In-situ Geochronology on the Mars 2020 Rover with KArLE (The Potassium-Argon Laser Experiment) 

Why KArLE?
A successful Mars exploration program has revealed chapters of Mars history, but in this book, the pages are ripped out of the binding and scattered across the surface. An examination of each page reveals interesting information, but there is no way to read the book in its logical order. Geochronology is the tool that puts page numbers onto the individual pages, and allows the book of Martian history to be read in its proper order. The KArLE experiment performs the first dedicated in situ geochronology investigation on Mars, bringing clarity to Mars 2020 samples and context to its landing site.

Science Goals and Objectives
The Potassium (K) - Argon (Ar) Laser Experiment (KArLE) addresses several high-priority goals of the NASA Planetary Science Decadal Survey and Mars Exploration Program Analysis Group. Augmenting the anticipated suite of Mars 2020 science instruments, the KArLE science goals directly map to key Mars 2020 mission objectives. The proposed investigation goals are:
1. Determine the age of lithologic units investigated by the Mars 2020 mission to understand when they formed or subsequently altered on the Martian surface and how long they may have been energy sources for biological activity.
2. Add context to the geologic and biologic environment investigated by the Mars 2020 mission by using the age of local lithologic units to place them in a larger context of geologic, atmospheric, and climate history.
3. Use age information to help scientists select well-documented samples to be cached for future return.

Investigation Overview
The KArLE experiment centers on a low-cost, mechanically simple chamber, and uses separate supporting instruments that are part of the anticipated Mars 2020 payload to make its analysis:
- Sample introduction via the coring/caching system
- Elemental analysis via Laser-Induced Breakdown Spectroscopy (LIBS)
- Noble-gas analysis via mass spectrometry (MS)
- Volume determination via optical imaging

The KArLE experiment is very flexible in its implementation and can be accomplished using any combination of these components, regardless of their specific provider.

KArLE analysis methods have been developed, tested, and validated by three independent laboratories over 10+ person-years (NASA, University of Tokyo, University of Paris-Sud).

1. LASER INDUCED BREAKDOWN SPECTROSCOPY (LIBS)
   - LIBS spectra are collected with every laser pulse and averaged over multiple shots. Spectra are corrected for background, normalized to total radiances, and continuum subtracted. K abundance is determined by peak area comparison with standards.

2. MASS SPECTROMETRY (MS)
   - Quantitative gas abundances can be measured by different kinds of mass spectrometers. Ar levels in Martian samples are generally sufficient to measure against total gas pressures in the range of 10^-5 Torr. The number of shots required is determined by the Ar abundance, a function of both K abundance and age (older samples require fewer shots).

3. DENSITY (ρ) AND VOLUME (V)
   - K and Ar abundances are related by sample mass. KArLE calculates mass using sample density based on elemental composition and volume determined by optical imaging, which is accurate to within 10% (see French et al., this conference).

4. USING MEASUREMENT DATA TO DETERMINE AGE (T)
   - When a rock forms, different minerals have different parent abundances. As the rock ages, more and more daughter forms and the parent is used up. Measuring this ratio allows for dating.