RÜMKER HILLS: A LUNAR VOLCANIC DOME COMPLEX

EUGENE I. SMITH
Division of Science, University of Wisconsin-Parkside, Kenosha, Wi., U.S.A.

(Received 24 July, 1973)

Abstract. The Rümker Hills, a volcanic dome-flow complex in the northern Oceanus Procellarum, is characterized by overlapping plains-forming units with lobate scarps, volcanic domes, a 60 km ring, and a scarp which separates the plateau from surrounding mare materials. Plains-forming units are interpreted as fluid volcanic flows, and domes as viscous extrusions. One dome may be a strato-volcano. The ring system is discordant with regional structural trends and probably has a local origin. The Rümker Hills is the closest lunar analog to the large martian shield structures revealed on the Mariner 9 photographs of Mars.

1. Introduction

The Rümker Hills, 80 km in diam, is an elevated mare dome complex in the northern Oceanus Procellarum. It is characterized by volcanic domes, plains-forming units, a 60 km diam ring structure, and a scarp which separates the plateau from surrounding mare materials.

Previous authors observing the Rümker Hills through telescopes and on Earth-based photographs interpreted the plateau as a laccolithic uplift (Herring, 1960), and a dome complex (Westfall, 1964; Kopal, 1966). Wilkens and Moore (1955) indicated that Rümker was observed as a ruined ring by Goodacre.

There are many resemblances between the Rümker Hills and the large shield structures revealed on the Mariner 9 photographs of Mars. Both represent large accumulations of volcanic materials in sparsely cratered volcanic plains, and both belong to aligned volcanic systems. Most of the volcanic shields on Mars are aligned on a broad northeast trending ridge on the eastern margin of Tharsis. The largest of the shields, Nix Olympica, lies on the western margin of this ridge (Carr, 1973). In comparison the Rümker Hills is the northernmost of a series of volcanic plateaus including the Aristarchus Plateau (Moore, 1965, 1967) and the Marius Hills (McCauley, 1967) which are aligned along the axis of the Oceanus Procellarum. The Rümker Hills is however different in overall morphology to the large martian shields. It lacks the shield shape and large summit crater which are characteristic of the martian features. This possibly suggests a difference in the nature of volcanism which formed the Rümker Hills and martian shields. The Rümker Hills is the closest lunar analog to the martian shield volcanoes.

This paper describes the geology of the Rümker Hills based on detailed study of Lunar Orbiter 4 high resolution photographs 163 and 170 and Earth-based photographs from the Catalina and Pic-du-Midi observatories. A geologic map of the Rümker Hills is shown in Figure 1. A preliminary version of this map at a scale of

The Moon **10** (1974) 175–181.

