# ON THE STRUCTURE OF THE CRATER ALPHONSUS

Astronomy

1967

SovietRxiv

## Abstract

## Full Text

UDC 523.34

*Astronomy*

G. S. Shteinberg

# ON THE STRUCTURE OF THE CRATER ALPHONSUS

*(Presented by Academician A. P. Vinogradov on 8 February 1967)*

At the present time, when detailed photographs of the lunar surface are available, the geological structure of the Moon can be deciphered using the experience gained in the geological interpretation of aerial photographs. The proposed analysis of the geological structure of the crater Alphonsus was carried out on the basis of photographs taken by the *Ranger 9* rocket system. The scale of the photographs ranged from 1 : 1,000,000 to 1 : 5000; for consideration of the regional geological situation, photographs obtained from ground-based observatories were used ([1], [2]).

Interpretation of small-scale photographs (Fig. 1) shows that the principal direction of tectonic structures (faults) in the region of the craters Ptolemaeus–Walter is north-northeast (NNE); the northwestern direction is of subordinate importance; faults of latitudinal direction are indirectly reflected in the latitudinal polygonal boundaries of certain craters; no faults of meridional direction have been established. The axial (median) ridges and chains of elevations in the craters Alphonsus, Arzachel, and Regiomontanus, in the graben-like structure between the craters Alphonsus and Arzachel, and also the fault Rupes Recta in Mare Nubium have an NNE orientation (Fig. 1).

Faults with displacement, narrow rift-like valleys, and furrows of NNE trend are morphologically expressed most clearly and in a number of cases cut across the ring ridges bounding the craters. Within the craters, however, these faults cannot be traced (3).

Faults of NNE direction were undoubtedly renewed more than once, since alongside fresh forms that are morphologically clearly expressed there are fragments of strongly eroded furrows, linearly oriented elevations, and chains of semi-flooded craters of the same NNE strike.

The ring ridge of the crater Alphonsus, more precisely the inner slopes of the ridge, appears on small-scale photographs as a continuous system of ring faults (Fig. 1); on large-scale photographs this system breaks up into a series of en echelon, overlapping arcuate faults (Fig. 2). In the northern part of the ring ridge a horizontal displacement is recorded, established from the mismatch of

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

the boundaries of the foot of the ring ridge ([4]). Within the ring ridge such a displacement cannot be established, since this zone, lying on the continuation of the axial ridge, has been so intensively tectonically reworked that within it, against the background of faults of NNE strike, it is not possible to trace concentric faults of latitudinal direction (Fig. 2). The southern sector of the ring ridge is torn apart by an extensive graben-like depression extending in the direction of the crater Arzachel. In the axial part of this depression there is a complexly constructed ridge of NNE strike, passing in the north into the axial ridge of the crater Alphonsus. The boundaries of the graben-depression

**Fig. 1**

do not disrupt the annular ridge bounding the crater Arzachel.

Along with the NNW disturbances, most strongly expressed in the northern and southern parts of the annular ridge, on the western outer slope of Alphonsus there is a system of concentric disturbances (Fig. 2). Some of them pass at a fairly considerable distance from the crater, in plain areas partly flooded by Mare Nubium.

In the northwestern and southern sectors of the annular ridge, typical stratovolcanoes are distinguished on large-scale photographs; they are conical elevations with a base diameter of 6–10 km and a summit crater (Fig. 3).

**Fig. 2**

In the internal structure of the crater, three regions should be distinguished: the western region, the eastern region, and the axial (median) ridge. The western and eastern regions are identical in structure. Tectonics in these regions is manifested rather intensively; however, the distribution of small pits within the crater Alphonsus is, for the most part, random. In any case

Fig. 3

Fig. 3. Volcanic mountains in the northwestern part of the ring ridge of Alphonsus

Fig. 1

Fig. 2

Fig. 1. The region of the craters Ptolemaeus–Walter (reproduced from Kuiper' s Atlas of the Moon) and its tectonic scheme (see p. 320)

Fig. 2. The crater Alphonsus ( “Ranger 9” ) and its tectonic scheme (see p. 320)

Legend for Figs. 1 and 2: 1, 2—ring fractures and disturbances expressed in the relief; 3—tectonic disturbances, furrows; 4—deep rift-like furrows, troughs; 5—boundaries of maria; 6—boundaries of the inner and outer slopes of craters; 7—central hills; 8—a) volcanoes; b) funnels, craters; 9—boundaries of the axial ridge; 10—axial ridges, chains of elevations; 11—uplifted areas; 12—areas of subsidence of the mare, inner parts of craters: I—Ibn Sina, II—Spörer, III—Ptolemaeus, IV—Alphonsus, V—Albategnius, VI—Arzachel, VII—the Enarium Peninsula, VIII—Thebit, IX—Purbach, X—Regiomontanus, XI—Mare Nubium, XII—Straight Wall, XIII—Walter.

morphologically expressed tectonic control is not established. In the axial ridge the tectonics is manifested considerably more intensely than in the western and eastern zones.

Such are the principal facts established in the deciphering of the photographs. Below are set out the conclusions drawn from the established facts.

1. The subordination of the main intracrater structural elements (axial ridges, chains of elevations) to the regional structural plan is, from the geological point of view, entirely regular. Many examples may be cited in which, under terrestrial conditions, the distribution of volcanic apparatuses in calderas, depressions, and grabens is controlled by regional tectonics (5–7). From the standpoint of the meteoritic hypothesis, which regards the origin of the crater as an accidental process unrelated to the geological development of the region, this regularity cannot be explained.

