# PROMINENT VOLCANIC SOURCE OF VOLATILES IN THE SOUTH POLAR REGION OF THE MOON.

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**Introduction:** Pyroclastic glasses have surfaces that are enriched in volatiles like S, Ag, Cd, Zn, and Br (*e.g.*, [1-3]) by factors of 3 to 400 compared to their interiors. That suggests modest chemical etching or abrasion may remove them for *in situ* resource utilization (ISRU) (*e.g.*, [4]). Some of the pyroclastic deposits are enriched in ilmenite (*e.g.*, [5]), which can be reduced to produce oxygen (*e.g.*, [6]), providing another ISRU opportunity. Because pyroclastic deposits are fine-grained, easily excavated, transported, and processed, they are an attractive target for sustainable exploration.

**Pyroclastic Vent in Schrödinger Basin:** Because of that ISRU potential, an immense ~400 m-tall pyroclastic deposit in the Schrödinger basin was among the Tier I and II targets during the Exploration Systems Mission Directorate (ESMD)-phase of the Lunar Reconnaissance Orbiter (LRO) mission. Models of those types of eruptions indicate C-O gas phases were involved (*e.g.*, [7]), although new analyses of Apollo 15 and 17 glasses [8-9] suggest that H-O species are involved too, augmenting solar wind volatiles that are implanted in the regolith ([10] and references therein).

We calculated H-O volatiles produced by the young volcanic vent, which has a Lunar Orbiter Laser Altimeter (LOLA)-derived volume of ~190 $km^3$. These calculations are based on pyroclastic volatile abundances inferred from green and orange glasses [8-9] and models of eruption [7]. In addition to $H_2O$, we calculated the abundances of CO, $CO_2$, F, Cl, and S. The degassed minimum to maximum masses are: $H_2O = 3.0 \times 10^{13}$ to $1.6 \times 10^{14}$ g; $CO = 4.1 \times 10^{13}$ to $4.1 \times 10^{14}$ g; $CO_2 = 7.0 \times 10^{12}$ to $7.1 \times 10^{13}$ g; $F = 1.2 \times 10^{12}$ to $4.6 \times 10^{12}$ g; $S = 1.4 \times 10^{13}$ to $2.6 \times 10^{13}$ g; and $Cl = 0$ to $2.2 \times 10^{11}$ g. These values are substantial. The mass of water, for example, is 12,000 to 62,000 times larger than that in an Olympic-size pool. There are a couple of approximations one has to make in the calculations, but those might change the values by factors of only a few. The volatile abundances are so large that any variation in those approximations is not very significant.

**Cold Traps within Schrödinger Basin:** Some of the volatiles may be trapped within cavities in Schrödinger (*e.g.*, lava tubes, crevices in the impact units, and the interior of the vent itself) that are emerging from extensive geologic analyses of the Schrödinger basin [11-13]. In addition, illumination analyses indicate portions of a nearby crater floor fracture and two simple craters are in permanent shadow where volatiles can be incorporated into regolith. Thus, there may be ice-rich deposits within Schrödinger that could be analyzed and utilized by future lunar surface missions.

**Transport of Volatiles to the Lunar South Pole:** The Schrödinger vent is one of the largest on the farside and occurs ~500 km from the lunar South Pole. There will be a strong tendency for the volatiles to migrate towards the pole (*e.g.*, [14-15]). The vent may be less than 2 billion years old [16] when the Moon was in its current orbital/spin configuration, so any volatiles released could be en route to the South Pole. Recent mapping suggests the vent may be older [17]. In either case, we suggest the transport of those volatiles be modeled and predictions made for abundances en route, so that future measurements can be used to test transport mechanisms.

**Conclusions:** These results indicate a mission to the Schrödinger basin, initially designed to evaluate the lunar magma ocean and lunar cataclysm hypotheses [11, 18], may simultaneously be able to address some of the exploration (ISRU) issues relevant to the Human Exploration and Operations Mission Directorate (HEOMD). Indeed, the immense pyroclastic deposit in Schrödinger, coupled with potential volatile deposits, further enhances Schrödinger as an exploration target.

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