**SUMMARY**

Enceladus geysers apparently draw water from a subsurface ocean, but the sustainability of conduits linking ocean and surface is not understood. “Tiger stripes” sourcing the geysers should be clamped shut by tidal stresses for much of the 1.3 day orbit, and liquid-water channels of geysers should freeze over quickly as eruptions should be intermittent. However, new observations show sustained geysering, both throughout the orbit and since 2005. A simple model of tiger stripes as tidally-flexed slots that puncture the ice shell can simultaneously explain the persistence of the eruptions through the tidal cycle; observed phase lag of eruptions relative to tidal stress; maintenance of fissure eruptions over geological timescales; and Enceladus' power output. Delay associated with freezing and refilling of O(1) m-wide slots with ocean water generates a phase lag, while tidally pumped in-flow leads to heating and mechanical dissipation that staves off slot freezing (Fig. 1). The turbulent dissipation that matches the observed phase lag of Enceladus (thick black curve) requires an ocean above the water table. This is consistent with the observation of near-surface tensile fractures of tiger stripes (orange arrows; “IR” corresponds to infrared cooling at the bottom (Fig. 1). Subject to sinusoidally time-varying extensional stress, slot-normal tidal stress dependence of amplitude of aperture is (5-2) x 10^4 Pa modified by elastic interactions between slots, the water table initially falls, water is drawn into the ocean (which is modeled as a constant-pressure bath), and slots widen. Wider slots allow stronger eruptions because flux of a supersonic choked flow increases with nozzle width (9). Later in the tidal cycle, the water table rises, water is flushed from slots to the ocean, slots narrow, and eruptions diminish (but never cease). W0=5 m slots oscillate in phase with on, W=1 m slots lag a by 1 radians. Resonant slots (W=1 m, tidal quality factor 1) lag a by 1 radian. Net liquid flow feeding the eruptions is negligible compared to tidally-oscillating flow (+1 m/s for W0=1 m). Turbulent liquid water flow into and out of slots generates water temperature homogenized by turbulent mixing. Aperture variations and vertical pumping help to disrupt ice feeding at the water table. A long-lived slot must satisfy the heat demands of evaporitic cooling at the water table (about 1.2x the observed IR emission) plus re-melting of ice in-flow driven by the pressure gradient between the ice and water in the slot (10). Turbulent dissipation can balance this demand for W0=1-3 m, corresponding to phase lags of 0.5-1 rad, as observed. Eruptions are then strongly tidally-variable but sustained over the tidal cycle. W0=1 m slots freeze shut, wider slots widen, and eruption diminish. Near-surface temperatures ~10 m wide are suggested by modeling of high-temperature emission (11), consistent with near-surface vent flaming. Rectification by choke points (9), condensation on slot walls, and ballistic fall-back (3), could plausibly amplify the <2-fold slot-width variations in our model to the 5-fold observed plume variations.

**SIMPLE SLOT MODEL**

Fissures are modeled as parallel rectangular slots (stress-free width W0, open to an ocean at the bottom (Fig. 1). Subject to sinusoidally time-varying extensional stress, slot-normal tidal stress dependence of amplitude of aperture is (5-2) x 10^4 Pa modified by elastic interactions between slots, the water table initially falls, water is drawn into the ocean (which is modeled as a constant-pressure bath), and slots widen. Wider slots allow stronger eruptions because flux of a supersonic choked flow increases with nozzle width (9). Later in the tidal cycle, the water table rises, water is flushed from slots to the ocean, slots narrow, and eruptions diminish (but never cease). W0=5 m slots oscillate in phase with on, W=1 m slots lag a by 1 radians. Resonant slots (W=1 m, tidal quality factor 1) lag a by 1 radian. Net liquid flow feeding the eruptions is negligible compared to tidally-oscillating flow (+1 m/s for W0=1 m). Turbulent liquid water flow into and out of slots generates water temperature homogenized by turbulent mixing. Aperture variations and vertical pumping help to disrupt ice feeding at the water table. A long-lived slot must satisfy the heat demands of evaporitic cooling at the water table (about 1.2x the observed IR emission) plus re-melting of ice in-flow driven by the pressure gradient between the ice and water in the slot (10). Turbulent dissipation can balance this demand for W0=1-3 m, corresponding to phase lags of 0.5-1 rad, as observed. Eruptions are then strongly tidally-variable but sustained over the tidal cycle. W0=1 m slots freeze shut, wider slots widen, and eruptions diminish. Near-surface temperatures ~10 m wide are suggested by modeling of high-temperature emission (11), consistent with near-surface vent flaming. Rectification by choke points (9), condensation on slot walls, and ballistic fall-back (3), could plausibly amplify the <2-fold slot-width variations in our model to the 5-fold observed plume variations.

**ACKNOWLEDGEMENTS**

We thank Or Bialik, Chris Chyba, Wim Degruyter, Shawn Ewald, Eric Gaidos, Terry Hurford, Leif Karlstrom, Doug MacAyeal, Michael Manga, Isamu Matsuyama, Karl Mitchell, Alyssa Rhoden, Max Rudolph, Britney Schmidt, Krista Soderland, Joseph Spitale, Dave Stevenson, Robert Tyler, and Steven Vance.

**REFERENCES**