SPECTRAL AND PHOTOMETRIC INDICATORS OF ACTIVE PLUME DEPOSITS ON EUROPA. M.M. Hedman[1], L.C. Quick[2] P. Schenk[3] [1]University of Idaho, 875 Perimeter Dr. MS 0903, Moscow ID 83844 (mhedman@uidaho.edu), [2]Planetary Science Institute, 1700 East Fort Lowell Rd., Suite 106, Tuscon AZ 85716 (lquick@psi.edu), [3]Lunar & Planetary Institute, 3600 Bay Area Blvd. Houston TX 77058 (schenk@lpi.usra.edu)

Recent Hubble Space Telescope observations have found evidence that Europa could be emitting plumes of water vapor similar to those Cassini has observed emerging from Enceladus' south pole [1,2,3]. If Europa is actively venting material from beneath its surface, this would provide new opportunities for assessing the properties of any subsurface bodies of water. However, the plume signal from Europa does not appear in all of the available observations, so any activity on this moon is likely intermittent or only intermittently detectable, which complicates any effort to directly observe this phenomenon.

An alternative way to search for recent activity on Europa is to look for fallout on the surface. Such plume deposits are persistent and so should be easier to map and could therefore help guide efforts to find regions where material has erupted onto the surface. Several dark patches on Europa's surface have been interpreted as plume deposits [4,5], and recent work has examined the spatial distribution of potential plume fallout on the moon [6]. However, thus far there has not been a detailed analysis of what such deposits would look like in terms of distinctive spectral and photometric properties.

In principle, plume deposits can be identified based on a number of different morphological and spectrophotometric criteria. However, in practice morphological evidence for plume deposits often requires high-resolution data that are usually very limited in extent. Consequently, spectral and photometric indicators are far more appealing tools for performing global searches for recent activity. The spectral and photometric properties of plume deposits can be diagnostic either because the plume material has a distinctive chemical composition or because the fallout has a different particle size distribution from typical regolith. For example, organic materials in a recent plume deposit will probably be less processed by ambient radiation than the rest of the surface. However, it is difficult to predict *a priori* what the composition of the plume might be, and for icy moons like Europa, where water ice is common both on the surface and in the plumes, it may be hazardous to assume strong compositional variations can serve as a reliable indicators of plume deposits. Hence we will initially focus our attention on variations in the particle size distributions.

Studies of Saturn's moon Enceladus have already demonstrated how plume activity can influence the spectral properties of an icy moon. The material lofted above this moon's surface consists of both gas and fine particles, but many of the particles are not launched with sufficient speed to escape the moon's gravity, and so fall back onto the surface. Global variations in the moon's color match the expected distribution of plume fallout [7,8], and near-infrared spectra reveal variations in water-ice band depths that probably reflect trends in the sizes of particles able to travel different distances from the plume sources [9,10].

We have started to investigate the trends in surface particle properties that active plumes could generate on Europa's surface. Assuming that particle plumes on Europa have similar velocity distributions as those on Enceladus, the ballistic model of [5] may be used to estimate the thickness, T, and width, $2R$, of plume deposits on these moons for various particle sizes. Tables 1 and 2 shows the results of these calculations for a plume with optical depth τ = 0.15 [3] that has been erupting for 20 days with various particle launch velocities. We have assumed a deposit porosity, ϕ = 65%, between that of freshly fallen snow, ϕ = 90%, and dense snow, ϕ = 45% [5]. Table 1 shows that the largest particles will produce the thickest deposits, while Table 2 shows the proximity of particles to the vent as a function of eruption velocity for both Europa and Enceladus. These numbers can be used to infer the surface distribution of plume fallout as a function of particle size. Using plume particle distributions on Enceladus as a baseline [11], we will continue this analysis in order to place more rigorous constraints on the distribution and dimensions of plume deposits on Europa.

The varying distribution of different plume particles on the surface will influence multiple spectral and photometric features, and further investigation is needed to ascertain which spectral and photometric parameters are most likely to be robust tracers of recent plume activity. Such investigations will employ theoretical regolith light-scattering models. These models will not only reveal how parameters like band depths, visible colors and phase curves can be used to seach for plume fallout, but also clarify whether similar variations are easier to see in certain viewing geometries.

r_p (μm)	1 μm	T (mm)	2 μm	T (mm)	3 μm	T (mm)
$V_{min}{}^{a}$ (m/s)	180	0.07	120	0.8	95	3
$V_{max}{}^{a}$	220	0.05	220	0.4	170	2
$V_{Enropa/thoery}{}^{b}$	252	0.05	252	0.4	252	0.4
$V_{Enceladus/ISS}{}^{c}$	313.5	0.04	313.5	0.3	313.5	0.3
$V_{Europa/HST}{}^{d}$	700	0.02	700	0.1	700	0.1

Table 1. Plume deposit thickness as a function of particle size and eruption velocity. [a]Minimum and maximum particle velocities from [11].[b]Maximum Europa plume eruption velocity from [4,5]. [c]Maximum Enceladus plume eruption velocity reported in [12]. plume eruption velocity reported in [1].

V (m/s)	$\boldsymbol{R_{Europa}}$ (km)	$\boldsymbol{R_{Enceladus}}$ (km)
95[a]	7	80
120[a]	11	127
180[a]	25	287
220[a]	37	428
252[b]	48	562
313.5[c]	74	870
700[d]	371	4336

Table 2. Deposit half-width, *R*, as a function of particle eruption velocity for plumes on Europa and Enceladus. [a]Minimum and maximum particle velocities from[11].[b]Maximum Europa plume eruption velocity from [4,5]. [c]Maximum Enceladus plume eruption velocity reported in [12]. [d]Europa plume eruption velocity reported in [1]/

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