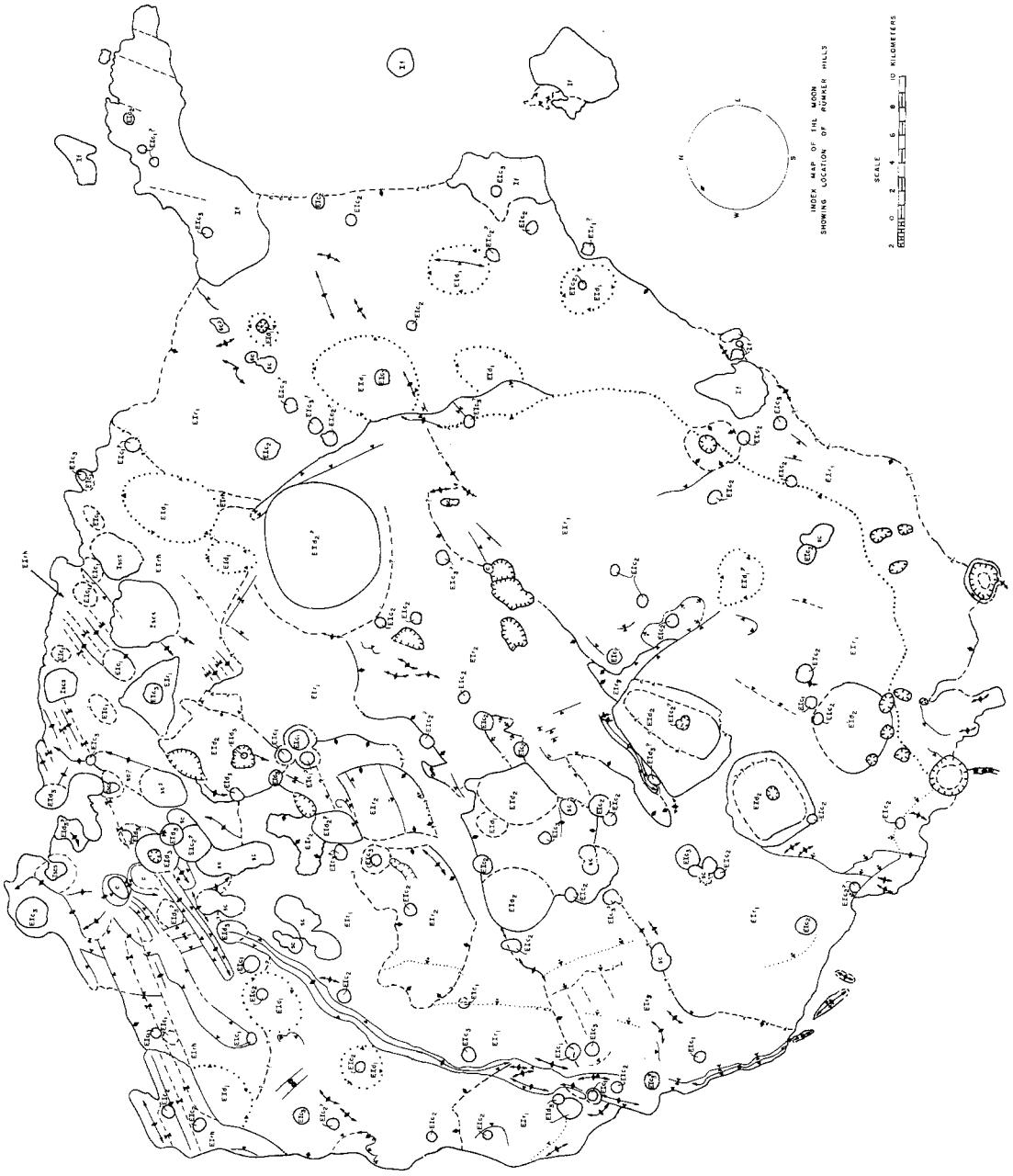


Fig. 1. Generalized geologic map of the Rümker Hills (for explanation of the symbols see Section 7)

1 500000 is found as an insert on the Preliminary Geologic Map of the Rümker Quadrangle of the Moon (Eggleton and Smith, 1967).

2. Plains-Forming Units

Three plains-forming units interpreted as fluid volcanic flows are on the Rümker Hills (Figure 1). Relative age of these units is indicated by superposition. Plains-forming units are from oldest to youngest: (1) a widespread, heavily cratered unit which is characterized by smooth to gently undulating terrain (EIr_1*, Figure 1). In the southeast the unit is broadly domed. (2) A moderately cratered unit (EIr_2, Figure 1) which locally has scarp contacts facing EIr_1. These scarps commonly have well developed lobate form (Point 1, Figure 2), and are interpreted as flow fronts. In the east, the unit is heavily cratered, but on close inspection many of these craters are aligned rimless depressions suggesting an endogenic origin (Point 2, Figure 2). (3) A lightly cratered, finely textured unit which is characterized by broad, gently undulating, subparallel, northeast trending ridges with crests 0.5 to 1 km apart (EIr_3). The unit extends from the base of a broad dome 20 km to the mare and seems to obscure several northwest trending ridges.

The northern part of the Rümker Hills is a subdued lineated topography locally embayed by mare material (EIrh). This terrain is older than other plains-forming units and probably represents lineated Fra Mauro Formation modified by a thin deposit associated with volcanic activity in the southern part of the Rümker Hills. Several patches of hummocky and smooth Fra Mauro Formation outcrop to the northeast and east of the Rümker Hills (Eggleton and Smith, 1967).

