Lunar Base Research Data

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This is a collection of research material, formulas and ideas for designing a small lunar base

LACK OF EXPOSED ICE INSIDE LUNAR SOUTH POLE SHACKLETON CRATER

This paper explores the Shackleton crater on the lunar south pole for signs of water. “whether or not an amount of concentrated hydrogen on the lunar poles (1) forms water-ice is both a scientifically intriguing issue and a potentially important research subject in order for humans to settle on the Moon and travel further into space. Possible reservoirs of hydrogen on nie lunar poles are permanently shadowed areas (PSAs), which receive no direct sunlight and are extremely cold (2,3). Because the present rotation inclination of the Moon is nearly zero (1.5? from normal to the ecliptic plane), topographic lows on the lunar poles become PSAs. Shackleton Crater, which lies at the lunar south pole, has therefore been considered as a possible water-ice reservoir in its PSA. Bistatic radar observations made by the Clementine probe (4,5)” from the opening paragraph. [18]

HYBRID LIFE SUPPORT SYSTEMS WITH INTEGRATED FUEL CELLS AND PHOTOBIOREACTORS FOR A LUNAR BASE

This paper has many tables and chart for human needs as well as air scrubbing with algae, and electical needs, “Table 3 Minimum and expanded mass inputs and outputs of human needs” on page 171. [19]

AGE MAKES MOON CRATER ATTRACTIVE SITE FOR LUNAR BASE

Nature online article describing the Shackelton crater as a prime canidate for base with rims of crater year round sunlight. “

A piece of prime real estate on the Moon is much older than previously thought, which means theres been more time for water ice to have collected there. The conclusion, based on analysis of data from the SMART-1 mission, makes the crater a very attractive site for a lunar colony, according to scientists behind the study. moonShackleton crater may be blessed with ice deposits in its darkened corners.NASA/JPL/USGS

Shackleton crater is 20 kilometres across and sits near the Moons south pole. It is being eyed as a site for a lunar base because its bottom is permanently shadowed a prerequisite for storing ice, if it exists there. Conversely, the crater’s rim seems to benefit from almost year-round sunshine, essential for any solar-powered base.

Scientists led by Paul Spudis of the Lunar and Planetary Institute in Houston, Texas, have now used images from the European Space Agencys SMART-1 probe to work out the craters age from a careful count of the smaller impact craters around it. We found it to be much older than previously thought, says team member Ben Bussey of the Applied Physics Laboratory in Laurel, Maryland.

The Solar System is full of debris that bombards all the bodies within it at roughly the same rate, so counting the craters and noting how they overlap can give an indication of age. Previous estimates of the craters age had ranged from less than 1 billion to 3.3 billion years old.

But the more detailed images from SMART-1’s Advanced Moon micro-Imager Experiment (AMIE) allowed the team to age Shackelton as roughly 3.6 billion years old. The work is published in Geophysical Research Letters1. Home from home

This is good news for humans thinking about staying on the Moon for a while. Theres been a lot more time for possible ice to accumulate, says Bussey, and over billions of years it is feasible that you could build up a significant reserve.

There is still debate about whether ice could have been brought to the Moon by comets, or delivered as the hydrogen-rich solar wind reacted with oxygen in the Moons surface rocks to produce thin films of water.

Busseys theory that an older crater will have allowed more ice to accumulate will stand up only if the ice came to the Moon on comets, says Manuel Grande of the University of Wales, Aberystwyth, UK, who worked on the SMART-1 mission. A solar wind source could deposit ice, but at such a slow rate that losses would cancel out any large-scale accumulation of ice.

The presence of any water on the Moon still hasnt been proved conclusively, adds Grande. But evidence of hydrogen was found at both poles by NASAs Lunar Prospector probe in 1999. It seems perverse to think theres hydrogen there without it being water, Grande says.

Future data will come from the Japanese space agency and its Kaguya mission, launched in September 2007, says Bussey. Other future Moon fact-finding missions include NASAs Lunar Reconnaissance Orbiter, now expected to launch in early 2009 after a recent delay. The Indian Space agency is launching Chandrayaan-1 in September, with instruments on board to work out the geology and chemistry of the Moons surface, especially at the poles. "Between [these missions] we hope they will map out the most promising locations that will have ice," says Bussey.

