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SCRATCHING THE SURFACE: THE ETHICS OF HELIUM-3 EXTRACTION

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ABSTRACT

Terrestrial mining is ethically problematic by virtue of its directly destructive impact and by virtue of its contribution to both the depletion of fossil fuels and (through the use of the latter) to the raising of $C0_2$ levels in the atmosphere. Extraction of helium-3 (^{3}He) from the lunar regolith would share two of these same problems, i.e. resource depletion (which I will suggest is the *soft problem* of lunar mining) and destructive impact (which I will suggest is the *hard problem*). In response to the *hard problem*, in spite of the fact that the Moon is a lifeless place, I will argue that we do nonetheless have reasons for lunar protection. Firstly, it is a culturally-significant object; secondly, familiar appeals to planetary 'integrity' (notably by Holmes Rolston) may be supported by appeal to a 'last-man argument'; finally (and following Hannah Arendt) living in places which we value is integral to our humanity and this should shape and inform our move beyond the Earth. However, none of these consideration will yield sufficient grounds for ruling out *all* mining under *all* circumstances and for *all* purposes. Different justificatory narratives may then be told for and against any particular proposal. Even so, it is difficult to envisage what kind of narrative could be used to justify destructive mining on an extensive scale other than the familiar narratives which are already used to justify space exploration as such, i.e. those concerning terrestrial advantage; a duty to extend life (or human life); and a naturalistic appeal to a human longing to explore. I will suggest that the latter is by far the least convincing justification. A tendency to expand into new areas is a species trait and not a standard character trait of individual humans. As such, the expression of this trait is not a requirement for human well-being. What this leaves us with is, on the one hand, the terrestrial advantage of a cleaner form of nuclear energy and, on the other, a duty to extend life (or human life) which might be served by the lure of this unique source. However, with regard to terrestrial benefits all is not so simple as it might seem. And, as for the duty to extent human life, while the duty is perhaps both real and noteworthy, it can only be what Kant referred to as an imperfect duty, i.e. a duty which may be fulfilled in several different ways. As a result, only if the other plausible ways of fulfilling this duty were blocked off or, more ethically problematic, should extensive and destructive ^{3}He mining be regarded as the default option.

Keywords: mining, integrity, duty, lunar protection.

INTRODUCTION

What follows is a provisional consideration of the ethics of Helium-3 (^{3}He) mining, a scratching of the surface of this issue in an attempt to show that something deeper and more comprehensive may perhaps be said (and ought to be said). This light isotope has repeatedly been cast in the role of an energy saviour for an overcrowded and under-resourced world with the promise that nuclear fusion, based upon the Deuterium-^{3}He reaction, will become one of humanity's primary sources of energy or, more modestly, that it will replace nuclear fission (Lewis 1997; Santarius et al. 2006). If we can mine or capture even relatively modest amounts of ^{3}He off-world, we may be able to shift to safer and cleaner systems of nuclear power based upon the least radioactive forms of fusion technology. We may be able to do so while sustaining standards of living and we may even be in a position to think a little more seriously about building fusion-based propulsion systems which are capable of reaching nearby stars (Spencer 1966; Gilster 2004; Zubrin 1999).

1. THE LUNAR OPTION

Setting aside the point that fusion technology has yet to become economic (and assuming that at some point it may do so) what makes this otherwise attractive picture of our near future problematic is the proposed source. From a purely logistical point of view, the Moon is the best candidate for ^{3}He mining. The gas giants at the outer edges of the solar system do have far richer reserves but they are a long distance away. If ^{3}He capture is to happen anytime soon, say in the next half century or so (the usual time-frame for the beginnings of a shift to fusion power) it may have to take place much closer to home. Discounting Mercury and Venus (because they are too hot to work on) and Mars (because it is too atmospherically-protected to have built-up significant ^{3}He reserves) there are only two serious candidate sources: asteroids and the Moon. But while asteroids may be good for a one-hit option, until we are able to park them in orbit, successive returns will be impractical. This is likely to push the costs of mining through the roof. It stands in the way of operational stability and the establishment of infrastructure. Added to which, the concentration of ^{3}He within asteroid regolith is probably less than within lunar regolith. Asteroids are gravitationally weaker than the Moon and do not retain ejected material nearly so well. As a result, they (again probably) have far less *mature* regolith. (These are familiar and plausible claims which stand in need of empirical verification.)

