L2 Archean terrains < older than 2.5 Gy >

I would rather understand one cause than be King of Persia. —Democritus of Abder.[1]

Continents are subject to being broken and reworked in their margins. Reworking of cratons can be wide (1000 km is the present width of the Rocky mountains orogenic belt of North America). Breakage of cratons has no respect for age (***Figure L2.1***).

Fragmentation preceded by agglomeration of supercontinents has occurred possibly five times since the end of the Archean. Much Archean continental crust is found reworked as part of younger structural provinces. Existing Archean structural provinces are remnants, in total area less than half of what existed by the end of the Archean. Archean geological history, readable from the rocks of these, spans some one and a half billion years.

The Superior (structural) province in Canada is a craton fragment vast in area in which mica K-Ar radiometric ages record an end-time of thermal metamorphism at 2.5 Ga. This date is used in Canada to define the end of the Archean Eon. The culminating orogeny of the Superior province (which ended about 300 million years before) is called the *Kenoran*. However, no panorogeny (worldwide orogeny) is evidenced that would indicate that a single supercontinent then existed. Archean craton fragments of other continental terrains are many which have not been recrystallized in their exposed (shield) parts since well before 2.5 Ga.

Some features of the Archean that are less or more:

Less is the near absence of platform and miogeoclinal limestone facies.

More are: 1) The greater amount of primordial heat and radioactive-element abundances that made for a steeper geothermal gradient (***Figure L2.2***). Direct evidence of this is that komatiite (the volcanic equivalent of plutonic peridotite), which melts at a temperature of 1,580 ºC, stopped being erupted after 2.5 Ga. 2) The thick turbidite graywacke, pillow lavas and volcanic-proximal BIFs that are common. 3) The thick refractory keels that characterize diamond yielding Archean cratons (Clifford's rule).

Three quarters of shield exposed Archean crust is "granitic rock" mostly granodiorites and tonalites. (name derived from Tonale Pass, northern Italy. *Note*: *Tonalite* is a synonym of *quartz diorite* but is restricted in its use for this in which biotite and hornblende are the predominant mafics rather than hornblende and pyroxene.)[2] On continental microcontinents (already old island-arc terrains) that accreted and stabilized during the Archean, are basin-accumulations of Huronian-like quartzose detritals. Different though in these are sand grains and pebbles of pyrite and stream-placer uraninite and siderite. Also, 2.45 Ga and before are shallow-water facies of *reduced* ironformations, highly carbonaceous shales, which are not enriched in redox-sensitive elements, and palaeosols that are not oxidized.[3] This is evidence that free oxygen (O_2) was absent from the Archean atmosphere.

Lee R Kump in 2001 floated the idea that a buildup of oxygen gas released to Earth's surface began when oxidized mantle rocks, heated from below by the core, and from within by radioactivity, began to ascend to the surface. Before the end of the Archean, free oxygen was prevented from accumulating in the atmosphere by its reaction with rocks rich in reduced iron that later sank. Only by about 2.7 Ga, when most of the lower mantle was filled with this oxidized material, did the return of it begin, ending this oxygen sink.[4]

The record is that during the Archean, before the existence of continental plates, the style of plate tectonics was different. Swept together then were

voluminous complexes of island-arc volcanic flows and pyroclastics, and graywackes locally derived from them. These volcanics and sediments either remain draped across, or are sunken as synclinoria between, diapirically intruded granite-gneiss domes (as well exampled in the Pilbara shield, Western Australia) that rose from their base. The *vertical-tectonics* is of *diapirism* (dome up) and *sagduction* (synclinoria down).[5]

The present geographic location of surviving Archean craton fragments, scattered by Pangea's breakup, is a reminder of how plate tectonics can stir the pot. Correlation between Archean remnants is likely to be an exercise in futility. Even more so as continents formed by 2.5 Ga were assembled in a thin (hotter Earth) lithosphere that was originally everywhere oceanic. ❑

Figure L2.1 [6] **The present distribution of Archean structural provinces.**
The breakup of Pangea, which began 0.18 Ga, divided the Early Proterozoic structural provinces São Luis that stabilizes 2.0 Ga, and the Archean structural provinces Nain, and Madagascar, that stabilized 3.5 Ga.

