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The peaks of eternal light: A near-term property issue on the moon

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ABSTRACT

The Outer Space Treaty makes it clear that the Moon is the 'province of all mankind', with the latter ordinarily understood to exclude state or private appropriation of any portion of its surface. However, there are indeterminacies in the Treaty and in space law generally over the issue of appropriation. These indeterminacies might permit a close approximation to a property claim or some manner of 'quasi-property'. The recently revealed highly inhomogeneous distribution of lunar resources changes the context of these issues. We illustrate this altered situation by considering the Peaks of Eternal Light. They occupy about one square kilometer of the lunar surface. We consider a thought experiment in which a Solar telescope is placed on one of the Peaks of Eternal Light at the lunar South pole for scientific research. Its operation would require non-disturbance, and hence that the Peak remain unvisited by others, effectively establishing a claim of protective exclusion and de facto appropriation. Such a telescope would be relatively easy to emplace with today's technology and so poses a near-term property issue on the Moon. While effective appropriation of a Peak might proceed without raising some of the familiar problems associated with commercial development (especially lunar mining), the possibility of such appropriation nonetheless raises some significant issues concerning justice and the safeguarding of scientific practice on the lunar surface. We consider this issue from scientific, technical, ethical and policy viewpoints.

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1. Introduction

Existing international agreements, the Outer Space Treaty (OST) in particular, seem to exclude the appropriation of the Moon and other celestial bodies by any terrestrial state and, by implication, private appropriation also. Under the OST, space is the 'province of all mankind'. Yet there are clear pressures towards the recognition of property rights in space [1]. The most obvious example here is the *Space Resource Exploration and Utilization Act* passed by the US Congress in 2015.[1] The possible introduction of a wider regime of property rights has also been much discussed [2–4]. Disagreement over the likely shape of any future rights regime is strong and the arguments do not look like they will be resolved until one or more practical examples of appropriation for use are at hand. Such practical examples have seemed far off. Here, however, we suggest an example that could become urgent in within years rather than decades.

Because the issue of legality is to the fore, property rights on the Moon are often discussed against the backdrop of a convenient fiction, an assumption that the Moon is more or less uniform and that, for the most part, occupying one region of the Moon would not deprive others of lunar resources. However, in his recent review of the latter, Crawford (2015) [5] brings together the latest lunar maps from a wide range of sensors and these show a highly structured surface at kilometer scales. They show the extent to which lunar resources are not uniformly distributed. Appropriation by one agent or group of agents could deprive others of important opportunities, and could thereby generate a situation of injustice. A favorite example of a relatively rare resource is water, which may persist in permanently dark craters [6], which in turn occupy thousands of square kilometers in the polar regions (Fig. 1 [7]) [8,9]. Even so, they still occupy only a small fraction (0.1%) of the total lunar surface.

Scarcer still are the regions of permanent solar illumination, the "peaks of eternal light", described in section 2. If such peaks can be

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[1] https://www.congress.gov/114/bills/hr1508/BILLS-114hr1508rh.pdf.

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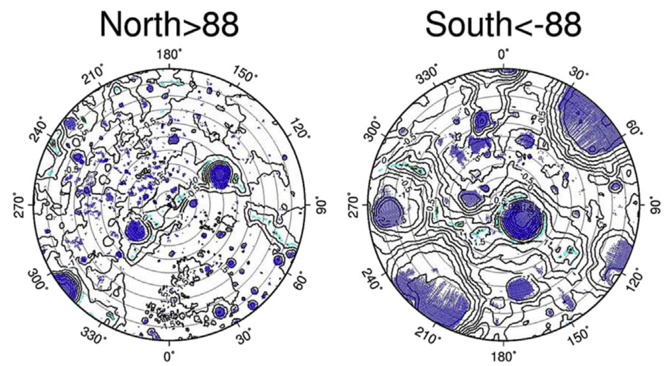

Fig. 1. Lunar Polar regions (88–90°) showing zero illumination regions (purple) and high illumination regions (light blue) [Source [7]: Noda et al., 2008].

found near to permanently dark craters then we have hit the lunar resource jackpot: a region with great resources next to a region with abundant power. Just as the proximity of iron and coal mines in England was an important spur to the Industrial Revolution [10], so this combination of power plus resource may spark or at least facilitate industrial development on the Moon. As we will see this combination is also extremely rare on the Moon and it is the power supply that is scarcest of the pair.

As always when resources are concentrated, this clustered distribution of high illumination regions will eventually lead to disputes over rights to those resources. And the scarcer (and more valuable) the resource, the more eager we may expect agents to be in staking their claim once the resource is believed to have been reliably identified. The first case of trusted identification might trigger a "scramble for the Moon" comparable in some respects to the "scramble for Africa" which began with the identification of mineral resources in the Congo in the 1880s [11]. And here, the appeal to the African precedent may be a better fit than any appeal to the 19th century American frontier, given the high level of resources, and state-led activity which the former required by contrast with the appropriation of resources by small groups of individuals in the American West. Given the growing realization that the Moon does have scarce concentrations of resources, the issue of appropriation, which has appeared distant, may soon emerge as a more practical problem in urgent need of solution.

