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General laws of spatial-temporal distribution of the Earth's impact structures*

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Abstract. A brief review of the author's catalog of the Earth's Impact structures, presented on the site of ICM&MG [1, 2], is given in this paper. For the research into general laws of distribution with space of the impact structures compiling the catalog and for the analysis of their parameters it is offered to use one of the independent versions of the control and visualization system for natural phenomena, named EISC-system (Earth's Impact Structures Catalog).

1. The Earth's impact structures catalog

Currently, the presented catalog is one of the most complete among all published ones and contains 1526 records. The list of the new structures not included into any of known catalogs (for example [13, 14]) and supplemented by the author is given in Table 1. Sources of these data are publications in the literature (papers, books), reference journals (RJ) VINITI "Geology and geophysics", as well as private messages of the researchers: B.S. Zejlik (IGS, Kazakhstan), K.K. Khazanovich-Wulff (Planetology Department RGS, St. Petersburg), S.Yu. Engalychev (VSEGEI, St Petersburg), N.A. Filin (local investigator), Kristóf L. Kakas (Budapest, Hungary), T. Bodoky (Budapest University, Hungary), Wieslaw Czajka (Warszawa, Poland), James Corbett (Ireland), Karl Sasse (Bremen, Germany), Dr. Mariano Castelo Branco (Brazil Universidade), Matteo Chinellato and F. Pezzotta (Tessera, Venezia, Italy), Gerhard Schmidt, David Rajmon (Houston, USA), etc. (the families of oral messages authors are signed with cursive font in Table 1).

Table 1. The list of supplementary structures not reflected in known world catalogs (192 names)

Name of structure	Continent	Valid	Latitude	Longitude	Age (Ma)	D (km)	Reference
Agit Khangay, Mongolia, W. Uliastay	As	1	47.3	96.4	up.PZ	5.1	RJ
Aktyubinsk, Kazakhstan	As	2	50	55.3	$<$ T/J	250	RJ
Aldanskaya, Russia, Aldan	As	2	60	125	AR	900	[3]
Algamskiy, Russia, Algama river	As	1	56	129.5	MZ	35	RJ
Alnon*, Sweden	Eu	1	62.26	17.46	$\sim$365	9	*K. Khaz-Wulff* [5]

*Supported by RFBR under Grant 11-01-00410-a.

Table 1. (*Continuation*)

Name of structure	Cont-inent	Valid	Lat-itude	Long-itude	Age (Ma)	D (km)	Reference
Alpiyskaya*, Alpian Mt.	Eu	2	43	8	~ 250		RJ
Altyn-Kazgan, Kazakhstan, Kostanai	As	2				0.08	RJ
Amirante*, Indian ocean, Amirante island	IO	2	-7.2	56.33	~ 100	900	RJ
Amundsen Bay^{c}*, Canada	AN	2	70.6	-125	0.013	280	[9]
Andorra, Eastern Pyrenees	Eu	2	42.52	1.55	MZ-KZ	17	[6]
Angaro-Undinskaya, Russia	As	2	55.7	94.5			RJ
Angarskaya, Russia, Angara	As	1	52.9	103.5		25	RJ
Antarctida*, Antarctica	An	2	-90	0	1270 ± 190	8000	RJ
Aqtoghay, Kazakhstan	As	0	46.97	80.04		4	*B.S. Zeilik* [3]
Arctic*, Arctica	Ar	3	-72	-35		5500	*B.S. Zeilik* [3]
Arganaty, Kazakhstan	As	0	49.5	67	P/T	315	*B.S. Zeilik* [3]
Aydarly, Kazakhstan	As	0	46.95	80		2.7	*B.S. Zeilik* [3]
Badhyz, Turkmenistan, Kushka	As	2	36	62	NE-Q	15	[6]
Bahama hot spot*, Bahamas	AN	2	25	-78	251		RJ
Baikalskaya, Russia, Baikal	As	2					RJ
Baikonurskaya^{c}, Kazakhstan	As	0	46.25	63.75		170	*B.S. Zeilik* [4]
Baisha China, Hainan Is.	As	2	19.22	109.45	0.7	3.5	RJ
Baiyang dian, China, N. W. Hebei	As	2	39	116	~ 0.01		RJ
Bakony Hungary, W. Bakony	Eu	1	47	17.5	~ 30	20	RJ
Baryshskaya, Russia, Ul'yanovsk reg.	Eu	2	53.85	47.59		2.,3	*J.A. Spirichev*
Bavarskiy Germany, Bavaria	Eu	2				0.011	RJ
Belostok, Poland	Eu	2	53.23	23		2	*W. Czajka*
Beloye ozero, Russia, Vologda reg.	Eu	1	60.16	37.65	MZ	40	*K. Khaz-Wulff* [5]
Belyje Peski^{c}, Russia, Sosnovyi Bor city	Eu	3	59.895	29.085	0.1		*S.V. Makarov*
Bering sea*, N. Pacific Oc.	PO	2	61	-176	~ 65	2000	[3]
Bolzano, Italy, Bolzano	Eu	3	46.723	11.426		26.95	*M. Chinellato*
Borovoe ozero, Russia, Moscow reg.	Eu	3	55.875	38.592		0.47	*N.A. Filin*
Buffin Bay^{c}*, Canada	AN	2	71.5	-82.5	0.013	120	[9]
Buzashinskaya, Kazakhstan	As	2	44.93	52.37		140	[3]
Cape York*, Greenland	NO	2	76.63	-72.8	Q		RJ
Central Iran, Iran	As	2					RJ
Central-Karakumskiy, Turkmenistan	As	2	40	62	~ 40	220	[3]
Chadobetskoye, Russia, Chadobets riv.	As	2	59	99	PZ	70	RJ
Chanchjogo, China, Tszisjuan', Hebei	As	2	38	114.5	170		RJ
Chelkar-Aral'skaya^{c}, Kazakhstan	As	0	47.3	61	~ 0.01	420	*B.S. Zeilik* [4]
Chernogolovka 1, Russia, Moscow reg.	Eu	3	55.99	38.45		0.3	*N.A. Filin*
Chernogolovka 2, Russia, Moscow reg.	Eu	3	55.02	38.37		0.05	*N.A. Filin*
Chernomorsko-Maloasiat-skaya*, Black Sea	As	1	38.7	33.6	Pliozen	1700	[3]
Chippeva bassin^{c}*, USA, Michigan lake	AN	2	44.37	-86.9	0.013	60	[9]

