Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 56 (1963)
Heft: 2

Artikel: A geometric terminology of the structural features of the moon
Autor: Bülow, Kurd von / Green, Jack / Amstutz, G. Christian
DOI: https://doi.org/10.5169/seals-163047

A Geometric Terminology of the Structural Features of the Moon[4])

By **Kurd von Bülow**[1]), **Jack Green**[2]) and **G. Christian Amstutz**[3])

ABSTRACT

Lunar physics and chemistry are working with connotation-free tools and nomenclatures. An equivalent geometric, purely descriptive nomenclature for the surface features of the moon is not yet available. Most of the terms presently used contain genetic connotations and imply therefore assumptions.

In recognition of this fact an international, purely descriptive terminology is here proposed. It contains subdivisions according to the size, the shape (linear and ring features) and the place of occurrence (terrae, maria).

A connotation-free terminology should first of all contain purely geometric terms such as ring, polygon, line, wall. In addition it may consist of descriptive and figurative expressions which describe by comparison, such as the terms mare, continent, valley, fissure, mountain, or ray. It should avoid terms which imply a (premature) genetic connotation, such as the terms volcanic craters, impact, craters, meteor scars, etc.

It is hoped that this descriptive nomenclature may serve as an objective basis for the discussions on the exogenous and the endogenous theories of lunar features, and that it will contribute towards the advancement of our basic concepts and theories on the structures of the moon and the planets.

INTRODUCTION

Professor George Sarton wrote in his "Introduction to the History of Science":

"The greatest conquest of science, ... is the notion of the relativity of knowledge; that is, our trust in science, though steadily increasing, is always qualified and limited...".

In many natural sciences it is not fashionable yet to accept and examine the fact that the largest source of relativity of knowledge rests within man himself. This inner frontier of scientific research is still taboo in many sciences, especially because we do not like to discover that our theory on the origin of some natural object is a projection out of our own subconscious. Some of these relationship have been shown elsewhere by one of the present authors (G.C.A.).

It is somewhat more fashionable, to examine our external tools of research and to see whether, and to what degree they might be sources of error.

The value of a genetic theory is among other things also a function of the tools with which the observations and their analyses have been performed. One most important tool or step in an objective of any natural phenomenon is the description.

1) University of Rostock, Germany.

2) North American Aviation, Inc., Downey, California.

3) University of Missouri, School of Mines and Metallurgy, Rolla, Mo.

4) Presented at the forty-second Annual Meeting of the American Geophysical Union, in Washington, D. C., April 1961.

Physics and chemistry are fortunate in having well defined scales, constants, and measuring systems with which to record and to describe natural objects.

The geometric description of geological phenomena is usually left to the geologist. A glance into his tool kit reveals a bewildering collection of terms, many of which are not free of genetic connotations. Almost everything which has a genetic connotation in geology requires assumptions. Assumptions are subject to controversial interpretations.

The uncritical use of these terms with genetic connotations creates the erroneous impression that we know exactly how the features on the surface of the earth or on the moon were formed. This is of course not true. The following are examples of terms with genetic connotations: *volcanic* craters, *impact* craters, *explosion* craters, meteor scars, etc. These terms are descriptive, but they also introduce an interpretation at a time when we may know very little or nothing about the processes responsible for the cone-shaped rings called craters, or the long linear patterns termed faults or meteor scars.

One may of course close his eyes and pretend that we have the correct genetic answer. We are convinced, however, that one of the prerequisites to objective research is the recognition of the fact that there are different schools of thought, and this is certainly true with regard to the theories on the origin of the surface features on the moon.

We believe that there is only one way out of this impasse of opinions; this is: more basic research which does not start from premature assumptions. In order to do this type of objective research we need objective tools and, above all, an objective vocabulary, and a connotation-free terminology – which is purely descriptive and which does not force us to accept a theory and many assumptions, before we have had a chance to describe and examine the object.

The geologist-morphologist actually has an objective way of describing surface features. This is an accurate topographic map, without any man-made alterations. However, for the purpose of discussion and description we also need terms.

In recognition of the fact that many terms used at present are not free of premature connotations and assumptions, the authors met at the 1960 International Geol. Congress to discuss lunar terminology. It is based on the unanimous intention to attempt setting up a terminology which is as purely descriptive as possible and does not force the scientist to make up his mind about a process before he has even started to make notes about his observations.

One way to offer an objective description is of course to use purely geometric terms. Many features on the moon can be adequately described with purely geometric names such as ring, plane, line, hexagon, slope, cone, etc. In addition to the geometric term, the exact size can be given.

However, it is often desirable to also have a somewhat more figurative or comparative descriptive terminology. For this purpose an attempt has been made to set up a descriptive terminology which can be used by anyone, no matter whether he favors an endogenous or an exogenous origin for most of the moon features.

The following pages offer a systematic list and brief descriptions of the terms proposed. It might be mentioned beforehand, that the dark areas and the light areas on the moon are also given two different names which reflect without commitment on the possibility that we are dealing with two different compositions: The material of the light areas is called terra material and that of the dark areas mare material.

