

L20 Early Hadean < 4.45 to 4.55 Ga >

The worlds come into being as follows: many bodies of all sorts and shapes move from the infinite into a great void; they come together there and produce a single whirl, in which, colliding with one another and revolving in all manner of ways, they begin to separate like to like.

—Leucippus (480-420? BCE), *reiterated by* Diogenes Laertios (early 200s CE).⁶

In the massive bombardment scenario for the formation of the planets, the atmospheres of the stony planets are secondary. Their compositions, even when adjusted for subsequent air conditioning (by losses to space of the lightest gases, reactions with the planet's crust, volcanic exhalations, and, on Earth, life) can only tell of circumstances unique to the particular planet that each shrouds. The composition of the gases of the original nebula must be sort in Sun's composition corrected for four and a half billion years of fusion alterations.

Pierre-Simon Laplace's nebula hypothesis promulgated in 1796 was of an initially hot revolving nebula that under the guidance of purely physical laws, gravitationally collapses axially into a star and a flattened disk about it that continued to collapse inward leaving behind successive rings of hot matter with whirls from which coalesced the planets, satellites, and other bodies of the system.⁷ To replace this hot origin for Earth, Thomas Chrowder Chamberlin (1843-1928) with astronomer Forest Ray Moulton (1872-1952) in 1904 put forward a cold one⁸ in which planets form by the accretion of small, solid, planetesimals after a close encounter between Sun and another star. This, in harmony with the kinetic theory of gases, could account for the presence of water in Earth's atmosphere and hydrosphere. Bailey Willis, thereafter, could write without preamble: "The dust particles gathered to form the globe."⁹ This simple view did not survive *Surveyor* and *Apollo* landings on firm ground that silenced Harold Urey's (1893-1981) alarm that "the craft will sink out of sight into the dust!"

The Early Hadean Era (before Moon's terrae rocks crystallized 4.45 Ga) began with Earth as a solid body ca. 4.55 Ga. Accretion of the solar system, beginning 4.5682 Ga,¹⁰ is physically recorded by the oldest meteorites (fallen to ground asteroids). Earth accreted in a neighborhood that, according to Stuart Ross Taylor, "had become as dry as the Sahara as water and other volatiles were swept out by the early active Sun to where Jupiter was forming" (**Figure L20.1**, p. 689).¹¹

Sun's composition is used to calculate the relative abundances of materials in the original nebula. Had Earth not been bombarded after Sun turned on *and* had it accreted to its present size very early in the origin of the solar system, it would now have more than one-thousand times the amount of water than it does. Also, Earth's atmosphere would have one-hundred times more of the inert gases neon and argon than it does, and krypton would be less rare, though (relax Superman!) kryptonite would yet be absent from our natural world (although manufactured HXeOXeH does give pause).¹²

Doppler-spectroscopy detected extrasolar planets (228 counted by 2008 about stars within 200 pc)¹³ are all giants (bias of technique?) that could not have formed in their present close-in high eccentricity orbits as even at apogee the stars they orbit would have melted their rocky cores before they got started. Instead, computer-model revisions of planetary-system origins is that the early state is chaotic. Then, "hot Jupiters" barrel inward from some far place where each could have coalesced. Also, some move out:

For our solar system, Edward W. Thommes reasons that the massive icy planets Uranus and Neptune formed in close proximity to gassy Jupiter and Saturn, then bullied past these behemoths into the far reaches of the solar system where, as now, matter is too rarefied for such planets to have grown so huge within the lifetime of the solar system.¹⁴

And:

"It seems dangerous to lump [stony] Mercury and [gas-giant] Jupiter into one class of astrophysical object." say extrasolar "planet" hunters Geoffrey W. Marcy and R. Paul Butler.¹⁵ □