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EVOLUTION OF A METEORITE CRATER AS A PROCESS OF RANDOM DISPLACEMENTS

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16. Abstract

An examination of the ages and sizes of 114 terrestrial impact craters shows that their aging kinetics can be described by the diffusion laws. The macrodiffusion coefficient which determines random displacements of mineral masses on the earth has a mean value of 0.02 sq m/year. The amount of matter in a crater that contains information about the impact event decreases with time according to the 1/T law. The basic characteristic parameter of a crater is its initial area, inasmuch as sufficiently large craters are nearly surficial formations. The relaxation time of a crater is proportional to its initial area.

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EVOLUTION OF A METEOR CRATER AS A PROCESS OF RANDOM DISPLACEMENTS

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Information on crater age and dimensions plays an important role in the study of terrestrial metorite craters (as is the case with any geological object). Unfortunately, reliable evaluations of absolute age are available for only a small number of actual craters (Table 1). However, even this little information allows us to establish certain parameters. /82*

For example, an analysis of the distribution of cosmogenic structures on the Earth's surface according to age T and dimensions D [Fedynskiy et al., 1978; Zotkin et al., 1978] makes it possible to state that the ratio T/D^2 or its inverse ratio plays a substantial role in the study of these objects' evolution. In particular, the virtual absence of craters for which $T/D^2 > 100$ years x m^{-2} indicates that the lifetime, or the true relaxation time, T_e, of craters as geological objects on the Earth's surface is determined by the value of D^2, i.e. area S (Figure 1). From research [Fedynskiy et al., 1978], we know that

$$T_e \approx 50\,S, \qquad (1)$$

where T_e is expressed in years and S in m^2.

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*Numbers in the margin indicate pagination in the foreign text.