3. Domes

The Rümker Hills contain over 30 domes which include: (1) topographically fresh, irregular to convex upward bodies which are less than 2 km in diameter (EId_3). An example (Point 3, Figure 2) is 1.5 km in diam and grades into a ridge to the south. These features are probably extrusive volcanic domes. (2) Subcircular to irregularly shaped, flat topped to convex upward bodies which have sharp contacts with surrounding plains-forming units (EId_2). An example is at Point 4, Figure 2, and is 7.5 km by 3.1 km in diam, with summit crater 600 m wide and approximately 240 m deep. It is surrounded by a terrace which varies in width from 1.3 to 3 km. Dome at Point 5, Figure 2, 9.0 by 8.5 km in diam, is a broad convex upward body, partially surrounded by a relatively uncratered zone 1.3 km wide. These features are also interpreted as extrusive volcanic domes. Another dome (Point 6, Figure 2) is approximately 6.5 km in diam and has a summit pit 1.6 km in diam with a central mound. The summit crater is breached to the south and connected to a series of lobate plains-forming units by a ridge. This dome may in fact be a stratovolcano

* EI = Eratosthenian-Imbrian in age (Lunar Stratigraphic Time Scale).

Fig. 2. Lunar Orbiter 4, high resolution photograph 163 showing the Rümker Hills. Points are explained in text.

with the lobate plains units representing volcanic flows. (3) Low subcircular-to-irregularly shaped flat topped to convex upward bodies, 1.7 to 7.8 km in diameter, which have indistinct contacts with plains-forming units (EId_1). They were probably formed either by intrusions uparching surface layers or by broad extrusions.

4. Craters

Three types of craters are on the Rümker Hills: (1) Isolated bowl-shaped craters with raised rim and associated ejecta interpreted as meteorite impact craters. These craters are grouped into three classes with EIc_3 representing topographically fresh craters and EIc_1 subdued rings (Figure 1). (2) Chained bowl craters interpreted as secondaries

from a Copernican* primary crater (sc., Figure 1). A probable source is the crater Pythagoras, 400 km to the northwest of the Rümker Hills. Several large subdued craters in the northern part on the plateau may be craters related to the Sinus Iridum event (Point 7, Figure 2). (3) Rimless, flat floored craters which are on plains-forming units and domal summits. The crater at Point 8, Figure 2, is terraced and is associated with a southeast trending linear depression. To the northeast (Point 9, Figure 2) are a group of elongated flat-floored craters that form a rille.

5. Scarps, Ridges and the Ring System

Orientation of scarps and ridges on the Rümker Plateau shows northeast and northwest trends with the northeast direction dominating (Figure 3). These trends correspond to the prominent structural directions in the northern part of the Oceanus Procellarum, as revealed by mare ridge trends (Figure 3), and also correspond to major directions of the lunar tectonic grid (Strom, 1964). These data suggest strong regional structural control for ridges and scarps on the Rümker Plateau. The ring