2. The presence of NNW-trending dislocations in the Sea of Clouds—the youngest formation of the region (8)—and their absence in the inner parts of the craters is apparently a consequence of the fact that, during the mare period, the relatively uplifted crater region was stabilized and tectonic movements of the regional plan within it ceased.

3. The interrelation of regional (linear) tectonics and local (concentric) tectonics, connected with the internal development of the crater, is expressed, on the one hand, in the intensive dissection of the ring ridge by NNW-trending dislocations, and, on the other, in the extension of ring concentric dislocations beyond the limits of the crater. Under terrestrial conditions, mutually conditioned structures whose development is determined, on the one hand, by regional tectonics and, on the other, by volcanic processes are distinguished under the name of volcano-tectonic structures. As a rule, these are large ring depressions, the diameter of which reaches one hundred kilometers (9, 10). It is possible that the majority of lunar craters are volcano-tectonic structures.

4. The presence of NNW-trending dislocations in the ring ridge of Alphonsus and their absence in the intracrater area indicate that there was a break between the formation of the ring ridge and the intracrater outpourings

of lava and, accordingly, that the formation of the ring ridge and the intracrater outpourings cannot be regarded as a single-act process.

5. Several distinct tectonic zones are confidently distinguished in the crater Alphonsus: the ring ridge, the eastern and western intracrater areas, and the axial ridge. All this indicates a long duration in the development of the structure.

6. Intracrater tectonics, manifested with particular intensity in the axial ridge, is apparently volcanogenic tectonics proper and is due to stresses developing during the movement of magma toward the surface. The network of faults in the axial ridge is ordered (Fig. 2), and it is extremely unlikely that such a system of faults arose as the result of random meteoritic impacts.

7. The supposition of an ignimbritic composition of the material covering the intracrater surface (4) appears to be erroneous. Ignimbrites are a product of acid volcanism, the result of deep magmatic differentiation, whereas, in terms of the content of radioactive elements in acid rocks occupying significant areas, none have been established on the Moon ( "Luna-10" ). Moreover, in the opinion of the majority of researchers (11–13), ignimbrites are deposits of glowing clouds; under the conditions of the lunar vacuum, glowing clouds would be immediately degassed, and the sintering of deposits (i.e., the actual process of formation of ignimbrites) without the participation of a gas phase is impossible (14).

The noted regularities testify to the prolonged and regular geological development of the crater Alphonsus and the adjoining terri-

···tory. The following schematic sequence of development of the crater seems possible:

a) Against the background of regional tectonic movements, an annular volcanic ridge is formed; within the crater a weakened zone (the future axial ridge) is established, corresponding to the principal tectonic direction.

b) Tectonic stabilization of the region and prolonged intracrater volcanism, apparently of the fissure type. By analogy with volcanism on Earth occurring in tectonically stabilized zones (platforms, oceans), the composition of the lavas is probably basic, weakly differentiated.

c) At late stages, the areas of manifestation of volcanic activity in the crater diminish, and volcanism becomes localized in the long-lived weakened zone —the axial ridge.

d) The extinction of the linear volcanic group proceeded from the periphery toward the center (by analogy with the Earth; compare, for example, the Avacha, Zhupanovo, Karymsky, Gamchen, and other linear volcanic groups). At the final stage, activity is concentrated in the central peak, which is confirmed by the results of spectrometric studies (15).

The author considers it his duty to express gratitude for advice, discussion, and support in carrying out the work to Corresponding Member of the Academy of Sciences of the USSR G. S. Gorshkov, N. A. Kozyrev, V. K. Prokofiev, K. M. Tikhonravov, L. V. Ronca, K. P. Florensky, A. V. Khabakov, and E. N. Ehrlich.

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

Received
2 II 1967

## CITED LITERATURE

1. G. P. Kuiper, *The Photographic Lunar Atlas*, Chicago, 1960.
2. G. P. Kuiper, *Orthographic Atlas of the Moon*, Tucson, 1963.
3. A. V. Khabakov, *On the Basic Questions of the History of Development of the Surface of the Moon*, Moscow, 1949.
4. L. V. Ronca, *Nature*, **209**, No. 5019, 182 (1966).
5. G. S. Steinberg, *Bull. Volcanological Station*, No. 38 (1964).
6. G. S. Steinberg, L. A. Rivvosh, *J. Geophys. Res.*, **70**, No. 14 (1965).
7. E. N. Ehrlich, *Geotectonics*, No. 4 (1965).
8. A. V. Khabakov, in: *On the Moon*, 1960.
9. E. A. Healy, *New Zealand J. Geol. and Geophys.*, **7**, 1 (1964).
10. E. N. Ehrlich, *Geotectonics*, No. 6 (1966).
11. G. E. Enlows, in: *Problems of Paleovolcanism*, IL, 1963.
12. R. L. Smith, in: *Problems of Paleovolcanism*, IL, 1963.
13. T. Ishikawa, M. Minato et al., in: *Problems of Paleovolcanism*, IL, 1963.
14. F. R. Boyd, in: *Problems of Paleovolcanism*, IL, 1963.
15. N. A. Kozyrev, in: *New Data on the Moon*, Publishing House of the Academy of Sciences of the USSR, 1963.

*Note: Figure translations are in progress. See original paper for figures.*

*original.*