

'Snowball Earth' out with a bang?

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Ever since the discovery that Earth had once been glaciated to a far greater extent than it is today, the Ice Age has been an iconic feature of secular geology. Although a single ice age in the recent past challenged the notion of uniformity of Earth's gradual processes, the uniformitarian multiplication of Earth's glacial periods was quickly heralded as a victory for the antiquity of Earth, despite the evidence supporting a single glaciation.¹ Over the succeeding decades, geologists have inferred dozens of alleged glaciations, predominately in five major periods of geohistory (table 1), the oldest of which are the Huronian glaciations (2.45–2.22 Ga) in the Early Proterozoic.² These

Huronian glaciations, among others, are opined to have been uncommonly extensive, dominating the majority of Earth's surface, even to the equatorial regions. Popularly termed 'snowball Earth', this inference has nearly gained consensus in secular geology and great repute in the entertainment sector. Notwithstanding this popularity, numerous challenges plague these uniformitarian notions, chief of which is the lack of a melting mechanism to end the perpetuation of these global ice ages. In a desperate attempt to save the paradigm, a recent study has suggested that an asteroid impact terminated the Huronian glaciations (figure 1).

The old story

Beginning in the mid-nineteenth century, geologists began recognizing evidence for a glaciation in recent geohistory that far exceeded the present glacial extent. Following the trend to minimize the influence of the Genesis

Flood, some geologists heralded the discovery of an ice age as accounting for the surficial deposits ('diluvium') previously relegated to a diminutive Genesis Flood, allegedly eliminating the need for a Flood-based geology. Although the presence of an ice age challenged uniformitarian doctrine ('the present is the key to the past'), geologists soon inferred other supposed glaciations throughout geohistory that coincided appropriately with the cyclicity of gradualistic geology. These cycles of glacial and interglacial alternations have been identified in five major periods of Earth's history, the earliest being the glaciations of the Early Proterozoic. These early ice ages, equalling three discrete glacial periods between 2.45–2.32 Ga, and possibly a fourth ending at 2.2 Ga (the Makganyene Glaciation^{3,4}), have been termed the 'Huronian glaciations' based on the initial identification of 'tillites' (alleged lithified glacial deposits) in Southern Canada.² Paleocontinental reconstructions suggest that these supposed tillites formed along the equator, indicating that glaciations had dominated the majority of Earth's surface in the Early Proterozoic. This has resulted in the popular sobriquet 'snowball Earth' for these and other similarly pervasive glaciations.⁵

Despite the overwhelming consensus, numerous challenges continue to plague these alleged ancient glaciations. Much of the diagnostic criteria used to identify ancient ice ages can be explained by mass wasting;⁶ even the initiation (and thus the cyclicity) of an ice age is wholly inexplicable in secular geology.⁷ Snowball Earth particularly lacks a forcing mechanism to end an ice age. Such an extensive glaciation would produce such a high reflectivity (albedo) that it would be nearly impossible to heat Earth out of a glaciation, especially during a time when solar irradiance was greatly diminished.⁸ To account for these challenges, numerous rescuing mechanisms have



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Figure 1. The naturalistic paradigm of multiple ice ages has long been plagued by a lack of a plausible mechanism for initiating glaciation, and, in the case of those glaciations allegedly near global in scale, a failure to explain their cessation. A recent study claims that the Huronian 'snowball Earth' glaciations were terminated by an asteroid impact, but rather than solving the dilemma of heating Earth out of a perpetual global glaciation, the study merely confirmed the obvious: the naturalistic paradigm of multiple ice ages is doomed.

been proposed, including an increase in volcanism accompanied by an influx of greenhouse gases, although this also suffers from major difficulties.⁹

A new twist

Faced with these insurmountable challenges, what can secular geologists do? Following the resurgence of naturalistic neocatastrophism in recent decades, a greater number of secular geologists have begun to rely on extra-terrestrial forcing mechanisms, as did Ericson *et al.* in their recent Goldschmidt abstract¹⁰ and paper in *Nature Communications*.¹¹ After investigating the Yarrabubba Crater of the Australian Outback, Ericson *et al.* proposed that an asteroid impact strengthened the termination of the global Huronian glaciations (figure 1).

Located in the Archean Yilgarn Craton of Western Australia, the Yarrabubba Crater is replete with shatter cones, pseudotachylites,¹² and other diagnostic criteria that confirm it as one of the largest impact craters in the area and it has been dated as among the oldest along the craton,¹³ if not the world.¹¹ Despite the evidence for an impact, the granitoids and greenschists that harbour this impact structure have made dating this site anomalous. Early research by McDonald *et al.* suggested an upper limit of 2.65 Ga, based on the interpretation that the Barlangi Granophyre was an impact melt,¹⁴ although later researchers preferred 1.1 Ga, based on pseudotachylite dikes.¹³ Upon this groundwork, Ericson *et al.* dated the impact to no more than about 2.6 Ga, as calculated by McDonald *et al.*, but preferred a date of 2.2 Ga. This younger age roughly coincides with the end of the Makganyene Glaciation, the finale of the Huronian glaciations at 2.22 Ga.² Ericson *et al.* opine this impact melted a considerable volume of ice and ejected it into the atmosphere. This would allegedly lower the cumulative albedo of the

terrestrial cryosphere while increasing the atmospheric levels of water vapour, producing a greenhouse warming and thus ending the Huronian glaciations. It was not long before the Ericson *et al.* proposal began gaining attention from the popular media for its allegedly novel solution to snowball earth, including an article in *Science*.¹⁵