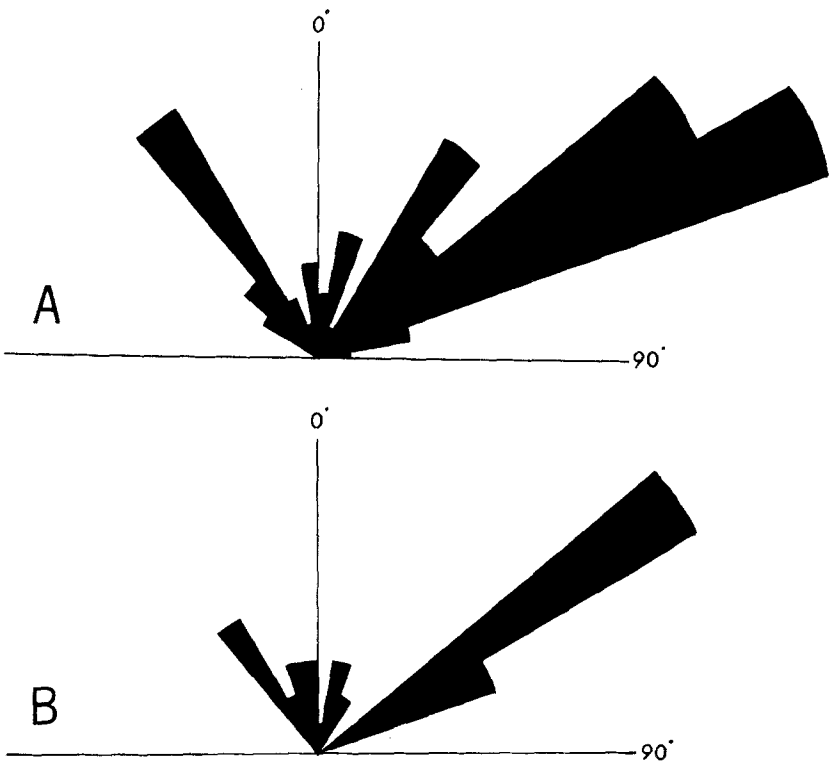


Fig. 3. Rose diagram for 112 ridges and scarps on the Rümker Hills (A) and 76 mare ridges in the vicinity of the Rümker Hills (B).

* Copernican in age.

structure which completely surrounds the central portion of the plateau, however, is discordant with these structural trends. Segments of this ring may in places correspond to regional grid directions. The ring, 60 km in diam, is composed of a ridge system in the west, mare ridges in the south, and a scarp in the east. Eleven domes, three sinuous rilles, and two rimless depressions touch the ring along its circumference. The ring's origin is local and it seems to control the position of numerous endogenic morphologies. It may in fact be the surface expression of a lunar ring dike.

North, northeast and northwest trending mare ridges run discordantly into the Rümker Plateau. Initial activity in the Rümker Hills may have been localized by the intersection of these ridges.

6. Summary

The present topography of the Rümker Hills is predominantly constructional. The plateau is probably composed of a series of overlapping lava flows interrupted by local dome and ring related extrusions. Broad intrusions locally warp these units. Coalessing lava flow margins form the scarp which surrounds the plateau. The scarp surrounding the broad martin shield Nix Olympica may have a similar origin.

7. Explanation of Symbols Used on the Geologic Map of the Rümker Hills (All Stratigraphic Units Are Fully Described in the Text)

Plains-Forming Units

EIr_3 – Lightly cratered, highly textured plains
EIr_2 – Moderately cratered plains with lobate scarps
EIr_1 – Widespread, heavily cratered plains
EIrh – Subdued lineated plains
If – Fra Mauro Formation

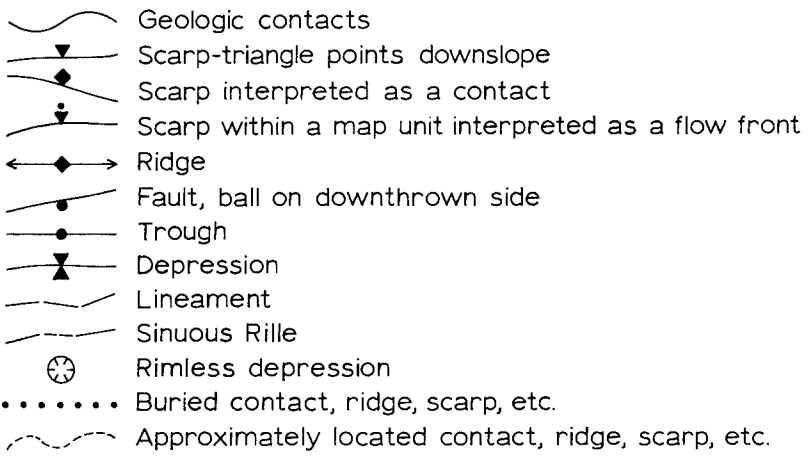
Domes

EId_3 – Topographically fresh convex-upward domes
EId_2 – Subcircular to irregular domes with scarp contacts
EId_1 – Subcircular to irregular domes without scarp contacts

Craters

EIc_3 – Sharp bowl craters
EIc_2 – Partially eroded bowl craters
EIc_1 – Heavily eroded bowl craters
sc – Secondary craters
Iscs – Craters possibly related to the Sinus Iridum event

Scarps, Ridges, Contacts and Other Symbols



Acknowledgments

Research was supported by NASA grants NGR 32-004-062 and NGR 50-009-001.

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