Pb-Pb and Rb-Sr DATES FOR ZAGAMI AND NORTHWEST AFRICA 7034 USING CODEX

F. S. Anderson[1], J. Levine[2], and T. J. Whitaker[1], [1]Department of Space Operations, Southwest Research Institute, Boulder, Colorado 80303, USA (anderson@boulder.swri.edu), [2]Department of Physics and Astronomy, Colgate University, Hamilton, New York 13346, USA.

Introduction: Using an instrument called CODEX (Chemistry, Organics, and Dating Experiment) intended for in-situ dating [1-4], we have obtained Pb-Pb dates for Zagami and Northwest Africa (NWA) 7034. We have previously demonstrated young Rb-Sr dates for Zagami [5] consistent with other Rb-Sr estimates [6], however, our new Pb measurements indicate an age of 3600 Ma, consistent with previous anomalously old Pb measurements for the SNC meteorites [e.g., 7]. Proposed explanations for this paradox include terrestrial Pb contamination, that the SNC's are actually ancient and reset in Rb/Sr, or that there are multiple isotopic reservoirs sampled by the impact process. In the future, we plan to use CODEX to test these hypotheses by making measurements on outcrops in-situ on Mars, avoiding terrestrial or impact mixing.

Complementary analyses: In our resonance ionization experiments, atoms ablated from the sample surface by a first laser pulse are excited by subsequent pulses of lasers tuned to electronic transitions in the elements of interest, and are finally ionized from the excited states. Turning the post-ablation lasers off altogether converts our instrument into a laser ablation mass spectrometer, and we have used data collected this mode as an aid in identifying the minerals we analyze [8]. Furthermore, tuning the post-ablation lasers to resonantly excite Pb rather than Rb and Sr allows us to gather geochronological data in the Pb-Pb system, which has the advantage that an age may be determined from isotopes of a single element, so that elemental fractionation in our instrument becomes irrelevant.

Synthesis of ages from multiple isotopic systems: For many planetary specimens, different isotopic systems yield different age estimates [e.g., 9], and each isotopic system provides necessary clues to help interpret the complex geologic history of the specimen. Similar discrepancies between very old Pb-Pb ages and very young ages from other radioisotopic systems have been observed for many Shergottites [e.g., 10], and the proposed interpretations have planetary-scale implications for our understanding of Mars's geologic history. For example, Borg et al. [6] argue that the young Rb-Sr and Sm-Nd ages imply crystallization of Zagami only 166 Ma ago, which implies that Mars has been geologically active for at least 96% of its history, and they believe that the U-Pb system has been disturbed. Disputing this, Bouvier et al. [10] argue that the 4048 Ma Pb-Pb age represents the crystallization of Zagami (and similarly for the other Shergottites), and that the other isotopic systems have been reset by the ejection of the meteorites from Mars. This interpretation obviates the need to for Mars to have remained geologically active for most of its history. Recently, Bellucci et al. [11] proposed an elegant interpretation of their Pb isotopic data for Chassigny by postulating a reservoir of extremely radiogenic Pb, globally distributed on the surface of Mars, perhaps by an ancient impact event. The persistence of such a reservoir is plausible only if Mars has had no tectonic recycling for nearly all of its history. In short, conclusively determining a quantity as fundamental as the global cooling rate of Mars will rely on geochronological data from multiple isotopic systems. To this end, we have also begun experiments to measure Sm and Nd isotopes with our instrument. In the model proposed by Bellucci et al., the "unsupported" radiogenic Pb becomes incorporated into Martian meteorites during their ejection from Mars. Alternatively, in the understanding of Bouvier et al. [10], ejection resets the other isotopic systems. Either way, multi-isotopic in situ dating of rocks on Mars's surface, such as we propose to do, would avoid all of the chronological complications associated with ejection, and therefore offer a much clearer view of Mars's history. With all of its complementary modes of analysis, CODEX can assess the composition, chronology, and concordance of contextualized planetary samples collected in situ.

References: [1] F. S. Anderson et al. *LPSC* 1246, 2 (2017); [2] F. S. Anderson et al. *LPSC* 2957, 2 (2017); [3] S. Beck et al., *LPSC,* 3001, 2 (2017); [4] T. J. Whitaker et al. *LPSC* 2328, 2 (2017); [5] F. S. Anderson et al. *RCMS* 29, 191 (2015); [6] L. E. Borg et al. *GCA* 69, 5819 (2005); [7] A. Bouvier et al. *EPSL* 240, 221 (2005); [8] S. Foster et al. *LPSC* 47, 2070 (2016); [9] D. Papanastassiou et al., *LPSC*. (1976), vol. 7, pp. 2035-2054; [10] A. Bouvier et al. *EPSL* 266, 105 (2008); [11] J. Bellucci et al. *EPSL* 433, 241 (2016).