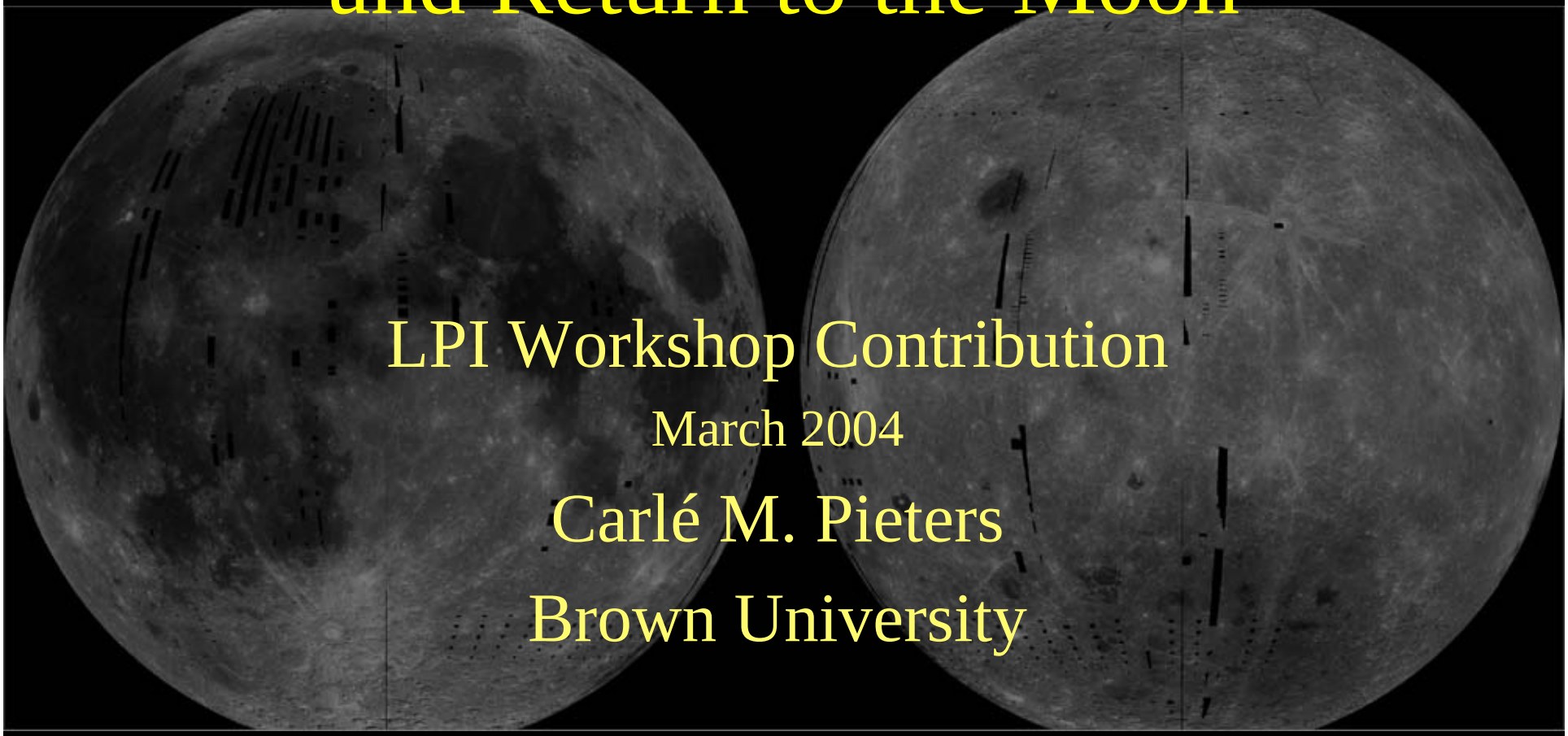
Lunar Exploration and Return to the Moon



LPI Workshop Contribution

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Topics

- Assumptions and initial recommendations
- Brief overview of resource knowledge and remote sensing data
- Summary of most recent NRC exploration strategy recommendations
- Thoughts and suggestions relevant to the new Exploration Initiative

Assumptions

- NASA restructuring involves a long term commitment to exploration.
  - Near term goal involves the Moon and using it as a springboard to other parts of the solar system.
  - Human exploration of Mars is an integral part of NASA's vision.
  - Resource development and utilization is key to success.
- The lunar component will begin with a lander and an orbiter (both of which may be part of an integrated series).
- The immediate issue is to recommend optimum use of these initial lunar missions.

