THE CHRONOLOGICAL RECORD OF IMPACT CRATERING (CRATER STRUCTURES AND EJECTA) ON EARTH – WHAT WE KNOW AND WHAT WE DON'T KNOW

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Impact cratering, the collision of asteroids and comets with planetary bodies, is a fundamental geological process that has played a significant role in the evolution of Earth's crust and can trigger climatic perturbations and mass extinctions. Although there are over two million impact craters recognized on the Moon [1], the vast majority of impact structures that formed on Earth have been lost as a result of heavy metamorphism, deformation, and destruction of crust associated with Earth's dynamic plate tectonic processes. Today there are approximately 200 confirmed impact structures on Earth, the oldest of which dates to *ca.* 2.23 Ga [2], and about 50 further impact-related deposits (ejecta layers, breccias, etc.), which extend the impact archive back to *ca.* 3.5 Ga (e.g., [3-4]). Despite representing a limited database, the terrestrial record offers an invaluable resource for reconstructing the role of impact cratering in Earth's history, as well as offering insights into the evolution and bombardment history of the inner Solar System more generally. Key to this is understanding when Earth's impact structures formed; for example, accurate and precise ages allow us to test if impacts may have coincided with known extinctions (e.g., [5-6]), or if they occur in clusters that may reflect events in wider Solar System (e.g., [7-8]).

However, the available geochronological data for the terrestrial impact record represents a major gap in our understanding. Less than half of the approximately 200 confirmed impact structures have been directly dated with radioisotopic or other analytical techniques, with the precision and accuracy of these impact ages varying significantly. The ages of the remaining structures are often only loosely constrained by stratigraphic setting or simply the age of the target rock, if the latter is even known. In 2012, Jourdan et al. [9] proposed that "A dating campaign is urgently needed if we are to fully understand the role of impacts in Earth history." Encouragingly, the past decade has seen major advances in our efforts to date terrestrial impact craters. Advances in U–Pb analyses of shocked and impact-melt-grown accessory phases, for example, have included (i) the integration of microstructural characterization and high-spatial-resolution analyses, in order to better target impact-aged domains of heterogeneous grains (e.g., [10-11]); the application of the now widely available laser ablation–inductively coupled plasma mass spectrometry (LA-ICPMS) technique (e.g., [12-13]); and high-precision age determination in the era of chemical abrasion and the EARTHTIME initiative [14].

Here I will provide an overview of (i) what we know regarding the timing of impacts on Earth, drawing on valuable recent compilations and analyses by, for example, Schmieder and Kring [15] and Kenkmann [16]; (ii) methods used to date impacts, with emphasis on the advances recently made in utilizing the U–Pb system in shocked and melt-grown accessory minerals as well as the relative strengths and weakness of various analytical techniques, in order to give the audience an idea of which tools might best suit their samples and research questions; and (iii) what we don't know and what I consider the most critical unanswered questions and areas for future research in the chronological record of impact cratering on Earth.

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