IMPACT EARTH – NEW INSIGHTS INTO THE TERRESTRIAL IMPACT RECORD AND CRATERING PROCESSES. G. R. Osinski[1], R. A. F. Grieve[1], P. Hill[1], J. Newman[1], P. Patel[1], G. Tolometti[1], [1]Centre for Planetary Science and Exploration / Dept. Earth Sciences, University of Western Ontario, London, ON, Canada (gosinski@uwo.ca).

Introduction: It is now widely recognized that impact cratering is one of the most important and fundamental geological processes in the Solar System [1, 2]. Indeed, impact craters are one of the most common geological landforms on the majority of the rocky planets, asteroids, and many of the rocky and icy moons of the inner and outer Solar System. Once thought to be purely a planetary science "problem", it is also now apparent that impact events have profoundly affected the origin and evolution of Earth [3]; from its environment (e.g., [4, 5]) and habitability [6–8] to the production of economic resources [9]. Furthermore, the fireball event of February 15th 2013 in Chelyabinsk, Russia [10], served as a wakeup call that impact events are not a thing of the past and could still, in practice, occur at any time.

As we enter a new era of understanding and exploration of our Solar System it is clear that there is a need, more than ever before, for understanding impact cratering processes. It is becoming increasingly clear that meteorite impacts were a fundamentally important process during the first 500 million years of Earth's evolution, and of other planetary objects throughout the Solar System. What was the role that impact melting played in forming early crusts? Were impact-generated hydrothermal systems where life originated? At the same time, as we explore the surface of the Moon and Mars with rovers and work towards bringing back samples, impact craters provide probes into the interior of these bodies, excavating material that would otherwise be out of reach. But from what depth(s) does this material originate?

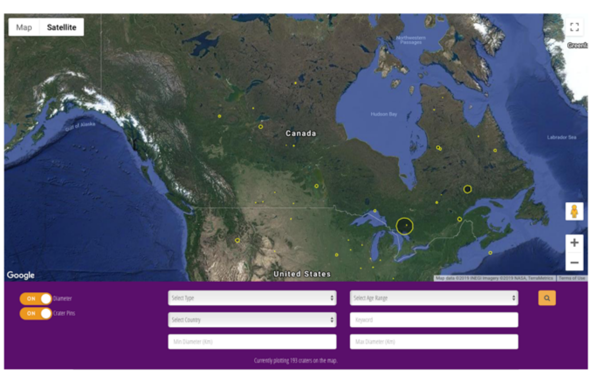

Fig. 1. Landing page for the Impact Earth database.

Of course, meteorite impacts also metamorphose [11] and melt [12] large volumes of target materials, complicating interpretation of the original igneous, sedimentary, or metamorphic record of interest. It has also become clear that even distinguishing between endogenic and impact-generated igneous rocks is a complicated and difficult process (see review by [12]), as exemplified by the re-interpretation of some Apollo samples originally classified as being of volcanic origin, as impact melt rocks [13].

The impact cratering record on Earth offers the only ground-truth for the interpretation of planetary datasets and samples and, currently, provides the only opportunity for conducting field geological and geophysical studies. Through the new *Impact Earth* initiative we present a comprehensive review of the impact cratering record on Earth. A central feature of the website (www.impactearth.com) is a new searchable database of all confirmed impact craters on Earth and many of their most important attributes, such as age, size, target rocks, and discovery year (Fig. 1).

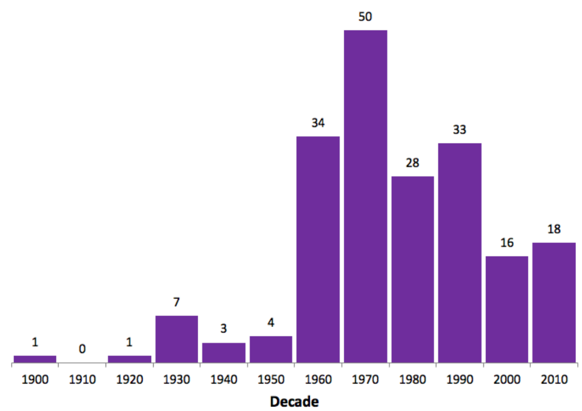

Fig. 2. Number of impact craters confirmed on Earth, binned by decade (year marks the start of the decade).