Challenges galore

A common consideration, particularly for those skeptical of an impact inducing the End Cretaceous mass extinctions,¹⁶ is that coincidence does not necessitate causation. However, age estimates of the local geology ranging from 2.65 to 1.1 Ga make it hard to even show that the Yarrabubba impact was coincident with the cessation of the Huronian glaciations. Such a wide array of possible dates should caution researchers against possibly forcing the numbers, but even so the termination of the Huronian glaciations is subject to much debate,¹⁷ making it impossible to prove coincidence.

Even if the Yarrabubba impact was indeed coincident with the end of the Huronian glaciations, the impact would merely correlate to the Makganyene Glaciation, the final of four distinct Huronian glaciations. If the preceding three glaciations could be terminated

without impacts, why is an impact required to end the fourth glaciation? Even so, the Makganyene Glaciation is the most tenuous and debated of the four, as it has been discovered only in southern Africa¹⁸ and possibly China.¹⁹ So little is known about this ‘glaciation’ that secular geologists must infer a minimum age of 2.2 Ga, based on dating flood basalts which unconformably overlie the alleged tillites,^{3,20} allowing a date greater than 2.2 Ga to be acceptable. How difficult it is to prove coincidence between two events, the dates of which are not known!

Computer simulations in the Ericson *et al.* paper suggested a variety of climatic responses to the impact, most of which indicated only minimal response. Unlike the optimism of Ericson *et al.*, some scientists doubt that enough ice could be melted and ejected into the atmosphere to initiate the necessary greenhouse effect.¹⁵ Even if adequate quantities of liquid water could be introduced into the atmosphere, the Yarrabubba impact produced extensive ejecta that would raise aerosol levels in the stratosphere. Having a high albedo in their own right, these aerosols would quickly become nucleation sites for the newly melted water in the atmosphere. Because cool air can retain little water before reaching the dew point, this newly melted water could not be long

Table 1. Secular geologists postulate that Earth has undergone five major glacial phases. Glaciations of both the Early Proterozoic (Huronian glaciations) and Neoproterozoic are thought to have been global in scale, leading to their vernacular sobriquet ‘snowball Earth’. Compiled from Crowell.²¹

Geological Period	Approximate age range
Pleistocene	11,700 ka to 2.6 Ma
Late Paleozoic	256 to 338 Ma
Late Ordovician–Early Silurian	429 to 445 Ma
Neoproterozoic	520 to 950 Ma
Early Proterozoic	2.2 to 2.4 Ga

retained in the cool, dry atmosphere of the snowball earth climate before condensing. These resulting clouds, known to meteorologists as some of the most influential thermostatic regulators in the atmosphere, would merely equalize the greenhouse effect by reflecting incoming solar radiation, which would have been lower due to the faint young sun paradox.⁸ Rather than commencing a runaway greenhouse effect, these factors could initiate a negative feedback mechanism that would soon terminate any net heating introduced by the Yarrabubba impact.

Conclusions

Ever since the discovery of the Ice Age, uniformitarian geology continues in vain to understand this unparalleled phenomenon. Although cyclic glaciations may better coincide with uniformity, repeated ice ages only multiply the challenges. To remain internally consistent with the application of their diagnostic criteria, the uniformitarians are compelled to postulate global glaciations despite the various difficulties. Oddly enough, secular geologists seem more than content to propose global inundations of ice but abhor any suggestion of a global flood!

The lack of a forcing mechanism to end snowball Earth leads to the production of such *ad hoc* suggestions as an inexplicable increase in volcanism or a mystifying influx of atmospheric greenhouse gasses. The asteroid impact of Ericson *et al.* suffers a similar fate. Not only is causation impossible to demonstrate, but even the coincidence of the impact with the end of the final Huronian glaciation is dubious. Rather than terminating a glaciation, an impact may even reinforce the glaciation by adding highly reflective ejecta and aerosols into the atmosphere and producing high albedo clouds. The Ericson *et al.* study also neglected the effects of the lower levels of solar irradiance due to the faint young sun paradox. Indeed, instead

of solving the mystery, Ericson *et al.* merely reinforced the reason for doubting the multiple ice age paradigm. Because of the failure of uniformitarian postulates, some secular researchers continue to search for a causal forcing mechanism to terminate the Huronian ‘snowball Earth’ glaciations. As long as the impact of the Genesis Flood on our planet is ignored, the Ice Age will remain a baffling puzzle to secular researchers.

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