DEC 28 1965 ~~Roman~~

T-24219

National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-3760

7110

ST - LPS - 10431

GPO PRICE $ ______

CFSTI PRICE(S) $ ______

Hard copy (HC) 1.00

Microfiche (MF) .50

ff 653 July 65

ON THE INAPPLICABILITY OF THE BALDWIN CORRELATION FOR THE DETERMINATION OF THE CAUSES OF EMERGENCE OF LUNAR CRATERS

by

G. S. Shteinberg

(USSR)

FACILITY FORM 602

N66 39994	
(ACCESSION NUMBER)	(THRU)
6	1
(PAGES)	(CODE)
CR-79089	30
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

22 DECEMBER 1965

ON THE INAPPLICABILITY OF THE BALDWIN CORRELATION FOR THE DETERMINATION OF THE CAUSES OF EMERGENCE OF LUNAR CRATERS *

Doklady A. N. SSSR,
Astronomiya
Tom 165, No. 1, 55 - 57,
Izd-vo "NAUKA," 1965

by G. S. Shteinberg

N66-39994

SUMMARY

Comparing the results of research by other authors with some observations of volcanic craters after aerial photographs taken in eastern volcanic belt, the present author points to the necessity of detailed morphological analysis of the latest data on lunar objects, comparing them with meteoritic and volcanic forms, since any alternate approach to causes having conditioned the formation of lunar relief does not allow a satisfactory explanation of all the facts observed. The author states that the "single-eventness " in the formation of meteoritic forms, and the duration and phase multiplicity of volcanic activity, must unconditionally, find reflection in the morphology of craters.

author

Among the important conclusions in favor the meteoritic hypotheses of lunar crater formation stand the correlations established by Baldwin [1] . This author has shown, indeed, that for bomb and missile-produced funnels for meteorite, terrestrial and lunar craters the ratio of funnel diameter to respectively the bottom depth wall height and explosion energy, these correlations constitute a unique sequence. The Baldwin conclusions were accepted by partisans of the meteoritic hypothesis [2 - 5] , despite the fact that they point only to the explosive character of crater formation [6] .

Calderae are the greatest volcanic objects morphologically resembling lunar craters. Depending upon the formation mechanism, these can be subdivided as follows: a) cave-in calderae (Glenco type); b) explosion calderae (Krakatau type) [7] . For calderae whose formation is attended by eruption of enormous amounts of pumice and ignimbrites, most of the authors assume the explosive genesis.

The question of volcanic (calderic) genesis of lunar craters was examined more than once [8, 9] . On the basis of gravimetric works, I. Yokoyama estimated the ener-

---

* O NEPRIMENIMOSTI SOOTNOSHENIYA BOLDUNA DLYA OPREDELENIYA PRICHIN VOZNIKNOVENIYA LUNNYKH KRATEROV

gy by the displacement of volcanic material at eruptions having led to caldera formation and established the empirical dependence of the explosion energy on caldera dimensions [10]. We plotted in Fig. 1 A the combined graph of energy dependence on the diameter, drawn from data brought out in Baldwin and Yokoyama works, respectively [1] and [10]. As may be seen from this graph, calderae hit the curve, established for missile, meteoritic, nuclear, and lunar craters. The same conclusion is found to be valid for the dependence, linking the depth of funnels (craters, calderae) with their diameter (Fig. 1 B). The results obtained are quite regular, for the deformation of terrestrial (lunar) surface as a result of near-surface explosion depend only on the medium's properties and explosion energy; they are not dependent on the type of explosion whether it be chemical, nuclear, meteoritic, or volcanic. Thus, from the fact that lunar craters satisfy the correlations established for explosion craters, one cannot conclude upon their meteoritic origin, since these correlations are also valid for volcanic objects. Other criteria are thus required in order to refer craters to either the meteoritic of volcanic category.

