LUNAR OUTGASSING INTERACTIONS WITH THE REGOLITH. A. P. S. Crotts[1] and C. Hummels[1], [1]Columbia University, Department of Astronomy, 550 West 120th Street, New York, NY 10027 (arlin, chummels@astro.columbia.edu).

Introduction: Several developments in the past few years inspire us to question how volatiles might leak from the lunar interior and how this might manifest itself in existing or future data. Among these developments are 1) the discovery that picritic glass spherules from the deep lunar interior, liberated in fire fountains, are relatively rich in water and sulfur [1,2]; 2) the finding that some eroded areas on the lunar surface inconsistent with impact craters were modified relatively recently, probably in the past several million years, in a manner consistent with a massive outgassing event [3], and 3) the locations of episodes of ^{222}Rn outgassing, as observed on *Apollo 15* and *Lunar Prospector*, are geographically coincident with sites that have consistently produced over history reports by observers of optical transient lunar phenomena (TLPs), as are the residuals of recent ^{222}Rn outgassing as traced by ^{210}Po [4,5].

In particular we ask if TLPs might be generated by outgassing. Until 20 to 30 years ago, optical transients on the lunar surface (Transient Lunar Phenomena: TLP or LTP) were seen as an important, outstanding lunar mystery in need of study [6,7,8]. Since then, we have gained little understanding of TLPs, excepting for developments listed above. The debate on even the reality of TLPs as a coherent physical effect (as opposed to observer error) has been limited to the popular literature, both pro and con [9,10]. We find the results of our model interesting in the context of this debate.

Models of Explosive Outgassing: In a recent paper, we explore in the interaction of gas penetrating the regolith via seepage, fluidization and explosive disruption [11]. The latter is calculated for a source of gas rising from the interior and meeting the base of the regolith as a point source. For a 15 m regolith depth, a gas flow of greater than about 3 g s^{-1} is sufficient to eventually build up a sufficient overdensity (amounting to about 1 tonne for 20 AMU gas) such that the gas punctures the regolith and is explosively liberated into the vacuum. After this heavy regolith particles (larger than about 0.1 mm) quickly fall into the crater blown by this explosion, but lighter particles expand into a partially ballistic/partially gas-supported cloud that expands over several km radius and for several minutes before disappearing. The area affected and timescale of this model event turns out to be similar to the observed quantities typical of TLPs. The lightest dust particles can be accelerated up to about 50 km altitude. A layer of fresh regolith is generated which can likely be detected to about 1 km radius for of order 1000 y before being lost to gardening effects, and much longer in the central crater (~ 30 m diameter). We also discuss how during the outburst event pressures inside the cloud linger near the Paschen minimum condition and speculate that charge separation within the cloud might cause coronal discharge effects. We discuss in detail how these hypotheses based on this straightforward model might be tested via remote sensing.

Seepage through the Regolith: We also calculate the conditions in the past under which water vapor leaking from the interior might have undergone a phase change in order to produce water ice at significant depths in the regolith (of order 10 m or more), and for large regions near the poles find that ice might accumulate into significant masses (depending on the outgassing rate). These might be expected to survive over geological time scales. We discuss at length how these might be detected via remote sensing, as well.

Finally, given the possible long-term presence of water ice interacting with the regolith, we speculate that one eventual outcome of this interaction might be the filling of regolith particle interstices by motile material in a manner similar to cement, as might be further aided by the presence of sulfates as seen in lunar volcanic glasses. This requires further investigation, but would possibly result in a concrete-like layer formed over the ice, which would tend to thicken as the ice migrates downward due to the thermal evolution of the regolith.

References: [1] Saal A. E., Hauri E. H., Cascio M. L., van Orman J. A., Rutherford M. C. & Cooper R. F. (2008) *Nature*, 454, 192. [2] Hauri E. H., Saal A. E., van Orman J. A., Rutherford M. C. & Friedman B. (2009) *LPS XL*, 2334. [3] Schultz P. H., Staid M. I. & Pieters C. M. 2006, Nature, 444, 184. [4] Crotts A. P. S. (2008) *ApJ*, 687, 692. [5] Crotts A. P. S. (2009), *ApJ*, 697, 1. [6] Lunar Geoscience Working Group (1986) *Status & Future of Lunar Geoscience*, NASA SP-484.; also Grant H. H., Vaniman D. T. & French B. M. (1986) *Lunar Sourcebook* (Cambridge U. Press), p. 654. [7] Geake J. E.. (1976) *Report of Ad Hoc Working Group, Comm. 17, IAU*, Proc. IAU Gen. Ass'y, 16, p. 150. [8] Various authors in TLP special issue (1977) *Phys. Earth & Planet. Interiors*, vol. 14. [9] Cameron W. S. (1991) *Sky & Tel.*, 81, 265. [10] Sheehan W. and Dobbins T. (1999) *Sky & Tel.*, 98, 118. [11] Crotts A. P. S. & Hummels C. (2009) *ApJ,* submitted (also http://arxiv.org/abs/0706.3952).