TABLE 1

RELATIONSHIP OF METEORITE CRATER AGE AND SIZE

/83

1 Кратер, место нахождения	2 D, км	3 T, год	4 Метод иссле-дова-ния	5 T/S, год/м²	6 Литература
1	2	3	4	5	6
7 Ярдымлы, СССР	0,002	20	п	6,37	Кашкай, Алиев, 1961 18
Haviland, USA	0,011	1000	г	10,52	Robertson, 1978
Dalgaranga, Australia	0,021	25000	г	72,21	Barringer, 1967
8 Сихотэ-Алинь, СССР	0,026	32	п	0,06	Фесенков, 1947 19
Dogubayazid, Turkey	0,035	56	н	0,05	Sander, 1972
9 Соболевский, СССР	0,05	200–250	г	0,10–0,12	Хрянина, Иванов, 1977 20
Campo del Cielo, Argentina	0,07	$3,95 \cdot 10^3$	г	1,02	Cassidy, Renard, 1973
10 Илуметса, СССР	0,08	$6,03 \cdot 10^3$	у	1,02	Серебряный, Пуннинг, 1976 21
Wabar, Saudi Arabia	0,09	$(6,4 \pm 2,5) \cdot 10^3$	т	1,01	Storzer, Wagner, 1977
11 Каали, СССР	0,11	$2,66 \cdot 10^3$	у	0,28	Серебряный, Пуннинг, 1976 21
Henbury, Australia	0,15	$(4,2 \pm 1,9) \cdot 10^3$	т	0,24	Storzer, Wagner, 1977
Odessa, USA	0,17	$22 \cdot 10^3$	г	0,97	Barringer, 1967
Boxhole, Australia	0,18	$50 \cdot 10^3$	н	1,97	То же 22
Aouelloul, Mauritania	0,25	$(3,25 \pm 0,5) \cdot 10^6$	т	66,46	Storzer, Wagner, 1977
Monturaqui, Chile	0,48	$1 \cdot 10^6$	г	5,53	Engelhardt, 1974
Temimichat, Mauritania	0,50	$(2–5) \cdot 10^6$	г	10,19	Fudali, Cassidy, 1974
Wolf Creek, Australia	0,85	$(100–110) \cdot 10^3$	г	0,18	Hodge, 1970
Wipfelsfurt, West Germany	0,85	$14,8 \cdot 10^6$	г	26,72	Classen, 1977
Darwin crater, Australia	1,0	$(0,74 \pm 0,04) \cdot 10^6$	т	0,94	Storzer, Wagner, 1977
Pretoria Salt Pan, South Africa	1,1	$1,0 \cdot 10^6$	н	1,05	Classen, 1977
Barringer, USA	1,2	$30 \cdot 10^3$	г	0,03	Шумейкер, 1968 23
Hummeln, Sweden	1,2	$(500 \pm 100) \cdot 10^6$	г	442	Carstens, 1975
12 Табун-Хара-Обо, Монголия	1,3	$30 \cdot 10^6$	г	22,61	Шкерин, 1976 24
Tremorgio, Swiss Alps	1,4	$(20–50) \cdot 10^3$	г	0,01–0,03	Bachtiger, 1977
Liverpool, Australia	1,6	$(150 \pm 70) \cdot 10^6$	г	74,64	Guppy et al., 1971
Talemzane, Algeria	1,75	$1,0 \cdot 10^6$	г	0,42	Classen, 1977
13 Западная, СССР	1,75	$(169 \pm 5) \cdot 10^6$	р	70,30	Вальтер, Рябенко, 1977 25
Lonar, India	1,8	$50 \cdot 10^3$	т	0,02	Frederiksson et al., 1973
Tenoumer, Mauritania	1,9	$(2,5 \pm 0,5) \cdot 10^6$	г	0,88	French et al., 1970
Roter Kamm, South West Africa	2,4	$< 70 \cdot 10^6$	г	15,48	Waddington, Dence, 1975
14 Шунак, СССР	2,5	$12 \cdot 10^6$	г	2,45	Фельдман и др., 1979 26
Holleford, Canada	2,5	$(550 \pm 50) \cdot 10^6$	г	112,1	Dence, 1965
Kelly West, Australia	2,5	$550 \cdot 10^6$	г	112,1	Tonkin, 1973
15 Ротмистровская, СССР	2,7	$(95–106) \cdot 10^6$	р	16,60	Вальтер, Рябенко, 1977 25
16 Зеленый Гай, СССР	2,5	$(100–135) \cdot 10^6$	г	65,02	То же 22
West Hawk, Canada	2,7	$(100 \pm 50) \cdot 10^6$	г	17,47	Robertson, Grieve, 1975
B.P. structure, Libya	2,8	$< 120 \cdot 10^6$	г	16,25	French et al., 1974
Sreinheim, Germany	3,0	$(14,8 \pm 0,7) \cdot 10^6$	г	2,09	Engelhardt, 1974; Storzer et al., 1971
17 Гусевский, СССР	3,0	$< 65 \cdot 10^6$	г	9,20	Масайтис и др., 1978 27
Poplar Bay, Canada	3,0	$(100 \pm 50) \cdot 10^6$	г	14,15	Trueman, 1976
New Quebec, Canada	3,2	$1 \cdot 10^6$	г	0,12	Dence, 1965
Jeptha Knob, USA	3,2	$350 \cdot 10^6$	г	43,54	Classen, 1977

