

THE HADEAN

L10 The first half-billion years record

< the rock cycle has turned in Earth's earliest rocks, some minerals survive >

I would tell you all but I am too old to know everything.¹

Because of subduction, which continues today, Earth's oceanic crust is nowhere older than 180 My (late Middle Jurassic). Of continental crust, which does not subduct, the oldest, which the ongoing rock cycle has not rejuvenated, has a radiometric age of 3.96 Gy (billion years old). That age establishes, by default, the beginning of the Archean Eon. What can be said of the time before the oldest surviving Earth rocks?

To date Earth's beginning we assume that it originated, along with other bodies in the solar system, from a single gravitationally bound mass of gas and dust. Of that, iron meteorites are samples of planetesimal primordial cores that excluded (lithophile) parent isotopes of lead (Pb) when they formed by melt differentiation but incorporated radiogenic (Pb-206 and Pb-207) and non-radiogenic lead (Pb-204 and Pb-208) isotopes (which being lead are siderophile) in ratios, presumably, unchanged from the beginning. Stony meteorites, by contrast have uranium isotopes (which being uranium are lithophile) radiogenic parent isotopes of lead (U-238 decays to Pb-206, and U-235 decays to Pb-207). To the extent that meteorites are closed systems, a straightforward calculation of their age involves knowing radiometric-decay constants and measuring the amounts of radiometric-lead isotope species in these as ratios against non-radiogenic species. These ratios will be different from those obtained from the iron-meteorite data. From a consideration of both, the age of the original condensates of the solar system is revealed by the slope of a straight line fitted to data points in a graph of: Pb-206/(Pb-204 or Pb-208) against Pb-207/(Pb-204 or Pb-208). In 1953, **Clair(e) Cameron Patterson** (Pat) (1922-1995) was the first to determine, this way, that Earth originated about 4.5 Ga (billion years ago). After excitement palpitations that had his mother see him briefly to hospital, he mailed to Holmes a bouquet:



“I wish to reiterate my personal indebtedness to your pioneering work in this field. It was outstandingly inspiring and ingenious.”²

In 1956, Patterson published the presently accepted 4.55 ± 0.07 Ga for when Earth first became a solid body.³ In keeping with the eon names (from today back): Phanerozoic (apparent animal life), Cryptozoic (hidden animal life), the eon before is most often called *Azoic* (without life). But that is a misnomer. One cannot reason that life did not exist during the Azoic unless some mechanism be whereby bacteria sprang *ex nihilo* (out of nothing) at the Cryptozoic's beginning. Better than Azoic Eon for time before the Archean is the whimsical name Hadean (Greek for “of the underworld”) Eon (**Footnote L10.1**).

Earth rocks that existed during the first half-billion years were thoroughly reworked during Late Heavy Bombardment 3.82-3.85 Ga the end of which is the accepted end of the Hadean.⁴

Detrital zircons that date Hadean in age have been found in igneous rocks, Australia.⁵ They are judged to be detrital because they are rounded. The process that rounded them was evidently not partial dissolution, which would have left etched pits, but from its style was mechanical. Being thus, they did not crystallize as one of the minerals of the igneous rocks that contain them. (Zircons are common accessory minerals in granite and do not grow in basic and ultrabasic magmas). Evidently

they were incorporated at some time after they had been subject to the surface operation of the rock cycle. That is, they were originally in a granitic igneous rock that crystallized in the Hadean. This was raised above sealevel where weathering released the zircons. Zircons resist chemical weathering. At the surface they underwent transportation that resulted in their rounding. So before the Archean, some continental terrains evidently did come into being but did not escape rock-cycle reworkings.⁶

The oldest found zircons date 4.4 Gy. These occur in metamorphosed sediments at Jack Hills, in the Narryer Gneiss Terrane, Yilgarn Craton, Western Australia, and are detrital clasts. They have high $\delta^{18}\text{O}$ values and micro-inclusions of SiO_2 indicating the zircons crystallized (at temperature $\sim 700^\circ\text{C}$) anatexically in a wet granite.⁷ Simon A. Wilde in 2001 opined that the magmatic oxygen-isotope ratios found indicate involvement of supracrustal material that has undergone low-temperature interaction with a liquid hydrosphere and that the (one) $4,404 \pm 8$ My zircon they have investigated provides the earliest evidence for continental crust and oceans on Earth.⁸ Was there any place though for Darwin’s imagined “little warm pond” for life’s start and continuance in the pummeled Hadean world?

Earth, as part of the solar system, began its coalescence 4.567 Ga. Some *Apollo*-returned Moon samples are almost of that age, and of that age are some rocks fallen to Earth as meteorites. □

Footnote L10.1 Time before the Proterozoic is by common usage referred to as the Archean, Archaeozoic, Cryptozoic, or the Azoic. “Azoic” meaning “no life” has repeatedly been found to be a misnomer. In 1833, Edward Forbes told a meeting of the British Association for the Advancement of Science that results of dredging the Mediterranean, going as deep as 230 fathoms from the H.M.S. *Beacon*, Royal Navy survey ship, indicated, when extrapolated, that below 300 fathoms lay a vast “azoic zone.” However, Charles Wyville Thomson on the *Challenger* 1872 to 1876 circumnavigation of the globe⁹ found that: “Animal life is present on the bottom of the ocean at all depths,” and he moved the azoic from the deep ocean floor to an intermediate ocean depth. But, Robert Kunzig writes in *Deep-Sea Biology*, *Science*, 2003, shortly thereafter “when nets were invented that could reliably bring back samples from intermediate depths ... it was very much alive”¹⁰ and is where diversity lurks rivaling that of the rainforest, including fireworks jellyfishes and—in some accordance to Socrates’ imagining that there “nothing is in the least worthy to be judged beautiful by our standards”—the pigbutt worm and the “vampire squid from hell” described by Claire Nouvain.¹¹ Walter Brian Harland in 1989 recommend that a 3rd and first division of the Precambrian be called the *Priscoan*¹² rather than the *Hadean* (term coined by Preston Ercelle Cloud in 1972).¹³ However, Hadean remains generally preferred for being whimsically suggestive of a mythical underworld of heat and confusion.

Figure L11.1¹
The selenologic time scale and column

