Graham Ryder was a premier lunar scientist who pioneered many of our most important concepts about the Moon and its evolution. Graham passed away on January 5, 2002, as a result of complications from cancer of the esophagus. He received his B.Sc. from the University of Wales (Swansea) (1970) and his Ph.D. from Michigan State University (1974), specializing in the petrology of igneous rocks. He did postdoctoral study with John Wood’s group at the Smithsonian Astrophysical Observatory, was subsequently employed by Northrup Services Inc. in the Lunar Curatorial Facility at NASA Johnson Space Center, and since 1983 has been a Staff Scientist at the Lunar and Planetary Institute in Houston. Graham’s work was instrumental in several areas of lunar science. He was among the first to recognize evidence in the lunar sample collection that mare volcanism began very early, before the end of the “late heavy bombardment.” Graham’s work with highland rocks and breccias clarified the processes and history of the lunar crust. He produced detailed catalogs and guides to the Apollo lunar sample collections, facilitating the scientific work of the entire sample community. As a result of these efforts, he was intimately familiar with the sample collections and could recite detailed characteristics of various samples and the results of studies associated with each. Graham’s work helped provide the basis for understanding the geological context and petrological characteristics of the samples, which greatly advanced our understanding of the Moon’s evolution. As part of his interest in the geological process of impact, Graham studied terrestrial impact breccias and melts and fully participated in the revolution in terrestrial geology that resulted from study of the Cretaceous-Tertiary impact and subsequent mass extinction. In recent years, Graham became interested in the problem of the early cratering history of the Moon (the so-called “lunar cataclysm”) and undertook to obtain very precise radiometric ages of lunar impact melts to address this problem. This work produced revised estimates for the ages of major lunar impact events, a set of data that must be explained to unravel fully lunar history.

Graham’s quick wit and insightful commentary enlivened many of the scientific meetings he organized, convened, and attended over the course of his career. Discussions that veered off track were soon brought back to point by Graham’s encyclopedic knowledge of the sample collection. Graham thoroughly enjoyed the give and take of serious scientific debate, but he also enjoyed mischievously skewering pomposity, questioning conventional wisdom, and reminding the community of inconvenient facts and constraints on newly proposed “syntheses” and models. Graham is survived by his daughter Abigail, his parents and siblings in England, and hundreds of friends and colleagues around the world. Lunar science has benefited greatly from Graham’s work and our lives have been enriched by his presence. We will miss him.

— Paul D. Spudis

Chairs: B. A. Cohen
L. Dones

Hartmann W. K.* [INVITED, 30 minutes]

*Interplanetary Correlation of Geologic Time Using Cratering Data [#1876]*

Basic principles of age estimation, based on crater populations, are discussed. Using a lunar calibration method, we can estimate ages of all terrestrial planets. The possible cataclysm at 3.9 Gy remains a puzzle.
Cohen B. A.* [INVITED, 15 minutes]
Geochronological and Geochronological Constraints on Early Lunar Bombardment History [#1984]
The major geochronological and geochronological properties of impact melt rocks and breccias, including siderophile-element contamination and unique age distribution, are considered as constraints on the proposed Lunar Cataclysm or Late Heavy Bombardment.

Dones L.* [INVITED, 30 minutes]
Dynamics of Possible Late Heavy Bombardment Impactor Populations [#1662]
The existence of the later lunar basins implies the existence of a massive dynamical reservoir that can store small bodies for some 600–Myr after the Moon formed. We will discuss four recent models for such reservoirs.

Neukum G.*   Ivanov B. A.
Early Lunar Cratering Record [#1263]
The projectile SFD derived from lunar craters demonstrate a good fit to the SFD of asteroids in the modern Main Belt. Whatever the nature of the LHB is, projectiles, which creates the most ancient crater populations, are collisionally evolved.

Chambers J. E.*   Lissauer J. J.
A New Dynamical Model for the Lunar Late Heavy Bombardment [#1093]
We describe a new dynamical model for the late heavy bombardment in which a 5th terrestrial planet existed on an orbit that became unstable after 600 Myr, began crossing the asteroid belt, and enhanced the flux of impactors into the inner Solar System.

James O. B.*
Distinctive Meteoritic Components in Lunar “Cataclysm” Impact-melt Breccias [#1210]
Lunar impact-melt breccias formed during the 3.9-Ga cataclysm contain distinctive and diverse meteoritic components having higher Au/Ir and Ge/Ir, and in many cases higher Ni/Ir, than the meteoritic components in granulitic breccias formed prior to 3.9 Ga. This evidence favors a lunar cataclysm.

Chen J. H.*   Pananastassiou D. A.   Wasserburg G. J.
Re-Os Isotope Systematics in Lunar Soils and Breccias [#1818]
Lunar soil and breccia samples show a narrow range in $^{187}\text{Os}/^{188}\text{Os}$, in the range for H-chondrites and unfractionated irons. All samples show enrichments in $^{187}\text{Re}/^{188}\text{Os}$, possibly reflecting loss of Os, associated with the terminal lunar cataclysm.

Chapman C. R.*   Cohen B. A.   Grinspoon D. H.
What are the Real Constraints on Commencement of the Late Heavy Bombardment? [#1627]
Evidence concerning pre-Nectarian impact rates is subject to strong sampling biases for impact melts, favoring recent melts, perhaps due to preferential surficial deposition. Pending 3-D modelling, a “cataclysm” may or may not have occurred.

Elkins Tanton L. T.*   Hager B. H.   Grove T. L.
Magmatic Effects of the Lunar Late Heavy Bombardment [#1422]
Giant impacts can create large volumes of melt through instantaneous in-situ decompression and later convective melting. We present models for melt creation under the lunar basins, with hypotheses for the formation of the mafic lower crust and the mare basalts.