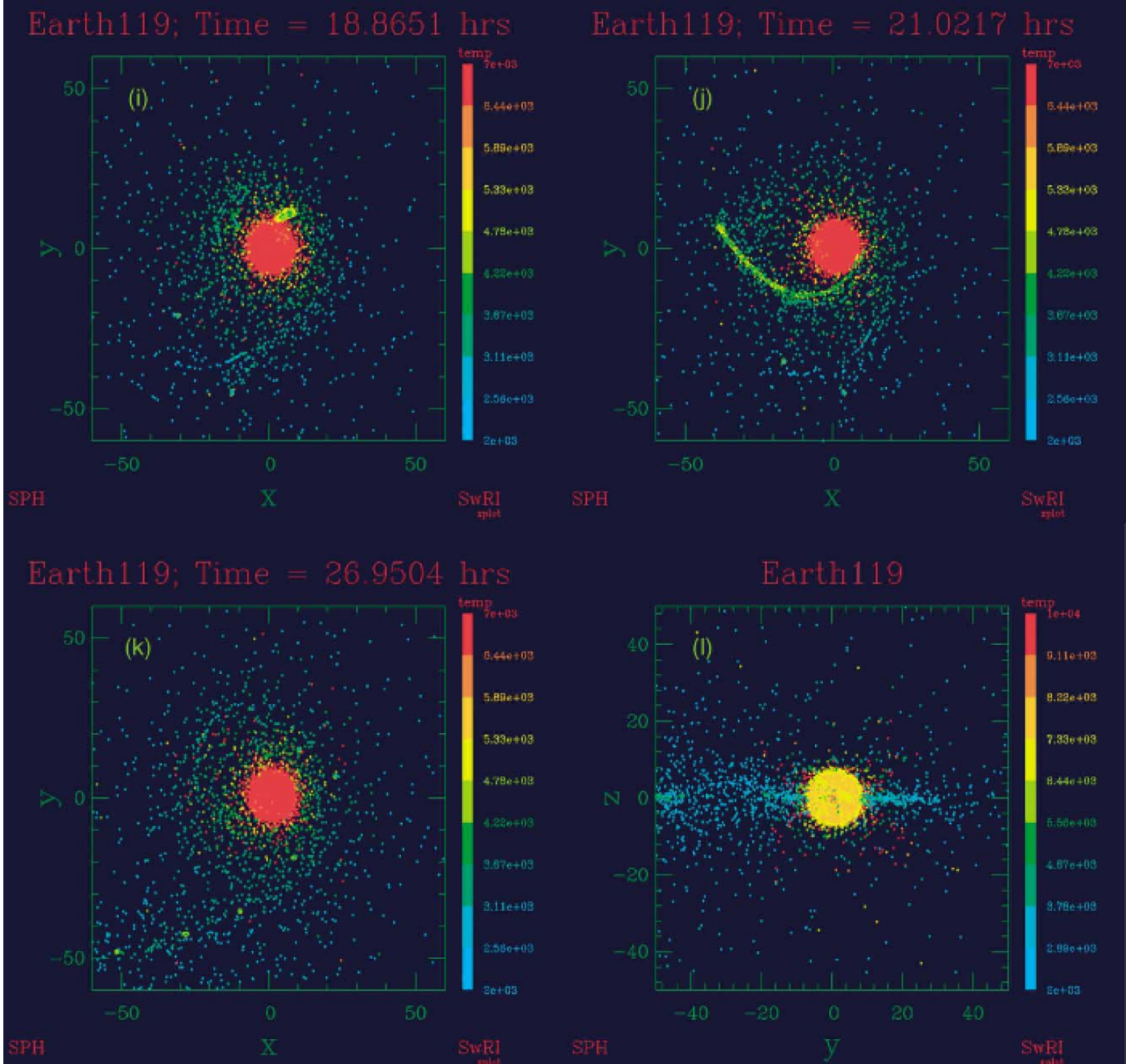
y
X
SPH
SwRI
xplot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3.11e+03
2.56e+03
2e+03
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0
−50
y
−50
0
50
X
SPH
SwRI
xplot
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5.89e+03
5.33e+03
4.78e+03
4.22e+03
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3.11e+03
2.56e+03
2e+03
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y
−50
0
50
X
SPH
SwRI
xplot
Earth119; Time = 26.9504 hrs
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2.56e+03
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y
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0
50
X
SPH
SwRI
xplot
Earth119
(l)
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8.22e+03
7.33e+03
6.44e+03
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3.78e+03
2.89e+03
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SPH
SwRI
xplot