The dependences established by Baldwin bear a statistical character; for lunar and terrestrial craters, the deflections from strict regularity are sufficiently noticeable. The opinion of B. Yu. Levin [5] that this discrepancy is "incomparably greater" (for the ratio of depth to diameter) is not corroborated by calculations. B. Yu. Levin estimates that claderae constitute "cave-in formations at volcano summits," that is, he considers only an insignificant group of the so-called summit calderae, while calderae proper are vast depressions with diameters from 20 to 25 km; during the latest years annular volcanic depressions were detected of which the diameters were from 30 to 50 km [11]. Secondly, the depth of calderae, taken down from topographic maps, is underrated, for calderae (and particularly the summit type) are filled with deposits of subsequent volcanic activity. For the cases when the true depth of a caldera is determined by gecgraphical methods [12, 13], the discrepancy is less than for lunar objects. In Fig. 1 B, the interval of depths $\underline{d}$ was taken from the minimum ones, taken down from the map (!) to the maximum ones determined by geophysical methods, that is, the separated region is widened along the abscissa axis. However, even in this case, the discrepancy for calderae does not practically differ from that for lunar craters.

When making aerial photographs in the eastern volcanic belt, we identified, aside from calderae, a series of volcanic formations morphologically similar to lunar craters and satisfying the Baldwin correlations. Among these, we should mention maar Valentina (Fig. 2 A), maar in the Uzon caldera, maar Galya on the southern shore of the Kronotskiy lake (Fig. 2 B), the Shtyubel' crater in Ksudach caldera, the chain of craters on the southern slopes of the caldera of the Krashennikov volcano and others [14]. The number of such examples may be extended. They will be considered at further length in a subseqent work.

Analysis of the available data shows that an alternate statement of the problem of causes, conditioning the formation of lunar surface relief, does not allow a satisfactory explanation of all the observed facts. At the present time, when detailed large-scale photographs of lunar surface have been obtained, it would be necessary to pass to a detailed morphological analysis of lunar objects and their comparison with meteoritic and volcanic forms with the view of working out subdivision criteria. The "one-eventness" in the formation of meteoritic forms and the duration, and "multiphaseness" of volcanic activity unquestionably find reflection in the morphology of craters.

I wish to express my deep gratitude to Professor P. P. Sharonov and A. V. Khabakov for the useful remarks and their assistance in carrying out the work.

* * *THE END* * *

Institute of Volcanology of the
Siberian Division of the USSR
Academy of Sciences

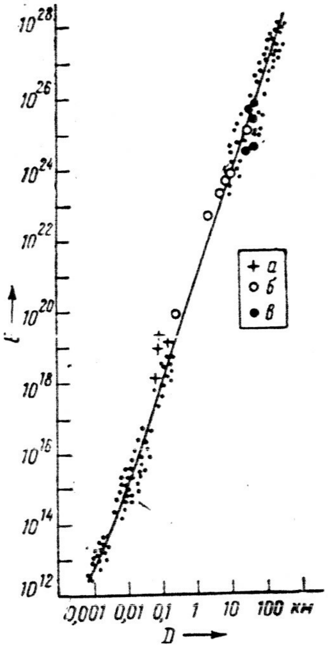
Received on 20 April 1965

Contract No. NAS-5-3760
Consultants & Designers, Inc.
3240 Wilson Boulevard
Arlington, Virginia

Translated by ANDRE L. BRICHANT
on 23 December 1965

REFERENCES

1. R. B. BALDWIN. The Face of the Moon, Univ. Chicago, 1949.
2. H. C. UREY. Sky and Telescope, 15, No. 3, 1956.
3. SPENCER JONES. Proc. Roy. Inst. Gr. Brit., 35, No. 3, 1953.
4. J. SADIL. Mesic, Praha, 1953.
5. B. YU. LEVIN, E. L. RUSKOL. Vopr. kosmogonii, v. 8, 1962.
6. K. P. STANYUKOVICH. Sborn. Luna, M., 1960.
7. V. I. VLODAVETS. Tr. Moskovsk. obl. ped. inst., 9, v. 4, 1947.
8. A. V. KHABAKOV. Ob osnovnykh vopro-akh razvitiya poverkhnosti Luny, M., 1949.
9. B. J. ESCHER. Bull Volcanol., Ser. II, 8, 1949.
10. I. YOKOYAMA. J. Faculty Science, Hokkaido, Univ. Ser. VII, Geophys., 1957.
11. E. A. HEALY. New Zealand, J. Geol. and Geophys. 7, 1, 1964.
12. I. YOKOYAMA. Intern. Symp. Volcanol., Japank 1962.
13. I. YOKOYAMA. Nature, 191, 4792, 1961.
14. G. S. SHTEYNBERG. Byull. vulkanol. stantsiy, No. 37, 1964.