Table 1. (*Continuation*)

Name of structure	Conti-nent	Valid	Lat-itude	Long-itude	Age (Ma)	D (km)	Reference
Choshskaya guba, Russia, Arkhangelsk reg.	Eu	1	67.28	46.6	D3	125	*K. Khaz-Wulff* [5]
Contozerskiy graben, Russia, The Kola isthmus	Eu	2	68.11	36.11	∼365	8	*K. Khaz-Wulff* [5]
Corbett (=Newcastle), Ireland	Eu	2	52.45	−8.91			*J. Corbett*
Cuban*, W. Cuba	AN	2	20	−83	K/T	300	RJ
Curbun-Shivi, Russia, Tuva	As	1				0.1	RJ
Danilov lakes (5 cr.), Russia, Omsk reg.	As	3	56.796	77.107	Millennia	1	Newspaper
Depskiy, Russia, Khabarovsk terr.	As	2					RJ
Dinaro-Carpathian, Carpathians Mt.	Eu	2	46.5	22	Pg/Ng	1000	[3]
Dneprovsko-Donetskaya, Russia	Eu	2	48	37		160	[3]
Dora-Maira-Massiv, Italy, Westalpen	Eu	2	45.5	8			RJ
El Gasco, W. Spain, El Gasco	Eu	1	41.4	−6.34			RJ
Elizabeth^c, USA, New Jersy–New York	AN	3	40.6	−74.26	0.013	25	[9]
Enyahinskiy, Russia	As	2				0.5	Tyumenneftegeo
Essey massiv, Russia, NW of East Syberia	As	2	68.81	102.18	251	4.5	*K. Khaz-Wulff* [5]
ES-1, Yemen	AS	2	18.15	50.07		0.77	RJ
Fanshan, China	As	2	27.33	123.38			RJ
Filippovskaya, Russia, Novosibirsk reg.	As	1	54.35	81.33	T-lower J	20	[6]
Fountein Pond, Gujarat, India	As	2	22.51	70.2		1.5	RJ
Gar'skiy, Russia, Khabarovsk terr.	As	2					RJ
Gorski Kotar*, Slovenia	Eu	2	45.45	14.6	∼65	20	RJ
Gozdow Crater, Poland	Eu	2	50.79	23.82		9	*W. Czajka*
Great Kuonamki, Russia, NW of East Syberia	As	2	70	111	251		RJ
Groppovisdomo, Italy, Emilia Romagna	Eu	2	44.78	9.7		2	*M. Chinellato*
Gulinskiy, Russia, NW of of East Syberia	As	2	70.91	101.2	251	> 50	*K. Khaz-Wulff* [5]
Haapajarvi (Happajarvi?), Finland	Eu	2	63.75	25.16			RJ
Hainan, China, Hainan Is.	As	2	19	110		500	[3]
Humersly*, W. Australia	Au	1	−22.5	118.5	2541+18	40	RJ
Ilkurka, Australia	Au	1	−28.37	127.43	< 299	15	[7]
Inagly massiv, Russia, Transbaikalia	As	2	53.2	116.55	136 ± 5	5,5	*K. Khaz-Wulff* [5]
Ingily massiv, Russia, Transbaikalia	As	2	57.95	134.1		12	*K. Khaz-Wulff* [5]
Jebel Wagf as Suwwna, Jordan	As	2			Q	5.5	RJ
Kamenny, Russia, Altai, Teletskoye lake	As	3	51.77	87.31	∼0.002	0.36	*V.G. Luzhetskiy*
Kamensk-Uralskaya, Russia, Ural	As	2	56.41	61.56		80	RJ
Kaminsk pits, Poland	Eu	2	54.35	20.4		0.4	*W. Czajka*

