EARTH'S EXPECTED IMPACT CRATER RECORD ON REGIONAL AND GLOBAL SCALES. T. Platz[1], G.G. Michael[1], O. Hartmann[1], T. Kenkmann[2], [1]Planetary Sciences & Remote Sensing, Institute of Geological Sciences, Freie Universität Berlin, Berlin, Germany (thomas.platz@fu-berlin.de), [2]Institute for Earth and Environmental Sciences – Geology, University of Freiburg, Freiburg, Germany.

Introduction: There are currently 183 confirmed impact structures known on Earth [1]. Despite the ongoing search for new impact sites their identification proves difficult due to varying degrees of erosion and/or obliteration of previously exposed surfaces. A systematic search for impact craters for a given diameter which formed on a surface of a given age may be assisted by predictions of expected crater populations on given geological units.

In this study we present preliminary results of expected crater populations for selected regions. First, we briefly describe the method to transform the lunar impact crater record to Earth conditions. Second, we apply our approach to the Deccan Traps flood basalts, a unit which formed over a relatively short period of time. Third, selected crater statistics for Precambrian units are presented.

Scaling the lunar crater record to Earth conditions: The lunar impact craters were transformed into hypothetical projectiles using the scaling laws proposed and refined by [2,3], assuming mean densities for the projectiles and the target surface of 2.7 g/cm^3 and 3.0 g/cm^3, respectively. Impact velocities for the Moon (17.5km/s) and for Earth (26.3km/s) were taken from the literature [e.g., 2,3]. The gravitational focusing due to Earth's larger mass at the given imapct velocity of 26.3 km/s is 1.083. Note the function of the gravitational focusing is non-linear and the resulting factor is larger for lower impact velocities. The chronology function of [4] for Earth has been used.

Deccan Traps flood basalts: This flood province in western India extends over 500,000 km^2 [5] A short major eruption period of 1-2 Myrs is anticipated with the eruption onset starting at or slightly before the Cretaceous-Tertiary boundary [5,6]. One crater is known to have impacted onto the basaltic surface. Lonar crater is 1.83 km in diameter and formed about 52 ka ago [6].

Based on our calculations, we would expect with 92.4% confidence, three craters in the diameter range of 1.7-2 km to have formed in the volcanic province (Table 1). However, only one crater, Lonar crater, has been found in this diameter range. With a 100.0% confidence about 11 craters equal to or larger than 1.2 km in diameter are expected.

Table 1: Calculated impact crater population for the Deccan Traps province.

Crater bin [km]	Mapped exposure		Probability to see		
	Expected N_{cum}	Observed craters N_{cum}	fewer than observed	as observed	more than observed
1	20.8	1	0.00%	0.00%	100.00%
1.1	14.9	1	0.00%	0.00%	100.00%
1.2	11.0	1	0.00%	0.00%	100.00%
1.3	8.31	1	0.02%	0.02%	99.95%
1.4	6.41	1	0.16%	0.16%	99.67%
1.5	5.04	1	0.65%	0.65%	98.71%
1.7	3.27	1	3.79%	3.79%	92.41%
2	1.89	0	-	15.15%	84.85%
2.5	0.92	0	-	39.97%	60.03%

The discrepancy can be explained by erosion processes that took place since the time of impact. Geophysical investigations at Meteor (Baringer) crater, AZ, USA, showed that the 1.2 km diameter crater has a 350 m deep reaching breccia lens [7]. Assuming that this is the maximum depth down to which any effects of a simple crater of this size can be recognized, a minimum of 350 m of erosion occurred on the Deccan Traps flood province, suggesting an average minimum erosion rate of 0.0054 mm/a.

Global geology of the Earth: We used a GIS product provided by [8] which is a compiliation of individual regional geological maps. For the purpose of this study we have simplified this global geological map and grouped the units by their respective Era of formation (Cenozoic, Mesozoic, Paleozoic) (Fig. 1). Units older than 541 Ma are summarised as Precambrian units.

If the area of all Precambrian units is considered, we expect to find a multiple of what is observed in the diameter range of 10-30 km.. In Table 2 expected and observed crater populations are listed. We emphasise that in the larger crater diameter range expectations are not met by observations. This is caused by the applied minimum surface age of 541 Ma. If we were to use an age of 4 Ga for all Precambrian units, we would expect to see at least 18 craters with diameters of 150 km or larger. This would be in stark contrast to the one crater, Vredefort (160 km diameter), found in this size range. Note in our dataset we used the 130-km diameter for Sudbury.

