CANDIDATE (CRYO)VOLCANIC FEATURES IN THE OUTER SOLAR SYSTEM: OBSERVATIONAL CONSTRAINTS. P. Schenk and L. Prockter, Lunar & Planetary Institute, Houston TX (schenk@lpi.usra.edu).

Introduction: Volcanic resurfacing is a key geologic indicator of heat within planetary bodies, due to the requirements of melting and mobilizing crustal and mantle materials. With the survey of major bodies of the Solar System complete, except for unobserved areas and remaining large KBOs, we reexamine the sometimes controversial record of (cryo)volcanic features on ice-rich bodies, with the objective of classifying features by type and likelihood of origin, including an assessment of morphologic and topographic constraints on formation.

Jovian Satellites: Voyager observed extensive bands of higher albedo resurfaced terrains on Ganymede inferred to be resurfaced by liquid water lavas [1]. Galileo's higher resolution observations indicate pervasive block faulting in many areas leading to the alternative hypothesis of tectonic resurfacing [2]. Limited topographic mapping indicates some bright bands are depressed, more in keeping with volcanic flooding [3], perhaps triggered by pressure-release melting [3] and indicating that Ganymede was warm enough to mobilize water at some time. Associated irregular caldera-like walled depressions are interpreted as late-stage volatile-rich eruptions [3]. Galileo's limited high-resolution sampling of Europa revealed surprisingly few examples of overt volcanism, although there are low-albedo smooth plains surrounding some chaos features [e.g., 4], as well as diffuse surface deposits alongside some major double ridges and lenticular domes [5]. Much of Europa's resurfacing appears to be dominated by solid-state vertical mobility in the form of diapiric intrusions [6]. Definitive interpretations of ridges and other structures, and an understanding of processes in the ice shell, are required to definitively characterize (cryo)volcanic features on this moon.

Mid-sized Icy Moons: Voyager observed limited evidence for volcanism at Saturn [7]. Aside from venting at Enceladus, Cassini mapped smooth plains on Dione as hemispheric in scale and centered on two irregular walled depression reminiscent of those on Ganymede and supporting volcanic interpretations [8]. New materials in Elsinore Corona on Miranda take the form of narrow parallel 500-m high ridges that have been interpreted as linear extrusions of viscous icy materials [9]**.** Similarly, smooth-floored down-dropped graben on Ariel may indicate viscous resurfacing [9]. Ammonia-hydrate mixtures were proposed based on inferred higher flow viscosities and compositional complexity with distant from the Sun. Double ridge 'tiger stripes' lead to comparison with ridges on Miranda & Triton as possible eruption sources and especially Europa, given the dark coloration and flanking smooth deposits of younger ridges. Low-lying resurfaced plains of Vulcan Planum of Charon could be due to (cryo)volcanism or the foundering of crustal blocks and replacement by 'mantle' materials [10].

Triton & Pluto: Voyager at Triton revealed the most explicitly volcanic terrains in the Outer Solar System, a 600-km-wide low volcanic plain of unknown composition scarred by pit chains and an 80-km wide caldera, Leviathan Patera [11], all reminiscent of low-viscosity volcanics such as the basaltic Snake River or Kilauea sites. Unresolved is the solar vs. geothermal origins of Triton's geysers. Observed Plutonian volcanism is very different, restricted to a low plain populated by scarp-walled depressions and the 3-6 kilometer-high edifices Wright and Piccard Mons [12]. Composition and emplacement on Pluto remain unclear but could be due to overlapping domical extrusions.

Ceres: Mobility of ice or salt-rich phases was postulated on Ceres but overt evidence is limited. Ahuna Mons (and similar) domes are likely viscous extrusion [13]. The preferred though unconfirmed interpretation of the dome in the central pit of Occator crater [14] is that of a laccolithic subsurface intrusion that uplifted and fractured the surface of the carbonate coated pit.

Outstanding Questions: There is a rich variety and complexity of (cryo)volcanic landforms on icy bodies, perhaps related to composition. Key unresolved issues are the timing of resurfacing events and links to tidal/thermal evolution, and the paucity of constraints on the compositions of any of these materials and their rheology during extrusion. Return with advanced instruments is required.

References: [1] Shoemaker, E. et al. (1982) *in Satellites of Jupiter,* U. Ariz. Press. [2] Pappalardo, R. et al. (2004) in *Jupiter*, Camb. U. Press. [3] Schenk, P. & W. McKinnon (2001) *Nature,* 410, 57; Showman, A. et al. (2004) *Icarus*, 172, 625. [4] Prockter, L. & P. Schenk (2005), Icarus, 177, 305. [5] Fagents, S. (2003) *J. Geophys. Res.,* 108, 5139. [6] Greeley, R. et al. (2004) in *Jupiter*, Camb. U. Press. [7] Morrison, D., et al. (1986) in *Satellites*, U. Ariz. Press. [8] Schenk, P. et al. (2018) in *Enceladus and the Icy Moons of Saturn*, U. Ariz. Press. [9] Jankowski, D. & S. Squyres (1988) Science, 241, 1322; Schenk, P. (1991) *J. Geophys. Res.* 96, 1887. [10] Schenk, P. et al. (2018) *Icarus*, in press; Beyer, R. et al. (2018) this meeting. [11] Croft, S. et al. (1995) in *Neptune and Triton*, U. Ariz. Press. [12] Moore, J. et al. (2016) *Science*, 351, 1284; Singer, K. et al. (2018) this meeting. [13] Ruesch, O. et al. (2016) *Science*, 353, 1005. [14] Quick, L. et al. (2018), *Icarus*, in press; Schenk, P. et al., (2018) *Icarus*, in press.