Crater Chains on the Lunar South Pole

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Introduction

Crater chains, or catenae, are lines of regularly spaced impact craters, relatively the same size and age. They are most commonly formed as a result of a comet or asteroid with low tensile strength being pulled apart by the tidal forces of a larger astronomical body during a close pass to one another during orbit. The comet or asteroid separates into a train of fragments roughly equal in size which then proceed to collide with the surface of the larger body (usually a moon or planet), leaving a distinct trail of same aged craters that radiate out in a straight line from a single original impact site.

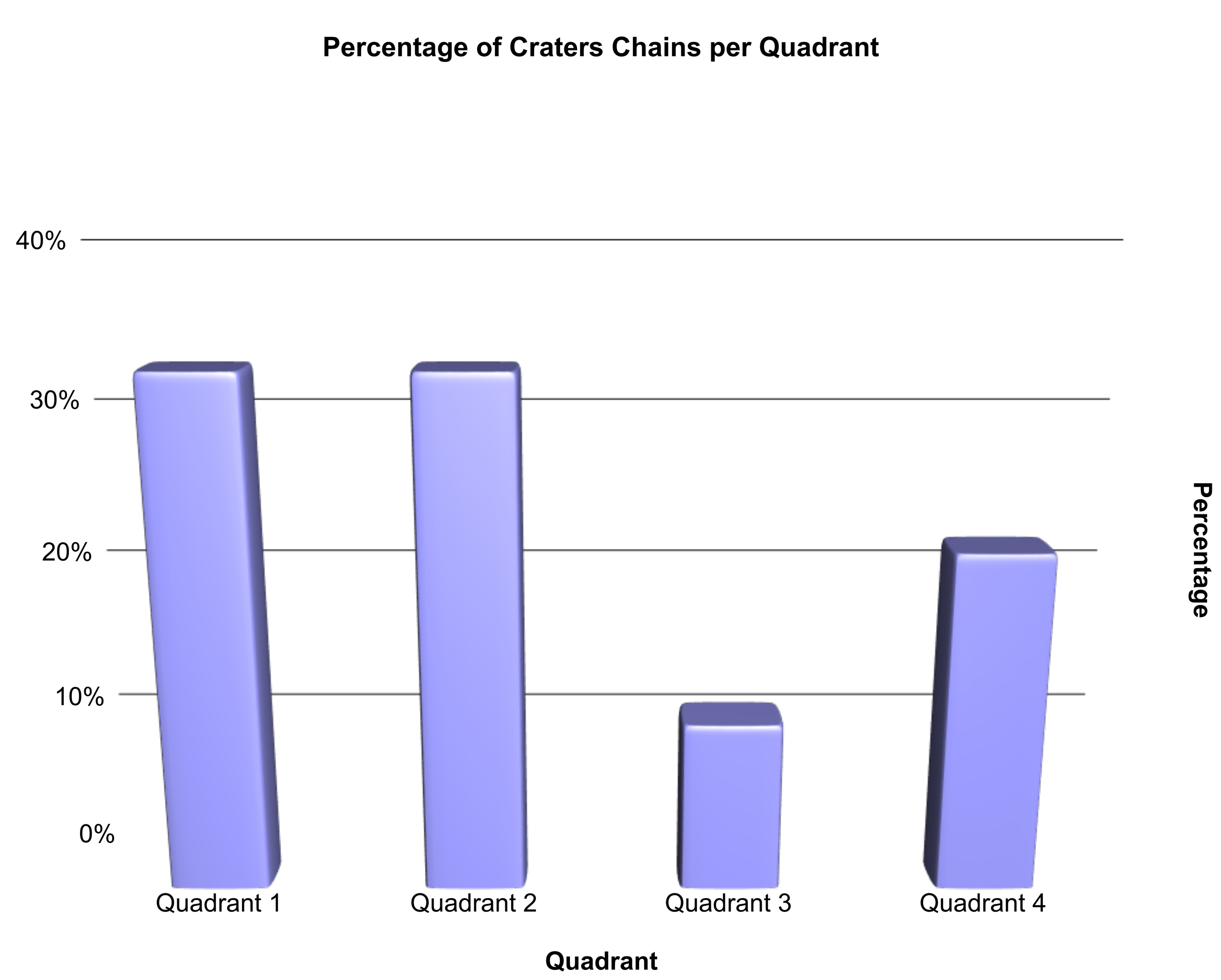
The purpose of this study was to identify catenae on the surface of the lunar south pole by studying and analyzing the mosaic photograph of the lunar south pole from the LROC Wide Angle Camera (WAC). The process was complicated by the immense amount of land area needing to be examined and the plethora of impact craters that cover the lunar surface. In order to mount these obstacles, we developed a method of crater chain recognition through the specifications of certain crater chain standards as seen below.

