Development of the Potassium-Argon Laser Experiment (KArLE) instrument for in situ geochronology measurements

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Motivation
- Absolute dating of planetary samples is an essential tool to establish the chronology of geological events, including crystallization history, magmatic evolution, and alteration
- Other in situ instruments to measure rock ages have been proposed, but none have reached TRL 6, because isotopic measurements with sufficient resolution are challenging
- KArLE is a new development effort under the NASA Planetary Instrument Definition and Development Program (PIDDP) begun in late 2011
- The aim of KArLE is to determining the age of several kinds of samples to ±100 Myr, sufficient to address a wide range of problems in planetary science
- Additional benefits derive from the fact that each KArLE component achieves analyses common to most planetary surface missions, such as elemental analysis and imaging

Laser Induced Breakdown Spectroscopy (LIBS)
- Measurement goal: ≤10% relative K abundance

KArLE Concept of Operations
- Unprepared sample (~2 cm) introduced by the spacecraft
- Infrared laser ablates a pit in the rock
- K measured using laser-induced breakdown spectroscopy (LIBS)
- Liberated Ar measured using quadrupole mass spectrometry (QMS)
- K and Ar related by volume of the ablated pit using optical measurement (OM)
- Testbed verification used two samples: rhyolite and microcline

Quadrupole mass spectrometry (QMS)
- Measurement goal: ≤2% absolute 40Ar abundance

Optical measurement
- Measurement Goal: 2% in ablation volume
- Volume x rock density yields the ablated sample mass - necessary to relate absolute Ar and relative K measurements
- Evaluating existing optical methods for accuracy and precision before integrating chosen optical method into KArLE

Development Path
- Task 1: Construct vacuum chamber and integrate LIBS and QMS
- Task 2: Conduct end-to-end tests on analog samples
- Task 3: Verify optical requirements and integrate into operations
- Task 4: Integrate SAM/ChemCam spares (if available)
- Task 5: Produce candidate flight design and requirements for PIDDP step 2

**Ar abundance in microcline and rhyolite test samples. The mass spectrometer magnetic field was set to the 40Ar peak position and run in continuous measurement mode during the LIBS measurements. 40Ar buildup from background is small compared to the amount released from the sample. The microcline measurement is the total release from 200 laser shots and the rhyolite from 370 laser shots.**