PRODUCTION OF VOLATILES AT LUNAR PYROCLASTIC VOLCANIC VENTS.
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Introduction: More than 100 pyroclastic deposits have been identified on the lunar surface [1]. These volatile-rich eruptions were principally driven by C-O gas phases (*e.g.*, [2]), although new analyses of Apollo 15 and 17 glasses [3-4] suggest H-O species are also involved. Once liberated at the lunar surface, these volatiles would have augmented solar wind volatiles implanted in the regolith ([5] and references therein). To assess that volcanic contribution, the compositions of pyroclastic glasses collected at the Apollo 15 and 17 landing sites are used to calculate the production of volatiles degassed in lunar pyroclastic eruptions of different sizes on the Moon.

Degassed Volatile Abundances: The abundances of CO_2, H_2O, F, S, and Cl were determined in very-low-Ti and low-Ti glasses from Apollo 15 (15427,41) and high-Ti glasses from Apollo 17 (74220,864) [3]. Diffusive degassing models were then used to infer original magmatic volatile abundances. In a complementary study, the abundances of H_2O, F, S, and Cl were measured in melt inclusions trapped in olivine within pyroclastic glass spherules from the same Apollo 17 sample [4]. The goal was to measure directly the volatile abundances that existed in the magma prior to any degassing. In addition, models of the fire-fountain eruptive process that produced the Apollo 17 glass provide an independent estimate of the CO and CO_2 that was liberated [2]. In the calculations that follow, the CO and CO_2 abundances of [2] are used. The H_2O, F, S, and Cl abundances determined by [4] are generally lower than those of [3] and are used here to be conservative in estimates of degassed volatile mass.

The degassing of the volatile components is not equal – a larger fraction of the CO and CO_2 (100%) and H_2O (98%) species were lost compared to that of F (45%), S (19%), and Cl (57%) [2-4]. The corresponding minimum to maximum abundances liberated per erupted mass are 105 to 1050 ppm for CO, 18 to 183 ppm for CO_2, 77 to 401 ppm for H_2O, 3 to12 ppm for F, 36 to 67 ppm for S, and 0 to 0.6 ppm for Cl. The bulk density of a primary pyroclastic unit is taken to be 2.04 g/cm^3, which is the measured value in a portion of sample 74002 [6]. This sample is the upper part of a drive tube through orange soil that is adjacent to the soil clod sample 74220 used in the analyses of [2-4]. Sample 74220 is 92.3 to 95.9% glass [7], while the top of 74002 is 91.2% glass and the 90 to 150 µm fraction is 99.9% glass [8].

Multiplying the bulk density times the volume of a pyroclastic deposit produces the mass of spherules. Using the volatile abundances and degassing fractions described above, one then derives the mass of volatiles degassed as shown in Figure 1. These volumes are substantial, but also represent lower limits of the contribution of volcanically-produced gases to the lunar exosphere and regolith. Other types of lunar basalt eruptions released volatiles, as indicated by the 3.4 Ga vesicular mare basalt 15016 and other samples (15529 and 15556) from the Apollo 15 site, and need to be evaluated with a similar set of calculations.

Conclusions: Water and CO+CO_2 masses produced at the lunar surface are on the order of 10^{12} to 10^{15} g for pyroclastic volumes of 10 to 500 km^3. These substantial masses are presented with the caveat that they are based on data inferred mostly from Apollo 15 and 17 materials. Samples of additional vent material, like that at the Schrödinger basin (*e.g.*, [9-10]), are needed to determine if those values are valid for other lunar pyroclastic vents.

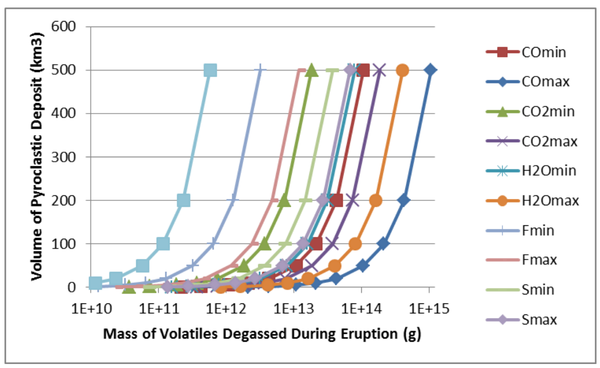

Fig. 1. Mass of volatiles degassed during eruptions producing pyroclastic deposits with volumes up to 500 km^3.

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