**DID LHB END NOT WITH A BANG BUT A WHIMPER? THE GEOLOGIC EVIDENCE.** D. R. Lowe[1] and G. R. Byerly[2], [1](Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305, drlowe@stanford.edu), [2](Department of Geology and Geophysics, Louisiana State University, Baton Rouge, LA 70803, glbyer@lsu.edu)

**Introduction:** Lunar evidence of Late Heavy Bombardment has been interpreted to suggest that large-body impacting declined rapidly after about 3.8 Ga and that by 3.5 Ga the terrestrial bombardment rate was not much greater than the impact rates of today [compare 1,2]. In 1986 and 1989 [3, 4] the authors and colleagues described four major layers of spherical particles in the 3.22-3.55 Ga Barberton greenstone belt (BGB), South Africa, ranging from 3,472 to 3,243 Ma and interpreted them to represent the products of large impacts. These impacts generated rock vapor clouds that condensed and the solidified spherules fell to Earth, forming layers of essentially pure spherules that, where undisturbed by later currents, total as much as 35 cm thick [5, 6, 7]. In most areas, large wave and current events accompanied spherule deposition, even in otherwise quite and probably deepwater environments. These high-energy events have been interpreted as the result of tsunamis generated by the impacts. Subsequent Cr isotopic studies [8, 9] have demonstrated the presence of extra-terrestrial chromium in three of these impact layers. Estimates of bolide size based on bed thicknesses, spherule diameters, Ir and Cr fluxes of S2, S3, and S4 suggest impactors in the range of 20-100 km in diameter [5, 7, 10, 11]. S1 has been found in both the BGB of South Africa and Pilbara of Western Australia [12].

**Newly Discovered Mid-Archean Impacts:** Since describing and interpreting these early impact layers, we have identified at least three additional thick layers of spherules (for example, Fig. 1) in the Barberton belt that likely represent deposits of large impacts, and two new layers that display some geological features associated with impacts (unusual breccias or spherules). They span an age range from about 3,400 to about 3,230 Ga (Fig. 2 - strat column with ages and spherule layer positions). Two of these new layers, where observed, are composed of essentially pure spherules in beds 25-40 cm thick: one contains abundant spherules admixed with ripped-up detritus in a wave- or current deposited layer over 1 m thick. We have not yet completed geochemical studies of these new spherule beds, but they exhibit all of the same compositional, textural, and sedimentary features that initially led us to interpret the S1-S4 beds as impact deposits.

All of these layers are composed of essentially pure spherules where fall deposited (Fig. 3 provides an additional example): none appears to contain large particles of ballistic debris generated during the impacts, nor have we observed shock features in quartz or zircon. We have interpreted them to represent debris deposited far away from the impact sites. Each of the 7 discovered impact and probable impact layers within the 3,472-3,230 interval (230 myr) in the BGB is thicker than any known distal impact deposit formed at any time during the last 2,000 myr of Earth history.

**Discussion:** Large impact layers have been identified to date in most of the major sedimentary units in the BGB. Intervening sections are composed largely of volcanic rocks where the record of impact events is unlikely to be preserved and it seems likely that other large impacts occurred during this period without leaving a record. These layers suggest that Earth continued to be bombarded by large extraterrestrial objects late into the Archean, at least until 3.2 Ga. The large sizes possible for these objects means that, while none was probably a sterilizing impact, many may have severely heated the oceans and atmosphere and boiled off the upper layer of seawater. These objects would have had significant effects on early life, including restricting the possible role of photosynthesizers, which require both access to light and environmental temperatures below about 73 degrees C. They may also have severely disrupted the early Archean crust and near-surafce geodynamic system. The 3.8-3.2 Ga development of the Earth's surface environment and life may have been constrained largely by the continuing flux of large impactors. Only as that flux declined in the Late Archean were stable surface systems established within which non-thermophilic organisms and a stable geodynamic system could develop and evolve.