References Spudis, P. D. et al. Geophys. Res. Lett., 35, L14201 (2008) — Article —"

ANALYSIS OF A LUNAR BASE STRUCTURE USING THE DISCRETE-ELEMENT METHOD

This paper lists some insulating characteristics of lunar regolith. "As the moon lacks an atmosphere, frequent and strong micro-meteorite bombardment endangers human life (meteorites andmicrometeorites arrive to the surface with approximately a1030 km=s velocity"[21] "According to Silberberg et al. (1985), even when levels of solaractivity and cosmic radiation are low, the annual dose thathumans on the surface are exposed to is about 610 times morethan permissible, and the intensity is particularly high duringperiods of solar flares"[21]

INFLUENCE OF LUNAR TOPOGRAPHY ON SIMULATED SURFACE TEMPERATURE

This paper has many temperature maps of the lunar surface and corrections for topogrophy. It contains formulas for temperature based on latitude and longitude[22]

EVIDENCE FOR SURFACE WATER ICE IN THE LUNAR POLAR REGIONS USING REFLECTANCE MEASUREMENTS FROM THE LUNAR ORBITER LASER ALTIMETER AND TEMPERATURE MEASUREMENTS FROM THE DIVINER LUNAR RADIOMETER EXPERIMENT

from abstract "The lunar South Pole exhibits enhanced reflectance at maximum temperatures below 110K that may indicate the presence of widespread surface water ice.Anomalously bright locations are found at both the North and South poles in regions of permanent shadow that may represent local concentrations of water frost.Reflectance excursions near 200K and 300K may indicate the presence of volatiles more refractory than water ice.There is a general correlation of temperature and reflectance that is attributed to the effect of space weathering. We find that the reflectance of the lunar surface within 5 of latitude of the South Pole increases rapidly with decreasing temperature, near 110K, behavior consistent with the presence of surface water ice. The North polar region does not show this behavior, nor do South polar surfaces at latitudes more than 5 from the pole. This South pole reflectance anomaly persists when analysis is limited to surfaces with slopes less than 10 to eliminate false detection due to the brightening effect of mass wasting, and also when the very bright south polar crater Shackleton is excluded from the analysis. We also find that south polar regions of permanent shadow that have been reported to be generally brighter at 1064nm do not show anomalous reflectance when their annual maximum surface temperatures are too high to preserve water ice. This distinction is not observed at the North Pole. The reflectance excursion on surfaces with maximum temperatures below 110K is superimposed on a general trend of increasing reflectance with decreasing maximum temperature that is present throughout the polar regions in the north and south; we attribute this trend to a temperature or illumination-dependent space weathering effect (e.g. Hemingway et al., 2015). We also find a sudden increase in reflectance with decreasing temperature superimposed on the general trend at 200K and possibly at 300K. This may indicate the presence of other volatiles such as sulfur or organics. We identified and mapped surfaces with reflectances so high as to be unlikely to be part of an ice-free population. In this south we find a similar distribution found by Hayne et al. (2015) based on UV properties. In the north a cluster of pixels near that pole may represent a limited frost exposure." Maximum and minimum temperatures north south pole [23]

EVIDENCE FOR EXPOSED WATER ICE IN THE MOON'S SOUTH POLAR REGIONS FROM LUNAR RECONNAISSANCE ORBITER ULTRAVIOLET ALBEDO AND TEMPERATURE MEASUREMENTS

This one had the circled out figures "Diviner measurements show that the Moons polar cold trapsform a temperature population distinct from the illuminated ter-rain, based on both annual maximum" [24]

THERMAL BEHAVIOR OF REGOLITH AT COLD TRAPS ON THE MOON'S SOUTHPOLE: REVEALED BY CHANG'E-2 MICROWAVE RADIOMETER DATA

" the inversion results showed that the maximum difference of diurnal temperatures between wet and dry regolith were no more than 0.5K. That is, the effect of water ice on subsurface thermal behavior can be neglected. " [25]

OPTIMIZED TRAVERSE PLANNING FOR FUTURE POLAR PROSPECTORS BASED ON LUNAR TOPOGRAPHY

Modeling energy usage of a lunar rover sites that remain illuminated for 91.8% of the year. eclipsed for 104 hours. Average Sun visibility illumination for longitude latitude. [28]

SITE SELECTION AND TRAVERSE PLANNING TO SUPPORT A LUNAR POLAR ROVER MISSION: A CASE STUDY AT HAWORTH CRATER

site planning and illumination graphics [27]