1	2	3	4	5	6
Skeleton, Canada	3,5	< 600 · 10^6	г	62,39	Waddington, Dence, 1975
Flynn Creek, USA	3,8	(360 ± 20) · 10^6	г	31,76	Roddy, 1968
Kofels, Austria	4,0	(8,9 ± 2,9) · 10^3 ?	т	0,001?	Storzer, Wagner, 1977
Ile Rouleau, Canada	4,0	< 300 · 10^6	г	23,89	Caty et al., 1975
Gow Lake, Canada	4,0	150 · 10^6	г	11,94	Thomas, 1977
28 Мишина Гора, СССР	4,0	350 · 10^6	г	27,87	Масайтис и др., 1978 27
Brent, Canada	4,0	(414 ± 20) · 10^6	р	32,96	Hartung et al., 1971
29 Кярдла, СССР	4,0	(440–500) · 10^6	г	35,03	Масайтис и др., 1978 27
30 Ильинцы, СССР	4,5	(395–400) · 10^6	г	24,85	Вальтер, Рябенко, 25 1977
Mien, Sweden	5,0	120 · 10^6	р	6,11	Bottomley et al., 1977
		(92 ± 6) · 10^6	т	4,69	Storzer, Wagner, 1977
31 Курская, СССР	5,0	< 200 · 10^6	г	10,19	Масайтис и др., 1978 27
Crooked Creek, USA	5,0	(320 ± 80) · 10^6	г	16,31	Engelhardt, 1974
Pilot, Canada	5,0	(300 ± 150) · 10^6	г	15,29	То же 22
Saaksjarvi, Finland	5,0	< 330 · 10^6	р	16,82	Bottomley et al., 1977
32 Мизарай, СССР	5,0	(500 ± 80) · 10^6	г	25,48	Масайтис и др., 1978 27
33 Жаманшин, СССР	5,2	(1,07 ± 0,05) · 10^6	т	0,05	Storzer, Wagner, 1977
Decaturville, USA	6,0	(500 ± 50) · 10^6	г	17,69	Engelhardt, 1974
Kentland, USA	6,0	< 450 · 10^6	г	15,92	Болдуин, 1968 42
Serpent Mound, USA	6,4	270 · 10^6	г	8,40	То же 22
Wetumpka, USA	6,5	< 70 · 10^6	г	2,11	Neathery et al., 1975
Middlesboro, USA	7,0	< 500 · 10^6	г	13,00	Engelhardt, 1974
34 Беенчиме-Салатин, СССР	8,0	< 65 · 10^6	г	1,29	Масайтис и др., 1978 27
Elbow, Canada	8,0	(70–80) · 10^6	г	1,39–1,59	Robertson, Grieve, 1975
35 Вапряйская, СССР	8,0	(130–195) · 10^6	г	2,59–3,88	Масайтис и др., 1978 27
Lac La Moinerier, Canada	8,0	(380–410) · 10^6	р	7,56	Bottomley et al., 1978
Lac Couture, Canada	8,0	(410–430) · 10^6	р	8,0	То же 22
Wanapitei, Canada	8,5	(37 ± 2) · 10^6	р	0,65	Robertson, Grieve, 1975
Deep Bay, Canada	9,0	(100 ± 50) · 10^6	г	1,57	То же 22
Redwing Greek, USA	9,0	200 · 10^6	г	3,15	Robertson, 1978
Bosumtwi, Ghana	10	(1,04 ± 0,11) · 10^6	т	0,013	Storzer, Wagner, 1977
Eagle Butte, Canada	10	(30–40) · 10^6	г	0,38	Robertson, Grieve, 1975
36 Карпинская, СССР	10	< 25 · 10^6	г	0,32	Масайтис и др., 1978 27
Oasis, Libya	11,5	(29,4 ± 0,5) · 10^6	т	0,28	Storzer, Wagner, 1977
37 Логойская, СССР	12	(120 ± 15) · 10^6	г	1,06	Верстенников, 1976, 43 устн. сообщ.
Serra da Cannghale, Brazil	12	< 300 · 10^6	г	2,65	Dietz, French, 1973
Nicolson, Canada	12,5	(300 ± 150) · 10^6	г	2,45	Engelhardt, 1974
Sierra Madera, USA	13,0	(150 ± 70) · 10^6	г	1,13	Engelhardt, 1974
Steen River, Canada	13,5	(95 ± 7) · 10^6	р	0,66	Robertson, Grieve, 1975
Wells Greek, USA	14,0	100 · 10^6	г	0,65	Stearns et al., 1968
38 Янис-Ярви, СССР	15	(720–730) · 10^6	р	4,08	Масайтис и др., 1978 27
Lappajarvi, Finland	14,0	1,8 · 10^9	р	7,93	Lehtinen, 1976
39 Оболонская, СССР	15	< 150 · 10^6	г	0,84	Вальтер, Рябенко, 25 1977
40 Эльгыгытгын, СССР	15	(5 ± 2) · 10^6	р	0,02	Гуров и др., 1978 44
Dellen, Sweden	15	235 · 10^6	р	1,33	Bottomley et al., 1977
41 Калужская, СССР	15	(400–430) · 10^6	р	2,26	Масайтис и др., 1978 27
Stopfenheim, Germany	18	(14,8 ± 0,7) · 10^6	г	0,06	Storzer et al., 1971
Mistastin, Canada	20	(38 ± 4) · 10^6	р	0,12	Mak et al., 1976 45
		(39,6 ± 4,46) · 10^6	т		Storzer, Wagner, 1977