Given that concentrations of ^{3}He, wherever found, tend to be low (i.e. measured in parts per billion) and that it takes an extremely long time for them to build up to significant levels, and given the substantial financial outlays that will be required for start-up costs, the processing of the most accessible concentrations of the most mature regolith is, from a strictly mining standpoint, the default option. Enthusiasts for ^{3}He mining (which includes at least some figures within all of the world's leading space agencies) seem to be entirely correct about this matter. Lunar ^{3}He is also, in the absence of an extensive off-world economy the only resource which *might* allow the initial stages of lunar settlement to 'pay its own way' or to do so at least in part, depending upon the cost of extraction and return-to-Earth technologies. As a consequence, the first major ethical challenge for lunar protection may well turn out to the issue of ^{3}He mining. It is, for example, closer to becoming an immediate ethical issue than the question of lunar property rights because, until there is an economically viable reason for going to the Moon and staying there, property rights will remain merely token, they will be rights at a distance.

2. DESTRUCTIVENESS OF PROCESS

Terrestrial mining is ethically problematic by virtue of its directly destructive impact and by virtue of its contribution to the depletion of fossil fuels and the raising of $C0_2$ levels in the Earth's atmosphere. Extraction of ^{3}He from the lunar regolith would share two of these same problems. Significant amounts of mature regolith would have to be processed in order to extract even a small amount of this isotope. Extraction would therefore be destructive, or at least intrusive to the point of re-shaping areas of the lunar landscape. It would also involve the removal of an important, and effectively non-renewable, resource. Weighing-up these difficulties I will suggest that the *hard problem* of ^{3}He mining concerns lunar damage and that, considered on its own, the problem of resource depletion need not be intractable and may be considered the *soft problem* of ^{3}He mining. Although future generations do have reasonable entitlements which we cannot flout, lunar mining of ^{3}He, if linked to further access i.e. to making the further reaches of the solar system accessible for ^{3}He capture, could allow us to leave far more than 'as much and as good' for future generations. (Here, as a matter of convenience, I use the classic Lockean formulation with regard to the correct usage of natural resources however I am not wedded to it.)

But just how destructive would the process of ^{3}He mining be? The option which is generally under consideration is the systematic extraction, crushing and heating of regolith to around 700 °C in order to release various gasses, including ^{3}He which could then be stored for later use in a fusion reactor. How much of the lunar surface would be affected is still something of an unknown. In part, it would depend upon the local composition of the regolith itself. Of course, we have lunar return samples to work from and they suggest an average concentration of about 4 parts of ^{3}He per billion (ppb) of regolith. But in some areas the figure is significantly higher, rising to 15 ppb partly because finer grains in some areas happen to expose more surface area per volume and hence have a higher capture ratio. There is also the lumpiness of the Moon's magnetic field to consider. The Solar wind which seeds the Moon with ^{3}He is deflected in an uneaven manner.

To add to our uncertainties, these figures only take account of strongly-bound ^{3}He. Weakly-bound ^{3}He, especially in high lunar latitudes, may be significantly more abundant (Slyuta et al. 2007). (And this could open up the possibility of ethically-unproblematic capture technologies with minimal surface disruption.) What is also likely to shape the pattern of mining is the varying depth of the regolith. The deepest regolith is correlated with reduced ^{3}He concentrations. And because of this, going deep to restrict the area which is mined might not be the

