Measuring The Width Of Rimae Prinz

By Raffaello Lena
GLR group

Introduction

Five rilles or rille segments lie to the north and northeast of the crater Prinz, a large Imbrian-Age crater flooded by Eratosthenian mare soils. The rilles occur mostly in a smooth, probably Eratosthenian, mare unit which exhibits relatively sharp contacts with an older, probably Imbrian, roughly-textured unit (Strain and El-Baz, 1975). The IAU's Rimae Prinz includes the four large rilles around the peak named Harbinger Mu and probably the one starting in the lower right. The thinner rilles in the west are an extension of the neighboring Rimae Aristarchus (Moon Wiki, 2008). However, in LAC 39 these prominent rilles were described as Rima Prinz I and Rima Prinz II. In LM-39 the Roman numerals had been dropped and Prinz I was renamed Rima Prinz with the remaining rilles unnamed. In LTO-39A3, Rima Prinz II had been provisionally renamed Rima Beethoven and some rilles named as Rima Handel and Rima Telemann (see Table 1). As a note of interest: the names described in LTO-39A3 were not accepted by the IAU. Strain and El- Baz (1975) describe the length of the rilles as being between 12 and 77 km and the widths as being, on average, 1.7 km. Average depth was measured at 156 m. In Apollo Over The Moon, the maximum width of Rima Prinz II is about 1.5 km. It is at least 100 m deep in the dark mare materials. In this article, I examine the sinuous rilles in Prinz. The width of the rilles was computed using an Apollo 15 image (AS15-M-2195) and, for comparison, a CCD telescopic image taken with a Maksutov Cassegrain 18 cm in diameter.

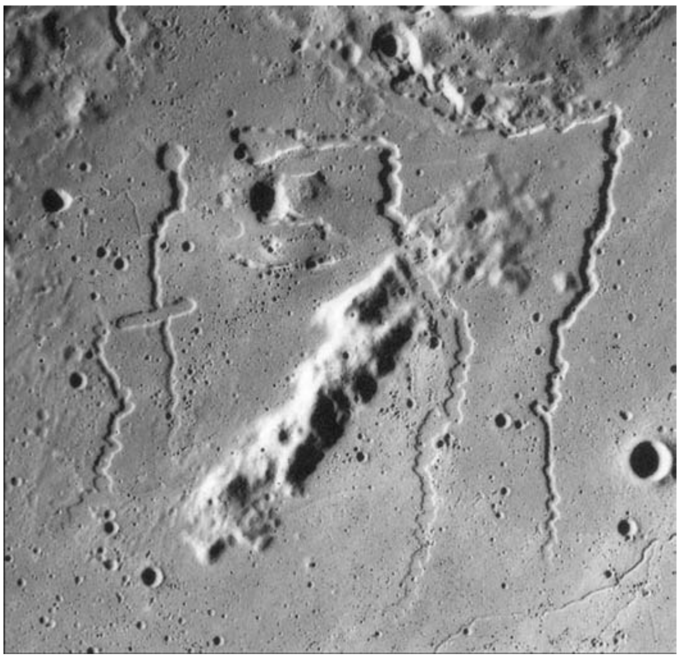

Figure 1: Apollo 15 image (AS15-M-2195) under rectified view. The corresponding rilles and rille segment are reported in Table 1.

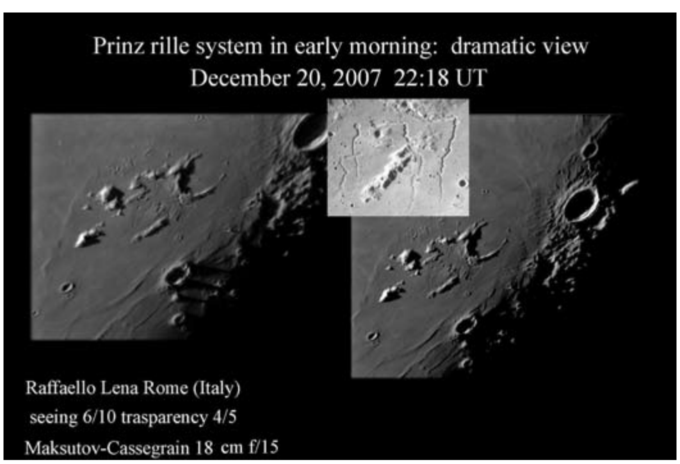

Figure 2: CCD telescopic image by the author. See also the cover image.