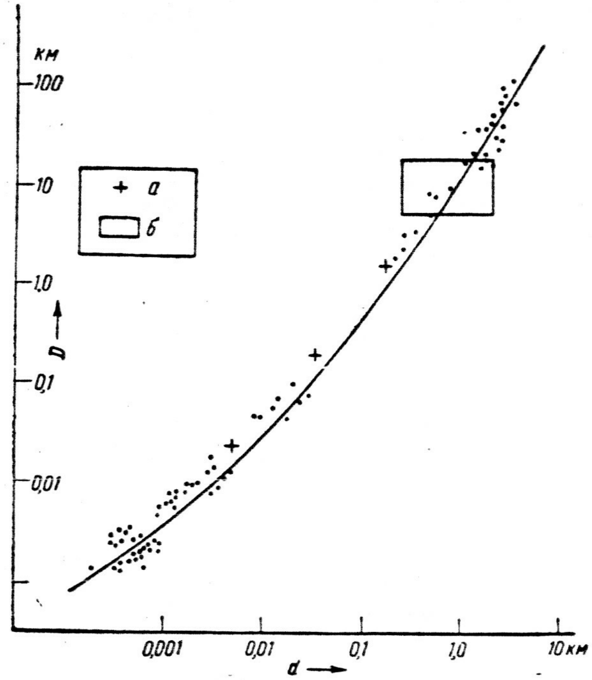


Fig. 1

A
Dependence of explosion energy on crater diameter; a - meteoritic craters; б - nuclear craters; в - calderae

B
Dependence of crater diameter in depth (Baldwin); a - meteoritic craters, б - caldera region

Fig. 2

A
Maar Valentina in the Karymsk volcano region

B
Maar Galya on the south shore of Kronotsk Lake

Do Not film

DISTRIBUTION

GODDARD SPACE FLIGHT CENTER

100	CLARK, TOWNSEND	
110	STROUD	
400	BOURDEAU	
610	MEREDITH	
611	MC DONALD	
	ABRAHAM	
	BOLDT	
	VKB	
612	HEPPNER	
	NESS	
613	KUPPERIAN	
614	WHITE	
615	BAUER	
	GOLDBERG	
	STONE	
	WHIPPLE	
640	HESS	(3)
	O'KEFFE	
641	CAMERON	
	LOWMAN	
252	LIBRARY	
256	FREAS	
630	GI for SS	(5)

NASA HEADQUARTERS

SS	NEWELL, NAUGLE
SG	MITCHELL
	SCHARDT
	ROMAN
	SMITH
	DUBIN
SL	LIDDEL
	BRUNK
	BRYSON
	FELLOWS
	HIPSHER
	HOROWITZ
SM	FOSTER
	ALLENBY
	GILL
	BADGLEY
RR	KURZWEG
RTR	NEILL
ATSS	SCHWIND
	ROBBINS
WX	SWEET

OTHER CENTERS

AMES
LIBRARY (3)
SONETT (5)

