CRATERS, FIRST SIGNIFICANT FIGURES, AND THE PIVOTAL YEAR OF 4,000,000,000 B.C.E.

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Orientale Basin, Big Pictures, and Lunar Origin. In 1961, G. P. Kuiper set up a globe and projection system that led to our discovery of the Orientale Basin , and recognition that multi-ring systems typify giant impact features.[1] This case exemplifies how "backing away" to look at gross features can allow discoveries that are missed in the usual quest for more detail. The basins raised the question of the largest impacts on the Earth and moon, leading to our work on a possible giant-impact origin of the moon.

Crater Chronometry. The fact that nature stamps out circular features on planets is a geologist's dream We discuss the vigorous literature on crater chronometry in the late 1960s and early 70s, including prediction of an age of ~3.6 Gy for lunar maria before Apollo [2]; prediction of ages of a few hundred My for lava plains on Mars, before recognition of such ages among most Martian meteorites [3], applications to regolith studies and erosion/deposition analysis, etc.

4 Gy ago: A Pivotal Period. To apply crater chronometry techniques to a current issue, we show that cratering data require an "explosive" era of lunar (& planetary?) surface brecciation and destruction around 3.9 to 4.1 Gy ago, regardless of whether the hypothetical "lunar cataclysm" happened or not.

Arriba y Adelante. Issues for future work include: (a) Improved measures of the production rate of 10-100 m primary craters; (b) extension of crater chronometry to the outer solar system; (c) refinement of studies on use of observed crater size distributions to analyze erosion and deposition history (as pioneered by Őpik in 1965-66); and (d) improved understanding of the crucial 1st 600 My of solar system history.

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References: [1] Hartmann, W. K. and G. P. Kuiper 1962. *Comm. Lunar and Planetary Lab.*, **1**, 51-66. [2] Hartmann, W. K. 1965. Icarus **4**, 157-165. [3] Hartmann, W. K. 1973 *J. Geophys. Res*., **78,** 4096-4116.