Digital images and measurements

Fig. 1 displays the Apollo 15 image (AS15-M-2195) under rectified view. The image shown in Fig. 2 was taken on December 20, 2007 at 22:18 UT using an 18 cm Maksutov Cassegrain and a Lumenera LU 075M. Figure 2 is composed using two different methods of processing. The label given to the rilles or rilles segments (Fig.3) is used here for practical reasons. In Table 1, the corresponding rilles are reported as they are named in the LTO-39A3. Fig. 4 is an enlarged por-

tion of the CCD image.
A calibration was obtained with the software LTVT by Mosher and Bondo using the 1994 UCLN list of benchmark locations. It's difficult to do the full measurements since the sides of the rilles are not well defined in some points.
A greater application of sharpening to the image gave over-processing with excessive width. Hence, a lightly processed image from the corresponding raw file was used (200 frames stacked of 1800). The calibration was verified by measuring the diameter of the crater Krieger C, a value of 4 km. The width of the rilles was also measured with the software Image J at the location where the rille showed fairly well-defined edges. The error was estimated as 360 m/pixel. The data are reported in Table 1. A considerable variation was measured along several locations and an average value for each feature was computed. The width of the rilles has been estimated using an Apollo 15 image along the same position (see Fig. 1 and 4) and averaging the measurements (Table 2). The scale is 100 m/pixel, computed based on the crater Krieger C . The widths obtained from the two images are shown in Fig. 5. The difference between the results obtained with a CCD telescopic image (Fig. 4) and the Apollo 15 image (Fig. 1) is shown in Fig. 6. In the diagram, the difference from the average value measured is reported so that the plus and minus values refer to the difference from the measurements of the Apollo image. Most probably, the remaining uncertainty in the measurements is related to the difficulty in distinguishing between the exact edge for some rilles.

Rille system	LTO 39A3	Width (km)	Average width (km)
D	Rima Beethoven	1.436	
		1.817	
		1.671	
		1.407	
		1.700	
		1.436	
		1.202	
		10.669	1.53±0.36
A	Rima Handel	1.114	
		1.612	
		1.700	
		1.495	
		5.921	1.48±0.36
C	Rima Telemann	1.085	
		1.201	
		1.670	
		1.377	
		5.333	1.33±0.36
F	Rimae Prinz	1.802	
		1.758	
		1.846	
		1.114	
		6.520	1.63±0.36
G	Rimae Prinz	1.055	
		1.084	
		2.139	1.07±0.36
E	Rima Beethoven	1.000	
		1.099	
		2.099	1.05±0.36
B	--	1.055	
		0.996	
		1.085	
		3.136	1.05±0.36

Table 1: Measurement using the CCD telescopic Image.

Rille system	Average width Apollo 15 image
D	1.58±0.10
A	1.41±0.10
C	1.40±0.10
F	1.53±0.10
G	1.12±0.10
E	1.10±0.10
B	1.15±0.10

Table 2: Measurement using Apollo 15 image.

As a note of interest, the measured widths in the CCD telescopic image for rilles A and F are slightly higher than the values computed from the Apollo image. The measurements, however, are consistent which each other since their error intervals overlap (Fig. 5). We get wrong values back when we measure rilles only as wide as the resolution limit of our telescope regardless of the accuracy of the measurement method: when a subject is just detected on an image but not resolved at all we get measures affected by over-sizing (Appendix 1).