(Abundant illustrations of the features defined are given in the detailed papers of the authors cited in the bibliography.)

GEOMETRIC TERMINOLOGY OF LUNAR SURFACE FEATURES

A. General terms and definitions

1. *Geology of the moon* or *lunar geology* (Not selenology or similar terms, because the Greek word $\gamma\tilde{\eta}$ (gae) is not so much a term for the planet as it is for the soil – the earthy, stony material on which we live and walk).
2. *Orientation* of global and local maps of the moon:
   a) Geological and topographic maps: N up.
   b) Astronomical maps: S up.
3. Opposite of "*lunar*" is "*telluric*" (*not terrestric or terrestriel*, since this is the opposite to oceanic).
4. *Regional geographical subdivisions* of the visible surface of the moon according to the new map of the U. S. Corps of Engineers.
5. "Tectonic" at the time being and for purely geometric descriptions to be replaced by the term "*structure*" or "*structural*".
6. *Terra material* for the bright material with relatively high albedo, *mare material* for the dark material with relatively low albedo.

In discussions on the possible genesis of lunar features, the terminology can also be kept as objective as possible and interpretative terms which imply many kinds of assumptions can be kept at a minimum. The following are a few terms which already refer to the genesis, i.e., processes, and therefore imply assumptions of a geometric change in time or $\Delta s/\Delta t$, or a compositional change in time or $\Delta c/\Delta t$, or both together, $\Delta s \cdot \Delta c/\Delta t$:

7. *Evolution of the crust* (German: "Thorakogenese" or "Thorakohistorie"): subdivided into pre-mare, mare, and post-mare periods.
8. *Supra-crustal* for processes or materials taking place or existing on the surface of the moon, *intra-crustal* for those within the crust. (The term *intra-lunar* may be used where a process or material is considered to pertain to any space or unit inside the moon. The three terms supra-crustal, intra-crustal, and intra-lunar take the place of the old terms exogenous and endogenous. As shown by Amstutz, 1961, the latter two terms should be reserved for more basic discussions on exo- or endogenous causes, not only in regard to the crusts of planets.)
9. *Exogenous* for forces, processes, or materials from outside the moon itself, *endogenous* for forces, processes, or materials from the moon itself, including the surface, the crust, and the interior.
   (In descriptions any interpretative terms such as "impact" or "volcanic" should be avoided at the present time.)

B. Terminology of structural features

I. LARGE FEATURES

a) *Terra,* pl. terrae (at the time being, terra is meant to be a purely descriptive areal name and is therefore not understood to be synonymous with land, continent, etc.).

definition: relatively bright and high surfaces or island-like unit areas, usually with distinct relief.
material: terra material (as a purely descriptive term, at the time being, without any genetic and compositional connotation).

b) *Mare,* pl. maria (purely descriptive figurative, and not synonymous with ocean, sea, etc.).

definition: relatively dark and lower level surfaces, with more or less "smooth" surfaces and little relief surrounded by terrae.
material: mare material (without any genetic and compositional connotation).

1) *true maria* (mountain maria, step-bordered maria): the borders towards the surrounding terrae are usually sharp and they have the character of steep slopes or look like walls (comparable to some "fault scarps" on the earth), and are often arcuate in shape.

2) *epi-terra maria:* the borders towards the surrounding terra are usually smooth and gradational, their coarse irregular, terra features (cliffs, mountains, "craters", rings, and clefts) often project from the mare surfaces in these areas and increase in number and size towards the border of this class of maria.

3) mare belt: includes the trough-shaped depression which contains the following true maria: Oc. Procellarum, M. Imbrium, M. Serenitatis, M. Crisium. (The following true maria in the southern terra area do not belong to this mare belt: M. Humorum and M. Nectaris.)

II. SMALL FEATURES

a) Small features of the terrae

1) *Linear features*

Structural lines: all linear elements. Various structural lines together form *systems* of *lines, grids, nets,* or *structural patterns. Clefts or rills: regular or irregular long, linear structures* with a lower medium part (channel-like, graben-like), and two parallel confining walls, usually in the middle of a uniform surrounding.
Width: usually less than one km.
Length: usually many km. up to several hundred km. Occasionally covered with "craterlets", like a string of pearls.
Fissures: open gaps or "crevices".
Fissure lines: cleft-like lines, not visibly open, which occur in groups or patterns.
Steps: lines which show a difference of elevation on both sides, for example the "straight wall" (which could be called straight cliff, more accurately). The rims of the true maria are steps. (As stated before, these resemble the fault scarps on the earth).

Valleys: broad, long, steep-walled valleys with relatively wide, flat floors, with a direction which corresponds generally to the structural pattern of the surrounding area. (Many are comparable in shape to grabens, but this term should be reserved for a genetic interpretation. The expression graben-like, however, may be used for descriptive purposes.)
"*Schollen*" or structural islands: structural elements of terra which are bordered by approximately straight lines. The lines may be steps or fissures.
Terra border steps: a relatively subsided area or "scholle" of terrae on the border of a mare.

