

L15 Great meteorite bombardment < Vredefort on Earth, Lunar cataclysm >



Monster I [an image of a comet drawn by Donata Almicci] am stranger
in shape and form / Th[a]n the harpy, the siren or the ghoul.

—*Enigma sonnet in Against the Donning of the Gown (Contro Il Portar La Toga)*
by **Galileo Galilei** and as translated by Giovanni F. Bignami.¹ (Galileo denounced
all comets as optical illusions conjured up in Earth's atmosphere. Illness kept him
from ever seeing one though his telescope.)

If his writing seems effortless, this is because much effort went into the writing.
—HR

On Earth, the oldest and largest meteorite-crater scar is the Vredefort structure (**Figure L15.1**), South Africa.² The impactor punched 2 Ga to a depth of 35 kilometers into the Kaapvaal shield and in forming the crater turned up all in its periphery past the vertical. The metamorphic grade and the radiometric age of crystallization of formations in this rim were not changed by the impact event.

The Vredefort structure provides a remarkable cross section through to the underlying mantle of the Early Archean continental crust. This section, exposed horizontally by erosion, shows Early Archean Witwatersrand supercrustals accumulated on the Kaapvaal craton that is itself comprised of two tectonically stacked lithosphere slabs. The stacking was by thrust faulting recorded by a regional shear zone that involved brittle-ductile deformation. The Vredefort discontinuity separates an upper continental lithosphere slab of granite crust of amphibolite metamorphic grade, from an underlying granite-greenstone crust of granulite metamorphic grade. The whole is thrust displaced, for the underlying “mantle” rocks have the chemistry of oceanic crust (serpentinized harzburgites).³

The Vredefort geology supports a model of craton origin by imbrication tectonism (thrust stacking) thickening, rather than by igneous thickening of continental lithosphere.

Earlier planetesimal bombardment on Earth is not preserved by direct evidence.

Where illuminated, Moon's grayish (<7% of sunlight is back scattered) circular-mare (lowland) formations are basaltic magma outpourings that occupy enormous craters that planetesimals punched through the brighter (7-10% of sunlight is back scattered) primary anorthositic terrae (highland) crust. Over ten thousand craters have diameters of over 30 kilometers and eighty exceed 300 kilometers in diameter. The great difference in age between the maria basalts (the youngest crystallized 2.4 Ga) and the oldest terrae igneous crust (the first crystallized 4.5 Ga) suggests no causal connection between mare basalt outpourings and impact breaching of the terrae.

The “Lunar Cataclysm” is when of most of Moon's craters formed. Large meteorite impacts generate seismic waves that cause the nearby rocks to be shocked (the rock is subjected to intense transient pressures that lastingly alters it in various ways). Shock events can be dated because argon clocks of minerals are reset in shocked rocks by Ar migrations at such times. Clustering of shock ages in lunar rocks (**Figure L15.2**) record a period of intense bombardment before 3.6 Ga.

From concentrations of metals in 3.9 billion years old lunar impact melts, Randy L. Korotev in 2002 concluded that “objects that struck the moon were asteroids.” This early bombardment is recorded by some 1,700 lunar craters at least 20 kilometers wide during a period then lasting between 20 million and 200 million years. Given that flux, he and Barbara A Cohen, estimate that more than 22,000 similar objects impacted Earth (6,400 Mars, and 3,200 Mercury).⁴ This bombardment of the inner solar system that appears to have begun suddenly 500-600 million years after the formation

of the solar system could be an illusion William K. Hartmann suggests for only when the extraterrestrial pummeling began to subside could impact melts survive to record it. The court is out as to whether any prior Earth-atmosphere survives.⁶

Earth's water has one deuterium isotope to every 7,000 atoms of standard hydrogen. Twice this ratio in spectral analyses of the chemical compositions of three comets (Halley, Hyakutake, and Hale-Bopp, during near-Earth passes in 1986, 1996, and 1997, respectively) shows these (from far reaches of the solar system) cannot be representative of the icy bodies that delivered water to Earth, if that was its source.⁷ □

Figure L15.1⁸ The Vredefort structure exposes continental crust and upper mantle in cross section.

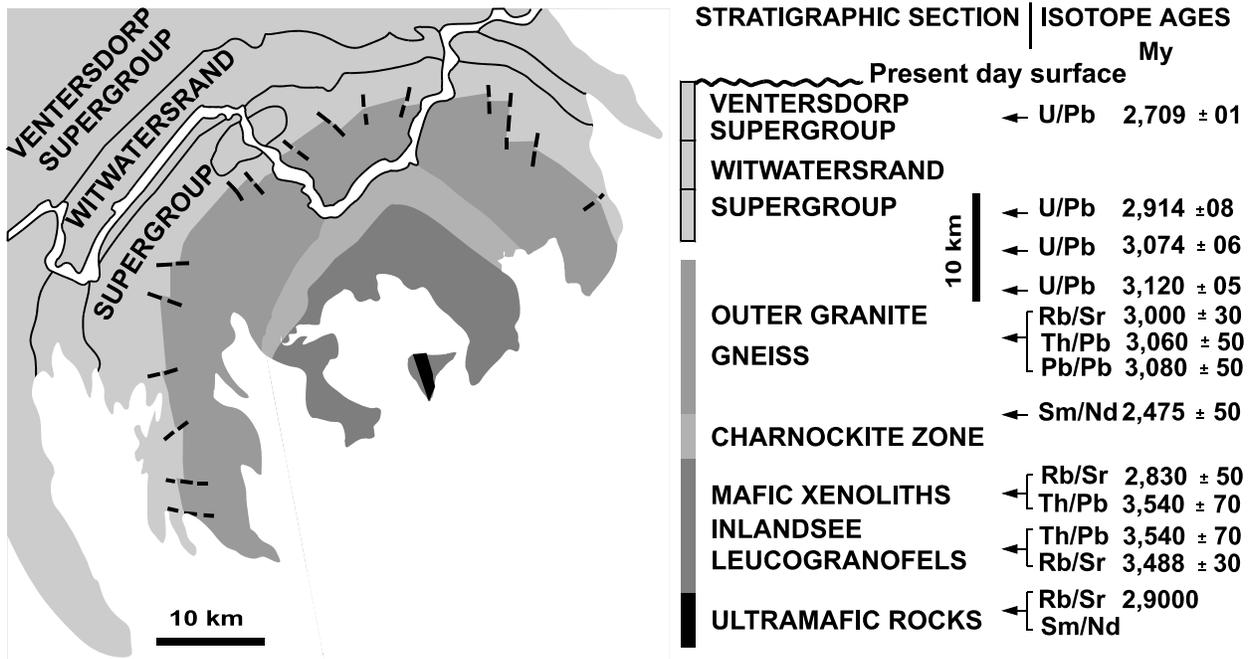


Figure L15.2⁹ Shock ages (Ar-Ar) for lunar highland samples.

Each plotted time interval is 0.2 Gy. The Late Hadean clustering of collision events at 3.85 Ga suggests to some that the history of the pummeling of Moon's terrae crust (crystallized 4.3 to 4.5 Ga) is unique and cannot be used to closely assign ages to pummelings recorded by other planets. Moon moves away from Earth and could have intercepted rings of debris that lay outward from where it first assembled as the large tide generating body that the faster spinning Earth accelerates in its orbit.