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1	2	3	4	5	6
46 Байдарацкий, СССР	20	$57 \cdot 10^6$	р	0,18	Маслов, 1977 53
		$95 \cdot 10^6$	г		То же
Hanghton Dome, Canada	20	$15 \cdot 10^6$	г	0,05	Robertson, Grieve, 1975
Gosses Bluff, Australia	22	$(133 \pm 3) \cdot 10^6$	р	0,35	Milton et al., 1972
Clearwater East, Canada	22	$(287 \pm 3) \cdot 10^6$	т	0,76	Storzer, Wagner, 1977
Rochechonart, France	23	$(150 \pm 10) \cdot 10^6$	р	0,36	Kraut, Becker, 1975
		$(198 \pm 25) \cdot 10^6$	т	0,48	Storzer, Wagner, 1977
Ries, Germany	24	$(14{,}7 \pm 0{,}4) \cdot 10^6$	т	0,03	То же 22
Strangways, Australia	24	$(150 \pm 70) \cdot 10^6$	г	0,33	Guppy, Brett, 1971
St. Martin, Canada	24	$(225 \pm 40) \cdot 10^6$	р	0,50	Robertson, Grieve, 1975
47 Каменская, СССР	25	$< 65 \cdot 10^6$	г	0,13	Масайтис и др., 1978 27
48 Балтышская, СССР	25	$(96–105) \cdot 10^6$	р	0,19	То же 22
Manson, USA	30	$(150 \pm 70) \cdot 10^6$	г	0,21	Engelhardt, 1974
Slate Island, Canada	30	$< 350 \cdot 10^6$	г	0,50	Halls, Grieve, 1976
Carswell, Canada	30	$(485 \pm 50) \cdot 10^6$	г	0,69	Robertson, Grieve, 1975
Clearwater West, Canada	35	$(287 \pm 43) \cdot 10^6$	г	0,30	Storzer, Wagner, 1977
Charlevoix, Canada	35	$(360 \pm 25) \cdot 10^6$	р	0,37	Robertson, Grieve, 1975
La Malbaie, Canada	35	$(365–460) \cdot 10^6$	г	0,38	Robertson, 1968
Araguainha Dome, Brazil	40	$< 250 \cdot 10^6$	г	0,20	Dietz, French, 1973
Siljan, Sweden	45	$365 \cdot 10^6$	р	0,23	Bottomley et al., 1977
49 Карский, СССР	50	$57 \cdot 10^6$	р	0,03	Маслов, 1977 53
		$95 \cdot 10^6$	г	0,05	То же 22
Richat, Mauritania	50	$< 300 \cdot 10^6$	г	0,15	Short, Bunch, 1968
50 Лабынкыр, СССР	60	$(150–300) \cdot 10^6$	г	0,05–0,11	Вальтер, Гуров, 1977, устн. сообщ. 54
Manicouagan, Canada	70	$(200 \pm 30) \cdot 10^6$	т	0,05	Storzer, Wagner, 1977
51 Пучеж-Катунь, СССР	80	$(183 \pm 3) \cdot 10^6$	р	0,03	Масайтис и др., 1978 27
52 Попигай, СССР	100	$38{,}9 \cdot 10^6$	р	0,004	То же 22
Sudbury, Canada	100	$(1{,}84 \pm 0{,}15) \cdot 10^9$	р	0,23	Robertson, Grieve, 1975
Vredefort, South Africa	140	$(1{,}97 \pm 0{,}1) \cdot 10^9$	р	0,13	Manton, 1965
Michigan basin?	> 100	$2{,}4 \cdot 10^9$	г	< 0,31	Hartung, 1978

56 Примечание: т – трековый, р – радиологический, у – углеродный, г – геологический, п – наблюдалось падение, н – метод неизвестен.