easiest economic option. Assuming a concentration of 4 ppb and a regolith density of around 2g/cm^3, it would require at least 250,000 tonnes of regolith to be processed in order to obtain 1kg of ^{3}He. How much of an area would have to be stripped in order to do so would depend upon how deep the mining would reach. Robert Zubrin (1999: 88) has suggested stripping an area of 1km square to a depth of 10 cm which could take us into roughly the right territory (0.8 kg of ^{3}He). However, it seems implausibly minimal for an actual mining operation as opposed to some less intrusive form of activity such as an expansive archaeological dig. Santarius, Kulcinski and Miley (2006) have suggested instead that we mine to about 3 meters deep using a bucket-wheel excavator. This would take us to the depths at which the ^{3}He concentration starts to fall off. In a perfect world this might yield around 24kg of ^{3}He over an excavation area of 1km square. To mine as much as a tonne of ^{3}He it would then take an area of more than 6km square.

However, for ^{3}He to become a serious player in the terrestrial energy mix it would have to at least match the existing contribution of nuclear fission (which supplies roughly 6% or thereabouts of our energy worldwide and 11% or thereabouts of energy production in the OECD countries). That might require as much as 40 tonnes of ^{3}He per year mined over an area of as much as 40 square km. Over several decades mining on this scale could start to eat up significant portions of the lunar surface. Admittedly, the data needs to be refined in all sorts of ways but these rough and ready figures convey something of the magnitude of destruction that could be involved in any process of extensive He^3 extraction, i.e. extraction geared to meet the aspirations outlined at the start of this paper, just so long as it was carried out by any familiar form of intrusive/destructive mining technique. It may also be prudent to acknowledge that limited mining concessions, geared initially to planetary protection and to the restriction of impact, could follow the familiar terrestrial pattern by operating as a beachhead for wider exploitation. If lunar protection is a genuine ethical requirement then, given the possible impact of He-3 mining, we have legitimate reasons for ethical concern.

3. REASONS FOR LUNAR PROTECTION

I will now suggest that we do have reasons to regard lunar protection as a genuine ethical requirement. More specifically, we have contributory reasons for doing so, reasons which may sometimes be overridden but never silenced (Dancy 2004:15). However, as a concessionary point, the independence of the final reason that I will offer may be open to question. Firstly, the Moon is a culturally-significant object. Given this, we should no more treat it as a *mere* resource (as a giant mine or quarry) than we should treat Stonehenge or the pyramids as a convenient source of building materials. This is another way of making sense of the idea (already enshrined in space law) that the Moon is part of the 'common heritage of mankind'. It may, of course, be pointed out that the Moon is not a human artifact whereas structures such as Stonehenge and the pyramids are. And this no doubt restricts the *ways* in which the Moon can realistically be viewed as culturally significant but not the fact that it has such significance. Moreover, this does not seem to be dependent upon how the present generation, or any particular generation of humans, happens to feel about the Moon.

After all, it is plausible to say that if we, on our travels, were to encounter the culturally-significant objects of alien beings (even if we could not understand *why* they were significant and even if there no longer happened to be any of the alien beings around) this would still be a reason to treat such objects in a special manner. (Although this presupposes a larger story about what can count as a reason and why it can do so.) Similarly, not only do *we* have reasons not to damage Stonehenge by virtue of its cultural-historic significance for *other* humans, but intelligent visitors from other worlds (if any such beings happened to exist) who encountered this region of space after the demise of humanity, would also have reasons to avoid damage to Stonehenge just as long as they were in a position to recognize the significance that Stonehenge once had for the (now defunct) humans. These comments outline a familiar 'indirect duties' approach towards the assignment of moral considerability: a special importance can be assigned to objects and structures without any appeal to their inherent value but by appeal to the fact that they are or have been important to other beings towards whom we continue to have duties of respect and care. We should care about the objects because we care about (or respect) those other beings.