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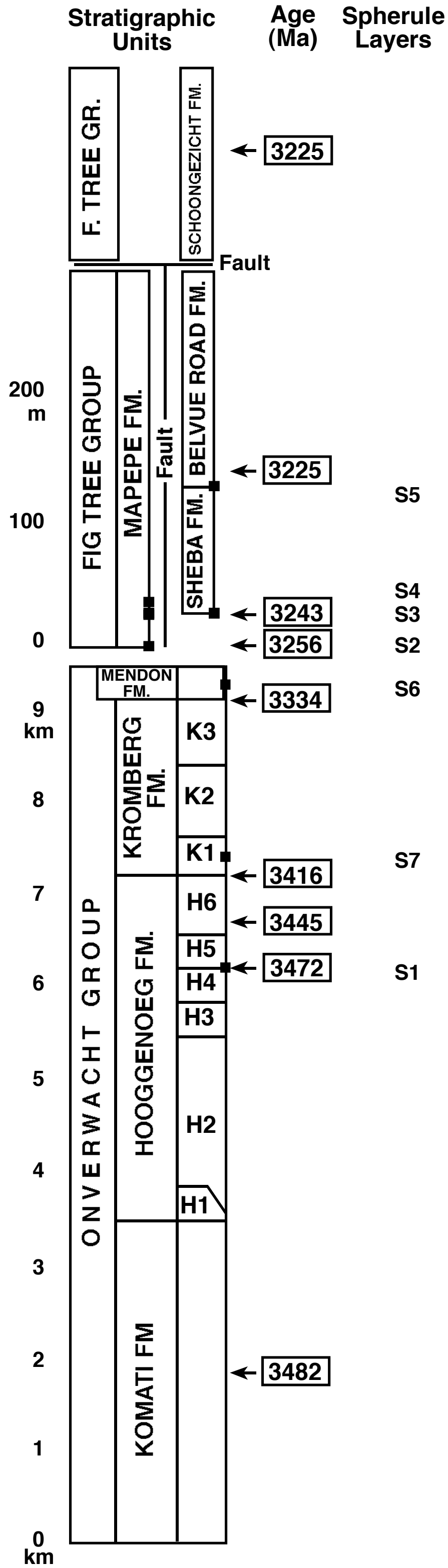


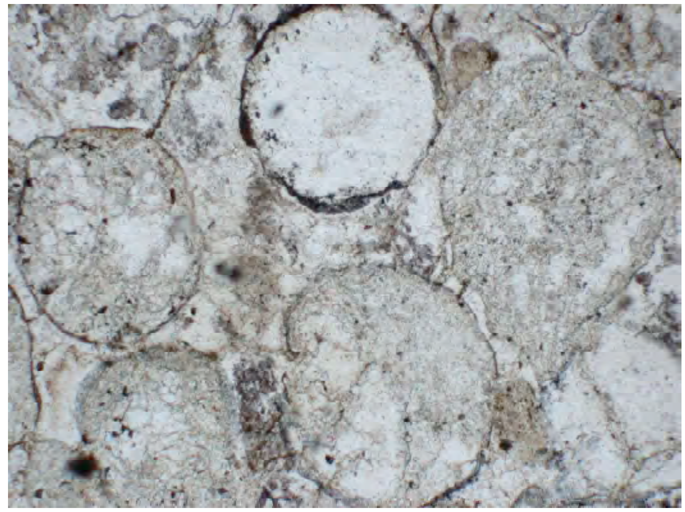

**Figure 1.** Impact spherules, layer S6, circa 3300 Ma. Longer dimension of photomicrograph is 2mm.

**Figure 2 (left):** Simplified stratigraphic column of portions of the Fig Tree and Onverwacht Groups in the Barberton grenstone belt showing the general ages of the stratigraphic units and locations and numbers of the spherule beds (black circles). Beds S1-4 are those originally described [3, 4] and beds S5-7 are those reported here for the first time. Stratigraphy from Lowe and Byerly [13].

**Figure 3**. Impact spherules, layer S5, in cross-polarized light with accessory plate. Textures suggest devitrification of spherules that were initially holohyaline. Longer dimension of photomicrograph is 2mm.