LANGLEY

160	ADAMSON	
235	SEATON	
	BABCOCK III	
213	KATZOFF	
303	ROBERTS	
242	GARRICK	
185	WEATHERWAX	(2)

J P L
NEWBURN
SPEED
CONEL
KOVACH
LOOMIS
WYCKOFF

U C L A
COLEMAN

U. C. at BERKELEY
WILCOX

U. of ARIZONA
KUIPER

U. of MICHIGAN
HADDOCK

N. O.
LIBRARY

S. W. C. A. S.
JOHNSON

W. P. A. F. B.
TDBX-T

T-24219

Gilfas Sh

National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-3760

ST - LPS - 10431

ON THE INAPPLICABILITY OF THE BALDWIN CORRELATION FOR THE DETERMINATION OF THE CAUSES OF EMERGENCE OF LUNAR CRATERS

by

G. S. Shteinberg

(USSR)

22 D E C E M B E R 1965

ST - LPS - 10431

ON THE INAPPLICABILITY OF THE BALDWIN CORRELATION FOR THE DETERMINATION OF THE CAUSES OF EMERGENCE OF LUNAR CRATERS *

Doklady A. N. SSSR,
Astronomiya
Tom 165, No. 1, 55 - 57,
Izd-vo "NAUKA," 1965

by G. S. Shteinberg

SUMMARY

Comparing the results of research by other authors with some observations of volcanic craters after aerial photographs taken in eastern volcanic belt, the present author points to the necessity of detailed morphological analysis of the latest data on lunar objects, comparing them with meteoritic and volcanic forms, since any alternate approach to causes having conditioned the formation of lunar relief does not allow a satisfactory explanation of all the facts observed. The author states that the "single-eventness " in the formation of meteoritic forms, and the duration and phase multiplicity of volcanic activity, must unconditionally, find reflection in the morphology of craters.

Among the important conclusions in favor the meteoritic hypotheses of lunar crater formation stand the correlations established by Baldwin [1] . This author has shown, indeed, that for bomb and missile-produced funnels for meteorite, terrestrial and lunar craters the ratio of funnel diameter to respectively the bottom depth wall height and explosion energy, these correlations constitute a unique sequence. The Baldwin conclusions were accepted by partisans of the meteoritic hypothesis [2 - 5] , despite the fact that they point only to the explosive character of crater formation [6] .

Calderae are the greatest volcanic objects morphologically resembling lunar craters. Depending upon the formation mechanism, these can be subdivided as follows: a) cave-in calderae (Glenco type); b) explosion calderae (Krakatau type) [7]. For calderae whose formation is attended by eruption of enormous amounts of pumice and ignimbrites, most of the authors assume the explosive genesis.

The question of volcanic (calderic) genesis of lunar craters was examined more than once [8, 9] . On the basis of gravimetric works, I. Yokoyama estimated the ener-

---

* O NEPRIMENIMOSTI SOOTNOSHENIYA BOLDUNA DLYA OPREDELENIYA PRICHIN VOZNIKNOVENIYA LUNNYKH KRATEROV

gy by the displacement of volcanic material at eruptions having led to caldera formation and established the empirical dependence of the explosion energy on caldera dimensions [10] . We plotted in Fig. 1 A the combined graph of energy dependence on the diameter, drawn from data brought out in Baldwin and Yokoyama works, respectively [1] and [10] . As may be seen from this graph, calderae hit the curve, established for missile, meteoritic, nuclear, and lunar craters. The same conclusion is found to be valid for the dependence, linking the depth of funnels (craters, calderae) with their diameter (Fig. 1 B). The results obtained are quite regular, for the deformation of terrestrial (lunar) surface as a result of near-surface explosion depend only on the medium's properties and explosion energy; they are not dependent on the type of explosion whether it be chemical, nuclear, meteoritic, or volcanic. Thus, from the fact that lunar craters satisfy the correlations established for explosion craters, one cannot conclude upon their meteoritic origin, since these correlations are also valid for volcanic objects. Other criteria are thus required in order to refer craters to either the meteoritic of volcanic category.