Secondly, familiar appeals to planetary 'integrity' (notably those made by Holmes Rolston) may turn out to be defensible, in which case we can go further than the indirect-duties approach and actually make a claim of intrinsic lunar value (Rolston 1986). Attempts have been made to argue, by fell swoop, that intrinsic value accrues *only* to sentient or, more restrictively, rational beings (Smith 2009). But we cannot make this move without disturbing exclusions and without the risk of turning our attitude towards sentience, or rationality, into a peculiar kind of fetish, one which not only restricts attributions of value but also divorces them from our actual (and

perhaps ineradicable) practices of valuing. At the very least, the burden of argument falls upon those who want to restrict intrinsic value to the rational or to the sentient. It falls upon their shoulders because they are challenging something deep. After all, there are and always have been contexts in which humans are prepared to treat at least some non-sentient objects as having an importance *in their own right*. The standard move which helps to make this clear is an appeal to some form of 'last-man argument' in which a fictional last man, with his dying action, wantonly destroys uninhabited forests, rivers, mountains or (in this case) the Moon in the knowledge that no sentient (or rational) being will be harmed as a result (Sylvan 1973; Midgley 1983). There is no *plausible* ethical tale that we can tell within which such a destructive action would be defensible. Instead, it looks akin to an act of vandalism. In terms which owe something to Mary Midgley, Robinson Crusoe does not get to blow up his island as a parting gesture (Midgley 1983: 36).

We may, of course, challenge the significance of such last-man thought-experiments, or (more generally) the significance of thought-experiments in moral contexts. And, on their own, they are admittedly inconclusive. However, what is on offer here are a series of contributory reasons for valuing rather than individually-conclusive reasons for doing so. Moreover, thought experiments of the last-man sort, while inconclusive, nonetheless do look like an indispensable tool when it comes to articulating important moral intuitions which a restricted repertoire of ethical concepts may leave us in danger of missing. Indeed, a repertoire restricted to ethical concepts such as 'rights', 'duties', 'consequences', and 'rational agency' may screen-off matters of ethical importance by rendering them almost unintelligible. As a symptom of this, we might think of a well-known (and well-crafted) paper by Christopher McKay, 'Does Mars have Rights?' to which the obvious answer is 'no' but only because this is the wrong question to ask (McKay: 1990). 'Does Mars have integrity?' or 'Does the Moon have integrity?' seem far closer to the kinds of query which may have an illuminating answer. And what may guide us towards a suitable answer in the context of the integrity of the Moon is not the (historically-constructed) cultural significance of this body but the history that it has in its own right, a history by virtue of which it is more appropriate to refer to the Moon by a name rather than a serial number. Indeed, Rolston suggests that naming and integrity go together: the practice of naming is, *up to a point*, a reliable indication of the presence of integrity (Rolston 1986: 172-73).

Finally, as well as an (indirect-duty) appeal to the Moon as part of the common heritage of mankind and a (direct-duty) appeal to its integrity, there are mixed appeals where concern for what is human and for what is non-human are not easily disentangled. Here, I have in mind the way in which Hannah Arendt brings the two together. According to Arendt, as we move into space we must preserve the sense of care and belonging which is integral to our humanity (Arendt 1963). Otherwise, moving into space (engaging in a figurative 'conquest of space') will do more harm than good. Preserving such a sense of care and belonging also need not be understood as excessively demanding. By all means we should still use the Moon, just as we use the Earth which we ourselves are part of, but if we *merely* use it, or regard it *merely* as a resource then we risk losing sight of a task of the ethical task of *being at home* in a larger region of space, a task which is different from learning to live in or near to a mining district. The places where we dwell, if we are truly to *dwell* anywhere and not merely to *exist*, must have meaning and significance for us. The language which is in play here is draws from the phenomenological tradition of philosophy and is somewhat more elusive than the broadly analytic terms in which I have set out the first two reasons for lunar protection. Nonetheless, I will take it that Arendt may be saying something that we should be reluctant to dismiss, something that may be deep or profound and which has echoes in the more recent literature (Arnould 2011: 181-88). We may, as noted previously, argue about the extent to which this represents an independent consideration and I will not quibble over this matter. I offer it as a *perhaps* independent consideration and at least as illuminating.

