LUNAR IMPACT CHRONOLOGY: STATUS, ADVANCEMENTS, IMPLICATIONS, AND THINGS TO CONSIDER.

H. Hiesinger[1], C. H. van der Bogert[1], J. B. Plescia[2], M. S. Robinson[3], S. Robbins[4], G. Michael[5], N. Schmedemann[5], B. Ivanov[6], W. Hartmann[7], L. Ostrach[8], J.-P. Williams[9], M. Zanetti[10], E. Speyerer[3], S. Werner[11], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Münster, Germany, Hiesinger@uni-muenster.de; [2]Johns Hopkins University; [3]Arizona State University; [4]Southwest Research Institute; [5]Freie Universität Berlin,; [6]Russian Academy of Sciences; [7]Planetary Science Institute; [8]USGS; [9]UCLA; [10]Western University Ontario; [11]University of Oslo.

Motivation: In 2006, the New Views of the Moon initiative published a seminal book that summarized our understanding of the Moon [1]. Since then, numerous innovative and highly capable space missions visited or are visiting the Moon, acquiring data at unprecedented quality and quantity. These data allow us to see the Moon in completely new ways. One area of research that has experienced significant progress since the first book is cratering chronology. Because an accurate understanding of the lunar chronology is not only important to derive absolute model ages (AMAs) of any lunar surface but is also extrapolated to date surfaces on other planetary bodies, it is well justified to reflect the current status, progress, and implications in a dedicated chapter.

In particular, the new global mosaics generated by the Kaguya SELENE (10 m/pixel) and Lunar Reconnaissance Orbiter Camera (LROC) Wide-Angle Camera (WAC; 100 m/pixel) have provided data that have allowed numerous new studies of lunar stratigraphy and crater size-frequency distribution (CSFD) measurements. The LRO Narrow-Angle Camera (NAC) provides higher resolution images with pixel scales of 0.5 m. These data have allowed comprehensive studies of previously uninvestigated mare on the near and far-sides [2-4], and more detailed studies of regions such as Orientale [5] and Australe [6]. The new data also allow a renewed investigation of the origins of light plains (e.g., [7-9]) and other plains deposits [10].

In addition to the many new geological investigations, LROC NAC resolutions have driven new investigations of the limitations of the CSFD technique in relation to, for example, the minimum tenable count area size [11], appropriate illumination conditions for measurements [12], count area definition – including slope constraints [13]; effects of target properties on crater diameters [14]; and significance of the population of secondary and self-secondary craters [15-17]. Finally, the new data are used to reinvestigate the locations used to calibrate the lunar chronology to improve the robustness/precision of the method [e.g., 18-21]. The current extension of the lunar crater production SFD shape down to ~2 m craters allows valuable interplanetary comparisons, for example with Mars [22].

Chapter Outline: We summarize the current outline for the lunar impact chronology chapter to provide a framework for its ongoing construction. We will heavily crossreference other chapters, including those on magmatic evolution, volcanism, tectonism, impact history, regolith and surface processes, the evolution of the lunar crust, and the interior of the Moon.

This chapter describes our general understanding of the lunar chronology and progress that has been made since the publication of [1]. We provide a historic perspective on CSFD measurements and the development of the lunar chronology. We then discuss the production function (PF) (e.g., origin, shapes, link to chronology) and the chronology function (CF) (e.g., CSFD of landing sites, sample information). Next, we describe method-specific factors that affect CSFDs (e.g., count area size/selection, illumination geometry, image resolution), followed by geology-specific factors (e.g., resurfacing, target properties, secondary craters, self-secondary craters). There will also be a short section on the graphical presentation of CSFDs and the fitting of the data to derive AMAs (e.g., cumulative, differential, Poisson timing analysis, randomness test, and error discussion). After a section on the application of the lunar chronology to date surfaces of other planetary bodies, the main focus of the chapter is to summarize the AMAs of various lunar surface features, including highlands, basins and craters, mare basalts, domes, pyroclastic deposits, Ina and other young volcanic features, light plains, and lunar scarps. This section provides the reader with a comprehensive compilation of AMAs to date as a reference. The final section elaborates on the implications of AMAs for lunar history and evolution, including volcanism, tectonism, the cataclysm, the recent impact rate and the thermal evolution of the interior, crossreferencing other chapters as necessary. The goal of this comprehensive chapter is to offer a valuable resource for people new to the field of dating planetary surfaces, people who are interested in AMAs for a specific region of interest, as well as space agencies, private enterprises, and decision makers.

References: [1] New Views of the Moon, 2006, Rev. Min. Geochem., 60 [2] Morota et al. 2009, Geophys Res. Lett., 36; [3] Paskert et al., 2015, Icarus, 257; [4] Hiesinger et al., 2011, LPSC, 42, 2179; [5] Whitten et al., 2011 JGR, 116; [6] Lawrence et al., 2015, LPSC, 46, 2739; [7] Meyer et al., 2016, Icarus, 273; [8] Thiessen et al., 2012, LPSC, 43, 2060; [9] Hiesinger et al. 2013, LPSC, 44, 2827; [10] Robinson et al., 2016, Icarus, 273; [11] van der Bogert et al., 2015, LPSC, 46, 1742; [12] Ostrach et al., 2011, LPSC, 42, 1202; [13] Meyer et al., 2016, LPSC, 47, 2740; [14] van der Bogert et al., 2017, Icarus, in press; [15] Williams et al., 2014, Icarus, 235; [16] Xiao and Strom, 2012, Icarus, 220; [17] Zanetti et al., 2017, Icarus, in press; [18] Hiesinger et al., 2012, JGR, 117; [19] Robbins, 2014, EPSL, 403; [20] Hiesinger et al., 2015, LPSC, 46, 1834; [21] Iqbal et al., 2017, LPSC, 48, 1258; [22] Hartmann and Daubar, 2017, MAPS, in press.