Table 1. (*Continuation*)

Name of structure	Conti-nent	Valid	Lat-itude	Long-itude	Age (Ma)	D (km)	Reference
Kanal-Lig, Slovenia	Eu	2	46.09	13.62			RJ
Karatauskaya, Kazakhstan	As	2	43.3	70.4		300	[3]
Karczmisko, Poland	Eu	2	50.385	22.649		0.06	*W. Czajka*
Khabarovskaya, Russia, Khabarovsk	As	2	48.6	135		100	RJ
Khibinskiy graben, Russia, The Kola isthmus	Eu	2	67.71	33.71	~ 365	40	*K. Khaz-Wulff* [5]
Kholbo lakes, Russia, Chernorud	As	2	52.99	106.72			RJ
Khymogna-Yagan, Russia, Khabarovsk terr.	As	2	51.5	133			RJ
Khuree Mandal Tsenkher, W. Mongolia	As	1			up Pz		RJ
Kleshino lake, Russia, Tver reg.	EU	3	57.85	35.27		1	*N.A. Filin*
Kostromskoy, Russia, Kostroma	Eu	2					RJ
Kotuykanskaya, Russia, N. Siberian plate	As	2			paleo-PR	250	RJ
Kozhimskaya, Russia, Pripolarje	As	2	65	61	520+5	160	RJ
Kozhozerskiy, Russia, Arkhangelsk, Onega	Eu	2	63.15	38.07	PR		[6]
Krugloye lake, Russia, Novosibirsk reg.	As	3	56.07	81.14		0.6	*V.G. Luzhetskiy*
Ladoga, Russia, Karelia	Eu	2	61	31	$0.06-0.065$	80	RJ
Laptev sea, Russia	As	3	75	115	J		[6]
Lasnamae, Estonia	Eu	2			0.02		RJ
Levezou, France, Rouergue	Eu	2	44.18	2.73		26	RJ
Llano, USA, Texas	AN	2	30.4	-98.7		500	[3]
Lotsuanly, China, Liaoning prov.	As	2					RJ
Lovich, Poland	Eu	2	52.03	19.87		1	*W. Czajka*
Lovozerskiy graben, Russia, The Kola isthmus	Eu	2	67.8	34.11	~ 365	30	*K. Khaz-Wulff* [5]
Lukovoe lake, Russia Moscow reg.	Eu	3	55.93	38.54		0.64	*N.A. Filin*
Luninskaya*, Russia, Barents sea	Eu	2			post-K	10×17	RJ
Madagascar 1, Madagascar Is.	Af	3	-15.68	46.72		289.3	*M. Chinellato*
Madagascar 2, Madagascar Is.	Af	3	-24.37	46.42		98.54	*M. Chinellato*
Madagascar 3, Madagascar Is.	Af	3	-18.84	46.22		12.15	*M. Chinellato*
Madagascar 4, Madagascar Is.	Af	3	-18.71	46.17		4.5	*M. Chinellato*
Madagascar 5, Madagascar Is.	Af	3	-17.82	47.41		11.95	*M. Chinellato*
Magyarmecske*, Hungary	Eu	1	46	18	< 299	7	*T. Bodoky*
Malobuzachinskaya, Kazakhstan	As	2					RJ
Mangueni, N. Niger, Mangueni Plateau	Af	3	22.994	12.631	≤ 144	1.7	*K. Krisztian*
Meggyespuszta, Hungary	Eu	2	47.07	17.93	p-Triassic	0.6	*K.L. Kakas*
Minas Gerais, Brazil	AS	2	-19.36	-43.94		0.1	RJ
Mongolia 4, Mongolia	As	3	46.50	98.4		11	Google Earth
Mongolia 5, Mongolia	As	3	46.38	98.6		7	Google Earth
Mongolia 7, Mongolia	As	3	46.64	98.195		6	Google Earth

Table 1. (*Continuation*)

