DEVASTATING CONSEQUENCES OF IMPACTS. STUDY OF TRACES OF PAST COLLISIONS

Expert Database on the Earth Impact Structures

V. K. Gusiakov, Z. A. Lyapidevskaya

Institute of Computational Mathematics and Mathematical Geophysics of RAS, Novosibirsk, Russia

Abstract. An Expert Database on the Earth Impact Structures (EDEIS) has been compiled and is being maintained in the Tsunami Laboratory of the Institute of Computational Mathematics and Mathematical Geophysics of SD RAS in Novosibirsk. This database is somewhat more liberal than the well-known Earth Impact Database maintained by the Planetary and Space Science Centre, University of New Brunswick, Canada. In addition to including the fully validated impact structures, the EDEIS also lists proposed structures whose impact genesis still needs validation. For any structure, the degree of confidence of impact origin is reflected by its validity index V, which varies from 4 (confirmed) to 0 (rejected) with intermediate values of 3 (probable), 2 (perspective) and 1 (proposed for further study). Classification of structures over the validity index is based on some sort of expert judgment and reflects the availability of impact criteria found at four different levels — morphological, geological, petrological, and mineralogical. Currently, the database contains 1020 structures, among them 214 with $V = 4$, 211 with $V = 3$, 455 with $V = 2$, and 47 with $V = 1$. 93 structures have validity index $V = 0$, because the once proposed impact origin was later disproved by additional studies.

Cataloging of impact structures discovered on the Earth surface is an important instrument for evaluation of frequency of impacts and for studying the comet and asteroid hazard. Presently there exist more than 10 global catalogs and databases on Earth impact structures. The widely-known Earth Impact Database (EID), maintained by the Planetary and Space Science Centre, University of New Brunswick, Canada [1] is considered to be a reference database in this field. The EID, currently having 176 craters, contains only those structures whose impact genesis has been confirmed over the whole

complex of evidences. Meanwhile, in the scientific literature and on the Internet, the data on many more structures, having some features of an impact origin, are being circulated and discussed. Systematization and cataloging of all these data was the main objective of an Expert Database on the Earth Impact Structures (EDEIS), that has been created and is being maintained by the Tsunami Laboratory of the Institute of Computational Mathematics and Mathematical Geophysics of SD RAS. The EDEIS was built on the basis of the initial catalog of impact structures developed in [2].

As is known [3, 4, 5], the full set of evidences for proving the impact genesis of a suspicious structure includes the study of four groups of criteria found on different spatial levels:

1. morphological criteria discovered on macro-spatial level (10^2–10^5 m) — circular form, presence of edge wall and central uplift (for complex structures), typical diameter/depth ratio, inconsistency with local geological settings and local hydrographic network (for lakes), associated craters;

2. geological criteria discovered on spatial level of 10^{-1}–10^2 m — ejecta layer, breccias, pseudotachylite**,** shatter cones, radial faults, presence of melt sheets and dykes;

3. petrological criteria discovered on spatial level of 10^{-4}–10^{-2} m — high pressure metamorphism of rocks and minerals, disordered structure of grains, presence of plagioclase feldspar, etc.;

4. mineralogical criteria discovered on micro-spatial level (10^{-6}–10^{-5} m) — planar deformation structure (PDFs), shocked quartz, micro spherules of different types (silicate, magnetite, carbon), translucent amorphous C, splash in Fe, Ni, Cr content, Iridium anomaly.

Normally, the process of proving the impact origin of a structure should include the investigation made on all four levels — starting from the initial identification on maps or satellite images (level 1), through the field study on level 2 followed by laboratory analysis on levels 3 and 4. However, for too many structures this process is still limited to the first, second or third levels, thus leaving some degree of uncertainty on the impact origin of a structure. In the EDEIS, this uncertainty is reflected by the validity index V varying from 4 (confirmed on all four levels), through 3 (probable) and 2 (perspective) to 1 (proposed for further study). Thus, classification of the structures over the validity index is based on some sort of expert judgment and reflects the availability of impact criteria found at four different levels listed above. This classification constantly changes thus reflecting availability of data in the literature and on the Internet.

