PLUMES ACROSS THE SOLAR SYSTEM – WHEN IS CRYOVOLCANISM IMPLICATED? C. J. Hansen[1], [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson AZ 85719; cjhansen@psi.edu.

Introduction: Twenty-seven years ago plumes were discovered jetting from the surface of Neptune's moon Triton [1, 2]. Since then water vapor and ice particles have been detected spewing from the south polar region of Saturn's moon Enceladus [3, 4, 5]. A tentative identification of water vapor erupting from Jupiter's moon Europa has come from Hubble Space Telescope ultraviolet images [6]. At Mars, solar-driven gas jets remain the best explanation for the seasonal activity that takes place every year associated with sublimation of Mars' seasonal CO_2 polar cap [7]. Studying the different plumes gives us insight into the diversity of processes driving eruptions and affects how we define cryovolcanic activity.

Enceladus and Europa: The Enceladus plume is clearly endogenic. Cassini radio science data show that there is a subsurface gravity anomaly consistent with a body of liquid water below the south pole [8] while images show libration that requires a global liquid layer [9]. The subsurface body of water supplies the ice particles and water vapor propelled from Enceladus' interior out to the vacuum of space through fissures across the south pole. Extensively studied by all the instruments on the Cassini spacecraft we now have detailed information on the composition and structure of Enceladus' plume and imbedded collimated jets, with implications for the composition and habitability of the ocean below the surface.

Europa's plume(s) are likely also water vapor, but ultraviolet data show that there are key differences between the eruptive styles of Enceladus and Europa. Europa's eruptions appear to be sporadic, in contrast to Enceladus where water expulsion is modulated by diurnal tides but otherwise continuous. The mass of water vapor erupted at Europa is 2 orders of magnitude larger than Enceladus [10, 11].

Mars: The jets at the poles of Mars are a surficial phenomena, driven by spring sublimation of the seasonal polar cap. Transmission of sunlight through a semi-translucent layer of impermeable seasonal CO_2 ice heats the ground below the ice, causing basal sublimation of the ice [7]. The trapped gas ruptures the ice, and erodes the surface, entraining loose material as it escapes out from under the ice layer. The particulates fall out on top in fan-shaped deposits oriented by the ambient wind. The properties of these solar-driven jets have been studied extensively by the HiRISE imager on the Mars Reconnaissance Orbiter [12].

Triton and Pluto: An interesting question is what drives Triton's plumes? Are they solar-driven like Mars or endogenic like Enceladus? The original assessment was that they were solar-driven [13], and the Mars model was largely inspired by Triton. But the circumstantial evidence that drove that conclusion was based on the fact that the subsolar latitude was in the southern hemisphere, as were the plumes.

Triton has a young surface age, <10 MY, derived from the lack of craters on its surface [14]. A new model of the interior of Triton shows that the combination of radiogenic heating with tidal heating due to Triton's obliquity could sustain a long-lived subsurface ocean, and sluggish convection, even without invoking substantial ammonia [15]. Triton's plumes reach 8 km altitude, erupting through an ambient atmosphere, before being carried away horizontally by the ambient wind. Although this can be achieved with solar-driven plumes, perhaps Triton's eruptions come from a deeper source. A regional endogenic source of eruptive activity like Enceladus should be considered.

An interesting test was provided by New Horizons Pluto observations. Pluto does not experience obliquity tides and is thus unlikely to have an endogenic energy source as proposed for Triton [15]. It does however have a nitrogen atmosphere in vapor pressure equilibrium with surface ice, that will form polar caps in the winter. If we had seen fans and/or plumes at Pluto in the north polar region now experiencing spring it would have bolstered the solar-driven hypothesis. But New Horizons did not detect any active plumes on the encounter hemisphere of Pluto [16].

Summary: The study of plumes, easily accessed by remote sensing, gives us insight into the energy, structure and processes hidden below the surface.

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