Name of structure	Conti-nent	Valid	Lat-itude	Long-itude	Age (Ma)	D (km)	Reference
Mongolia 14, Mongolia	As	3	46.20	98.3		5	Google Earth
Mongolia 15, Mongolia	As	3	46.15	98.28		2	Google Earth
Mongolia 16, Mongolia	As	3	46.08	98.25		1	Google Earth
Montecchio Maggiore, Italy, Veneto	Eu	2	45.46	11.46		4.5	*M. Chinellato*
Mousso, N. Chad	Af	2	17.96	19.88	early PZ	3.8	RJ
Mul'dayskiy, Russia, Transbaikalia	As	1	52.27	119.25	0.001	0.1	RJ
Muruktinskaya, Russia, Krasnoyarsk terr.	As	2	67.8	102.18	~ 65	60	[6]
Nestiar, Russia	As	2	56.56	45.33		0.62	RJ
Ngoro-Ngoro, Tansania	Af	2	−3	36.5		25	UNESCO-site
Niokolo, Senegal, south of Gambia river	Af	3	13.297	−13.47		0.15	*H. Moyson*
Nizhne-Tychanskaya, Russia, Krasnoyarsk terr., Evenkiya	As	2	61.38	97.35	before Cambrian	110	[6]
Nony, Russia, Khabarovsk terr.	As	2					RJ
North China	As	3	44.25	114.24		4	*A. Lichkovaha*
Orenburg, Russia	As	2					RJ
Orlevo lake, Russia	Eu	3	55.89	38.7		0.3	*N.A. Filin*
Ozero, Kazakhstan	As	3	50.55	51.7		19	*N.A. Filin*
Ocherskaya, Russia, Perm reg.	As	2	57.61	54.71			RJ
Ohdo, Japan, Gunma	As	2	36.5	138.8		~ 20	RJ
Ohotomorskaya, Russia, Okhotsk sea	As	2	55	150		1500	[3]
Okriba, W. Georgia	Eu	1	42.3	42.93	up Pc	5	RJ
Olenek rise, Russia, NW of East Syberia	As	2	71.18	123.58	D3	200	*K. Khaz-Wulff* [5]
Onezhskaya, Russia, Karellia, Zaonezhsk	Eu	1	62.3	35.3	1770−1740	125	RJ
Osinovik, Russia, Yaroslavl reg.	Eu	2	58.6	37.76		2.3	*S. Engalychev* [8]
Pacific Ocean*, Pacific	PO	2	20	−155	4500	9000	*B.S. Zeilik* [3]
Pacifican*, Pacific, SE	PO	2					RJ
Pelczy, Ukraine	Eu	2	50.46	25.58			*W. Czajka*
Pietronajc lake, Poland	Eu	2	54.13	23.07		0.2	*W. Czajka*
Polarno-Ural'skaya, Russia, Polar Ural	As	2	67.62	67.5	2023	190	RJ
Potomak^c, USA, Potomak river	AN	3	38.3	−77	0.013	16	[9]
Priaral'skaya*, Kazakhstan, Priaralye	As	2	43.3	62.3	Mz-Kz	750	[3]
Pricaspiyskaya*, Kazakhstan, N. Caspia	As	2	47.5	50.5	PZ/MZ	800	RJ, *B.S. Zeilik*
Pultusk, Poland	Eu	2	52.7	21.25			RJ
Racze lake, Poland	Eu	2	53.97	14.61		0.3	*W. Czajka*
Renehan, Australia	Au	1	−18.33	132.67	< 299	10	[7]
Saimaa^c, Finland	Eu	2	61.8	27	0.013	300	[9]
Salinas^c, USA	AN	2	32.3	−102	0.013	20	[9]
Samarovskaya gora, Russia, Khant-Mans	As	3	61	70	Pg & J		[6]
Samro ozero, Russia, Leningrad reg.	Eu	1	58.96	28.76	D3	8	*K. Khaz-Wulff* [5]
Sasovskaya, Russia	As	2	54.33	41.93	12.04.1991	0.028	RJ
Seligdarsky, Russia	As	1	58.5	125	MZ?	2	RJ
Semeytau, Kazakhstan	As	2	50.15	79.74		25	RJ

Table 1. (*Completion*)

