In-situ K-Ar dating based on UV-Laser ablation coupled with a LIBS-QMS system development, calibration and application

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Principle

Absolute age determination is necessary to check and calibrate the relative Martian chronology presently available from meteoritic samples. This is even observed for relatively young unknowns, mineralogy, and low K samples from Viluy basalts, which are at the limit of detection of the instruments.$^1$

Reference samples

Instrument calibration, and checking measurements reliability for Martian analyses, requires terrestrial analogues.

Application

Several air pipette analyses were conducted and highlighted the non-linear trend of the QMS instrument in the range 0.2 to 3010^-1A, corresponding to a range from 9.710^6 to 1.710^7 atoms of 40Ar.

Features and Calibration

Schematic diagram of the experimental setup

UV Laser

Features and Calibration

Ocean Optics HR2000+ / gate: 385-835 nm / resolution: 0.23 nm

Univariate analysis was selected to define a correlation between the LIBS signal and a known concentration using calibration curves based on standards analyses (glasses and reference samples).

The non-linear trend can be explained by self-absorption, the decreasing plasma luminosity and/or matrix effects.$^4$

Limits of detection and quantification

LOD: 0.14%  LOQ: 0.05%

LOD: 0.52%  LOQ: 0.19%

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Several analyses of reference plagioclases allowed us to define the relation between the ablation time and the ablated mass.

Indeed, the relation is obtained by comparison between QMS signal and the known content of 40Ar atoms per gram of the reference.

B.A. Cohen’s team develops a device based on the same principle, KARLE$^3$, at NASA GSFC

Perspectives

DALI project

The agency’s Development and Advancement of Lunar Instrumentation, or DALI program recently awarded funding to mature spacecraft-based instruments for use in future lander missions.

Knowing the precise ages obtained through potassium-argon dating would help scientists understand the Moon’s history, its formation, the effects of bombardment, and by extension, the history of the solar system. KAR.L.E is an especially good match to the DALI call because all of the necessary components have been proven on flight missions.

As part of the DALI project, we need to miniaturise KAR.L.E and calibrate the instruments for the moon.

PLS method

The intensity of each elemental peak is not a simple function of elemental abundance. Furthermore, LIBS data is sensitive to the composition of the sample. PLS method helps understand the bulk composition of the sample and refine the K calibration curve better than univariate analysis.