Crater Chain Criteria

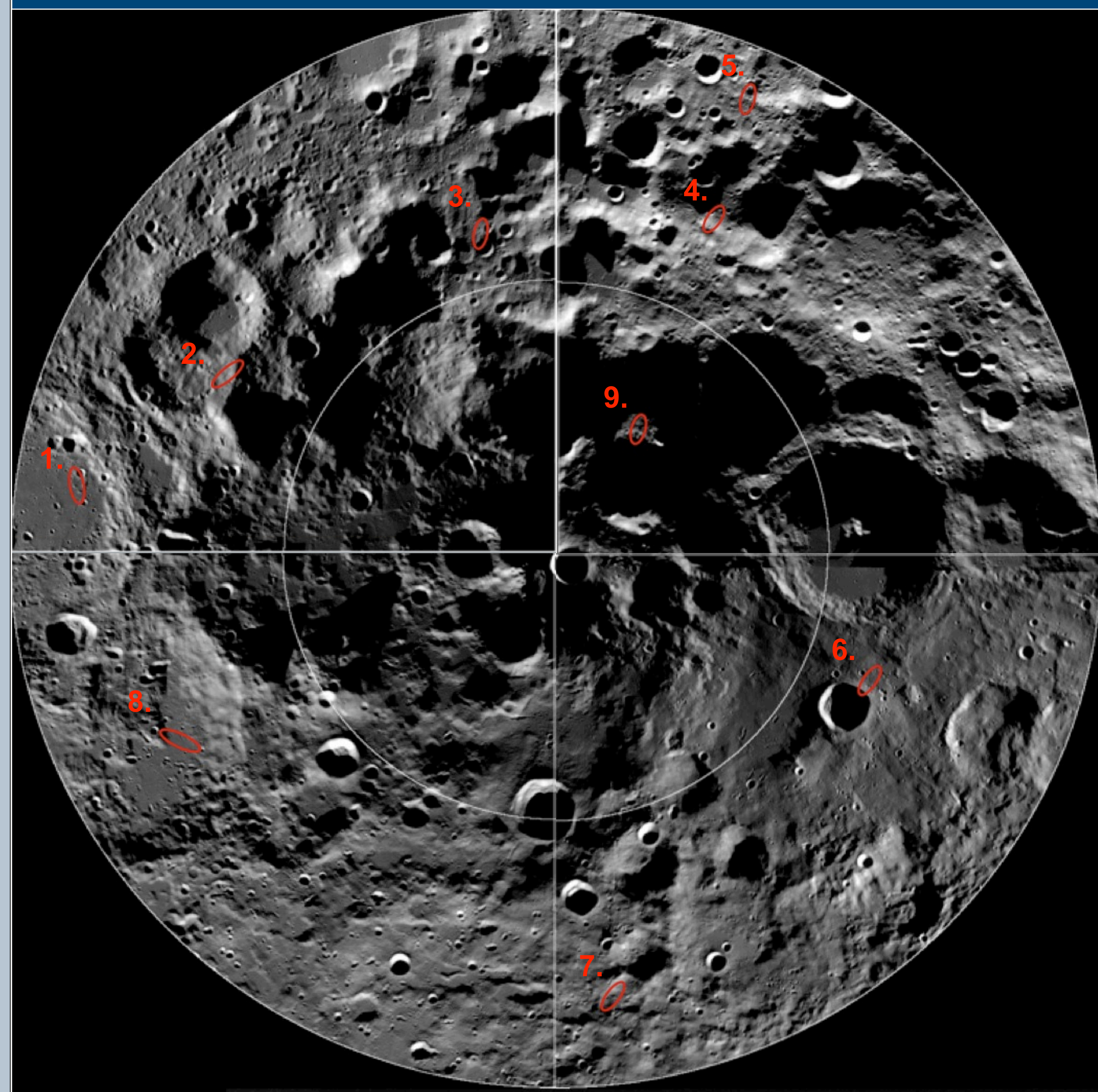
The following criteria was used to determine which crater groups qualified as crater chains:

1. Proximity: the individual craters in crater chains are close together, usually between 10 and 20 km. Craters in a chain often overlap but are never too distant from one another. If an arrangement of craters was significantly far apart, it was determined that it was not in fact a chain.
2. Age: age is a major factor in crater chain determination because craters in a crater chain are all made at the same time. Each possible crater chain was carefully examined for any discrepancies amongst the features of the different craters in the chain. Relative age of the craters was specifically determined based on the amount of regolith covering the craters, any other craters that had been superimposed on the craters in the chains, and the level of visible decay of the craters. If the craters in a chain displayed obvious age differences, they were not considered to be catenae.
3. Size: crater chains are generally small in size because they are the result of asteroids or comets (which are relatively small to begin with) being pulled apart into even smaller pieces. Very large possible chains of craters were ruled out with the reasoning that they were not actually crater chains, but rather only coincidentally linear in pattern because it would be rare for a comet of the size necessary to produce such large craters to be pulled apart by tidal forces.
4. Arrangement: crater chains are remarkably linear or near linear in shape because the fragments from the asteroid or comet all possessed similar velocities and trajectories as they impacted the lunar surface, resulting in a linear pattern to the collision sites. Any irregular arrangements of craters are probably not crater chains.

Distributions of Crater Chains

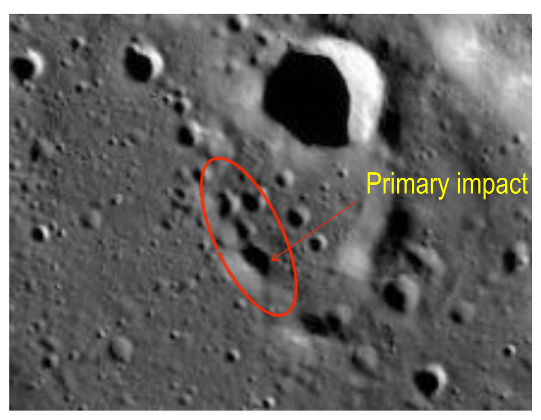


Overview of the Catenae



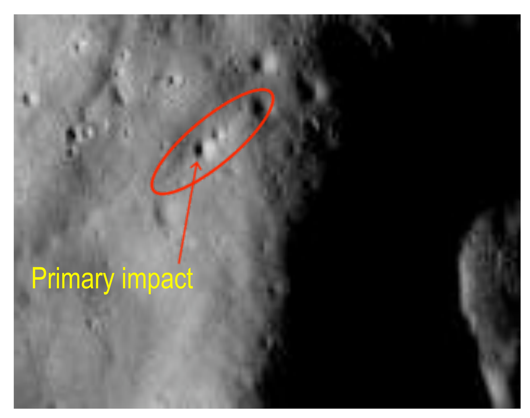
Individual Crater Chain Analysis

1.



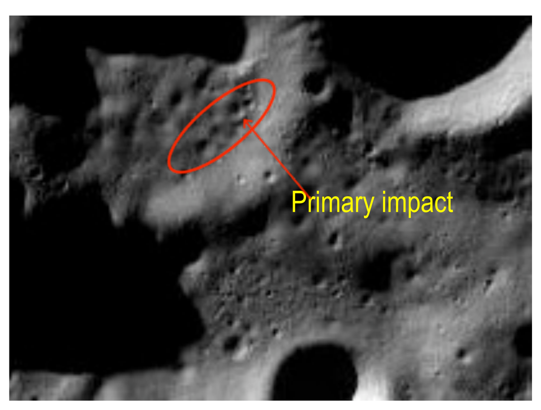
3 craters in the chain

2.



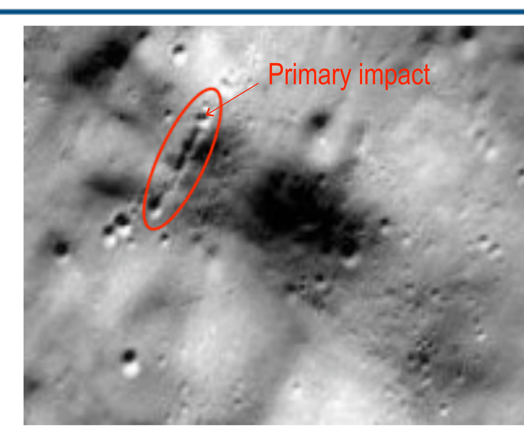
4 craters in the chain

3.