Name of structure	Conti-nent	Valid	Lat-itude	Long-itude	Age (Ma)	D (km)	Reference
Shan'dun'skaya, China	As	3	36.5	120		1600	[3]
Shatsky Rise*, NW Pacific	PO	2	36	158.5	144.6±0.8		RJ
Shakespeare Bay*, New Zealand	Au	1	−41.27	174	2		[9]
Solt Lake, USA, Hawaii	AN	2	21.35	−157.9		50	RJ
Sosnovoborskaya, Russia, Penza reg.	Eu	1	53.39	46.36		0.8	*Yu.A. Spirichev*
South Californian (3 cr.), USA	AN	2	30.5	−116		30;12	RJ
South Caspian sea, Kazakhstan	As	2	39	51		400	RJ
South Mangyshlak, Kazakhstan	As	2					RJ
Spas-Klepikovskiye, Russia, Ryazan reg.	Eu	3	55.22	40.2		0.5	*N.A. Filin*
Sredne-Russkaya, Russia	Eu	2	56	38	before Rf	200	[3]
Suhoye ozero, Uzbekistan	As	2					RJ
Svetloe ozero, Russia, Moscow reg.	Eu	3	55.896	38.695		0.03	*N.A. Filin*
Tana, Ethiopia	Af	1	12.67	37.3		70	RJ
Tbilisi, Georgia	Eu	1	41.71	44.78	up Pc		RJ
Tele, N. Congo	Af	2	1.34	17.15		2.8	RJ
Telmanskaya, Kazakhstan	As	3	44.85	78.63		0.01	*Yu. Trusov*
Timokhino, Russia, Yaroslavl reg.	Eu	2	58.58	37.72		2.7	*S. Engalychev* [8]
Togyz, Kazakhstan	As	0	47.5	60.4	∼0.01	20	*B.S. Zeilik* [4]
Tungussko-Taseyevskiye, Russia, N. Siberia	As	2			PZ / MZ	600	[3]
Tungusso-Baikal'skaya, Russia, N. Siberia	As	2	63	100	PZ / MZ	1300	[3]
Turgayskiy, Kazakhstan, Turgay	As	2	52	65	early Q		RJ
Ulutauskaya, Kazakhstan	As	2	47.5	65.5		100	*B.S. Zeilik* [3]
Valahskaya, Romania	Eu	2	46.5	24	Kz	600	[3]
Verhoyansko-Kolymskaya, Russia	As	2	67	150	∼100	1800	[3]
Visherskaya Russia, NE Ural	Eu	1	60.5	57.5			RJ
Vostochno-Africanzkaya (Victoria lake), Africa	Af	1	−0.58	32.96	KZ-MZ	800	[3] *K. Khaz-Wulff* [5]
Vychegda, Russia, Arkhangelsk reg.	Eu	3	61.32	47.85		0.5	*A. Dolnik*
Vyiazh ozero, Russia, Arkhangelsk reg.	Eu	3	62.48	41.23	KZ		[6]
Wichita^c, USA	AN	2	37.7	−97.7	0.013	2	[9]
Yama Korchazhikha, Russia, Buryat	As	1	52.183	106.767	0.08−0.1	0.2	*U.V. Kestlane*
Yazino, Russia, Yaroslavl reg.	Eu	2	58.6	37.67		2	*S. Engalychev* [8]
Yenisei, Russia	As	1	59	93.15	< 1	0.225	RJ
Yuzhno-Pribalkhashskaya,	As	1	45	75.5	J/T	380	*B.S. Zeilik* [3]
Zapadno-Pribaikal'skaya, Russia, N. Siberia	As	3	55	105	PZ / MZ	700	[3]
Zapadno-Sibirskaya & Kazakh-stanskaya, Russia, Ural	As	2	63	70		1000–2000	RJ
Zapadno-Tarhankutskaya*, Black Sea	Eu	2	45.5	32		20	RJ
Zhilansaid*, Kazakhstan	As	1	49.18	57.72	C?	0.6	RJ
Zondsko-Marianskaya*, Pacific Ocean, Sulu	PO	2	8,5	120		5000	[3]

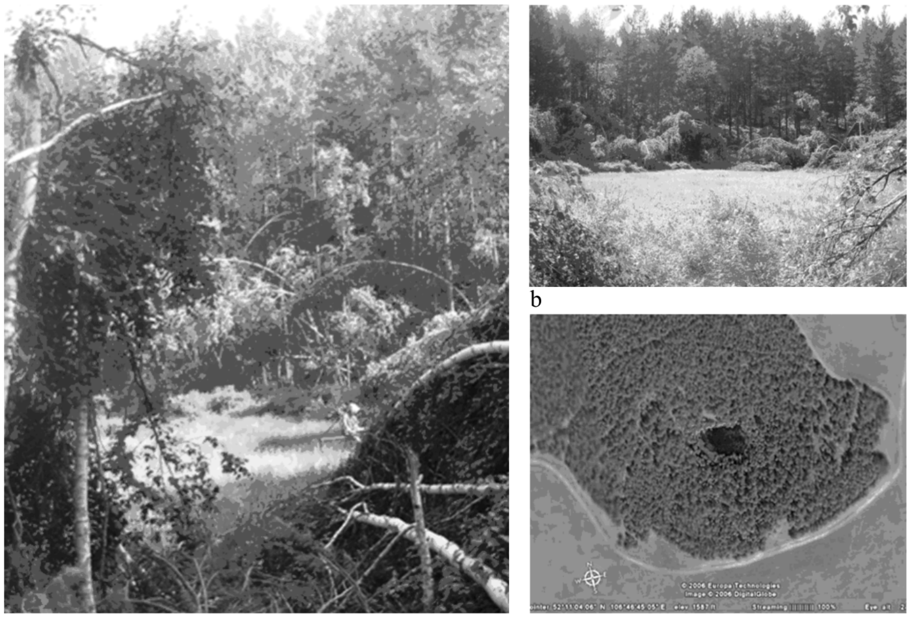

Figure 1. The 2010-fieldtrip photos (a, b) and Google Earth's map (c) of "Yama Korchazhikha"

For example, initially, the data on the structure "Yama Korchazhikha" were obtained in 2006 from oral messages of G.M. Ivanova and Dr. U.V. Kestlane, the participants of special Moscow meteoritic commission in the 80s, and then, in 2010, was supplemented with my own photographic materials (Figure 1, a–b).