Assumptions

Orbiter(s)

- Focus on assessing the global, regional, and local properties of the Moon that relate to long-term exploration goals.
- Measurement priorities* include high resolution data for:
  - Global gravity
  - Global positioning (geodesy)
  - Hyperspectral resource mapping
  - Targeted imagery
  - High resolution topography

*to be discussed

Lander(s)

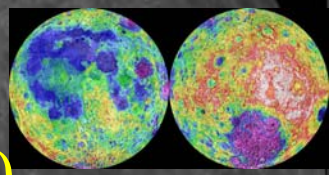
- Focus on character of the in-situ environment and operational requirements on the Moon.
- Target landing sites for specific* goals:
  - Polar resource (particularly H_2O) and environment assessment.
  - Soil beneficiation
  - Solar power
  - Etc.

Initial Recommendations

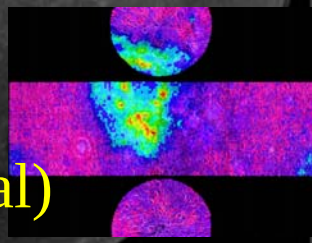
1. To achieve maximum return, implementation of the first orbiter and lander should be coordinated in order to meet goals that require two spacecraft (e.g. gravity, communication relay).
2. Since modern remote sensing instruments are high data-rate, and “real-time” operations with the lander is desired, the orbiter should be capable of high bandwidth communication.

Current Best Knowledge of Resource Character and Distribution

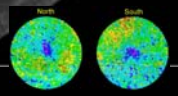
- Apollo & Luna samples [1969 - 1976]
  - Detailed baseline, but from limited nearside area