PERSISTENTLY ILLUMINATED REGIONS AT THE LUNAR POLES: IDEAL SITES FOR FUTURE EXPLORATION

Longest period in shadow, hours

The Moons slightly tilted axis results in regions near the poles to remain permanently shadowed while other nearby areas have extended periods of illumination. Lighting conditions of the poles were previously studied with Clementine UVVIS data and topo-graphic models from Earth based radar and laser altimeters mounted on orbiting spacecraft. LROC complements these analyses with higher resolution data (up to meter scale) that delimit and al-low the quantification of lighting conditions near both lunar poles,which enable more precise landing site selections and traverse analyses for both human and robotic polar missions. [28]

ILLUMINATION CONDITIONS AT THE LUNAR POLES: IMPLICATIONS FOR FUTURE EXPLORATION

Illustration of the modeled average illumination for selected locations among the best-illuminated in each polar region. [29]

ESTIMATION OF LUNAR SURFACE TEMPERATURES AND THERMOPHYSICAL PROPERTIES: TEST OF A THERMAL MODEL IN PREPARATION OF THE MERTIS EXPERIMENT ONBOARD BEPICOLOMBO

Thermophysical surface and subsurface mode

Heat capacity of the lunar regolith has been determinedfor different samples returned by the Apollo 11, 12, 14, 1
hermal conductivityPorous material under vacuum conditions such as the lunar orhermean regolith transfers heat in two different ways: thefirst issolid conduction through particles and across interparticle con-tacts and the second is radiation across void spaces

Many formulas[30]

THERMAL CONDUCTIVITY OF SURFICIAL LUNAR REGOLITH ESTIMATED FROM LUNAR RECONNAISSANCE ORBITER DIVINER RADIOMETER DATA

Temperture models for regolith [31]

CHARACTERISATION OF POTENTIAL LANDING SITES FOR THE EUROPEAN SPACE AGENCY'S LUNAR LANDER PROJECT

Lots of planning information and fundamental information [32]

THE PRODUCTION OF OXYGEN AND METAL FROM LUNAR REGOLITH

Produce oxygen from rock.[33]

THERMOPHYSICAL PROPERTY MODELS FOR LUNAR REGOLITH

many thermal equations[34]

SCIENTIFIC PREPARATIONS FOR LUNAR EXPLORATION WITH THE EUROPEAN LUNAR LANDER

Lots of Planning information, Dust plasma...[35]

ANALYSIS OF LANDING SITE ATTRIBUTES FOR FUTURE MISSIONS TARGETING THE RIM OF THE LUNAR SOUTH POLE AITKEN BASIN

Lots of data on the poles..[17]

ILLUMINATION CONDITIONS OF THE SOUTH POLE OF THE MOON DERIVED USING KAGUYA TOPOGRAPHY

Sout pole info [16]

ILLUMINATION CONDITIONS OF THE LUNAR POLAR REGIONS USING LOLA TOPOGRAPHY

Illumination data [15]

ILLUMINATION CONDITIONS AT THE LUNAR SOUTH POLE USING HIGH RESOLUTION DIGITAL TERRAIN MODELS FROM LOLA

More illimunation data[14]

THE GLOBAL SURFACE TEMPERATURES OF THE MOON AS MEASURED BY THE DIVINER LUNAR RADIOMETER EXPERIMENT

good temperature information [13]

DESIGN CONSIDERATIONS FOR LUNARBASE PHOTOVOLTAIC POWER SYSTEMS

Nasa Solar power info[12]

Heat storage and electricity generation in the Moon during the lunar night

More info[11]

Performance analysis of a lunar based solar thermal power system with regolith thermal storage

solar thermal Power [10]

Energy and provision management study: A research activity on fuel cell design and breadboarding for lunar surface applications supported by European Space Agency

Energy management study of fuel cells[9]

Exergy analysis of a lunar based solar thermal power system with finite-time thermodynamics

Solar thermal[8]

The water treatment and recycling in 105-day bioregenerative life support experiment in the Lunar Palace 1

water treatment [7]

Water management in a controlled ecological life support system during a 4-person-180-day integrated experiment: Configuration and performance

water treatment [6]

Lunar regolith thermal gradients and emission spectra: Modeling and validation

[5]

Determination of temperature variation on lunar surface and subsurface for habitat analysis and design

[4]

An overnight habitat for expanding lunar surface exploration

[34]

High frequency thermal emission from the lunar surface and near surface temperature of the Moon from ChangE-2 microwave radiometer

Temperature profiles of regolith. [2]

Moon surface thermal characteristics for moon orbiting spacecraft thermal analysis

[1]

Illumination conditions at the lunar poles: Implications for future exploration

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