Early Earth was bombarded by series of city-sized asteroids

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Artist's impression of the Hadean Earth. Huge, impact-generated lava lakes coexisted with surface liquid water, under a thick greenhouse atmosphere sustained by lava outgassing. Credit: SwRI/Simone Marchi, Dan Durda

Scientists know that the Earth was bombarded by huge impactors in distant time, but a new analysis suggests that the number of these impacts may have been 10 times higher than previously thought. This translates into a barrage of collisions—similar in scale to that of the

asteroid strike that wiped out the dinosaurs—on average every 15 million years between 2.5 and 3.5 billion years ago. Some of these individual impacts may have been much bigger, possibly ranging from city-sized to small province sized. Researchers are also considering what effect the impacts may have had on the Earth's evolving near-surface chemistry. This work is presented at the Goldschmidt Geochemistry Conference.

Earth's early years were unimaginably violent in comparison to today. Scientists believe that Earth was struck by a significant number of large asteroids (greater than 10 km in diameter), and this would have had significant effect on the Earth's near-surface chemistry and ability to support life. The effect of just one such collision was shown comparatively recently by the Chicxulub impact 66 million years ago, which led to the extinction of the dinosaurs. The early Earth, however, was very different to the Earth at the time of the Chicxulub impact, and so were the effects of collisions.

Impact craters from similar collisions can be seen on the Moon and other rocky planets, but atmospheric weathering and plate tectonics have tended to mask any direct evidence for ancient impact craters on Earth. However, echoes of these distant impacts can be seen in the presence of "spherules" found in ancient rocks; the huge impacts threw up molten particles and vapors which then cooled and fell to Earth to be embedded in rock as small spherical glassy particles. The greater the impact, the more these particles would have spread from the impact site, so global distribution of a thick spherule layer shows a huge impact.

Researcher Dr. Simone Marchi, of the Southwest Research Institute (Boulder, CO, U.S.) said, "We have developed a new impact flux model and compared with a statistical analysis of ancient spherule layer data. With this approach, we found that current models of Earth's early bombardment severely underestimate the number of known impacts, as

recorded by spherule layers. The true impact flux could have been up to a factor of 10 times higher than previously thought in the period between 3.5 and 2.5 billion years ago. This means that in that early period, we were probably being hit by a Chicxulub-sized impact on average every 15 million years. Quite a spectacle.

Meteor Crater, Arizona. This crater is the result of an impact of a 50m meteor, whereas the impacts described in the current work may have been hundreds of times bigger. Credit: Dr Dale Nations, AZGS.

"As we deepen our understanding of the early Earth, we find that cosmic collisions are like the proverbial elephant in the room. They are often neglected as we lack a detailed knowledge of their number and magnitude, but it is likely these energetic events fundamentally altered

the Earth's surface and atmospheric evolution.

"For example, one outcome we are looking at is to try to understand if these impacts may have affected the evolution of atmospheric oxygen. We find that oxygen levels would have drastically fluctuated in the period of intense impacts. Given the importance of oxygen to the Earth's development, and indeed to the development of life, its possible connection with collisions is intriguing and deserved further investigation. This is the next stage of our work."

Commenting, Dr. Rosalie Tostevin, of the University of Cape Town, said, "These large impacts would certainly have caused some disruption. Unfortunately, few rocks from this far back in time survive, so direct evidence for impacts, and their ecological consequences, is patchy. The model put forward by Dr. Marchi helps us to get a better feel for the number and size of collisions on the early Earth.

"Some chemical markers suggest there were 'whiffs' of oxygen in the early atmosphere, before a permanent rise around 2.5 billion years ago. But there is considerable debate surrounding the significance of these 'whiffs,' or indeed, whether they occurred at all. We tend to focus on the Earth's interior and the evolution of life as controls on Earth's oxygen balance, but bombardment with rocks from space provides an intriguing alternative."

Dr. Tostevin was not involved in this work.

Provided by Goldschmidt Conference