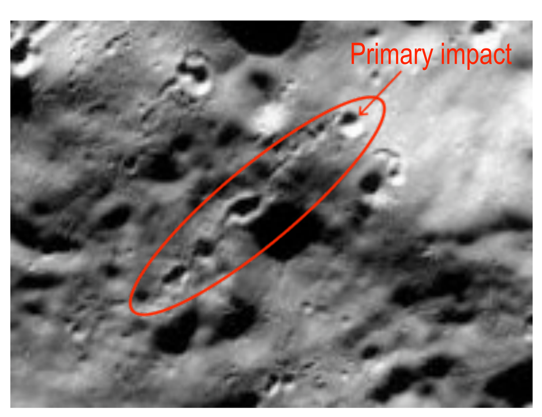
5 craters in the chain

4.



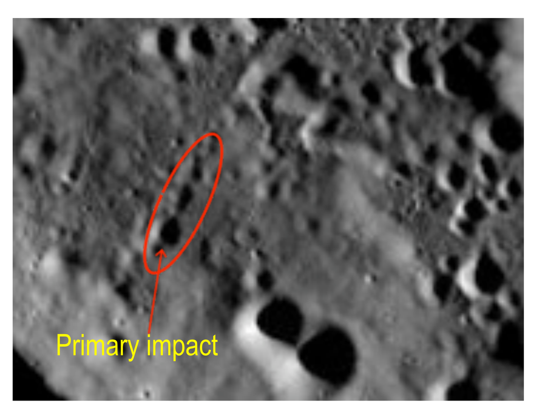
4-5 craters in the chain

5.



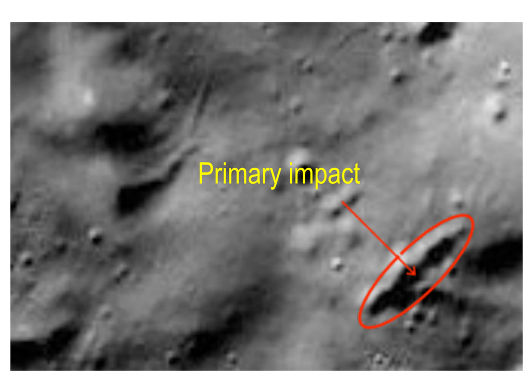
6 craters in the chain

6.



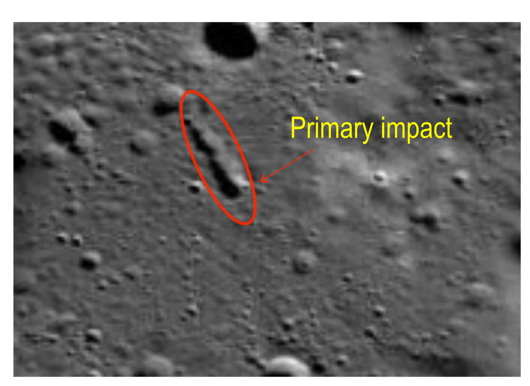
4 craters in the chain

7.



3 craters in the chain

8.