The results of this study show that the examined rilles are resolved in the CCD telescopic image used in this study without any over-processing. According to Apollo over the Moon, the widest rille measured is F (named as Rimae Prinz on LTO-39A3) : the average width amounts to 1.53 ±0.10

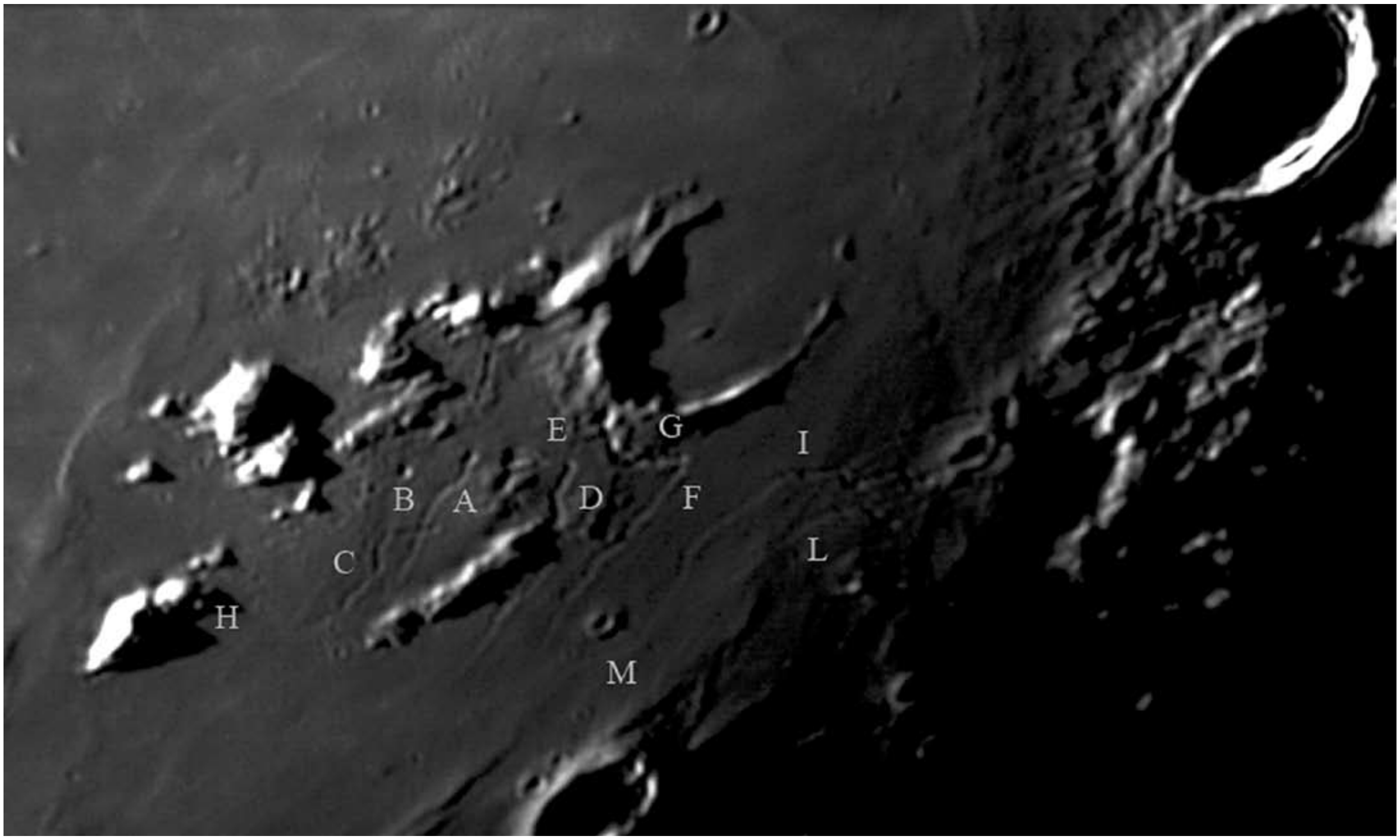

Figure 3: Rilles and their labels (The rilles M, I, L are an extension of the neighbouring Rimae Aristarchus).

km in the Apollo image and 1.63 ±0.36 km in the CCD telescopic image.