KEY: 1 - Crater, location; 2 - D, km; 3 - T, yr; 4 - Research method; 5 - T/S, yr/m²; 6 - Reference. 7 - Yardymly, USSR; 8 - Sikhote-Alin', USSR; 9 - Sobolevskiy, USSR; 10 - Ilumetsa, USSR; 11 - Kaali, USSR; 12 - Tabun-Khara-Obo, Mongolia; 13 - Zapadnaya, USSR; 14 - Shunak, USSR; 15 - Rotmistrovskaya; 16 - Zelenyy Gay, USSR; 17 - Gusevskiy, USSR; 18 - Kashkay, Aliyev, 1961; 19 - Fesenkov, 1947; 20 - Khryanina, Ivanov, 1977; 21 - Serebryanyy, Punning, 1976; 22 - Ditto; 23 - Shumaker, 1968; 24 - Shkerin, 1976; 25 - Val'ter, Ryabenko, 1977; 26 - Fel'dman, et al., 1979; 27 - Masaytis et al., 1978; 28 - Mishina Gora, USSR; 29 - Kyardla, USSR; 30 - Il'intsy, USSR; 31 - Kurskaya,

USSR; 32 - Mizaray, USSR; 33 - Zhamanshin, USSR; 34 - Beyenchime-Saalatin, USSR; 35 - Vapryayskaya, USSR; 36 - Karlinskaya, USSR; 37 - Logoyskaya, USSR; 38 - Yanis-Yarvi, USSR; 39 - Obolonskaya, USSR; 40 - El'gygytgyn, USSR; 41 - Kaluzhskaya, USSR;
42 - Boldyin; 43 - Veretennikov, 1976, oral communication;
44 - Gurov et al., 1978; 45 - Mak et al., 1976;
46 - Baydaratskiy, USSR, 47 - Kamenskaya, USSR;
48 - Baltyshskaya, USSR; 49 - Karskiy, USSR; 50 - Labynkyr, USSR;
51 - Puzhek-Katun', USSR; 53 - Maslov, 1977; 54 - Val'ter, Gurov, oral communication; 55 - NOTE: t - trek; p - radiological; y - carbon; г - geological; п - drop observed; H - method unknown.

TABLE 2

NUMBER OF MELTS IN A CRATER

1 Кратер	2 S, км²	3 V, км³	4 Литература
Mistastin	110	8	Grieve et al., 1977
West Clearwater	230	24	7 То же
5 Болтышский	310	19	8 Вальтер, Рябенко, 1977
Manicouagan	710	80	Dence et al., 1977
6 Попигай	7900	1700	9 Масайтис, 1979, устн. сообщ.

KEY: 1 - Crater; 2 - S, km²; 3 - V, km²; 4 - Reference; 5 - Boltyshskiy, 6 - Popigay; 7 - Ditto; 8 - Val'ter, Ryabenko, 1977' 9 - Masaytis, 1979, oral communication.

So as not to exclude totally destroyed cosmogenic structures -- astroblemes -- from the study, this work defines a crater as any geological-geophysical phenomenon which indicates that an impact meteor explosion took place at its location and from which we can evaluate the scale and time of the event. Under terrestrial conditions this approach is possible. The lifetime, or relaxation time T_e, is the time during which crater characteristics reach a certain level of geological noise, i.e., the property gradient between the crater and its surrounding environment disappears. Noise is understood as interference considered characteristic by modern methods of meteorite crater detection. Such a general approach must use more than crater morphology as a characteristic. A terrestrial meteorite crater -- or impact event -- is a set of characteristics -- morphological, geological-geochemical, geophysical [Dabizha, Zotkin, 1979]. Some of them disappear relatively quickly (relief, for example), while others remain virtually unchanged over the lifetime of the planet (fusion or high-baric minerals). Naturally, to evaluate the scale of the event, other information must be taken into account.

The study of the evolution of terrestrial craters according to changes in morphology is complicated by the fact that initial forms greatly depend on size. Small craters are deep, while large craters are flat and morphologically complex.

As with lunar craters, morphological classifications can be set up for terrestrial craters, but their relationship to evolution will probably be more complex, because lunar processes are more uniform. Thus, the Shunak or El'gygytgyn craters can be classified as relatively fresh, young objects; Ries belongs to the intermediate class, and Deep Bay or Yanis-Yarvi are old craters from which morphological features have been virtually erased. Morphological methods provide a wealth of information on lunar craters because a crater's relief is better preserved on the Moon and its evolution is slower. Therefore, morphology is the most available characteristic for lunar objects at present.

