THEIA – Thermal History Exploration Instrument for Artemis

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1. OVERVIEW

- THEIA enables in-situ thermoluminescence (TL) measurements to determine the lunar thermal and radiation environment
- Relevant for scientific exploration and in situ resource utilization (Fig. 1).
  - Surface temperature history
  - Subsurface thermal profiles
  - Timing of
    - boulder tracks/movement
    - landslide events
    - dust settlement
  - Differentiate petrology / lithologies
  - Subsurface radiation profiles and radiation shielding properties of lunar regolith
- Suitable for cold trap prospecting in support of lunar exploration, surface operations, and resource prospecting.
- THEIA can provide such information over the past several 10 My in real-time when deployed onto the lunar surface [1-3]
- Payload for
  - Ground-truth missions
  - Integrated into exploration rovers
  - Part of mobile science platform used during extra-vehicular activities

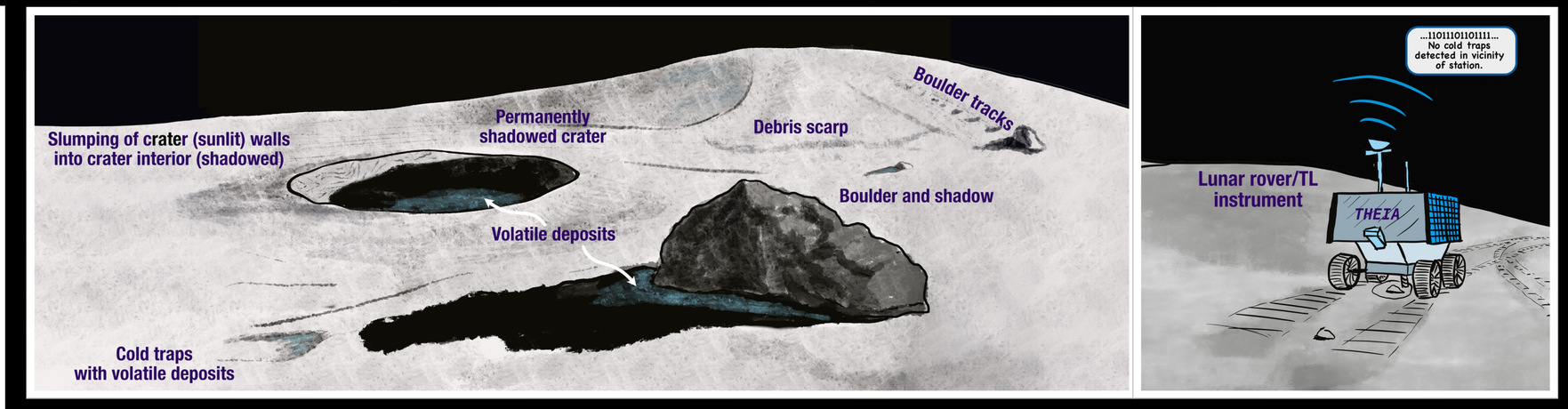

Figure 1: (left) Examples of scientific exploration and ISRU capabilities of THEIA integrated into an exploration rover (right)

2. DEVELOPMENT GOAL

Develop a flight-scale prototype instrument for in-situ TL measurements on the lunar surface. Raise TRL level from 3 to 4.

3. PROTOTYPE HARDWARE

I. Heating module

Watlow Ultramic 12x12 mm resistance heater up to 800 K

II. Light Detection module

Hamamatsu H7828 photomultiplier tube, amplifier, digitizer

III. Irradiation (x-ray) module

Moxtek Magnum x-ray tube with 0.1 mA beam current

IV. Central processing unit

Raspberry Pi 4 to operate modules, data collection

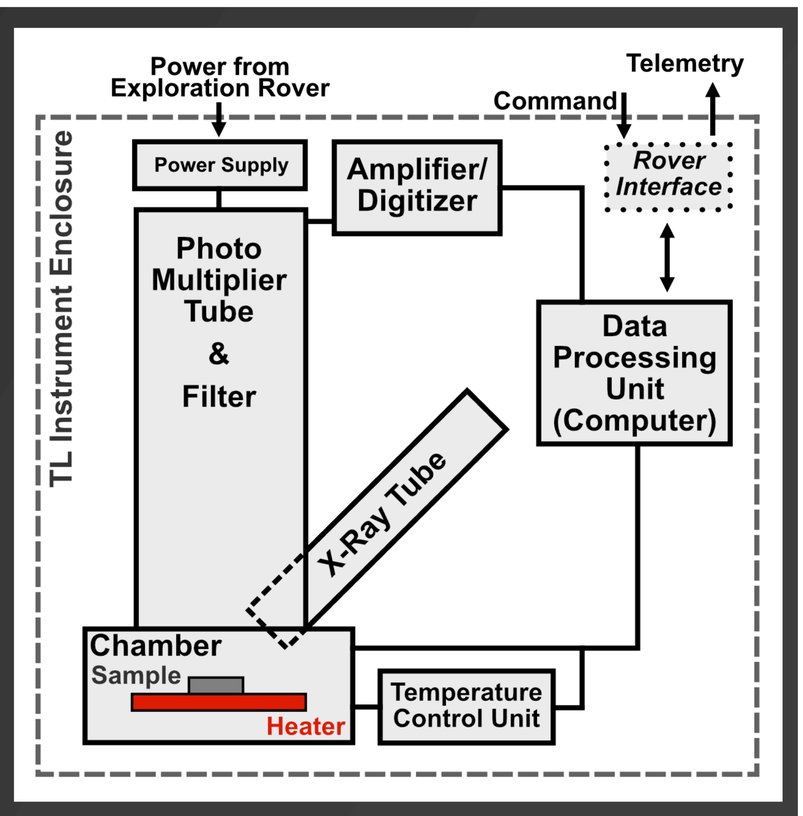

Figure 2: Block diagram of flight-scale TL instrument prototype as part of a rover instrument suite.

4. Operation Mode

- 4 mg sample delivered into the heating module
- Sample heated from ambient to ~800 K linearly
- Light detection module measures emitted light during heating
- X-ray source provides know dose rate for TL calibration purposes and to constrain the thermal and radiation history of the sample
- Peak power consumption of the instrument is 35 W.
- Low bandwidth: ASCII data files of one measurement is 40 kb uncompressed.
- Prototype instrument weight is ~2.5 kg

5. Status and Future Directions

- Instrument assembly underway
- Data validation by external TL measurements
- Laser-based instrument concept (THEIA2) in development
- Eliminates the need of sampling mechanism
- Can be mounted on rover side or underneath, or attached to a robotic arm

6. Acknowledgments

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7. Cited Literature

[1] Sehlke & Sears (2021) NASA ESF & ELS Abstract, [2] Sehlke, Sears and the ANGSA Science Team (2022) 53rd LPSC Abstract #1267. [3] Sehlke & Sears (2020) AGU Fall Meeting Abstract V013-0006.