I will take it that, together, the above appeals provide at least some contributory reasons for lunar protection including reasons for the restriction of mining. However, it is not obvious any of these three reasons for lunar protection, singly or in combination, will yield sufficient grounds for ruling out *all* mining under *all* circumstances and for *all* purposes. (I do not think that Arendt ever had any such thing in mind and Rolston explicitly rules it out.) By suggesting that the reasons for lunar protection are in fact contributory reasons, I am acknowledging that they may sometimes, or ultimately, be outweighed by other considerations. What they do, however, block off is any *laissez-faire* attitude which automatically, and without further justification, sets an entitlement to mine as the default position.

Different justificatory narratives may then be told for and against any particular mining proposal. Even so, it is difficult to envisage what kind of narrative could be used to justify ^{3}He mining on any damagingly-extensive scale other than the familiar narratives which are already used to justify expenditure upon space exploration i.e. terrestrial advantage of the sort flagged up at the outset of this paper; a duty to extend life or human life; and a

naturalistic appeal to some basic human longing to explore. Of these three, the latter is by far the least convincing given that a tendency to expand into new areas seems to be a species trait rather than a trait which is characteristic of the average individual human. By contrast with action which expresses our need to *belong*, action which is *expressive* of a longing to explore does not seem to be a necessary part of our human well-being. It is, instead, one way in which some humans may attempt to make themselves happy. As a justification for damaging the Moon, that may not be quite good enough.

CONCLUSIONS

What this leaves us with is, on the one hand, the significant terrestrial advantages of abundant and comparatively clean energy (assuming that a comparatively clean form of fusion can be made to generate more power than it consumes) and, on the other hand, a duty to extend life (or human life) which might be served by the lure of this unique resource and by the terrestrial breathing space that a better kind of energy production could offer us. If we do mine the Moon it will, no doubt, help to equip us as we extend our reach and attempt to improve our survival chances. However, with regard to terrestrial benefits all is not so simple as it may seem. Access to new forms of energy production are likely to open pathways to terrestrial harm as well as pathways towards a healing of the planet (or to the healing of our seriously-fractured and power-hungry societies). Eco-minded critics, with whom I am broadly in sympathy, who argue that we already have more energy than we can handle without causing terrestrial damage may have a point. Such damage has, up to the present, resulted not just from the limitations of existing fuels but from their inappropriate usage. A change of fuel source may make some of us more powerful but it is unlikely to make us any wiser. Furthermore, in the absence of a radical alteration in patterns of human behaviour, a good deal of energy from ^{3}He mining is unlikely to go towards a great life-enhancing project. It is likely to be used for comparatively trivial purposes such as advertising, waste and the enhancement of prestige. This is part and parcel of living in a society where choice is valued. However, there are some choices (the choice to be cruel, aggressive, destructive or wasteful) which may not be worth having and which, in some cases, we ought not to have.

With regard to the second consideration, the duty to extend life (or human life), this could only be what Kant referred to as an imperfect duty, i.e. a duty which can be fulfilled in several different ways. It is unlikely that a convincing case could be made for the mining of lunar ^{3}He as a *necessary* step in our human survival. There are, after all, other options such as the development of less-intrusive technologies for the capture of weakly-bound ^{3}He, technologies which would not involve mining in any familiar sense. And if this should be non-viable then there is the less efficient (but perhaps still efficient-enough) process of asteroid mining for ^{3}He. As already conceded, advocates of lunar mining are perfectly correct that this is not the best *logistical* option, but if lunar integrity is an important matter it may be a far better *ethical* option. It is tempting to go as far as to say that only if the other plausible ways of fulfilling our duty to extend life (or human life) were blocked-off would extensive lunar ^{3}He mining then become a defensible default option. While other options remain alive, shaping our future around extensive lunar mining will remain ethically problematic.

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