We can assume that area S is the basic energy characteristic of an impact crater. This is clear if we remember that fairly large craters are relatively flat objects. The majority of quantitative features and characteristics are somehow related to

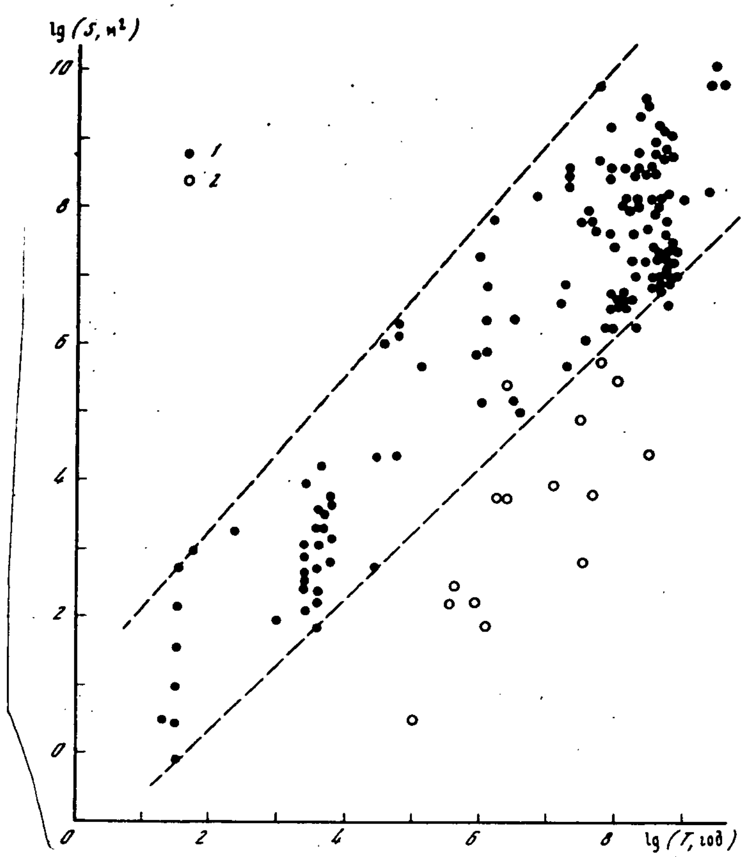

Fig. 1. Distribution of impact-explosive cosmogenic structures as a functin of their age and area.
1 - Meteorite craters on Earth; 2 - Lunar objects.

crater size: area determines how well a crater can be discerned on aerial or space photographs; the basic gravimetric /86 characteristic -- defect mass -- is not proportional either to size D or basic volume D^3, but to meteorite crater area D^2 [Dabizha, 1978]; the quantity of impact-altered matter preserving information on the impact event is also proportional to crater area.

The quantity of melted rock is an indicative example of the above (Table 2). Unfortunately, information on melt volume is currently available for only a few large craters.

In summary, we can conclude that the intensity of information on a crater (signal intensity) will be proportional to D^2, or crater area

$$I \sim S \sim D^2. \tag{2}$$

Craters disappear from the planet's surface due to innumerable random reasons. The majority of observable craters are strongly altered and changed. These changes depend on many circumstances, above all on the geological and tectonic conditions in the region where the cosmic body fell, the state of the planet's upper layers (core, viscous layer and their power ratio, as well as the presence of an atmosphere), and crater age and size [Dabizha et al., 1977]. Naturally, these factors determine the course of evolution not only for meteorite craters, but for geological objects of different origins. Crater evolution is one of the manifestations of the geological form of the movement of material, which has a definite specifcs [Kedrov, 1958; Bondarchuk, 1970]. As with physical and chemical forms of movement, which often become apparant through random wandering or diffusion, the geological form of motion (the evolution of a meteor crater) can be represented as the random displacement of the mineral masses making up the crater. Diffusion (random displacement of substances) can be postulated from equation (1), which indicates that the relaxation time of a geological disturbance is proportional to its linear dimensions squared.