Currently, the database contains the parametric catalog of 1020 structures, among them 214 structures with the validity index $V = 4$, 211 structures with $V = 3$, 455 structures with $V = 2$, 47 structures with $V = 1$, and 93

structures with $V = 0$. The last group of records includes the structures whose impact origin has once been proposed, but further investigation demonstrated clear evidence against the impact genesis. We keep these rejected structures in the database, because information about them is still circulating in the literature and on the Internet. In addition to the main parametric table, the database contains over 2440 photos and maps, 765 textual descriptions and 980 bibliographical references. For each structure, the main table contains the basic parametric data on geographical location, diameter, depth of depression, estimated age, etc., as well as additional data on availability of further impact criteria, degree of erosion, geophysical anomalies, finding extraterrestrial materials, etc. Each structure is provided with bibliographical references to the original publications, catalogs and web-sites that list this particular structure.

Geographical location of 648 impact structures, having the age estimates and validity from 4 to 1 is shown in Fig. 1. Spatial distribution of structures on the Earth surface is quite uneven reflecting geological conditions on the surface and the level of geological mapping of the territory.

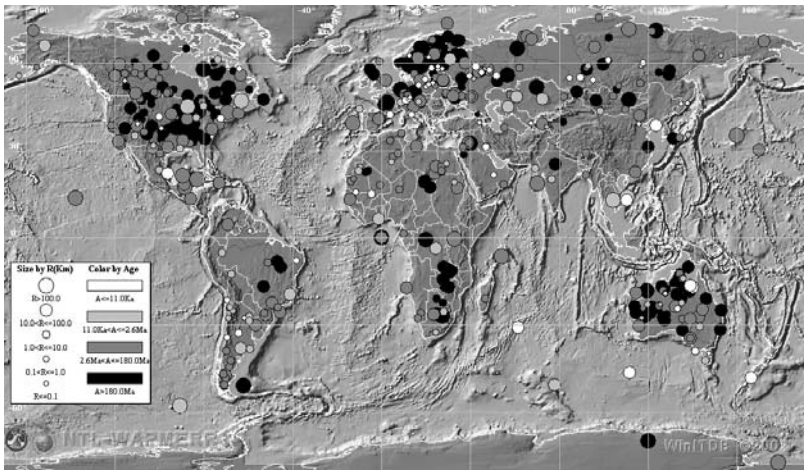
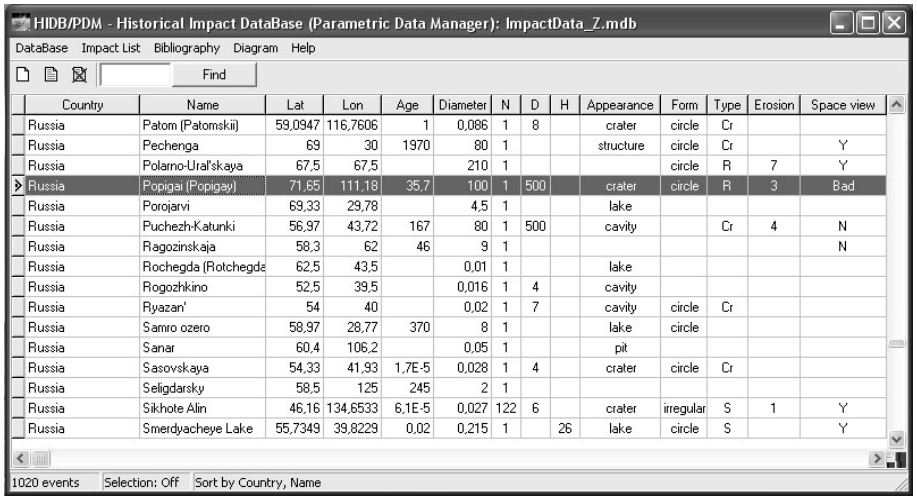


Fig. 1. Geographical distribution of 648 impact structures on the Earth surface, having age estimates. Size of circles is proportional to the crater diameter. Density of the grey color corresponds to four groups of age (see inserted legend).

The database was constructed in the DBMS MS Access and is provided with a specially developed user interface — PDM (Parametric Data Manager) graphic shell allowing a quick and efficient handling of data (retrieval, listing, editing, sorting, processing, and analysis). The PDM shell gives the user possibility to work with different type of information — table, textual, graphical. Some examples of the screen outputs provided by the graphic shell are shown in Figs. 2 and 3.



