1. Background

- Beautiful stratigraphy observed by Curiosity on Mars. Nobody knows exactly when these layers were formed. Knowing these absolute ages is important to understand the processes that emplaced these deposits.

2. In situ K–Ar dating

- Schematics of KARLE measurements. Spot-by-spot analyses yield the isochron age of target rocks, enhancing the reliability and accuracy of the K–Ar age measurement.

3. KARLE breadboards

- KAILE Sample Handling System (SHS). The SHS must be capable of ingesting a sample, achieving a vacuum seal, and enabling the measurements to be performed on the enclosed sample. A SAM-like elevator actuator seals the chamber. Samples are introduced into and ejected from the chamber by a spoon-like manipulator.

4. KARLE flight concepts (examples)

- KAILE enables various configurations, because
  - KAILE is a panther-vided instrument suite, agnostic to specific analysis providers
  - KAILE allows for flexible implementation with multiple sample delivery systems (e.g., core, pebble, and slab)
  - KAILE-specific hardware is mechanically simple sample handling system (SHS), which provides vacuum sealing and laser pits observation.

- Curiosity-like configuration. The mast mounted LIBS measures the sample in the KAILE chamber. The chamber could be mounted on the deck or inside the rover body. The gas processing system and the mass spectrometer is stored in the rover body.

- Point design for candidate KAILE flight configuration.

5. Results of LIBS experiments

- Detection limit of K₂O was 88 ppm.
- Measurement error was ≈20% when K₂O ≥2400 ppm.
- For 30 mJ, normalizing with K (within) gave the best results.
- For 15 mJ, normalizing with K (within) gave the best results.
- With a 30–mJ laser, K–Ar age can be measured with an error of 8% for a 4 Ga rock containing 3000 ppm K₂O.

6. Obtained Isochrons

- K–Ar isochron for the hornblende-biotite gneiss. The data points follow one regression line well, suggesting the viability of isochron measurements with the LIBS–MS approach. The slope and intercept yielded a K–Ar age of 750 ± 190 Ma and an initial 40Ar/39Ar ratio of 440 ± 280, respectively.
- ▶40Ar–K plot for a hornblende-biotite gneiss and (b) pyroxene gneiss samples. The “isochron” slopes agree with the K–Ar isochron determined for biotite separates with conventional methods.

7. Performance of K–Ar dating

- Compiled K–Ar dating results published from multiple labs. Results from multiple laboratories yield whole-rock ages within error of accepted ages and precision close to theoretical.
  - TRL 4 (validation in the laboratory)

8. Work in progress

- Using the laboratory breadboard to measure Mars and Moon analog materials
- Characterizing and optimizing the performance of the components
- Pursuing funding for construction and test of the flight concepts

References

[Cho et al., 2016a, PSS, Cho et al., 2016b, PSS, Cho et al., 2014, GGR, Devismes et al., 2016, GGR]

[Cho+ 2017, submitted to Appl Spectroscopy]