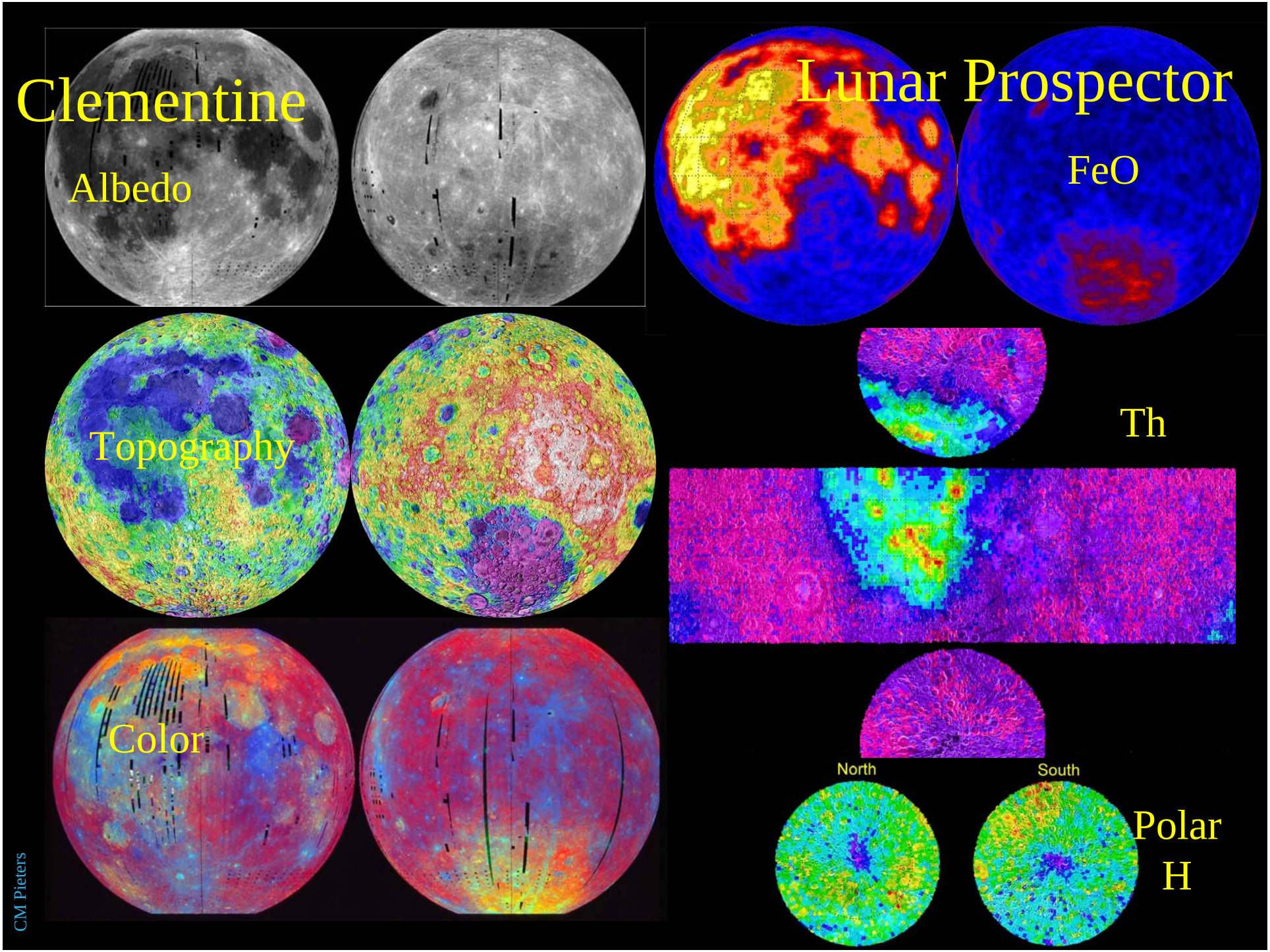


- Clementine [1994]
  - Global topography (~30 km horizontal; 50 m height)
  - Global 5-band color (~500 m spatial; soil maturity, rock type)



- Lunar Prospector [1998]
  - Distribution of Fe, Ti, radiogenic Th (~100 km spatial)
  - Concentration of H (or H_2O) at poles




Clementine
Albedo
Lunar Prospector
FeO
Topography
Th
Color
North
South
Polar
H
CM Pieters

NRC 2003 Integrated Exploration Strategy:

Priority recommendations for Lunar Discovery-class missions *relevant to the new Exploration Objectives*

- Geophysical network science
- Youngest lunar basalts (sample return)
- *Polar volatiles*
- *High resolution topography*
- *Hyperspectral mineral mapping*
- Impact chronology (sample return)
- Major element composition mapping
- *High resolution stereo imaging*
- *Geological site characterization*

Specific Thoughts and Perspectives in the Context of the Exploration Initiative

Lander

- To avoid ambiguity, the character of polar volatiles is best addressed with in-situ experiments.
- Identifying the nature of this potential resource should have highest priority for the first lander.
- Subsequent landers should target diverse areas of interest for specific tasks.

Orbiter

- Lunar remote sensing data needs to be brought into the 21st century.
- Any comparison of the quality and scope of Clementine and Lunar Prospector data to the extensive remote sensing data from MGS, Odyssey, Mars Express, and MRO highlights this lunar need.

Specific Recommendations for Lunar Orbital Measurements

- Global gravity
  - Important for low altitude and long lived spacecraft. Farside gravity needs dual spacecraft for direct link (hence recommendation #1).
- Global positioning (geodesy)
  - Targeting on the nearside is pretty good, but accuracy at the poles and farside is poor.
- Hyperspectral resource mapping
  - High spatial resolution measurement of composition is needed to assess diversity/homogeneity character of the surface. High spectral resolution spectroscopy (0.35 - 2.6 µm) is the most mature approach.
- Targeted imagery
  - The extremely limited high resolution lunar imagery was obtained using Apollo era near side (film) cameras.
- High resolution topography
  - Clementine topography is simply inadequate for long-term needs.