According to the solution of the diffusion equation, /87 the concentration of substances surrounding a diffusing two-dimensional object are expressed as:

$$I(r,t) = \frac{I_0}{4\pi\kappa t} e^{-r^2/4\kappa t}, \tag{3}$$

where r is the distance from the center; k is the diffusion factor; and I_0 is the initial concentration, if we consider the crater as a whole and ignore its structural details, i.e.

consider it a homogenous, compact geological disturbance (formally point-like). It gives not only the quantity of impact-altered substances, but all information on the crater. Knowing I is of practical interest not over great distances, but in a small region, near the center of the crater, where r is small. Then

$$I(t) = I_0/4\pi\kappa t. \tag{4}$$

In other words, the traits of a crater are inversely proportional to time and the diffusion factor (macrodiffusion).

Earlier it was stated that immediately following crater formation I_0 is proportional to S_0. Afterwards, intensity is inversely proportional to kt over time. It is important to remember that what changes is not the structure's dimensions, but the intensity of the anomaly; in other words - the intensity of the geological disturbance. On the other hand, crater diameter (with the exception of the smallest craters located on slopes) is the most stable and convenient of all traits and parameters. Crater dimensions reconstructed now are, in effect, the initial dimensions of these objects, i.e. D_0.

The ratio of crater area S, or D^2, to crater age T, i.e. S/T, is a parameter which characterizes the object's level of preservation, or how pronounced it is. Grieve and Robertson [1979] propose a similar parameter (preservation index), but chose the ratio of diameter D to age T. A certain correlation can be seen between this parameter and the level of preservation, which is qualitatively evaluated (in degrees) according to the crater's visible morphology and ejections [Grieve, Robertson, 1979] (Fig. 2).

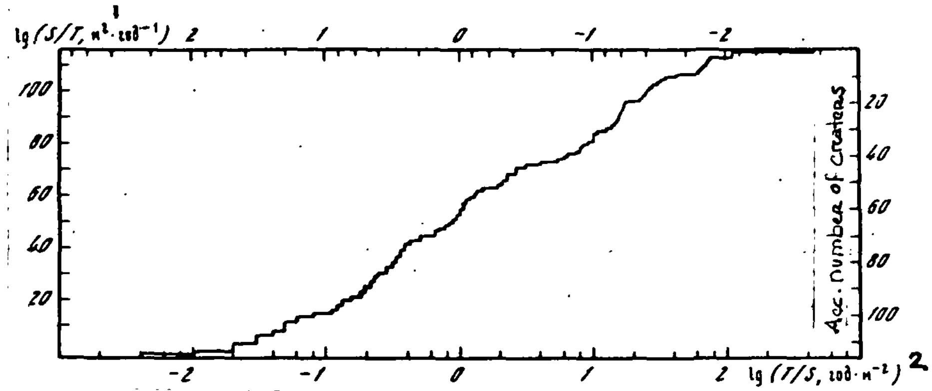

Fig. 2. Accumulated (integral) distribution of the number of meteorite craters in terms of adjusted age T/S (lower left) and in terms of the index for their condition S/T (upper right).
KEY: 1 - $m^2 x\ yr^{-1}$; 2 - $yr\ x\ m^{-1}$;

It is convenient to consider the inverse of T/S, or T/D^2, the adjusted, or normalized age of a meteor crater (see Table 1), which makes it possible to study impact structures with different dimensions in a single time scale and a single genetic order, while he numerical value of this parameter determines the crater's place on the evolutionary scale, all other conditions being equal. For example, the Popigay crater has a diameter of 100 km, is 30 million years old, and its T/S ratio is equal to 0.004(*years* x m^{-2}); in the above sense it is much younger and better preserved that the Sikhote-Alinskiy craters with dimensions of a few meters, which are only a little over 30 years old (T/S=40). Younger and better preserved craters will tend toward the upper boundary of the $1/50 \leq T/S \leq 50$ area in Fig. 1, and the older craters, toward the lower boundary.

A similar approach permits quantitative study of the evolutionary morphological order of lunar craters, proposed by K. P. Florenskiy et al. [Florenskiy et al., 1971; Florenskiy, Taborko, 1972; Basilevsky, 1976]. The level of crater diffusion, conditionally determined by the diffusion process, gives an independent evaluation of age by using the abovementioned /88
authors' "intersection method." Unfortunately, as Table 3 shows,

there is not enough data on the absolute age of lunar craters to derive the quantitative parameters involved in the random dispacement process.