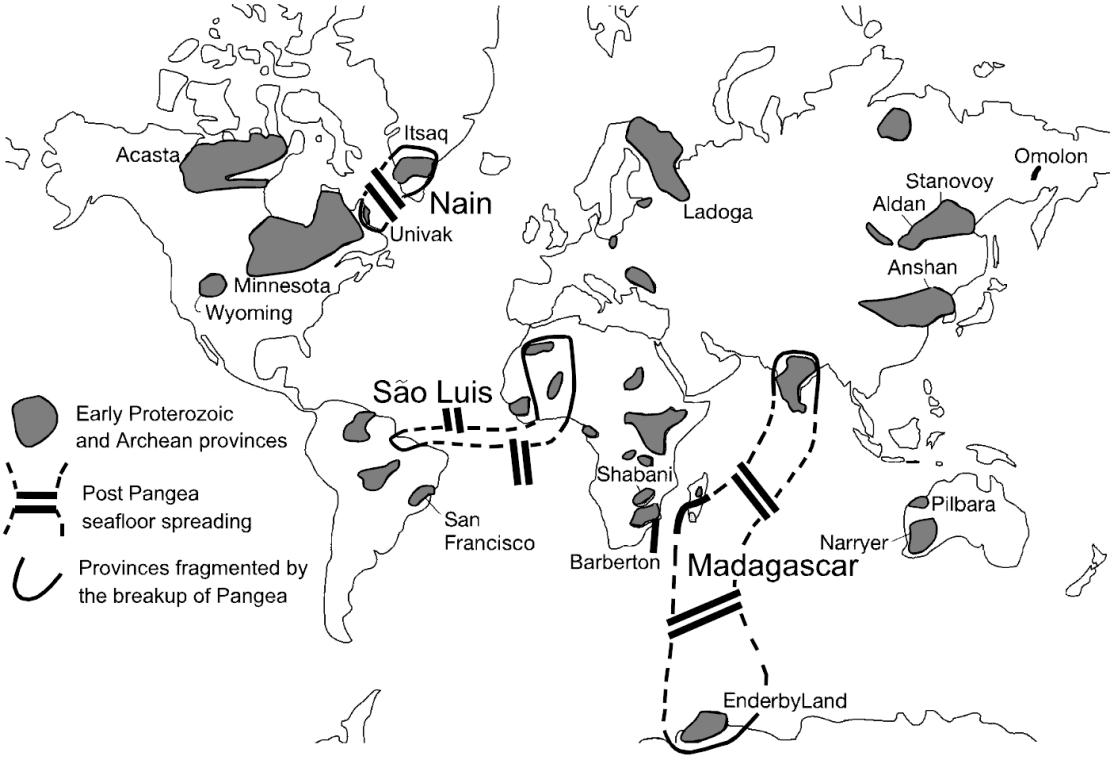
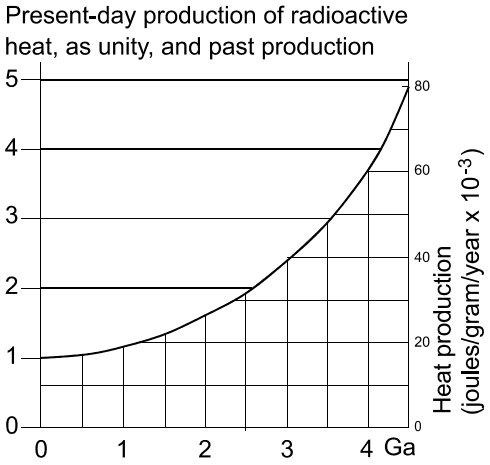


Figure L2.2 [7] Decline in the rate of heat released by radioactive elements in Earth through time.



"... practically all the energy liberated by atomic disintegration appears as heat. In addition to thorium and uranium, potassium[-40] is an important generator of heat by radioactivity, more by reason of its relative abundance in the rocks than for its own inherent radioactivity: rubidium, on account of its scarcity, may be neglected.

"The average amount of heat lost per annum by radiation into space and conduction to the surface, is some 60 calories per sq. cm. This is approximately equal to the radioactive energy produced by a layer 14 km. thick of granite, 16.5 km. of granodiorite, 52 km. of plateau basalt or gabbro, and 60 km. of peridotite." —J. A. Steers,1932.[8]