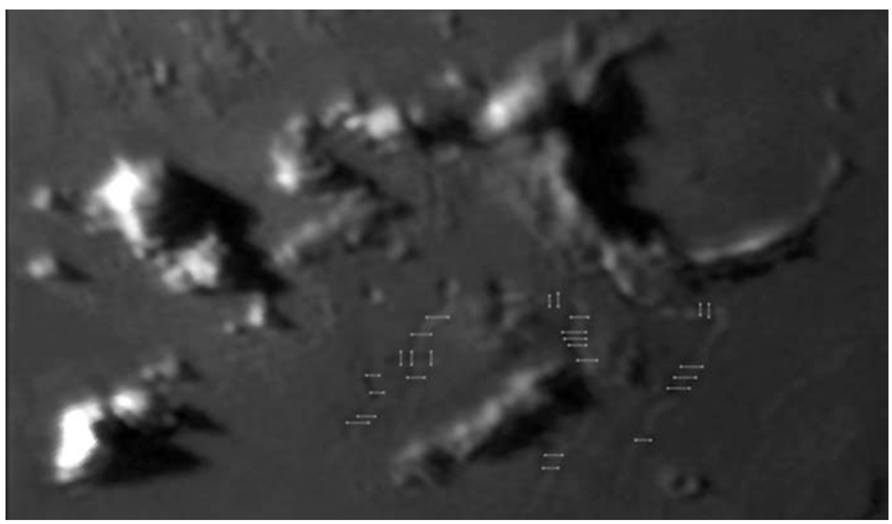

Figure 4: Rilles and locations where the measurements were computed.

References

Apollo Over The Moon; A View From Orbit, Chapter 6: Rimae (Part 1: Sinuous Rimae), Figures 192, 193, and 194 (part of Rimae Aristarchus/ Rimae Prinz near Krieger).

Astroscopic labs http://www.licha.de/astro_article_mtf_telescope_resolution.php

Lunar Aeronautical Chart (http://www.lpi.usra.edu/resources/mapcatalog/LAC/lac39)

Lunar Map series 39 (http://www.lpi.usra.edu/resources/mapcatalog/LM/lm39)

Lunar Topographic Orthophotomap (http://www.lpi.usra.edu/resources/mapcatalog/LTO/lto39a3_1)

Mosher J., Rimae Prinz (http://the-moon.wikispaces.com/Rimae+Prinz)

Mosher J. and Bondo H, 2006 (http://www.henriksucla.dk/)

Strain and El-Baz, Sinuous rilles of the Harbinger mountains region of the moon, 1975. LPSC, vol.6, pp. 786-788.