Table 2: Calculated impact crater population for all Precambrian surfaces . Their total area size is about 2.9×10^7 km^2. The observed crater population is listed to the right in cumulative numbers and per crater bin. For comparison, the expected crater populations are also listed for the entire Earth's surface and for the present-day land surface.

Crater bin	Expected Crater Population N_{cum}			Observed	
[km]	Earth's total surface	Earth's land surface	Area Precambrian	N_{cum}	Bin
10	440	128	24.8	17	2
11	399	116	22.4	15	1
12	366	106	20.6	14	
13	340	98.7	19.1	14	1
14	317	92.3	17.8	13	1
15	298	86.7	16.8	12	1
17	266	77.3	15.0	11	2
20	228	66.2	12.8	9	1
25	178	51.8	10.0	8	1
30	140	40.8	7.88	7	3
35	111	32.1	6.22	4	
40	87.5	25.4	4.92	4	
45	69.5	20.2	3.91	4	
50	55.5	16.1	3.12	4	
60	36.1	10.5	2.03	4	1
70	24.2	7.03	1.36	3	
80	16.6	4.84	0.936	3	
90	11.8	3.43	0.663	3	1
100	8.56	2.49	0.481	2	
110	6.36	1.85	0.358	2	
120	4.83	1.40	0.272	2	
130	3.74	1.09	0.210	2	1
140	2.95	0.857	0.166	1	
150	2.36	0.685	0.133	1	1

Discussion: The major outcome of this study is that with predicted impact-crater populations a systematic search is offered in identifying circular structures at given diameters. We are aware that surface erosion, deposition, weathering, tectonics (e.g., extension, compression), and plate movement, accretion, and subduction and other processes considerably affected the preservation of impact structures. Perhaps only the largest craters (e.g., >>20 km in diameter) did survive those geodynamic processes over a prolonged period of time. Conversely, erosion and other processes may also have a preservational effect. Impact craters buried by sediments (e.g., in basin, lacustrine, continental shelf environments) may be excated by – erosion. Either way, annual erosion rates and maximum depths of crater recognition (i.e., breccia) for various crater sizes need to be taken into consideration for a successful haunt for terrestrial impact craters.

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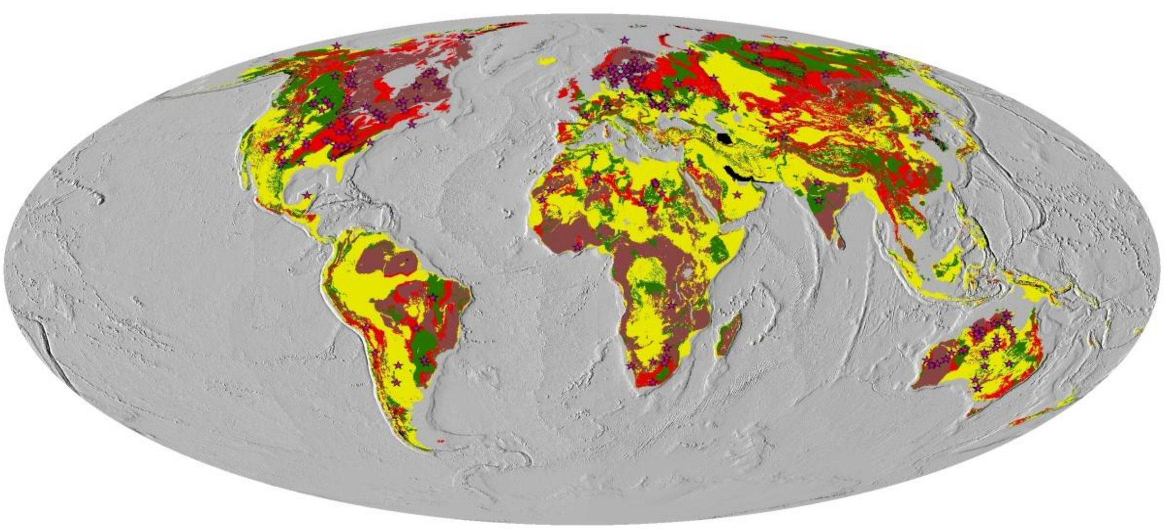

Figure 1: Simplified global geological map of the Earth (modified after [8]). Colours represent unit formation at different Eras: yellow – Cenozoic, green – Mesozoic, red – Paleozoic, brown – Precambrian, black - undifferentiated volcanics, ice etc. Note Greenland and Antarctica are not shown on this map. Pink stars represent locations of proven impact sites.