

REVISING LUNAR HISTORY WITH IN-SITU DATING OF THE MOON. F. S. Anderson¹, T. J. Whitaker¹, R. Wiesendanger², P. Wurz², S. Beck³, J. Levine⁴, ¹Southwest Research Institute, 1050 Walnut St, Suite 300, Boulder, CO (anderson@boulder.swri.edu), ²Physikalisches Institut, University of Bern, Bern, Switzerland, ³The Aerospace Corporation, Los Angeles, CA, ⁴Department of Physics and Astronomy, Colgate University, New York, USA.

Introduction: The chronology of the inner solar system is built on crater flux models extrapolated from the relationship between lunar crater densities and radiometric dates of well-provenanced lunar samples [e.g., 1, 2]. The modeled flux primarily constrain the era between 3.5 and 4.2 Ga, as well as the very recent past [2]. These results have been extrapolated to Mars, and throughout the solar system [3-8]. However, a comparison of numerous lunar chronology models illustrates differences between the models of up to one billion years for the period between ~2.8 to 3.3 Ga [2]. For the Moon and Mars, this period is geologically rich, including the cessation of abundant volcanism, and, for Mars, the apparent termination of volatile production and formation of hydrated minerals [e.g., 9, 10, 11]. Under the new chronology functions, these processes could have lasted for a billion additional years, undermining models for thermal evolution of the Moon [12]; similarly, Mars would have undergone a longer epoch of voluminous, shield-forming volcanism and associated mantle evolution, as well as a longer era of abundant volatiles and hence potential habitability.

These differences are in part due to different estimates of crater densities observed in Lunar Reconnaissance Orbiter data, and a lack of samples from terrains with N(1) crater densities of ~0.0015 km⁻² to 0.0025 km⁻². Thus, the most straightforward part of the chronology curve to refine is associated with previously unsampled Eratosthenian near-side terrains, such as the Aristarchus basalts. Large lava flows in the Schiaparelli region could be readily targeted for future missions. Similar regions could be identified for Mars, and used as a constraint on models relating cratering rates to the Moon, and hence the lunar chronology.

A Near-Side Lunar Mission: We have developed a mission concept [13-16] to address one billion year uncertainties in the history of the Moon [2] by landing on a large, homogenous lava flow of 2.5-3.5 Ga, obtaining 20 or more Rb-Sr and Pb-Pb radiometric dates, ultimately constraining the age of the surface to well within ±200 Ma (2-σ) [13, 17, 18]. Our lander would use an arm with a gripper and rake to reveal and acquire a sample [16]. This rock would be imaged with both the camera and NIR/IR spectrometer, before having a flat ground onto its face. It would then be re-imaged, and assessed for dating suitability. If the rock is a basalt appropriate for measurement, it is presented to our Chemistry, Organics, and Dating Experiment

(CODEX) for analysis. CODEX uses: a) laser ablation to vaporize a small amount of material from a sample surface, b) resonance ionization spectroscopy to provide selective, efficient ionization of the desired element, and c) mass spectrometry to provide isotopic information. The mass spectrometer is based on a TRL-8 reflectron time-of-flight (RTOF) unit designed and constructed by the University of Bern for the Luna-Resurs lunar mission. We have engaged in a half-decade of international cooperation, culminating in the delivery of a similar RTOF from the Bern group that is presently undergoing tests in our research facility.

CODEX rasters over hundreds of points to create an elemental and isotopic abundance image. These data points are used to produce isochrons, and place every point in context [17-19]. We have previously published Rb-Sr results for the Mars meteorite Zagami, and the Duluth Gabbro, a lunar analog [17, 18], and demonstrated that we can obtain Rb-Sr dates with accuracy better than ±200 Ma (1-σ). We have recently expanded our approach to include Pb-Pb [13], enabling tests of concordance, and with accuracy as good as ±50 Ma on zircons, up to ±90 Ma for difficult, low Pb abundance samples like lunar meteorite MIL 05035 (1-σ). We plan to make at least three, likely 10, and potentially up to 20 measurements of the lava flow, enabling us to obtain dates well-within ±200 Ma at 2-σ.

Conclusion: New radiometric constraints provided by CODEX will be used to reduce the ±1.1 Ga uncertainties in the crater flux models, and provide insight into terrains with N(1) crater densities of ~0.0015 km⁻² to 0.0025 km⁻².

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