As a result of this work, the most complete Database of all proven, probable, assumed and even erroneous structures of the cosmic origin has been collected. At present it consists of 223 proven, 251 probable, 951 possible, and 101 questionable craters. Two of 7 new proven structures Baikonurskaya and Chelkar-Aral'skaya have the comet origin. All comet craters are marked in the list with ^{c} and most of them have still 'possible' and 'questionable' validity. The seventh part of structures of this catalog (226 of 1526) are underwater or shelf and are marked in the list with *. This speaks about significant lack in our catalog of events associated with global aquatory.

The Earth's Impact Structure Catalog is already used by many researchers of the cosmogenic structures and is open for the extension with new information.

Visualization and analysis of the EISC-catalog data intended for the research into its general laws and correlations between various craters parameters will be carried out by using the geoinformation system of the visualization and analysis of natural phenomena developed by the author. The

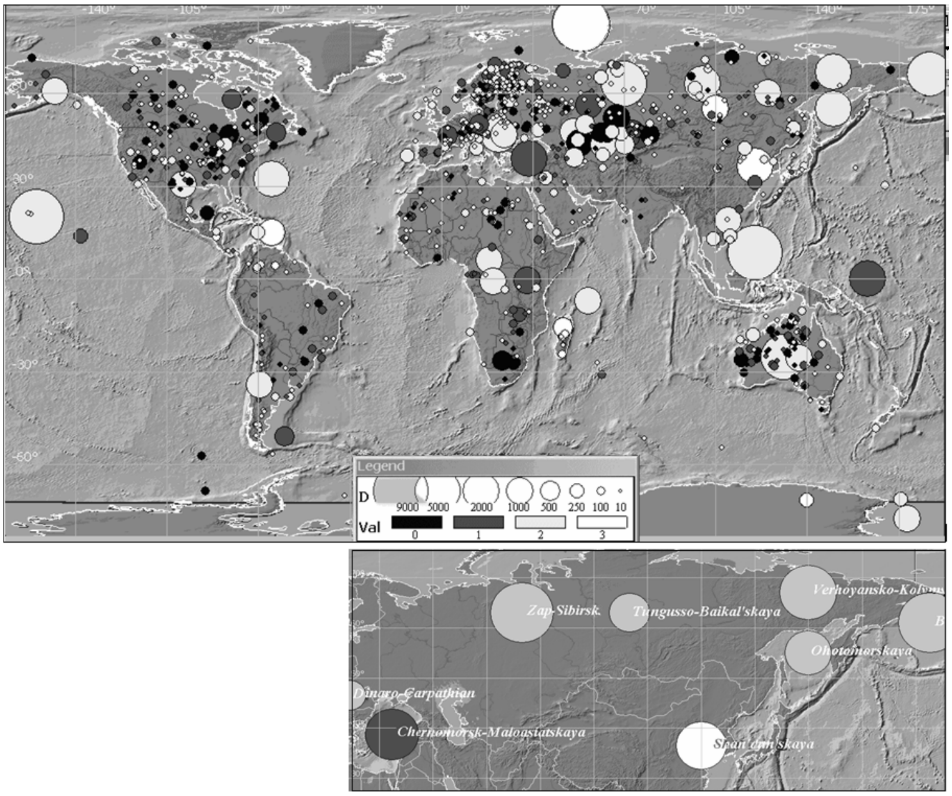

Figure 2. Visualization with the help of the EISC system (the map-building technology is described on [15]) of events from the impact structure catalog according to the given scale of diameter (D) and validity (Val). A fragment of the map with giablems ($D > 1000$ km) which are brought into the catalog from Zeilik's works [3] is separately shown

expert system EEDB [10] was first developed for the research into earthquakes and consecutively was adapted to other natural phenomena. Application of this software for the EISC-catalog allows making a new version of this system, called the EISC- system. A geographical subsystem of the later allows one to choose a working area of various scales from a review map of the whole world up to maps of separate astroblem zones or fault blocks and, also, to obtain accompanying cartographic information. The latter can include: impact craters locations (Figure 2), earthquakes epicenters, points of geophysical observation, volcanoes locations etc. In addition to the spatial visualization on a map, listing the catalog in the text form, the distribution graphs of various parameters, and the results of statistical data processing are placed in the system.

The mathematical support and the software of the EISC system allow making graphs of repeatability of events from various samples, different

