IMPACT EARTH – A 2021 UPDATE ON THE TERRESTRIAL IMPACT RECORD. G. R. Osinski[1], R. A. F. Grieve[1], P. J. A. Hill[1,2], J. Newman[1], [1]Institute for Earth and Space Exploration / Dept. Earth Sciences, University of Western Ontario, London, ON, Canada, [2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada (gosinski@uwo.ca).

Introduction: Impact cratering is one of the most important and fundamental geological processes in the Solar System, affecting all solid objects with rocky or icy surfaces [1, 2]. Indeed, meteorite 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. Observations of impact craters via orbital and landed space missions have provided a wealth of information on impact cratering processes and products, in particular on the pristine morphology and morphometry of craters on objects with little geological activity such as the Moon. However, the impact record on Earth offers the only potential for ground-truthing interpretations made on other planetary bodies and the opportunity for fieldwork, in depth sampling, and deep drilling, makes the terrestrial record of paramount importance for our understanding of the impact cratering process.

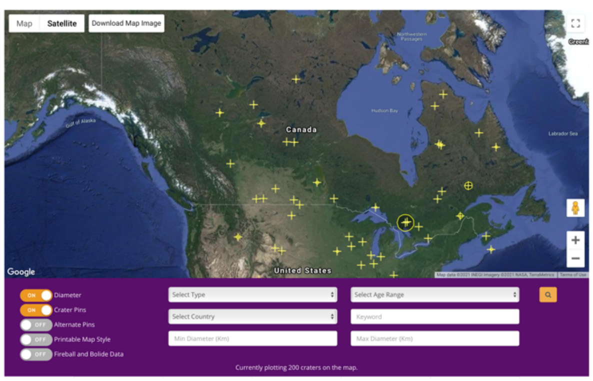

Fig. 1. The revised landing page for the Impact Earth database.

The goal of *Impact Earth* (www.impactearth.com) is to provide a holistic view of meteorite impacts, from fireballs, to meteorite falls, to the largest crater-forming events [3, 4]. The 3 main aims are to provide a resource for the research community by hosting the *Impact Earth* crater database, to promote the public understanding and interest in meteorite impacts, and provide resources for educators at the K-12 and university level. The foundation for the *Impact Earth* website (www.impactearth.com) is a searchable database of all confirmed impact craters on Earth and many of their most important attributes, such as age, size, discovery year, and target rocks (Fig. 1). Visitors to the website can choose a variety of options for displaying craters, such as by country or target rocks, or by selecting a range of diameters or ages.

A forthcoming review article in *Earth Science Reviews* [5] will expand the attributes provided to include information such as shock metamorphic features, impactites, geophysics, and post-impact hydrothermal alteration. This data will be made freely available on the *Impact Earth* website upon publication of this article.

In this contribution, we provide an overview and background on the *Impact Earth* crater database and an update on the number of confirmed structures as of December 2020 (Fig. 2).

Impact Earth – Background: The *Impact Earth* database traces its origins back to the 1950s when the systematic search for impact structures was initiated by in Canada by Dr. Carlyle S. Beals, the Dominion Astronomer of Canada. Out of this came one of the first lists of impact structures on Earth by Dence [5], which named 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, Ottawa, Canada. In 1997, impact studies were terminated at Canadian government research organizations. Portions of the database and the Impact Collection of the Geological Survey of Canada (GSC) were then 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 (Western) and Natural Resources Canada signed a Memorandum of Understanding in 2016 to transfer the collection to Western. Importantly, 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 thus 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: Through an exhaustive analysis of the original Geological Survey of Canada database and the ongoing analysis of the published literature, we list 200 confirmed impact structures in the *Impact Earth* crater database. For craters to be listed, well established evidence for shock metamorphism (e.g., planar deformation features [PDFs], shatter cones), high pressure polymorphs, or meteorite fragments, must have been identified and the data published in a peer-reviewed journal. As a result, several craters listed in the original GSC database, and listed elsewhere, are not included here.

It is notable that the previous decade (2010–2019) saw the confirmation of 24 new impact sites. Several craters discovered in the past decade are over 10 km in diameter (Hiawatha, Lake Raeside, Luizi, Pantasma, Saqqar, Tunnunik) suggesting that the conclusion that all craters >6 km in diameter have been discovered [7] is incorrect.

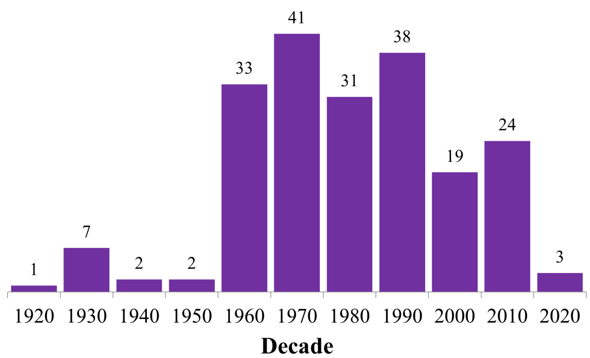

Fig. 2. Number of impact craters confirmed on Earth, binned by decade (year marks the start of the decade).

Resources for Educators: As noted at the outset, the *Impact Earth* initiative also focuses on education. For the K-12 level, we have designed an Impact Cratering Activity. This has designed using an inquiry-based learning approach where students develop their own impact experiments, thus learning about the scientific method. The aim of this activity is for the students to gain an understanding of the basic characteristics of impact craters and how they form. The core of this activity is where the students create their own craters in layered mixtures of flour and cocoa powder. All the resources for this activity are freely available for download on the *Impact Earth* website www.impactearth.com. For more senior students, this activity can be expanded to include rock kits (Fig. 3) that can be requested for loan through a simple online form.

Fig. 3. *Impact Earth* rock kit.

Recognizing that an obstacle to teaching students about meteorite impacts at the undergraduate and graduate level is the scarcity of materials. Most if not all Earth science departments in the world have hand samples of igneous, sedimentary, and metamorphic rocks, but very few have impactites – the products of meteorite impact. As such, the *Impact Earth* rock kits mentioned above are also available for loan to university and college instructors. For these more advanced levels, a selection of petrographic thin sections is also available, as are more specialized rock kits featuring the products of individual craters as well as a collection specifically focused on impact melt rocks. At present, kits are available for the Gow Lake, Haughton, Mistastin Lake, Sudbury and West Clearwater Lake impact structures in Canada, and the Ries and Rochechouart impact structures in Germany and France, respectively.

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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