The dependences established by Baldwin bear a statistical character; for lunar and terrestrial craters, the deflections from strict regularity are sufficiently noticeable. The opinion of B. Yu. Levin [5] that this discrepancy is "incomparably greater" (for the ratio of depth to diameter) is not corroborated by calculations. B. Yu. Levin estimates that claderae constitute "cave-in formations at volcano summits," that is, he considers only an insignificant group of the so-called summit calderae, while calderae proper are vast depressions with diameters from 20 to 25 km; during the latest years annular volcanic depressions were detected of which the diameters were from 30 to 50 km [11] . Secondly, the depth of calderae, taken down from topographic maps, is underrated, for calderae (and particularly the summit type) are filled with deposits of subsequent volcanic activity. For the cases when the true depth of a caldera is determined by gecgraphical methods [12, 13] , the discrepancy is less than for lunar objects. In Fig. 1 B, the interval of depths $\underline{d}$ was taken from the minimum ones, taken down from the map (!) to the maximum ones determined by geophysical methods, that is, the separated region is widened along the abscissa axis. However, even in this case, the discrepancy for calderae does not practically differ from that for lunar craters.

When making aerial photographs in the eastern volcanic belt, we identified, aside from calderae, a series of volcanic formations morphologically similar to lunar craters and satisfying the Baldwin correlations. Among these, we should mention maar Valentina (Fig. 2 A), maar in the Uzon caldera, maar Galya on the southern shore of the Kronotskiy lake (Fig. 2 B), the Shtyubel' crater in Ksudach caldera, the chain of craters on the southern slopes of the caldera of the Krashennikov volcano and others [14] . The number of such examples may be extended. They will be considered at further length in a subseqent work.

Analysis of the available data shows that an alternate statement of the problem of causes, conditioning the formation of lunar surface relief, does not allow a satisfactory explanation of all the observed facts. At the present time, when detailed large-scale photographs of lunar surface have been obtained, it would be necessary to pass to a detailed morphological analysis of lunar objects and their comparison with meteoritic and volcanic forms with the view of working out subdivision criteria. The "one-eventness" in the formation of meteoritic forms and the duration, and "multiphaseness" of volcanic activity unquestionably find reflection in the morphology of craters.

I wish to express my deep gratitude to Professor P. P. Sharonov and A. V. Khabakov for the useful remarks and their assistance in carrying out the work.

* * *THE END* * *

Institute of Volcanology of the
Siberian Division of the USSR
Academy of Sciences

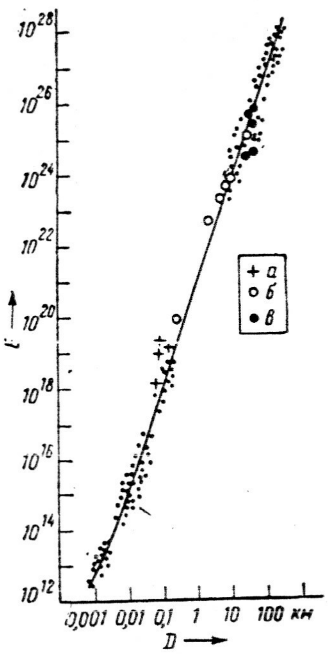
Received on 20 April 1965

Contract No. NAS-5-3760
Consultants & Designers, Inc.
3240 Wilson Boulevard
Arlington, Virginia

Translated by ANDRE L. BRICHANT
on 23 December 1965

REFERENCES

1. R. B. BALDWIN. The Face of the Moon, Univ. Chicago, 1949.
2. H. C. UREY. Sky and Telescope, 15, No. 3, 1956.
3. SPENCER JONES. Proc. Roy. Inst. Gr. Brit., 35, No. 3, 1953.
4. J. SADIL. Mesic, Praha, 1953.
5. B. YU. LEVIN, E. L. RUSKOL. Vopr. kosmogonii, v. 8, 1962.
6. K. P. STANYUKOVICH. Sborn. Luna, M., 1960.
7. V. I. VLODAVETS. Tr. Moskovsk. obl. ped. inst., 9, v. 4, 1947.
8. A. V. KHABAKOV. Ob osnovnykh vopro·akh razvitiya poverkhnosti Luny, M., 1949.
9. B. J. ESCHER. Bull Volcanol., Ser. II, 8, 1949.
10. I. YOKOYAMA. J. Faculty Science, Hokkaido, Univ. Ser. VII, Geophys., 1957.
11. E. A. HEALY. New Zealand, J. Geol. and Geophys. 7, 1, 1964.
12. I. YOKOYAMA. Intern. Symp. Volcanol., Japank 1962.
13. I. YOKOYAMA. Nature, 191, 4792, 1961.
14. G. S. SHTEYNBERG. Byull. vulkanol. stantsiy, No. 37, 1964.