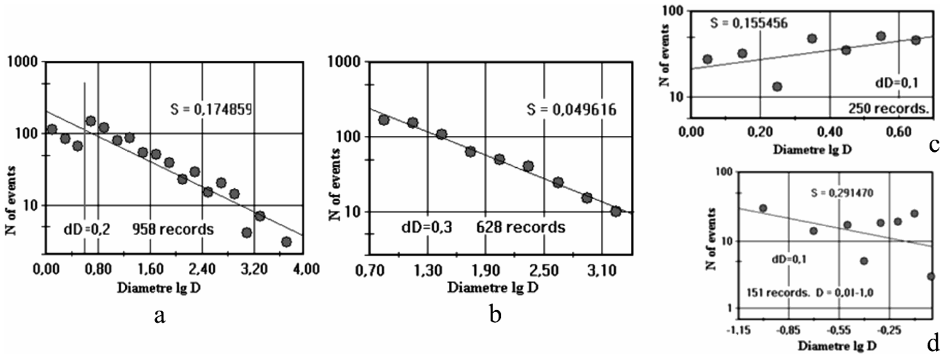

Figure 3. A repeatability graph of the Earth's impact events for the whole historical period and diameters of their craters (km): a) $D \geq 1$, b) $D \geq 5$, c) $1 \leq D \leq 5$, and d) $D \leq 1$. The regular distribution is observed only for 628 events with diameter $D \geq 5$ (graph b)

types of distribution of the integrated parameters values with time, space and with respect to one another.

The dependencies shown in Figure 3 give a detailed representation of distribution of the number of craters within diameters at the logarithmic scale and show a root-mean-square deviation of their random distribution from the regress line (dispersion S). Figure 3 a shows a sharp change of the graph behavior in the value $\lg D = 0.7$ ($D = 5$ km). A separate construction of graphs for $D > 5$, $1 < D < 5$, and $D < 1$ km shows an irregular distribution of the graph points in the last two graphs. This means the incompleteness of a set of the found craters in the range $D < 5$ km, as because of the problem of safekeeping of the small ancient surface structures, which were not protected from erosion by a sedimentary cover, and owing to a poor covering of studies of the most part of the Earth's surface at an enough detailed scale. The table of the impact structures distribution in various regions (Table 2) may confirm the latter.

In the Asian part of Russia (see Table 2), for example, a share of poorly investigated structures (validity 2, 3) in the total number of the discovered craters makes 68 % (79 of 116). The similar situation is in the European part of Russia, i.e., 64 % (48 of 75). A safer picture is in Kazakhstan, where structures are in identical distribution according to probability intervals. In South America, a share of poorly investigated structures makes ∼74 %, in Africa — ∼69, in Finland — ∼82, and in Sweden and North America — 56. The best covering of studies is observed in Canada: only 51 % of all structures have the category of doubtfully known.

The temporal distribution of the impact structures diameters shows a considerable irregularity of events (Figure 4), whose great part (40 % of craters) has no definition of the age at all and is localized on the last mark of time scale.

Table 2. Distribution of impact structures in various Earth's regions according to validity of craters (0 — proven, 1 — probable, 2 — possible, 3 — questionable)

Region	All	0	1	2	3	Region	All	0	1	2	3
Australia (Au)	116	27	19	64	6	Africa (Af)	179	23	33	110	13
Asia (As):	335	35	63	213	24	Europe (Eu):	444	59	59	308	18
Russia	116	14	23	70	9	Russia	75	12	15	40	8
Kazakhstan	51	13	14	21	3	Sweden	63	6	17	40	0
North America (AN):	258	65	47	129	17	Finland	71	12	1	56	2
Canada	112	34	21	52	5	Atlantic Ocean (AO)	9	0	1	8	0
USA	146	31	26	77	12	Indian Ocean (IO)	8	0	1	7	0
Central America(AC)	23	1	4	15	3	Arctic Ocean (NO)	7	0	1	5	1
South America (AS)	107	12	16	78	1	Pacific Ocean (PO)	21	1	2	18	0
Antarctica (An)	15	0	0	13	2						

The graph of Figure 5 shows the temporal growth of the number of discovered craters and demonstrates an appreciable backlog of the number of really discovered structures from the exponential law, which was proposed [11] in the 70s as the forecast: $N = e^{2.83+0.12t}$. Having analyzed the number of events in the impact structures catalogs published for different times a nonlinear square-law dependence of the number of really discovered craters on time: $N = 10t^2 + 13t - 11$ was constructed.

Using the proposed EISC-catalog some other graphs where plotted: a graph of the size of craters on their age, by which it is possible to estimate the time of impact structures relaxation. This graph is similar to the one published in A.I. Dabizha [11] and V.E. Petrenko [12] and is not shown here. The graph, describing morphological properties Depth vs. Diameter (D) of impact craters is more interesting (Figure 6). The averaging line of all the graph points independent of a target soil is described by the formula

$$\text{Depth} = 66.25\, D^{0.738}.$$

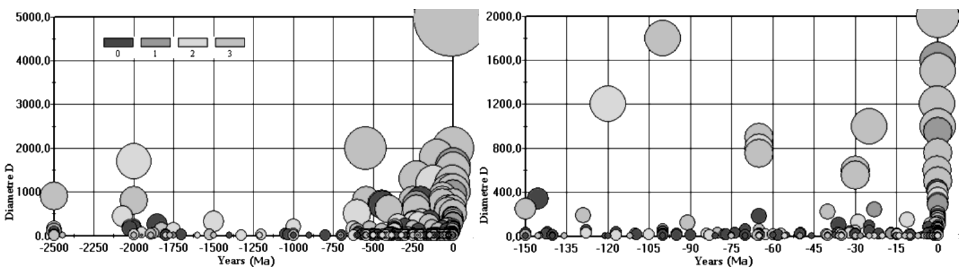

Figure 4. Distribution of the impact structures diameters on time (Ma). A color shows the validity of structures