2) *Ring and polygon features of terrae*
General subdivision: A logical, descriptive, geometric subdivision at present appears to be that according to size and shape. The smallest rings (up to 1 km in diameter) are always approximately circular, but fall into two different classes with regard to the nature of the rim. Some consist of definite cones with a central hole, others are merely a hole or hollow in the flattish surface of the moon. The similarity of the former to the volcanoes on the earth justifies the descriptive term "*cone craterlet*" (in quotation marks). The second may be described as "*flat craterlet*". The next size group of ring features (1–10 km), which are also always approximately circular and never polygonal, may be called "*crater*" also as a mere objective descriptive comparison. There is of course no objection to calling these small features also ring structures and to subdivide them according to size. Structures larger than 10 km may be called large or very large *rings* or *polygons* depending on their shape and size. Consequently, the following *definitions* are suggested:

Class I: *very small ring structures* or "*craterlets*": up to 1 km in diameter; central cone lacking.
Ia: "*cone craterlet*", a small cone shaped elevation with a hole in the center.
Ib: "*flat craterlet*" (or "flat rim craterlet", or "pit craterlet"), a small circular hole without a distinctly elevated rim.
Class II: *small ring structures* or "*craters*": 1–10 km in diameter; occasionally with complex rim or central cone; as a rule with a more or less elevated rim which has the shape of the base of a truncated cone. (Often strikingly similar in shape to calderas on the earth). Can be associated with Class I rings as parasitic structures.
Class III: *medium ring or polygonal structures:* 10–100 km in diameter, often associated in a regular or irregular geometric pattern with Class I and II structures.
IIIa: *medium ring structures:* with more or less distinct walls and a central plane (as defined below).
IIIb: *medium polygon structures:* with more or less distinct walls and central plane: the walls often continue or correspond to a neighbouring polygonal or linear structure.
Class IV: *large ring or polygonal structures:* over 100 km in diameter; otherwise the same as Class III.
IVa: *large ring structure:* same as class IIIa except for size.
IVb: *large polygon structure:* same as class IIIb except for size.

Detailed structures of rings and polygons

a′ *rims* may consist of *cone slopes* on the outside and *walls* or *inner walls* on the inside. The "flat craterlets" have no cone slopes.

b′ some rings appear to be filled with the dark mare material; they may be called "*mare material filled*".

c′ "long craters" are interconnecting "craters" which lead to graben-like features very similar in shape to the explosion fissures of Iceland – a comparison which is not meant to be a premature interpretation.

d′ *vague, indistinct rings or "craters"* in distinction to those which are well defined. (Terms such as "ruined" or "destroyed" craters involve assumptions; they ought to be avoided in a descriptive terminology).

e′ *central peak:* only to be used where there is really only one central peak; in the other cases expressions like *interior "craterlets"*, *cones*, *ridges*, etc., may be used.

f′ *interior terraces, rim terraces, concentric terraces* for the terrace or step-like portions within the ring structures.

g′ As stated above, *comparisons* with telluric tectonic or volcanic features should, in this descriptive, geometric nomenclature, only be made in a purely descriptive, geometric way and meaning. If terms other than the ones mentioned here are applied, the ending "*-like*" should be used (ex.: shield volcano-like, Vesuvius-like, etc.).

b) Small features of the true maria

1) *Linear features of the maria:* mare ridges of "mare wrinkles".
symmetrical, i.e. bi-lateral dam-like ridges.
asymmetrical, one-sided ridges or steps (comparable in shape to telluric lava fronts), (clefts, rills, fissures, etc., appear to be restricted to the epiterra maria regions; see below).

2) *Small ring structures* or "*craterlets*" (larger types of rings appear to be absent on true maria, but do occur on subsided terra-shelfparts, which are located at shallow depths below the mare surface. Examples include Archimedes, Arstillus, etc. on the submerged terra steps on the western slope of Mare Imbrium).
domes (topographic "swellings") appear to occur only on thick mare material masses and on filled rings.

c) Small features of the epi-terra maria

Epi-terra maria are terra portions which, due to their relatively low elevation, could be overflowed by mare material. Depending on the thickness of the mare material, the buried terra features are more or less clearly visible. All transitions are found between non-covered, open terra features to the true maria.

Conspicuous features are:

Half or almost completely "drowned" rings, sometimes still recognizable below thin mare material covers.
Equally the *linear structural patterns* are also often partly visible.

On thick mare material covers, island-like or "iceberg-like", mare material hills or series and rows of hills can be seen.
When the thickness of the mare material cover is very great, the features listed for "true maria" are seen.

d) The "Rays"
Ray-like patterns are known in all three areas, the terrae, the maria, and the epiterra maria, although they are usually best visible in the darker or maria areas. Normally the "rays" depart from ring features and may range from a few km to as much as 2000 or more km in length. They may be distinct lines of higher albedo than their "background" or very faint indistinct and irregular patterns, but still in a ray type pattern.

ACKNOWLEDGEMENT

We wish to acknowledge the critical reading and suggestions of Dr. Paul D. Proctor, University of Missouri, School of Mines and Metallurgy.

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