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CODEX: Assessing the Historical Context of Chemistry and Organics on Mars

F. Scott Anderson (1), Tom Whitaker (1), and Jonathan Levine (2)

(1) Southwest Research Institute, Boulder, United States (anderson@boulder.swri.edu), (2) Colgate University, Hamilton, United States (jlevine@colgate.edu)

The Chemistry, Organics and Dating EXperiment (CODEX) is a laser desorption time-of-flight mass spectrometer designed for use on Mars, which, by varying the type of ionization used, can operate as an elemental detector, an organics detector, and a radiometric dating instrument. CODEX uses three ionization modes: A) laser ablation mass spectrometry (LAMS) to measure chemistry and isotopes, B) two-step laser desorption/ionization mass spectrometry (L2MS) to measure organics, and C) laser desorption resonance ionization mass spectrometry (LDRIMS) to measure rubidium-strontium geochronology. Using these modes sequentially, CODEX interrogates hundreds of locations on the surface of a drill core, each of which are initially cleaned by laser ablation to remove surface contaminants. Using microscopic mapping, CODEX places elemental chemistry observations in spatial and temporal context with organic signatures revealing the complex historical context of chemistry and organics.

The modes of CODEX have been demonstrated on three well-known samples: a) the Boulder Creek Granite (chemistry and dating), b) the carbonaceous chondrite Murchison (organics and chemistry), and c) the Martian meteorite Zagami (dating). The BCG measurements result in a high-sensitivity chemistry measurements, with isotope ratio precision exceeding $\pm$0.35%; using dating mode, we derived an average age of 1727$\pm$62 Ma, as compared to a TIMS age of 1700$\pm$40 Ma. The measurements of the Murchison meteorite revealed hundreds of organic compounds consistent with an abiotic carbonaceous chondrite, and elemental abundances that match previous work. Finally, Zagami is a Martian meteorite with a Rb-Sr age of 166$\pm$6 Ma. Our measurements result in an age of 170$\pm$105 Ma, consistent with the previously published dates, and an accuracy exceeding NASA requirements ($\pm$200 Ma).