In this contribution, we provide an overview and background on the *Impact Earth* crater database. We verify the number of confirmed structures at 195 (Fig. 2) and discuss the exclusion of a small number of structures that are listed in other databases. We also show that with this new database in hand, it is possible to revisit many aspects of impact craters that have not been investigated for decades, such as the simple-to-complex transition in sedimentary vs. crystalline targets (Fig. 3).

Impact Earth – Background: The *Impact Earth* database traces its origins back to 1955 when the systematic search for impact structures was initiated by Dr. Carlyle S. Beals, the Dominion Astronomer of Canada. It initially involved the examination of over 200,000 aerial photographs of the Canadian Shield. The first published worldwide listing of impact structures on Earth was by Dence [14] and listed 50 structures, with an equal number of "possible" structures. Over time, additional structures were added, as were other data on their nature and characteristics and a searchable digital database was created and maintained initially at the Earth Physics Branch and later at the Geological Survey of Canada in Ottawa. When impact studies were terminated at Canadian government research organizations in 1997, the assets were offered to academia. As a result, portions of the database and the Impact Collection of the Geological Survey of Canada were made available through the Earth Impact Database at the University of New Brunswick. The collection was subsequently returned to the Geological Survey of Canada at the end of a 10-year loan agreement. The collection was then housed in Ottawa until The University of Western Ontario and Natural Resources Canada signed a Memorandum of Understanding in late 2016 to transfer the collection to Western. The collection not only includes impact crater materials, but the original impact database files, maps, and other paper files. The new *Impact Earth* database is an outgrowth of these earlier efforts but is a full relational-database, with enhanced available attributes and search capabilities.

Impact Earth – Number of confirmed craters: We have conducted an exhaustive analysis of the original Geological Survey of Canada database and the literature. We currently list 195 confirmed structures. It is notable that the past decade has seen an upswing in the number of confirmed impact structures, including 6 in the past 12 months. Notably, several craters discovered in the past decade are over 10 km in diameter (Hiawatha, Lake Raeside, Luizi, Pantasma, Saqqar, Tunnunik). The reason for this upswing is unclear but this suggests that the conclusion that all craters >6 km in diameter have been discovered [15] is incorrect.

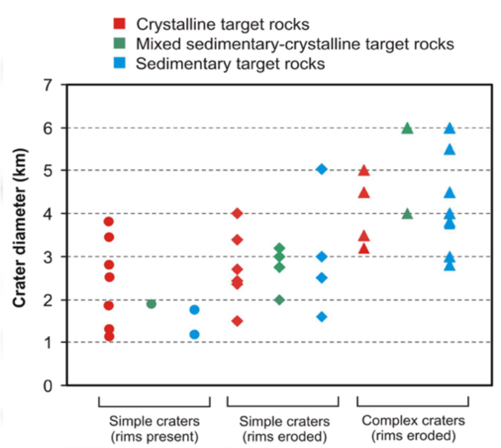

Fig. 3. Comparing the sizes of simple and complex craters in sedimentary versus crystalline targets.

Impact Earth – Revisiting the simple-to-complex transition diameter: It is widely cited that the transition from simple to complex craters on Earth occurs at a smaller diameter in sedimentary (2 km) as opposed to crystalline targets (4 km). This comes from the work of Dence [14] who based this observation on a compilation of 50 known structures at that time. Figure 3 shows that this inference requires updating, given the *Impact Earth* database. In particular, the simple-to-complex transition for craters developed in crystalline and mixed sedimentary-crystalline targets occurs over a range of diameters (~3–4 km). For sedimentary targets, the average transition diameter does appear to be at a slightly lower value of ~3 km, but the difference between craters developed in different target rocks is not as pronounced as previously noted. In addition, there are notable exceptions, such as the ~5 km diameter Goat Paddock structure which appears to be a simple crater but with features transitional to the complex morphology [16].

Impact Earth – A Resource for Research and Teaching: In an effort to increase the teaching of impact cratering at the undergraduate and graduate level, a variety of rocks kits are available that can be requested for loan through a simple online form. The foundation rock kits contain a variety of rocks from several impact craters around the world. More advanced kits are also available from several individual craters: the Gow Lake, Haughton, Mistastin Lake, Sudbury and West Clearwater Lake impact structures in Canada, and the Ries and Rochechouart impact structures in Europe.

Ongoing work: Future releases will include further attributes such as shock metamorphic effects, impactite types, and geophysical anomalies. As such, it is hoped that the *Impact Earth* database will provide an important new tool for researchers interested in meteorite impact craters and their effects.

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