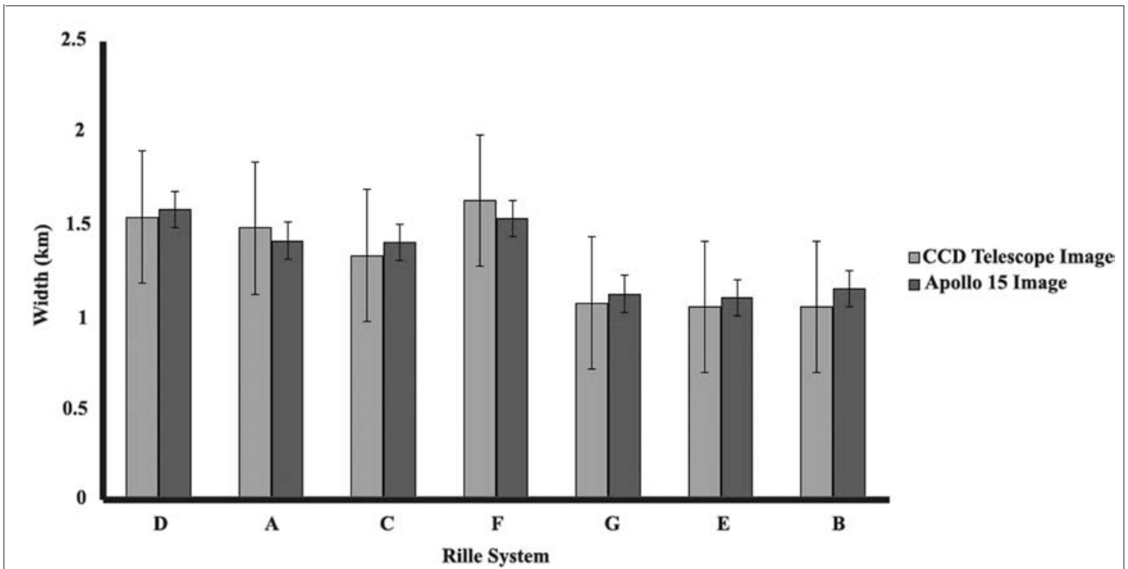

Figure 5: Width of the measured rilles.

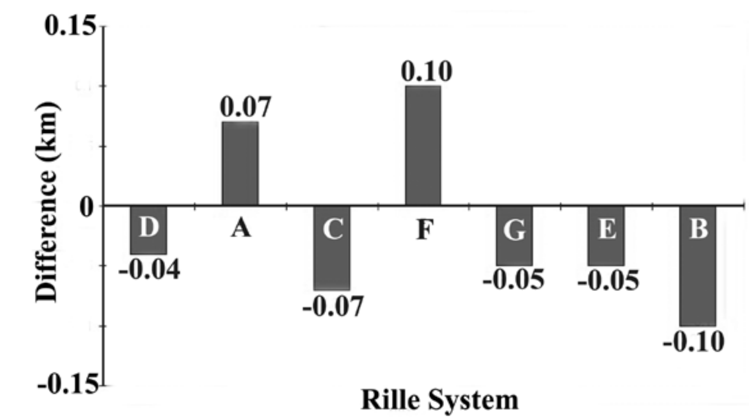

Figure 6 : difference between the average width in the CCD telescopic image and Apollo 15 image.

Appendix

The phenomenon of optical diffraction sets a limit to the resolution and image quality that a telescope can achieve. This limit is the effective area of the Airy disc, which limits how close two such discs can be placed. This absolute limit is called the diffraction limit (refer to the general definition in the astroscopic labs http://www,kucga,de/astro_article_mtf_telescope_resolution.php). This limit depends on the wavelength of the studied light (so that the limit for red light comes much earlier than the limit for blue light) and on the diameter of the telescope's mirror. This means that a telescope with a certain mirror diameter can theoretically resolve up to a certain limit at a certain wavelength. For conventional telescopes on Earth, the diffraction limit is not relevant for telescopes bigger than about 10 cm. Instead, the seeing or blur caused by the atmosphere sets the resolution limit.

Dawes found out by his own observations that:

Dawes's resolution limit [arc sec] = 116 / Aperture Diameter [mm] (for green light).

A more appropriate resolution limit has been proposed by C. Sparrow. He claimed that when the combined signal from two point spread functions (PSF) becomes a flat top the signals can still be separated. When we allow the combined signal to form not a flat top but a slightly-curved shape the distance between the two PSFs is just 1/2 of the radius of the Airy Disk.

Sparrow's resolution limit [arc sec] = 70 / Aperture Diameter [mm] (for green light).

For a telescope 178 mm in diameter (used in this study) the resolution limit is about 0.65 arc sec using the Dawes's formula and about 0.39 arc sec using Sparrow's formula.

The Apollo image shows that the true average width of Rima F is about 1.5 km, which from Earth is about 0.77 arc seconds. Under near ideal conditions a 180 mm aperture would be able to detect this wide of a rille. Shallower rilles and/or an over-processed image could give over-sizing (an artefact of processing caused by enhancing a bright/dark line pair beyond the resolution limit of the optical system).