Country	Name	Lat	Lon	Age	Diameter	N	D	H	Appearance	Form	Type	Erosion	Space view
Russia	Patom (Patomskii)	59,0947	116,7606	1	0,086	1	8		crater	circle	Cr		
Russia	Pechenga	69	30	1970	80	1			structure	circle	Cr		Y
Russia	Polarno-Ural'skaya	67,5	67,5		210	1				circle	R	7	Y
Russia	Popigai (Popigay)	71,65	111,18	35,7	100	1	500		crater	circle	R	3	Bad
Russia	Porojarvi	69,33	29,78		4,5	1			lake				
Russia	Puchezh-Katunki	56,97	43,72	167	80	1	500		cavity		Cr	4	N
Russia	Ragozinskaja	58,3	62	46	9	1							N
Russia	Rochegda (Rotchegda	62,5	43,5		0,01	1			lake				
Russia	Rogozhkino	52,5	39,5		0,016	1	4		cavity				
Russia	Ryazan'	54	40		0,02	1	7		cavity	circle	Cr		
Russia	Samro ozero	58,97	28,77	370	8	1			lake	circle			
Russia	Sanar	60.4	106,2		0,05	1			pit				
Russia	Sasovskaya	54,33	41,93	1,7E-5	0,028	1	4		crater	circle	Cr		
Russia	Seligdarsky	58,5	125	245	2	1							
Russia	Sikhote Alin	46,16	134,6533	6,1E-5	0,027	122	6		crater	irregular	S	1	Y
Russia	Smerdyacheye Lake	55,7349	39,8229	0,02	0,215	1		26	lake	circle	S		Y

Fig. 2. Parametric catalog of the impact structures listed in the main screen window of the PDM graphic shell.

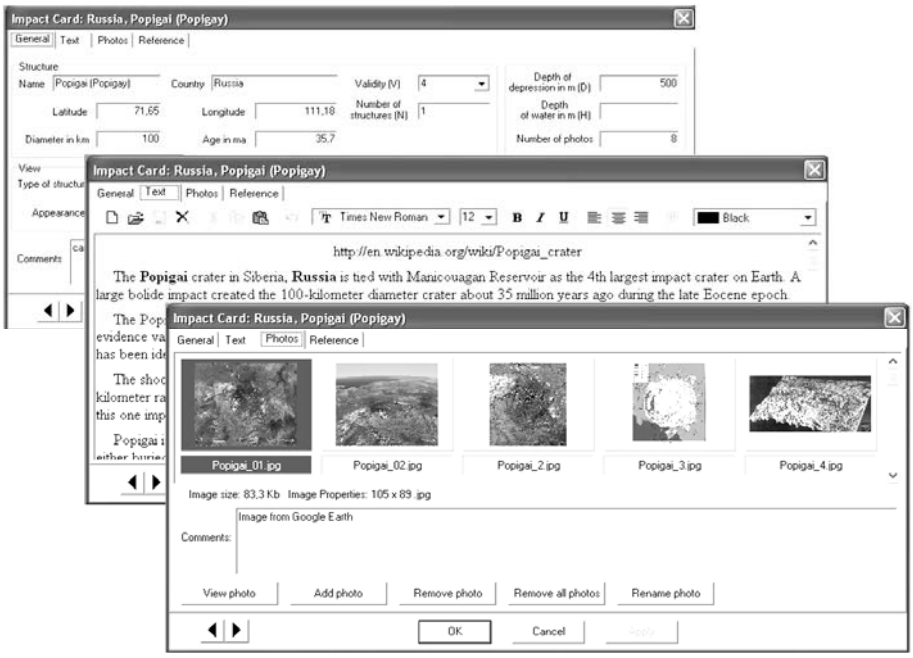


Fig. 3. Additional dialog windows provide detailed parametric data, textual description and collected graphic images for the selected structure (in this example — Popigai crater in the northern Siberia).

The main screen window lists the parametric catalog of impact structures containing the basic set of quantitative information related to a particular structure. By default, they are sorted by geographical location and structure's name. The user can easily re-sort the list (in ascending or descending order) by clicking on header of any column in the table. Double-click on any line in the table opens the additional dialog windows with more detailed data and information available for this structure (Fig. 3).

The full version of the database contains about 300 Mb of data and information and is distributed on a CD-ROM. The Internet version, providing the access to the main parametric catalog, can be found at the Tsunami Laboratory web-site: *http://tsun.sscc.ru/nh/impact.php*.

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References

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