TABLE 3

DIMENSIONS AND AGE OF CERTAIN LUNAR CRATERS AND SEAS

1 Кратер	2 Размер, км	3 Возраст, млн. лет	4 Литература
5 Без названия	$2 \cdot 10^{-3}$	0,1	Yokoyama et al., 1975
Bullet Crater	$1 \cdot 10^{-2}$	1,2 ± 0,2	То же 6
5 Без названия	$1{,}5 \cdot 10^{-2}$	0,3 ± 0,2	"
" "	$1{,}5 \cdot 10^{-2}$	0,75	Basilevsky, 1976
" "	$2 \cdot 10^{-2}$	0,4 ± 0,2	Yokoyama et al., 1975
Plum	$3 \cdot 10^{-2}$	30 ± 10	Basilevsky, 1976
Van Serg Crater	$9 \cdot 10^{-2}$	1,6 ± 0,5	Yokoyama et al., 1975
Spur Crater	$9 \cdot 10^{-2}$	2,6	Storzer et al., 1973
Head	$1 \cdot 10^{-1}$	40	Basilevsky, 1976
Shorty	$1{,}1 \cdot 10^{-1}$	10	То же 6
Surveyor	$2 \cdot 10^{-1}$	240	"
Cone	$3{,}4 \cdot 10^{-1}$	26	"
South Ray	$6{,}5 \cdot 10^{-1}$	2	"
Camelot	$7{,}3 \cdot 10^{-1}$	85	"
North Ray	$9{,}5 \cdot 10^{-1}$	50	"
Tycho	110	100	Neucum, König, 1976
Copernicus	125	850	То же
Mare Crisium	516	> 3270	Schaeffer et al., 1978
Mare Tranquillitatis	650	> 3700	То же
Mare Orientale	960	3840	Chao, 1977
Mare Imbrium	1100	3900	То же 6

KEY: 1 - Crater; 2 - Size, km; 3 - Age, million yr; 4 - Reference; 5 - Unnamed; 6 - Ditto.

A study [Fedynskiy et al., 1978] on the relationship between the number of known craters and their dimensions and age indicated that the probability of a crater being discovered, P, is proportional to S/T. Using the information given in the present article, we can define the physical meaning of this value more precisely: it is the information content, the distinctness of a crater as a geological object I living over time. More strictly speaking:

$$P \sim S_0/\kappa T, \qquad (5)$$

where S_0 is the crater's initial area and k is the macrodiffusion factor. Obviously, k varies significantly for different regions of earth and for different features making up information content. Variations in k, obviously, leads to the expansion, the broadening [or erosion] of the area a crater occupies in space (S,T). A increase in k shortens a crater's life, while a decrease in k prolongs it.

The distribution of the number of craters according to T/S (see Fig. 2) provides us with definite conclusions on the average value and variations of factor k. It follows from expression (5) that T/S is proportional to k if, as a rough estimate, we assume that the probability of all currently known craters being discovered is approximately equal. The distribution function (see Fig. 2) shows that T/S centers around a value of úl.4 year/m^2 and has a spread of about two orders of magnitude.

Thus, a study of the ages and dimensions of 114 meteor craters on earth showed that the kinetics of their aging and, consequently, the evolution of the crater population, can be described with diffusion laws. Here craters should be considered as a certain geological disturbance on a planet's surface caused by a meteor impact and exhibiting a series of different traits. The macrodiffusion factor, which defines the random displacement of mineral masses over the Earth, is around 2×10^{-2} m^2/year on the average. The basic distinctive energy characteristic of a crater is its initial area S_0.

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16. Abstract

@ ABS An examination of the ages and sizes of 114 terrestrial impact craters shows that their aging kinetics can be described by the diffusion laws. The macrodiffusion coefficient which determines random displacements of mineral masses on the earth has a mean value of 0.02 sq m/year. The amount of matter in a crater that contains information about the impact event decreases with time according to the 1/T law. The basic characteristic parameter of a crater is its initial area, inasmuch as sufficiently large craters are nearly surficial formations. The relaxation time of a crater is proportional to its initial area.

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