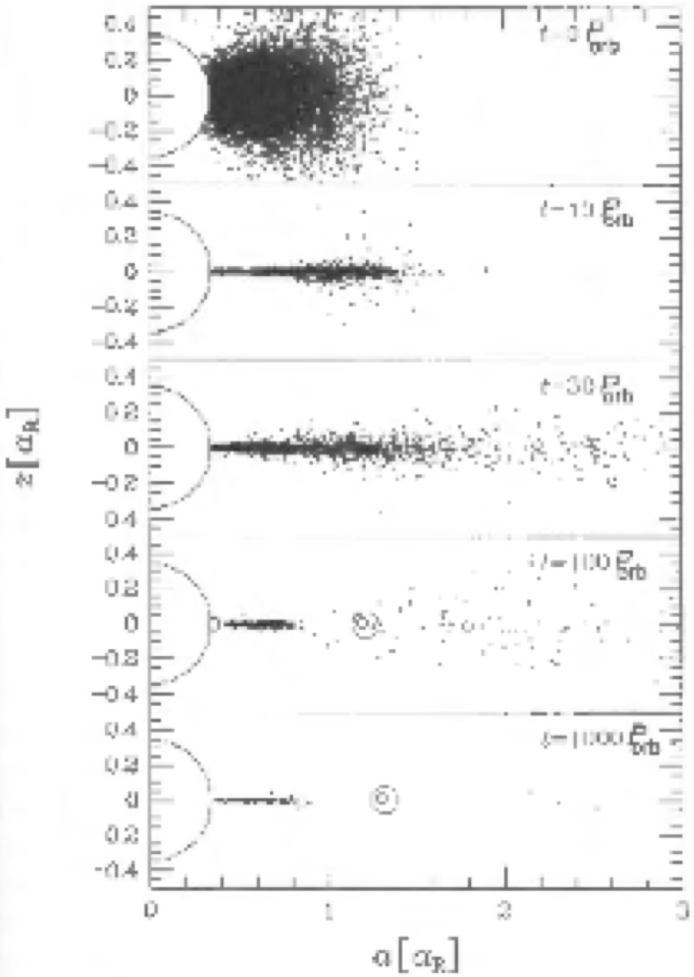

Figure 13.27 Snapshots of the protolunar disk in the r – z plane at t = 0, 10, 30, 100, 1000 P_{orb}, where P_{orb} is the Keplerian orbital period at the Roche limit. The initial number of disk particles is 10000, and the disk mass is four times the present lunar mass. The semicircle centered at the coordinate origin stands for the Earth. Circles represent disk particles and their sizes are proportional to the physical sizes of the disk particles. The horizontal scale shows the semimajor axis of disk particles in units of the Roche limit radius, a_R (see eq. 11.9). Note the very massive transient ring around the Earth. (Kokubo *et al.* 2000)

Late stages of formation, not shown in Canup simulations: debris accretes to form larger object plus a transient ring

Timing of Earth and Moon formation

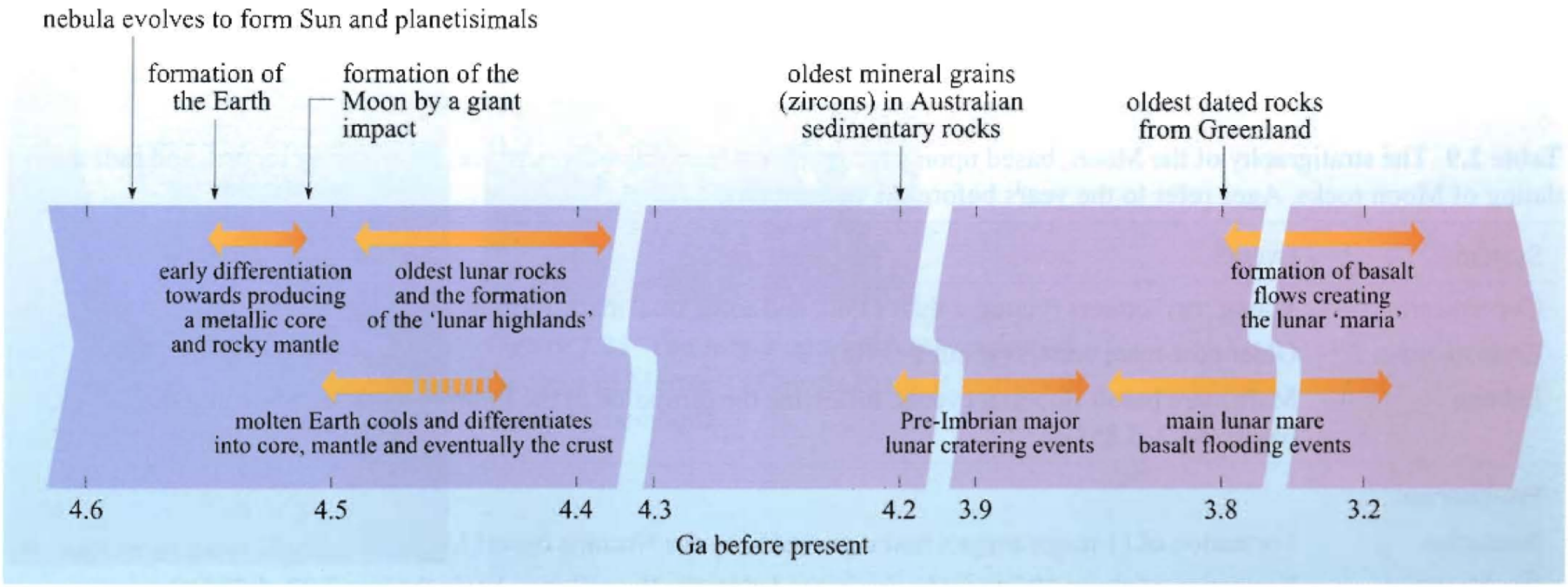

Figure 2.20 The timing of the formation of Earth and the Moon, based upon available chronological data, and indicating major planetary-forming and differentiation events.

Heating and cooling

Q: What are the sources of heat in a planet or moon?

Heating and cooling

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A: Accretion/impacts (potential energy)

Radioactivity

Tidal forces

Tidal forces can be neglected for the Moon compared to the other two (but not for Io!)

Because of the Moon's small core, it will have less radioactive heat source than an object with a larger core (eg Mercury)

Heating and Cooling

While heat production will depend on a planet/moon's volume (so go as R^3), cooling will depend on its surface area (proportional to R^2)

So large planets will cool more slowly than small ones

So we would expect to find more tectonic activity on large planets than, say, the Moon