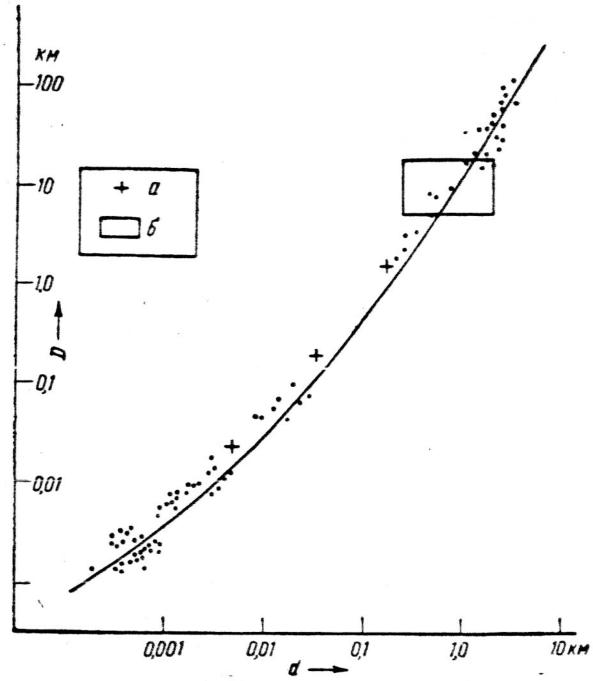


Fig. 1

A

Dependence of explosion energy on crater diameter; a - meteoritic craters; б - nuclear craters; в - calderae

B

Dependence of crater diameter in depth (Baldwin); a - meteoritic craters, б - caldera region

Fig. 2

A

Maar Valentina in the Karymsk volcano region

B

Maar Galya on the south shore of Kronotsk Lake

DISTRIBUTION

GODDARD SPACE FLIGHT CENTER

100	CLARK, TOWNSEND	
110	STROUD	
400	BOURDEAU	
610	MEREDITH	
611	MC DONALD	
	ABRAHAM	
	BOLDT	
	VKB	
612	HEPPNER	
	NESS	
613	KUPPERIAN	
614	WHITE	
615	BAUER	
	GOLDBERG	
	STONE	
	WHIPPLE	
640	HESS	(3)
	O'KEFFE	
641	CAMERON	
	LOWMAN	
252	LIBRARY	
256	FREAS	
630	GI for SS	(5)

NASA HEADQUARTERS

SS	NEWELL, NAUGLE
SG	MITCHELL
	SCHARDT
	ROMAN
	SMITH
	DUBIN
SL	LIDDEL
	BRUNK
	BRYSON
	FELLOWS
	HIPSHER
	HOROWITZ
SM	FOSTER
	ALLENBY
	GILL
	BADGLEY
RR	KURZWEG
RTR	NEILL
ATSS	SCHWIND
	ROBBINS
WX	SWEET

OTHER CENTERS

AMES
LIBRARY (3)
SONETT (5)

LANGLEY

160	ADAMSON	
235	SEATON	
	BABCOCK III	
213	KATZOFF	
303	ROBERTS	
242	GARRICK	
185	WEATHERWAX	(2)

J P L
NEWBURN
SPEED
CONEL
KOVACH
LOOMIS
WYCKOFF

U C L A
COLEMAN

U. C. at BERKELEY
WILCOX

U. of ARIZONA
KUIPER

U. of MICHIGAN
HADDOCK

N. O.
LIBRARY

S. W. C. A. S.
JOHNSON

W. P. A. F. B.
TDBX-T