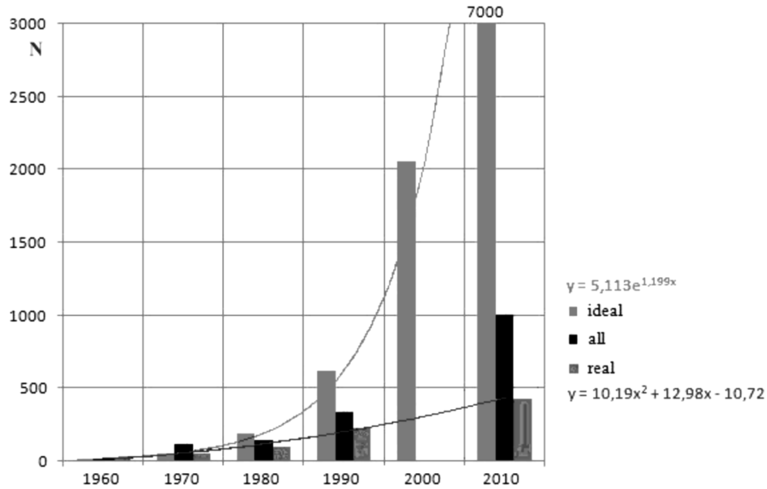

Figure 5. The growth with time of the number of open craters: ideal — expected growth, all — all the events of the EISC catalog, real — proven and probable craters

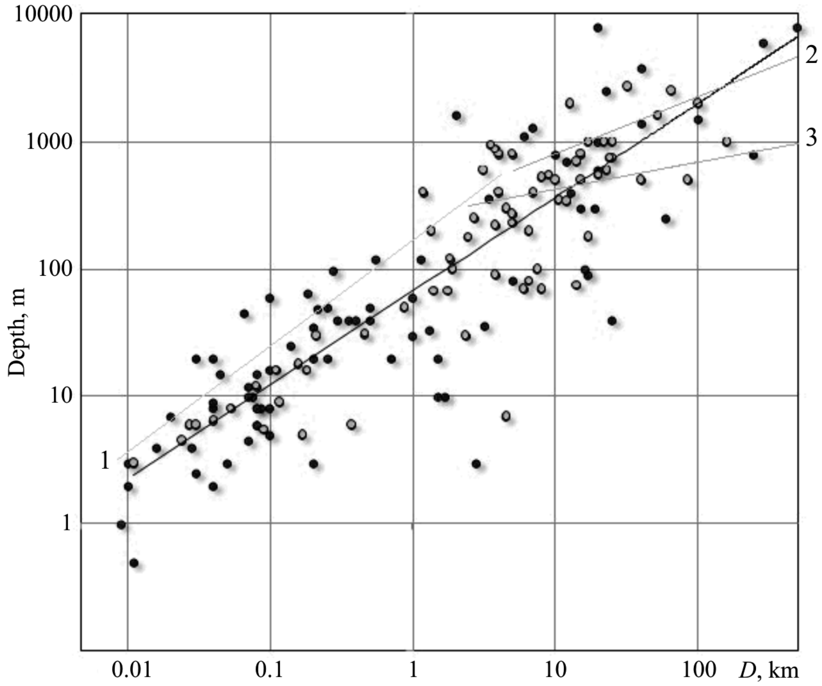

Figure 6. Morphological properties of the impact craters. Dark color allocates the proven structures. Lines 1–3 correspond to known dependencies of a crater depth on its diameter for various target soils: 1 — Depth = $159\,D^{0.829}$ for $D < 3.8$ km in crystal and $D < 1.2$ km in sedimentary soils; 2 — Depth = $52\,D^{0.189}$ for $D > 4$ km in crystal soils; and 3 — Depth = $204\,D^{0.27}$ for $D > 2.5$ km in sedimentary soils. Dependencies 1–3 are taken from [12]

Conclusion

Some general laws for impact structures and dependencies between various parameters of craters obtained with the use of the EISC-software for visualization and analysis of natural phenomena have been discovered. The mathematical support of the expert system EEDB allows making graphs of repeatability of events from various samples, other kinds of distribution of the integrated parameters values with time, space and with respect to one another. Irregularity of distribution of craters according to their age and size shows the incompleteness of a set of the detected craters in the range $D < 5$ km because of the problem of safekeeping of the small ancient surface structures and a poor covering of studies of the majority of the Earth's territories, and, especially, of the oceanic aquatory. A good regularity in graphs of repeatability of events with $D \geq 5$ km proves the satisfactory representativeness of our catalog in this range, due to the completeness of a set of big structures and giablems [3, 4].

Further development of the EISC program environment for its use in scientific projects associated with the analysis of impact origin processes is assumed.

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