Advantages of a Lunar Cryogenic Astronomical Observatory

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ABSTRACT

- **ESA and collaborating agencies are preparing to establish a Moon Village at a south polar site. Robotic precursor missions will include resource prospecting in permanently shadowed cold traps. The environment there is favorable for infrared and millimeter-wave astronomy. In this paper we examine the evolutionary development of a cryogenic observatory, beginning with small telescopes robotically installed and operated in conjunction with prospecting precursor missions, and continuing into later phases supported from the Moon Village. Relay communications into and out of the cold traps may be shared or else provided by dedicated links. Candidate locations can be selected with the help of data from the Lunar Reconnaissance Orbiter. The first telescope will be primarily a proof-of-concept demonstrator but it can have scientific and applications uses too, supplementing other space-based survey instruments observing astrophysical objects and potentially hazardous asteroids and comets. A south polar site sees only half or the sky but that half includes the galactic center and many other interesting targets. The telescopes can stare at any object for as long as desired, opening the prospect of gathering spectroscopic data on exoplanet atmospheres and cool stars. [Lisa please add more science discussion.] Preliminary design of the first telescope might be funded under a NASA call for lunar science payload concepts. An important additional product can be educational and outreach uses of the observatory, especially for the benefit of people in the developing world who can do southern hemisphere follow-up observations.**

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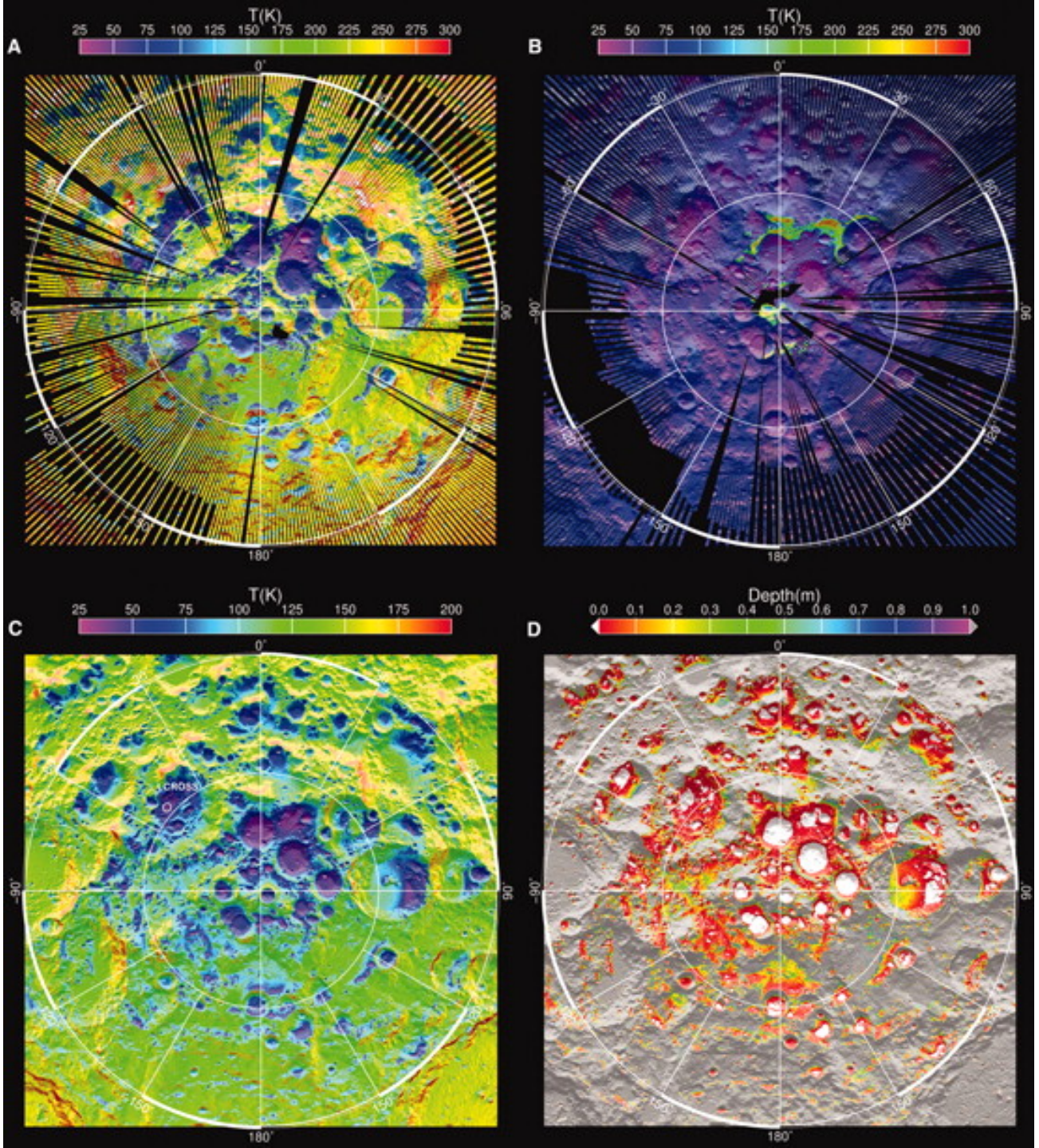
Beneficial Polar Environments

- Ambient temperatures in permanent shade may be as low as 40 K
- Prospecting for frozen volatiles will require sending robots in with drills
- Relay communications will probably be provided
- Initial proof-of-concept telescope payloads can pigygyback on prospecting missions

First Scientific and Other Goals

- Site views half of sky, but that includes the galactic center and many other interesting objects
- Telescopes can stare at any object for as long as desired
- Observations can complement those of other space observatories
- Infrared detection and characterization of hazardous objects can be among objectives


A
T(K)
25 50 75 100 125 150 175 200 225 250 275 300
B
T(K)
25 50 75 100 125 150 175 200 225 250 275 300
C
T(K)
25 50 75 100 125 150 175 200
CROSS
D
Depth(m)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

(A) Diviner-measured daytime bolometric brightness temperatures acquired between 11.4 and 13.6 hours local time (5). (B) Diviner-measured nighttime bolometric brightness temperatures acquired between 21.41 and 1.66 hours local time (5). (C) Model-calculated annual average near-surface temperatures and the location of the LCROSS impact in Cabeus Crater. (D) Model-calculated depths at which water ice would be lost to sublimation at a rate of less than 1 kg m−2 per billion years. The white regions define the locations where water ice can currently be cold trapped on the surface, the colored regions define the upper surface of the lunar ice permafrost boundary, and the gray regions define locations where subsurface temperatures are too warm to permit the cold-trapping of water ice within 1 m of the surface. [Ref. 1]

Conclusions and Recommendations

- South polar cold-trap resource prospecting is planned in several lunar programs
- This presents an opportunity to begin development of a cryogenic infrared and millimeter-wave astronomical observatory
- Funding may be available from several sources, including a NASA call for robotic lunar scientific payloads (Ref. 2)
- Sudies of goals and implementation may begin at low cost

References

- 1. Paige, D.A. et al., (2010), Diviner Lunar Radiometer Observations of Cold Traps in the Moon's South Polar Region

- 2. https://www.nasa.gov/feature/nasa-seeks-additional-information-on-small-lunar-surface-payloads