5 craters in the chain

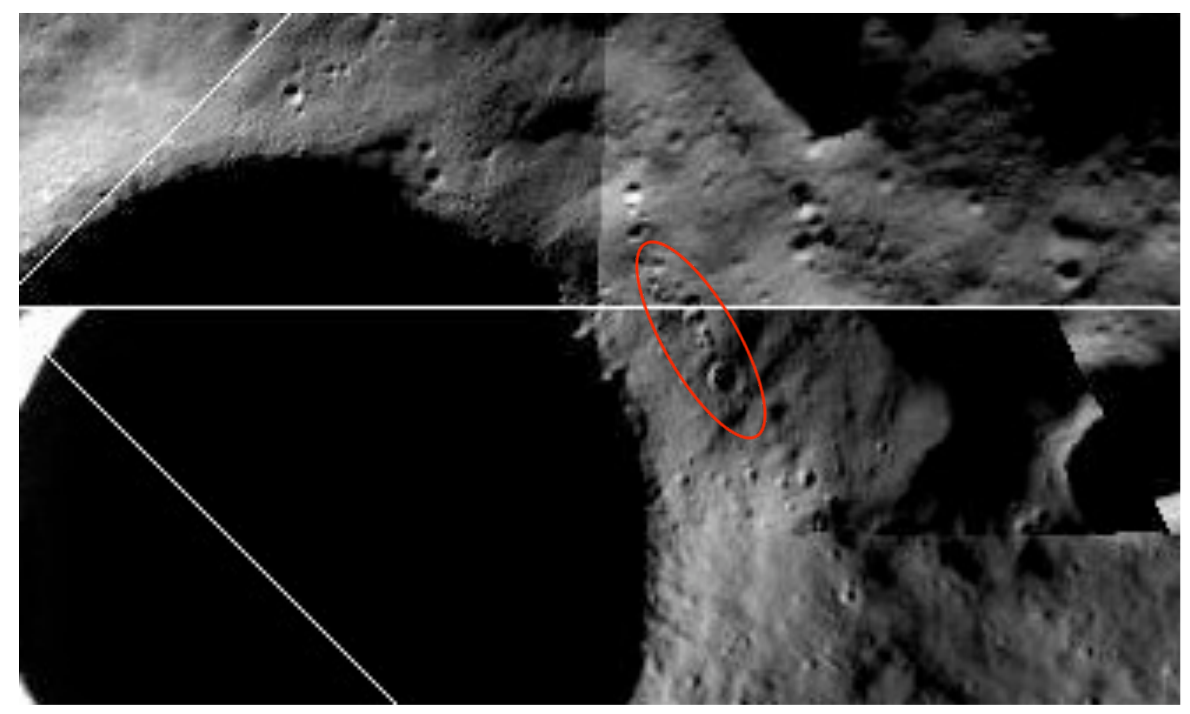
The Importance of Crater Chains

Crater chains are important geographical aspects of the lunar environment for several reasons. Primarily, they are fascinating areas of geological study where scientists can find multiple different geological interests at once. Because crater chains are the result of comet collisions, scientists should be able to find rock and soil samples from multiple different time periods and locations throughout the universe. Such diverse samples can give researchers important insights into the nature of the solar system.

Catenae are also incredibly promising sites for the development of a human lunar base. If, in the future, we decide to create a colony on the lunar surface, catenae possess several natural characteristics that are well suited for human needs and would offer prime locations to establish a base. Crater chains are natural shelters. They are secure crevices in the lunar surface that offer astronauts organic protection from the harsh lunar environment. Similar in shape to lava tubes, crater chains are nestled into the lunar surface and provide shelter from pernicious radiation and other damaging aspects of the moon and outer space. However, unlike lava tubes, crater chains are more secure and do not run the risk of collapsing like some lava tubes do. Crater chains also are rich in regolith from which oxygen can be extracted as breathable air. Furthermore, water ice, possibly delivered by the comets as they impacted onto the lunar surface to form the catenae, may be trapped in the crater walls at high latitudes and would act as an important resource for any civilization. Any water ice can be used not only for biological processes, but also as fuel for space craft or as another source of breathable air. All the possible uses for the water that might be found in lunar catenae would be invaluable to astronauts, as the cost of transporting such resources is astronomical.

Promising Crater Chains

9.



This chain (#9 on the large scale picture) is of particular interest because of it's strategic location close to the center of the pole right at the rim of a large crater. This promising site offers a multitude of different resources for a potential lunar base including long hours of sunlight, a possible water source inside both the large crater and the smaller craters of the chain, and the natural protection provided by the chain itself. This site would also be incredibly interesting from a geological standpoint because of the diverse array of geographic features.

Sources

- Davy Crater Chain: Implications for Tidal Disruptions in the Earth-Moon System by R.W. Wichman and C.A. Wood.
- Can Tidal Disruption of Asteroids Make Crater Chains on the Earth and Moon? by William Bottke, Derek Richardson and Stanley Love.
- Gravitational Aggregates: Evidence and Evolution by D. C. Richardson, Z. M. Leinhardt, H. J. Melosh, W. F. Bottke Jr., and E. Asphaug.
- Crater Chains on Callisto and Ganymede by P. Schenk.

Acknowledgements

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