MOONDB: 50 YEARS OF LUNAR SAMPLE DATA READY FOR THE DATA REVOLUTION. K. Lehnert[1], K. Markey[1], P. Ji[1], Y. Cai[1], K. Hodges[2], C. Mercer[2], J. D. Walker[3], J. Ash[3], C. Evans[4], and R. Zeigler[4], [1]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY; [2]Arizona State University, Tempe, AZ; [3]University of Kansas, Lawrence, KS; [4]NASA Johnson Space Center, Houston, TX.

Introduction: An estimated total of 570 kg of lunar material exists in the worldwide collection of lunar samples. Most of this material was brought to Earth by U.S. astronauts during the Apollo program. From this limited mass of lunar material, tens of thousands of sub-samples have been distributed to the science community for a vast number of studies that measured their chemical, mineralogical, and physical properties to generate fundamental knowledge about the timing and formation of the Earth-Moon system, the origin and evolution of the lunar mantle and crust, and the early evolution of all terrestrial planetary bodies [1, 2, 3, 4]. Research on lunar samples continues worldwide with new analytical measure- ments and new interpretations of existing data. In order to ensure that past, present, and future analytical data of lunar samples remain useful for future science and can be integrated with a rapidly growing and evolving research data infrastructure that supports advanced data mining, the NASA-funded MoonDB project has digitally restored and created a software ecosystem that makes these data not only findable and accessible, but interoperable and reusable.

MoonDB Phase 1: In 2015, NASA's Planetary Data Archiving, Restoration, and Tools program (PDART) funded the development of MoonDB (http://www.moondb.org) as a data system designed to restore and synthesize geochemical and petrological measurements from study of lunar samples (Phase 1). The MoonDB concept and architecture were modeled after PetDB, the widely-used and global synthesis of geochemical and petrological data for terrestrial igneous rocks [5]. Analytical data and metadata that provide a rich context for meaningful searches are stored in a relational database with a schema derived from the Observations Data Model Version 2 (ODM2) [6], a community information model for integrating hetero-geneous observation data. Between 2015 and 2017, major, trace, and isotope data for nearly 2,600 samples from approximately 650 references were compiled into the database. Human and machine-readable interfaces have been built to provide access to the data holdings. MoonDB's web application allows users to browse, search, and retrieve data, and currently allows for queries by mission, landmark, specimen type, sampling technique, analysis method, and analyte. Users can download the data in multiple forms, see data holdings, and access MoonDB APIs.

MoonDB also offers repository services for legacy and new datasets submitted by users to share their data and comply with funders' and publishers' policies for FAIR data (Findable, Accessible, Interoperable, Reusable) [7]. Additionally, MoonDB has created a comprehensive reference library of over 5,000 papers and abstracts related to lunar samples and meteorites that will become accessible and searchable in late 2019.

MoonDB Phase 2: Phase 2 of the MoonDB project began in 2018 and aims to expand MoonDB's utility and scientific impact. Community feedback obtained during MoonDB workshops at the LPSC conferences in 2015 and 2016 showed that MoonDB's utility would increase substantially if it would include geochron- ological data for lunar samples as well as compo- sitional and geochronological data for lunar meteorites. Compilation of these data types is currently underway. Data from approximately 160 lunar meteorite papers and 50 Ar/Ar geochronological papers will be added in 2019 to create a more comprehensive and scientifically valuable dataset. Other goals for the project include incorporating ArAR software to allow users to recalculate older Ar ages using self-consistent para-meter sets, archiving MoonDB data with the Planetary Data System (PDS4), and building an active MoonDB user community. Enhancements to the MoonDB web application are planned that will allow users to directly import compositional data of samples into the MELTS modeling software package; find samples with similar compositions; and to access pages that summarize available data and metadata for samples, methods, missions, and landmarks.

From MoonDB to AstroMat: The MoonDB project has inspired the development of a broader data system, the Astromaterials Data System (AstroMat, http://www.astromat.org) that will serve as a comprehensive data system for analytical data generated by the study of samples from all astromaterial collections curated at the NASA Johnson Space Center (JSC). Currently no equivalent data system exists for these collections. In addition to lunar data from MoonDB, AstroMat will include analytical sample-based and in-situ data from the Antarctic Meteorite, Cosmic Dust, Genesis, Hayabusa, Stardust, and Microparticle Impact collections, and incorporate additional data types such as mineralogical data, physical properties, images, and spectrography. AstroMat will also feature more advanced data search and data visualization tools. AstroMat's scope, architecture, community engagement, and project timeline will be described in a separate presentation at LPSC 2019.

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