In the case of the peaks of eternal light the resource in question is so scarce (roughly 1/100 of a billionth of the lunar area) that even a single country or company could, on its own, occupy them all, effectively denying that resource to others. In what follows, we show how scarce a resource they are, how they could be (in some sense) legally appropriated using ambiguities in the Outer Space Treaty to uphold such an appropriation. We then consider how to deal with this near-term rights issue on the Moon.

2. Peaks of eternal light

The "Peaks of Eternal Light" are highland regions near the lunar poles that receive sunlight virtually all of the time. I.e. they are (almost) never shadowed by other parts of the Moon. The existence of such peaks was first hypothesized by Beer and Mädler (1837, p.16) [12]. Over 40 years later, the popular science writer, Camille Flammarion gave them their poetic name: "montagnes de l'éternelle lumière" (translated as "peaks of eternal light") [13,14]. The small tilt of the Moon's spin axis to the ecliptic (1.54° versus 23.5° for the Earth) makes these peaks possible. In the 19th century it was not clear if any such peaks actually existed.

Searches for regions of nearly permanent sunlight have, however, become a priority for lunar explorers as they are excellent places to situate scientific experiments or human habitats. By providing a virtually permanent source of power from sunlight, equipment emplaced there can be simplified. The main advantages are that fewer high mass batteries need to be transported to the Moon to provide power during darkness, as periods of darkness are short, and that the rigors of the low temperature lunar night are mostly avoided, thereby simplifying instrument and habitat design.

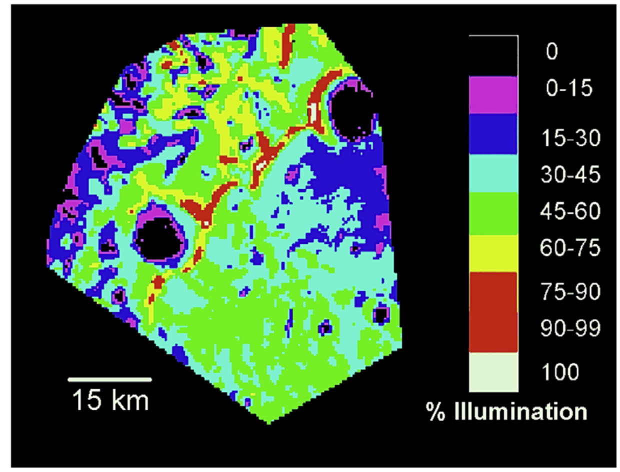

Fig. 2. Illumination map of the Moon's north pole, within about 30 km (1–1.5°). The narrow strips of orange, red and white are illuminated at least 75% of the time. Source: Bussey et al. (2005) [15].

The existence of peaks of eternal light is no longer conjectural. Over the past decade several lunar-orbiting spacecraft (SMART-1, Clementine, SELENE, Chandrayaan, Lunar Reconnaissance Orbiter) have mapped the lunar poles in increasing detail [5]. Some candidate "eternal light" regions near both the North and South lunar poles were found from these maps. An illumination map of the North polar region is shown in Fig. 2 [15]. The red and white areas have 90–99% and 100% illumination respectively. Note how thin these regions are. They are primarily ridges and crater rims.

The South lunar pole is a rather different matter. While the North Pole happens to be a highland region, the South Pole lies in the large (2500 km diameter) South Pole Aitken impact basin, several kilometers below the mean lunar surface. Bussey et al. (2005) [15] say that at the South lunar pole there is no permanently illuminated region, at least on the 500 m scale that they can measure. As a result there are no true "eternal light" regions at the south lunar pole. There are still, however, regions of high illumination [16]. Like the true "eternal light" regions in the north, these high illumination regions in the south are small, as seen in the topographic simulation shown in Fig. 3. The total area of high

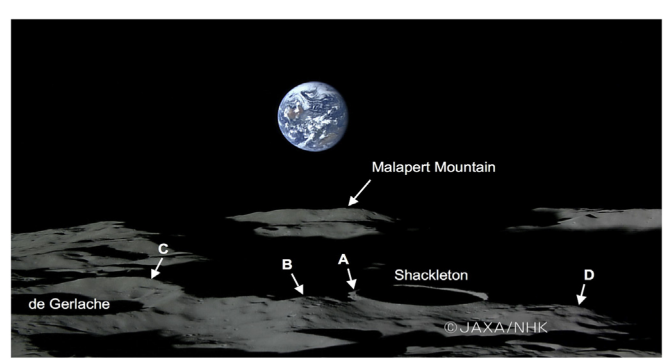

Fig. 3. Lunar South Pole, four peaks are identified which are illuminated more than 80% of the time. (source: Bussey et al., 2010 [17]).